STILLBIRTH, PERINATAL MORTALITY, AND THE EFFECT OF PRENATAL CARE SERVICES ON CHILD MORTALITY IN BANGLADESH

Abir Tanvir

BSc, MSc, Mstat

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

School of Science and Health

Western Sydney University

March 2017

Dedication

This thesis is dedicated to my parents (Md.Tazammul al Haque and Mrs.Feroza Haque), my beloved wife (Jahan Gulshan) and two sons (Jahin Tanvir and Azman Tanvir).

Acknowledgements

I would like to thank my supervisors, Dr Kingsley E. Agho, Professor Michael J. Dibley, Dr Abul Hasnat Milton, and Professor Andrew N. Page for their guidance, expertise, time and constructive feedback that provided valuable knowledge during my candidature. A special thanks to Dr Kingsley E. Agho, for his excellent supervision, constructive criticisms, extensive statistical and STATA programming guidance, promptness in reading my write-ups and encouragement from the inception of my PhD. Last but not least, the patience of my dear wife (Jahan Gulshan) and my beloved sons (Jahin Tanvir and Azman Tanvir) for giving me the space and time to do this study is gratefully acknowledged.

More importantly, I would like to thank Measure DHS ICF International for granting me permission to use the data sets for this thesis.

Author's Declaration

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

(Signature)

Abstract

Stillbirth, neonatal mortality and child mortality have remained a public health concern in low income and middle income countries, including Bangladesh. Steps taken to minimise this burden include antenatal care, and offering of drugs such as iron and folic acid supplements and tetanus toxoid vaccinations. This thesis utilises data from the 2004, 2007, 2011 and 2014 Bangladesh Demographic and Health Surveys, and carried out multilevel modelling for all analyses. This thesis first examines the factors associated with stillbirth in Bangladesh. It then explores the factors associated with perinatal mortality in the country. The thesis further examines the impact of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh. Finally, the factors associated with under-5 mortality are examined.

Chapter 5 presents the results of analysis of factors associated with stillbirth in Bangladesh. Findings in this chapter identifies some of the determinants of stillbirth to include low levels of maternal education, lack of husbands for mothers, household poverty, number of children per mother, and mother's limited access to newspapers. **Chapter 6** identifies factors associated with perinatal mortality in Bangladesh, and identified high body mass index of mothers, male infants, mother's delivery complications and non-use of contraceptives as significant determinants. **Chapter 7** identifies that mothers who were given no iron and folic acid (IFA) supplements and had less than two tetanus toxoid (TT) vaccinations, mothers who received no IFA supplements and had less than two TT vaccinations, and mothers who did not have any antenatal care, visits and did not receive any IFA supplements were significantly associated with under-5 mortality in Bangladesh. **Chapter 8** identifies mothers from the Sylhet region, older mothers, and mothers' low level of education as some of the factors associated with neonatal deaths. Non-working mothers and those with no schooling were some of factors associated with post-neonatal deaths. Almost similar factors were identified to be associated with infant, child, and under-5 deaths.

Table of contents

Contents

Dedication i

Acknowledgements ii

Author's Declaration iii

Abstract iv

Table of contents v

List of Tables x

List of Figures ix

Publications arising from PhD thesis x

Abbreviations xii

CHAPTER 1 1

INTRODUCTION 1

1.1 Introduction and statement of the problem 1

1.2 Research questions 7

1.3 Research objectives 7

1.4 Justification of the study 8

1.5 The study area 12

1.6 Definition of terms 14

1.7 Organisation of the thesis 15

1.8 Summary 16

References 17

CHAPTER 2 22

LITERATURE REVIEW AND THEORETICAL FRAMEWORK 22

2.0 Introduction 22

2.1 Global overview of stillbirth, perinatal, infant and child mortality 23

2.2 Overview of stillbirth, perinatal, infant and child mortality in South Asia 26

2.3 Overview of stillbirth, perinatal, infant and child mortality in Bangladesh 27

2.4 Risk factors for stillbirth, perinatal, infant and child mortality 28

2.5 Theoretical framework 30

2.7 Summary 43

References 45
CHAPTER 3 58
METHODOLOGY 58
3.0 Introduction 58
3.1 Bangladesh Demographic and Health Surveys 58
3.1 Data sources for answering the first research question 63
3.2 Data sources for answering the second research question 65
3.3 Data sources for answering the third research question 66
3.4 Data sources for answering the fourth research question 68
3.5 Summary 71
References 72
CHAPTER 4 73
STATISTICAL ANALYSES 73
4.0 Introduction 73
4.1 Multilevel Logistic Regression Modelling Approach 73
4.2 Analyses employed in answering the first research question 74
4.4 Analyses employed in answering the third research question 75
4.5 Analyses employed in answering the fourth research question 76
4.6 Summary 77
References 78
CHAPTER 5 79
PREVALENCE AND FACTORS ASSOCIATED WITH STILLBIRTH 79
5.0 Introduction 79
5.1. Basic characteristics of the study participants 79
5.2 Prevalence and odds ratios of stillbirth: results of univariate analysis 82
5.3 Factors associated with stillbirth: multivariate analyses 86
5.4 Summary 88
CHAPTER 6 89
PREVALENCE AND PREDICTORS OF PERINATAL MORTALITY 89
6.0 Introduction 89
6.1 Basic characteristics of the variables 89
6.2 Perinatal mortality (stillbirth and early neonatal) 93
6.3 Perinatal mortality (stillbirth and neonatal) 99
6.4 Factors associated with Perinatal mortality (stillbirth and early neonatal) 106

6.5 Summary ... 110
CHAPTER 7 ... 111
THE EFFECT OF ANTENATAL CARE, IRON FOLIC ACID SUPPLEMENTATION AND TETANUS TOXOID VACCINATION DURING PREGNANCY ON CHILD MORTALITY ... 111
7.0 Introduction ... 111
7.1 Basic characteristics of the study participants ... 111
7.2 Factors associated with neonatal, postnatal and child mortality ... 114
7.3 Summary ... 122
CHAPTER 8 ... 123
PREVALENCE AND FACTORS ASSOCIATED WITH UNDER-5 MORTALITY ... 123
8.0 Introduction ... 123
8.1 Basic characteristics of the study participants ... 123
8.2 Prevalence of neonatal, post-neonatal and infant mortality ... 128
8.3 Prevalence of child and under-5 mortality ... 136
8.4 Factors associated with neonatal mortality ... 141
8.5 Factors associated with post-neonatal mortality ... 147
8.6 Factors associated with infant mortality ... 154
8.7 Factors associated with child mortality ... 160
8.8 Factors associated with under-5 mortality ... 166
8.9 Summary ... 174
CHAPTER 9 ... 175
DISCUSSION ... 175
9.0 Introduction ... 175
9.1 Factors associated with stillbirth in Bangladesh ... 175
9.2 Factors associated with perinatal mortality in Bangladesh ... 177
9.3 Effect of antenatal care, iron and folic acid supplementation and tetanus toxoid vaccination on child mortality in Bangladesh ... 179
9.4 Factors associated with under-5 mortality in Bangladesh ... 180
9.5 Summary ... 185
References ... 186
CHAPTER 10 ... 191
SUMMARY, POLICY IMPLICATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH ... 191
10.0 Introduction ... 191
10.1 Overview of key findings ... 191

10.2 Strengths and weaknesses of the study 196
10.3 Policy Implications 197
10.4 Recommendations 198
10.5 Future research directions 200
10.6 Conclusions 200
References 202
Appendix A 203
Appendix B 213
Appendix C 228

List of Tables

Table 3.1: Categorisation of covariates used in the study. 70
Table 5.1: Characteristics of variables (n = 29,094), Bangladesh, 2004-2014....70
Table 5.2: Prevalence and unadjusted odd ratios and their 95% confidence intervals of stillbirth in Bangladesh, 2004-2014....83
Table 5.3: Risk factors for stillbirth: adjusted odds ratio (AOR) 87
Table 6.1: Characteristics of the study variables (n = 27,540) 90
Table 6.2: Prevalence and unadjusted odd ratios and their 95% confidence intervals of Perinatal mortality (stillbirth and early neonatal) 94
Table 6.3: Prevalence and unadjusted odd ratios and their 95% confidence intervals of Perinatal mortality (stillbirth and neonatal) 90
Table 6.4: Factors associated with Perinatal mortality (stillbirth and early neonatal): Adjusted odd ratios (AOR) 106
Table 6.5: Factors associated with Perinatal mortality (stillbirth and neonatal): Adjusted odds ratios (AOR)....108
Table 7.1: Characteristics of the study participants (n = 16722), Bangladesh, 2004-2011 ...112
Table 7.2: Community and Socio-economic factors associated with neonatal, postnatal and child mortality, Bangladesh, 2004-2011....116
Table 7.3: The effect of different combinations of iron supplementation, tetanus toxoid vaccination and antenatal care on neonatal, post-neonatal and child mortality, as determined by multivariate analysis, Bangladesh, 2004-2011 120
Table 8.1: Characteristics of variables (n = 22969)....124
Table 8.2: Prevalence and 95% confidence intervals of Neonatal, post-neonatal and infant mortality, Bangladesh (2004-2014) 131
Table 8.3: Prevalence and 95% confidence intervals of child and under-five mortality, Bangladesh (2004-2014)....137
Table 8.4: Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with neonatal mortality....131
Table 8.5: Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with post-neonatal mortality....136
Table 8.6: Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with Infant mortality....156
Table 8.7: Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with child mortality 146
Table 8.8: Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with under-five mortality....168

List of Figures

Figure 1.1: Location and map of Bangladesh showing the various divisions. 13
Figure 2.1: Conceptual framework for analysing factors associated with death of children < 5 years in Bangladesh. 31
Figure 3.2: Child (a) and under-5 (b) mortality rates per 1000 live births in Bangladesh (2004-2014) 141

Publications arising from PhD thesis

Abir T, Agho KE., Page AN., Milton AH. and Dibley MJ. 2015. Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011. BMJ open, 5(8), p.e006722.

Abir T, Ogbo FA, Stevens GJ, Page AN, Milton AH, Agho KE, 2017. The impact of antenatal care, iron-folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh. PLoS One.12(11):e0187090

Abir T, Agho KE, Ogbo FA, Stevens GJ, Page AN, Hasnat MA, Dibley MJ, Raynes-Greenow C, 2017. Predictors of stillbirths in Bangladesh: evidence from the 2004-2014 nation-wide household surveys. Glob Health Action.10(1):1410048

Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ANC	Antenatal Care
AOR	Adjusted odd ratios
BDHS	Bangladesh Demographic and Health Survey
BMI	Body mass index
BRAC	Bangladesh Rural Advancement Committee
CI	Confidence intervals
DHS	Demographic and Health Survey
ENDM	Early neonatal deaths or mortality
HDSS	Health and Demographic Surveillance System
HINARI	Health Inter Network Access to Research Initiative
HIV	Human Immunodeficiency Virus
HNPSP	Health Nutrition and Population Sector Program
HPNSDP	Health, Population and Nutrition Sector Development Program
ICDDRB	International Centre for Diarrhoeal Disease Research, Bangladesh
IFA	Iron and folic acid
JSTOR	Journal Storage
MDG	Millennium Development Goals
NIPORT	National Institute of Population Research and Training
NIPSOM	National Institute of Preventive and Social Medicine
PCA	Principal Component analysis
PHD	Doctor of Philosophy
PRS	Poverty Reduction Strategy
SDG	Sustainable Development Goals
SMC	Social Marketing Company
STI	Sexually transmitted infections
TFR	Total fertility rate
TRC	Technical Review Committee
TT	Tetanus Toxoid
TTF	Technical Task Force
TV	Television
TWG	Technical Working Group
UNICEF	United Nations Children's Fund
UOR	Unadjusted odd ratios
USAID	United States Agency for International Development
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Introduction and statement of the problem

Child mortality, including neonatal mortality is an important public health issue which reflects the developmental status of a country including Bangladesh, as it a good indicator of prenatal, delivery, and early postnatal healthcare as well as the health of both mother and child [1]. Previous studies [2, 3] have estimated that approximately 25-30% of all stillbirths occur during delivery, with the remainder occurring before delivery. A variety of suggested factors for stillbirth include infections and environmental hazards, which may affect maternal health, foetal development and survival during pregnancy.

1.1.2 Stillborn

Stillbirth is a professional and lay term that refers to a dead-born foetus [4]. Intrauterine death occurs either before onset of labour (antepartum death) or during labour (intrapartum death). Because of pregnancy complications or maternal diseases, foetuses may die intra utero, before onset of labour. No special reason, however, has been found for many antepartum intrauterine deaths. The main cause of death among almost all infants who were alive when labour started, but were born dead is complications arising during birth. It is therefore crucial to know at what point before birth the baby died, so that appropriate interventions can be planned accordingly. It is relatively easy to determine, in the context of childbirth care, approximately when the death occurred. The proportion of babies that die intrapartum is, therefore, a very important indicator enabling health personnel to take the most appropriate measures to prevent such deaths. Where women receive good care during childbirth, intrapartum deaths represent less than 10% of stillbirths due to unexpected severe complications.

Globally, approximately three million third-trimester stillbirths are said to occur [5]. Past studies have revealed that stillbirth rates can vary within countries, with economically poorer

communities having higher rates than their economically well-off counterparts [6]. About 98% of these stillbirths occur in low-income and middle-income countries, with 55% occurring in rural families in sub-Saharan Africa and South Asia, where skilled attendance and caesarean sections are lower than for urban families [2]. As at 2009, the stillbirth rate in Bangladesh stood at 36 per 1000 live births [7].

1.1.3 Perinatal mortality

Perinatal mortality refers to deaths of foetuses in the womb and of newborn babies early after delivery. This includes (1) the death of s foetus in the womb after 27 weeks of gestation and during childbirth (2) the death of a live-born infant within the first week of life or, (3) the death of a live-born infant within one month of life. The availability and quality of the health care of both mother and newborn is a reflection of the perinatal mortality rate. Globally, over 6.3 million perinatal deaths occurred in the year 2000, with almost all them (98%) occurring in developing countries and 23% in the least developed countries. The perinatal mortality rate is five times higher in developing than developed countries, with 10 deaths per 1000 total births in developed countries; 50 per 1000 total deaths in developing countries and over 60 per 1000 in the least developed countries. The rate is highest in Africa: 62 per 1000 total births, and especially in middle and western Africa, with rates as high as 75 and 76 per 1000 respectively. In Asia, the perinatal mortality rate is 50 per 1000 total births, with a maximum of 65 per 1000 in South-central Asia, the third highest rate among the subregions, only lower than those of Middle and Western Africa [8]. As at 2000, the perinatal mortality rate was 50 per 1000 births, and the number of perinatal deaths was about 217,000 [9].

1.1.4 Neonatal mortality

Neonatal death refers to the death of children soon after they are born. Many of such deaths occur in the first four weeks of life (referred to as neonatal death), and most of those during the

first week (early neonatal). Neonatal deaths that occur after the first four weeks are referred to as post-neonatal deaths. Neonatal deaths and stillbirths stem from poor maternal health, inadequate care during pregnancy, inappropriate management of complications during pregnancy and delivery, poor hygiene during delivery and the first critical hours after birth, and lack of newborn care. In many societies, neonatal deaths and stillbirths are not considered to be a problem, largely because they are very common. Many communities have adapted to this situation by not recognizing the birth as complete, and by not assigning any name, until the newborn infant has survived the initial period. Babies die immediately after birth because of a number of reasons: (1) they are severely malformed, (2) they born very prematurely, (3) they suffer from obstetric complications before or during birth, (3) they have difficulty adapting to extra-uterine life and (5) because of harmful practices after birth that lead to infections.

One of the causes of neonatal deaths has been low birth weight, which has been long associated with the death of many newborn infants, but is not considered a direct cause. Generally, about 15% of newborn infants weigh less than 2500 g. This percentage ranges from 6% in developed countries to more than 30% in some parts of the world. There is no doubt that maternal health and nutrition at conception are important determinants of weight at birth, neonatal health and frequency and severity of complications, and that maternal infections such as malaria and syphilis contribute to adverse pregnancy outcomes and thus to mortality.

Common causes of perinatal death in the absence of obstetric care include complications during birth, such as obstructed labour and foetal mal-presentation. In the most severe cases, damage to the brain and other organs causes the baby to die during birth or soon after. Disability could be caused by less severe asphyxia and trauma. Birth trauma has almost been eliminated by modern obstetric practices. Conversely, where modern obstetric care is not available, intrapartum or early postnatal deaths are very frequent. It is estimated that in developing countries asphyxia causes around seven deaths per 1000 births, whereas in developed countries

this proportion is less than one death per 1000 births. The majority of deaths occur soon after birth, some just before birth.

Infections in mothers and babies often cause prolonged labour or prolonged rupture of membranes. However, mothers are less susceptible than babies, and infections in infants are harder to detect. An estimated 26% of newborn infants are said to die as a result of infections occurring around birth. During pregnancy the uterus protects the baby from environmental infections. Despite this, some infections break through the safety barrier and affect the foetus.

Syphilis and HIV are the most common. Many babies are stillborn, die soon after birth or are infected themselves in countries where maternal syphilis is prevalent. Neonatal tetanus has been, and remains, a common cause of neonatal death in settings where lack of hygiene at birth and inadequate cord care are prevalent. This is because in such settings, many women are not immunized against tetanus and therefore are unable to protect the baby at birth. Most deaths from neonatal tetanus occur between the seventh and tenth day of life. Neonatal tetanus has been almost eliminated from many countries through massive tetanus toxoid immunization efforts. However, there are over 50 countries where the proportion of cases of neonatal tetanus is 1 per 1000 births in some districts. In many countries, infections are the main cause of neonatal death after the first week of life. Most of the time, these are acquired either in hospital as a complication of treatment for other perinatal conditions, or at home. Unhealthy cord care practices cause neonatal tetanus if the mother is not protected by immunization. Poor feeding practices cause diarrhoea and poor growth and an unhygienic environment causes sepsis. The relative contribution of each of these factors varies according to the health of the pregnant woman and the prevalence of endemic diseases such as syphilis or malaria, but mostly according to the availability of adequate care during pregnancy, childbirth and the neonatal period. Mostly, complications during pregnancy or childbirth, preterm birth and malformations

are caused by early neonatal deaths. As at 2012, the neonatal mortality rate in Bangladesh was 24 per 1000 live births [10].

1.1.5 Under-5 mortality

Under-5 mortality (child mortality for short) may be defined as the death of infants and children under the age of five or between the ages of one month to four years. The death of a child is often emotionally and physically hard on the parents. Many deaths in the most parts of the world go unreported. This is because many poor families cannot afford to register their babies in government registries.

The same causes and preventative measures that apply to infant mortality (i.e. for children younger than one year old) also apply to understanding child mortality.

Reduction of child mortality has been the fourth of the United Nations' Millennium Development Goals (MGDs). There has been a significant decline in preventable child deaths since 1990, with the global under-5 mortality rate declining by nearly half over this time period due to a rapid progress towards the Millennium Development Goals. Globally, the number of under-5 deaths declined from 12.7 million in 1990 to just 6.3 million in 2013 [11]; In 2013, 3.7 million children aged one month to 4 years of age died, down 7.6 million in 1990 [12]. About half of child deaths occur in Sub-Saharan Africa. However, despite advances, at the current pace the world will not meet the MDG target until 2026 [13].

In Bangladesh, infant and under-5 mortality rates for the past five years were 43 and 53 per 1000 live births respectively are reported to be on the decline, implying that Bangladesh was on track to achieve the MDG4 of 48 deaths per 1000 live deaths by the year 2015 [14].

1.1.6 Reducing childhood mortality – prenatal care services

A recent study in Indonesia found that the risk of early neonatal death in Indonesia was reduced by the provision of any form of antenatal care, including iron and folic acid (IFA) supplementation and tetanus toxoid (TT) vaccination during pregnancy [15]. This finding was

consistent with that of a recently reported trial of micronutrient supplementation during pregnancy in rural China, which found a 54% greater reduction in early neonatal death in infants whose mothers had received standard iron and folic acid supplementation than in those whose mothers had received folic acid alone [16].

Given that stillbirth and infant and child mortality remain a major public health challenge in many parts of the developing world, including Bangladesh, researchers have made considerable efforts to understand factors driving this burden. A number of studies have highlighted the factors that posed risk to stillbirth in both developed and developing countries [17-22]. These studies examined the maternal and biological factors associated with stillbirth. Socio-demographic factors were not highlighted. Further, findings of previous studies in Bangladesh examined risk factors of stillbirth [23, 24]. However, these studies were limited in scope as one concentrated on a rural area, and the other based its study on the slums of Bangladesh. Hence this study extends the frontier of knowledge by building on the past studies and poses the first research question, which is stated in the section that follows.

Past studies have examined risk factors of perinatal and neonatal mortality [25-31]. However, these studies were limited in scope and did not examine socio-demographic factors. In Bangladesh one of the studies on risk factors for perinatal mortality concentrated only on the intrapartum factors. Based on these past studies, this thesis builds on the previous research and presents the second research question, which is stated in the next section.

Previous studies have indicated the importance of IFA supplements and TT vaccinations in reducing the burden of stillbirth and child deaths [15, 16], this study presents another research question which is stated in the next section.

A number of past studies have shown that mortality rates among infants and children vary according to socio-demographic characteristics (for example; [32-36]). However these studies

were limited in scope; either because they did not specifically examine the socio-demographic factors associated with child mortality or the studies did not utilise nationally-representative data. This study attempts to build on the findings of the previous studies by advancing the existing knowledge beyond the understanding of infant/child mortality determinants at the individual level. Hence, the study states the fourth research question, which is presented in the section that follows.

1.2 Research questions

The study answered four basic questions:

1. What are the risk factors for stillbirth in Bangladesh?
2. What are the risk factors for perinatal mortality in Bangladesh?
3. What impact do antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy have on child mortality in Bangladesh?
4. What are the risk factors for under-5 mortality in Bangladesh?

1.3 Research objectives

1.3.1 General objective

The general objective of the study was to explore stillbirth, perinatal, child mortality and its effects in Bangladesh.

1.3.2 Specific objectives

The specific objectives of the study were:

1. To identify the risk factors associated with stillbirth in Bangladesh;
2. To identify the risk factors associated with perinatal mortality in Bangladesh;

3. To explore the impact of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh and
4. To identify the risk factors associated with under-5 mortality in Bangladesh.

1.4 Justification of the study

Stillbirth, infant and child mortality have remained a daunting challenge in Bangladesh. Several studies have been conducted on stillbirth [37], perinatal [38] and under-5 mortality [39] in Bangladesh. However, most studies involving Bangladesh have been on regional basis [40, 41]. Despite all the concerted international and national efforts to tackle the undesirable levels of infant and child mortality, poor child health outcomes continue to be of immense concern in Bangladesh.

One of the set goals of the Sustainable Development Goals (SDGs), Millennium Development Goals (MDGs) was the reduction of childhood deaths (MGD4 and SDGs), with the target to reduce childhood mortality rates by two-third between 1990, 2015 and 2025. Available statistics show that unlike most countries in South Asia, Bangladesh had been on track to achieving the MGD4 and SDGs. Despite, the achievements made in Bangladesh, there are calls for more research to inform the formulation of policies and programmes for appropriate health interventions to reduce the burden of infant and child mortality.

In order to draw scientific strategies to solve problems regarding stillbirth, perinatal, child and under-5 mortality, it is pertinent to focus research efforts on the determinants of these burdens and to examine the impact that antenatal factors have on child mortality in Bangladesh; hence the specific objectives of this thesis.

1.4.1 Identifying the risk factors associated with stillbirth in Bangladesh

Despite the fact that stillbirths represent a high percentage of perinatal deaths, their causes (direct and indirect) are not well understood, especially in developing countries and the

information on risk factors associated with stillbirths in Bangladesh is limited in that it comes from studies that are case-control and prospective cohort design. prospective cohort study conducted between March 7, 2011 and December 30, 2011 in rural Bangladesh identify previous history bleeding during pregnancy and increased maternal age to be strong predictors of stillbirths in rural Bangladesh [23] and a case-control study conducted between November 2008 and April 2009 in the slum of Bangladesh found older women (> 35 years), preterm delivery and prolong labour to be factors associated with stillbirths in the slum areas of Dhaka [24].

In Bangladesh, information on risk factors for stillbirths is limited at the national-level [23.24] and the generalizability of these findings to the broader Bangladesh population may be limited, given differences in socio-economic status and geographical regions. This thesis aims to examine the prevalence of and risk factors associated with stillbirths in Bangladesh, using pooled data from the 2004, 2007, 2011 and 2014 Bangladesh Demographic and Health Surveys (BDHS). Specifically, the aim of this study was to examine community, socioeconomic, infant and factors associated with stillbirth. Findings from this study could be used by health professionals to inform policies and programmes to reduce the rate of stillbirths.

1.4.2 Identifying the risk factors associated with perinatal mortality in Bangladesh

Perinatal mortality is an important indicator of obstetric care, health status and socio-economic development [42]. Because of this, there have been extensive studies on this hazard. For instance, a past study in Kenya identified and quantified risk factors for perinatal mortality in a Kenyan district hospital [27]. This Kenyan study also assessed the proportion of perinatal deaths attributable to labour complications, maternal undernutrition, malaria, anaemia and human immunodeficiency virus (HIV). Another elaborate study explored major risk factors for perinatal mortality in high-income by carrying out a systematic review and meta-analysis [18].

Apart from a study that examined perinatal mortality attributable to complications in child birth in Bangladesh [43], and another that examined neonatal mortality of low-birth weight infants in Bangladesh [31], no other study has explored factors associated with perinatal mortality in Bangladesh. This thesis seeks to identify and explore the risk factors for perinatal mortality in Bangladesh, results of which could be of immense help to public health professionals and other stakeholders in the country.

1.4.3 Exploring the impact of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh

In Bangladesh, there have a number of studies on the use of iron folic on pregnant women to prevent neonatal deaths; such as a study by West et al [44]. In that study, antenatal micronutrient compared with iron-folic supplementation was found not to reduce all-cause infant mortality up to age 6 months, but resulted in a non-statistically significant reduction in stillbirths and significant reductions in preterm births and low birth weight. Another study [45] assessed the association of antenatal with facility delivery care and perinatal survival. Antenatal clinic visits were found to be associated with improved perinatal survival in the Health and Demographic Surveillance System (HDSS) of the International Centre for Diarrhoeal Disease Research, Bangladesh (Icddr,b) in Matlab, Bangladesh. However, no such association was found in the government service area. The limitation of this study is that Matlab is a sub-district and such study cannot be generalised to the entire population. A systematic review to assess the effect of tetanus toxoid vaccinations on child mortality [46] identified only three studies of moderate-quality that provided supporting evidence of a large effect of tetanus toxoid immunization on neonatal tetanus mortality. One limitation of that systematic review was the dearth of high-quality trials. These discrepancies and limitations in results of past studies call for further examinations on the effects of antenatal care visits, iron-folic supplementations and tetanus toxoid vaccinations on child mortality in Bangladesh.

This thesis sought to utilise population data from the four most recent datasets of the BDHS (2004, 2007, 2011 and 2014) to assess the effect of antenatal care, iron-folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh. Results from our study would be useful to stakeholders in intensifying health care provisions to mothers, especially rural mothers.

1.4.4 Identifying risk factors associated with under-5 mortality in Bangladesh

The extant literature is replete with evidence that there exists a negative association between socio-economic variables of a child's parents and post-neonatal mortality [47-49]. There is also evidence of a close association between the risk of an infant's death and characteristics of their mother [50].

There have previously been studies conducted in Bangladesh about factors associated with neonatal and post-neonatal, child and under-five mortality [49, 51, 52]. The major limitation of these studies is the issue of generalisability because of limited number of deaths recorded in a single BDHS data set which makes it difficult to investigate which risk factors for child mortality that persist over time and the issue of sample size when conducting mortality research in a single district. For instance, Chowdhury et al [52] conducted studies on covariates of neonatal and post-neonatal mortality in Bangladesh by making use of the 2007 Bangladesh Demographic and Health Surveys (BDHS) dataset while, studies conducted by Quamrul et al [49] and Mondal et al [51] on child mortality were both conducted in Rajshahi and Natore districts in Bangladesh.

This thesis aims to identify specific factors that affect childhood mortality at different sub-periods of the first 59 months of life (post-neonatal, infant, child and under-5 mortality) in Bangladesh by using a pooled analysis of the 2007, 2004, 2011 and 2014 versions of the BDHS

[14, 53, 54]. Findings from this study may enable policy-makers to redirect resources to the most vulnerable children at greater risk of dying before the age of five.

1.5 The study area

Bangladesh, one of the countries on track to meet the target for the MGD4, was chosen as the study area. It is located in South Asia (on latitude 23.85˚N and longitude 89.93˚E), and bordered by India in the north, the Bay of Bengal in the east and west, while Myanmar surrounds it to the south. Bangladesh is the eighth most populous country in the world (the most densely populated non-island nation in the world) [55]. The population of Bangladesh was estimated at 158,512,570 as of July 1 2014, equivalent to 2.19% of the total world population. There were about 1,101 people per square kilometre, and 30% of its population was urban (47,334,620 people in 2014). The culture of Bangladesh is composite, and over the centuries has assimilated influences of Islam, Hinduism, Buddhism and Christianity. Bangladesh is largely ethnically homogenous, and its name derives from the Bengali ethno-linguistic group which comprises 98% of the population.

Bangladesh is divided into seven divisions and 64 districts. Each division is named after the major city within its jurisdiction that serves as the administrative capital of that division. The divisions are: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet.

Figure 1.1: Location and map of Bangladesh showing the various divisions.
Sources: 2014 Bangladesh Demographic and Health Survey

The rationale for selecting Bangladesh as the study area is multifaceted. First, one in every 23 Bangladeshi children dies before reaching their first birthday, and one in every 19 children does not survive to their fifth birthday [14]; and although these figures are relatively low, more efforts are needed to maintain or reduce them further. Second, the neonatal mortality rate for the past five years has been 32 deaths per 1000 live births, which is three times the post-neonatal mortality rate (10 deaths per 1000 live births) [14]. Although Bangladesh had been on track to meet the MGD4, more research is needed to sustain or reduce the declining numbers

of child mortality in the country. It is therefore momentous to study a country with such promising improvements in infant and child deaths.

1.6 Definition of terms

1.6.1 Stillbirth

According to BDHS [53,54], Stillbirth is defined as the birth of an infant that has died in the mother's womb, strictly, after having survived through at least, the first 28 weeks of pregnancy. The definition for stillbirth rate is:

$$\text{Stillbirth rate (SBR)} = \frac{\text{stillbirths}}{(\text{stillbirths} + \text{live births})} 1000 \quad (1.1)$$

1.6.2 Perinatal mortality

According to BDHS [53,54], perinatal mortality is defined as the number of stillbirths and deaths in the first week of life per 1000 live births. Early neonatal deaths that occurs within first week of life (< 7days) and neonatal deaths are that occurred within one month of life (< = 28 days). Hence, the definition for perinatal mortality is:

$$\text{Perinatal mortality rate (PMR)} = \frac{(\text{stillbirths+ early neonatal) deaths}}{(\text{stillbirths+ early neonatal) deaths} + \text{live births}} 1000 \quad (1.2)$$

$$\text{Perinatal mortality rate (PMR1)} = \frac{(\text{stillbirths+ neonatal) deaths}}{(\text{stillbirths+ neonatal) deaths} + \text{live births}} 1000 \quad (1.3)$$

1.6.3 Neonatal death

According to BDHS [53,54], neonatal death refers to the death of a live-born infant during the first 28 days after birth; early neonatal death is usually considered to be one that occurs the first seven days, whilst late neonatal death occurs after seven completed days but before 28 completed days. Neonatal mortality rate could be calculated as:

$$\text{Neonatal mortality rate (NMR)} = \frac{\text{neonatal deaths}}{\text{live births}} 1000 \quad (1.4)$$

1.6.4 Postneonatal death

According to BDHS [53,54],, postneonatal death refers to the death between the periods of 28 days to 364 days. Postneonatal mortality rate is defined as:

$$\text{Postneonatal mortality rate} = \frac{\text{postneonatal deaths}}{\text{live births}} 1000 \quad (1.5)$$

1.6.5 Infant death

This is defined as the death of a child under the age of one year [53,54]. Infant mortality rate is defined as:

$$\text{Infant mortality rate (IMR)} = \frac{\text{deaths of child} < 1 \text{ year of age}}{\text{live births}} 1000 \quad (1.6)$$

1.6.6 Child mortality

According to BDHS [53,54], child mortality, also known as under-5 mortality refers to the death of infants and children under the age of five, or between the age of one month and four years. Child mortality rate is calculated as:

$$\text{Under 5 mortality rate (U5MR)} = \frac{\text{deaths of children} < 5 \text{ years}}{\text{live births}} 1000 \quad (1.7)$$

1.7 Organisation of the thesis

This thesis is organised as follows: Chapter 1 presents the background to the study. Review of the extant literature and description of the theoretical framework are presented in chapter 2.

Chapter 3 presents the methodology employed in this study. The various statistical analyses applied in the thesis are presented in chapter 4. Chapter 5 presents results of risk factors associated with stillbirth in Bangladesh. Results of risk factors associated with perinatal mortality in Bangladesh are presented in chapter 6. Chapter 7 presents results of the impact of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh. Results on factors associated with under-5 mortality in Bangladesh are presented in chapter 8. Chapter 9 gives a discussion of the whole thesis. Finally, a summary and recommendations for future research are presented in chapter 10.

1.8 Summary

In this chapter, the introduction and statement of the problem to the study have been presented. The public health importance of stillborn, infant and child mortality, which reflects the developmental status of a country, has been highlighted. The research questions, research objectives and specific objectives have also been clearly given in this chapter. The next chapter deals with a critical review of the relevant literature on factors associated with stillborn, infant and child mortality in general and among Bangladeshi children in particular. It discusses current perspectives on stillborn and child mortality and reveals the gaps in the literature and stresses the need for the present study. The chapter ends with a summary.

References

1. Demirel G, Tezel B, Ozbas S, Oguz SS, Erdeve O, Uras N, Dilmen U: Rapid decrease of neonatal mortality in Turkey. *Maternal and child health journal* 2013, 17(7):1215-1221.

2. Lawn JE, Blencowe H, Pattinson R, Cousens S, Kumar R, Ibiebele I, Gardosi J, Day LT, Stanton C: Stillbirths: Where? When? Why? How to make the data count? *The Lancet* 2011, 377(9775):1448-1463.

3. Lander T: Neonatal and perinatal mortality: country, regional and global estimates: World Health Organization; 2006.

4. Organization WH: Coverage of maternity care: a listing of available information. Geneva: WHO, 1997. In.: WHO/RHT/MSM/96.28.

5. Goldenberg RL, McClure EM, Bhutta ZA, Belizán JM, Reddy UM, Rubens CE, Mabeya H, Flenady V, Darmstadt GL: Stillbirths: the vision for 2020. *The Lancet* 2011, **377**(9779):1798-1805.

6. Say L, Donner A, Gulmezoglu AM, Taljaard M, Piaggio G: The prevalence of stillbirths: a systematic review. *Reprod Health* 2006, **3**(1).

7. http://www.countdown2015mnch.org/documents/2014Report/Bangladesh_Country_Profile_2014.pdf [accessed on 21/8/ 2016, Sydney]

8. United Nations Department of Economic and Social Affairs: Population and vital statistics report (Statistical Papers Series A.). In., vol. LIV, No. 3. New York, United Nations; 2002.

9. WHO: Country, Regional and Global Estimates. In: *Neonatal and Perinatal Mortality.* Geneva; 2006.

10. UNICEF/WHO/The World Bank/UN Pop Div: Levels and Trends in Child Mortality. In., vol. Report 201 3. Geneva: WHO/RHT/MSM/96.28.

11. Qi Y, Niu J: Health selection effects in China's internal migration. *Asian Population Studies* 2013, **9**(2):142-155.

12. Global CG: regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015, **385**(9963):117-171.

13. Li X, Stanton B, Chen X, Hong Y, Fang X, Lin D, Mao R, Wang J: Health indicators and geographic mobility among young rural-to-urban migrants in China. *World health & population* 2006, **8**(2):5.

14. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International: Bangladesh Demographic and Health Survey 2011. In. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.; 2013.

15. Titaley CR, Dibley MJ, Roberts CL, Hall J, Agho K: Iron and folic acid supplements and reduced early neonatal deaths in Indonesia. *Bulletin of the World Health Organization* 2010, **88**(7):500-508.

16. Zeng L, Cheng Y, Dang S, Yan H, Dibley MJ, Chang S, Kong L: Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. *Bmj* 2008, **337**.

17. Raymond EG, Cnattingius S, Kiely JL: Effects of maternal age, parity, and smoking on the risk of stillbirth. *BJOG: An International Journal of Obstetrics & Gynaecology* 1994, **101**(4):301-306.

18. Flenady V, Koopmans L, Middleton P, Frøen JF, Smith GC, Gibbons K, Coory M, Gordon A, Ellwood D, McIntyre HD: Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *The Lancet* 2011, **377**(9774):1331-1340.

19. Little RE, Weinberg CA: Risk factors for antepartum and intrapartum stillbirth. *American journal of epidemiology* 1993, **137**(11):1177-1189.

20. Gardosi J, Madurasinghe V, Williams M, Malik A, Francis A: Maternal and fetal risk factors for stillbirth: population based study. *BMJ: British Medical Journal* 2013, **346**.

21. Frøen JF, Arnestad M, Frey K, Vege Å, Saugstad OD, Stray-Pedersen B: Risk factors for sudden intrauterine unexplained death: epidemiologic characteristics of singleton cases in Oslo, Norway, 1986-1995. *American journal of obstetrics and gynecology* 2001, **184**(4):694-702.

22. Di Mario S, Say L, Lincetto O: Risk factors for stillbirth in developing countries: a systematic review of the literature. *Sexually transmitted diseases* 2007, **34**(7):S11-S21.

23. Owais A, Faruque ASG, Das SK, Ahmed S, Rahman S, Stein AD: Maternal and Antenatal Risk Factors for Stillbirths and Neonatal Mortality in Rural Bangladesh: A Case-Control Study. *PloS one* 2013, **8**(11):e80164.

24. Nahar S, Rahman A, Nasreen HE: Factors Influencing Stillbirth in Bangladesh: A Case–Control Study. *Paediatric and perinatal epidemiology* 2013, **27**(2):158-164.

25. Essén B, Hanson BS, ÖSTERGREN PO, Lindquist PG, Gudmundsson S: Increased perinatal mortality among sub-Saharan immigrants in a city-population in Sweden. *Acta obstetricia et gynecologica Scandinavica* 2000, **79**(9):737-743.

26. Mavalankar DV, Trivedi C, Gray R: Levels and risk factors for perinatal mortality in Ahmedabad, India. *Bulletin of the World Health Organization* 1991, **69**(4):435.

27. Weiner R, Ronsmans C, Dorman E, Jilo H, Muhoro A, Shulman C: Labour complications remain the most important risk factors for perinatal mortality in rural Kenya. *Bulletin of the World Health Organization* 2003, **81**(8):561-566.

28. de Jonge A, van der Goes BY, Ravelli AC, Amelink-Verburg MP, Mol BW, Nijhuis JG, Gravenhorst JB, Buitendijk SE: Perinatal mortality and morbidity in a nationwide cohort of 529 688 low-risk planned home and hospital births. *BJOG: An International Journal of Obstetrics & Gynaecology* 2009, **116**(9):1177-1184.

29. Mercer A, Haseen F, Huq NL, Uddin N, Khan MH, Larson CP: Risk factors for neonatal mortality in rural areas of Bangladesh served by a large NGO programme. *Health Policy and Planning* 2006, **21**(6):432-443.

30. Zenger E: Siblings' neonatal mortality risks and birth spacing in Bangladesh. *Demography* 1993, **30**(3):477-488.

31. Yasmin S, Osrin D, Paul E, Costello A: Neonatal mortality of low-birth-weight infants in Bangladesh. *Bulletin of the World Health Organization* 2001, **79**(7):608-614.

32. Suwanjutha S, Ruangkanchanasetr S, Chantarojanasiri T, Hotrakitya S: Risk factors associated with morbidity and mortality of pneumonia in Thai children under 5 years. *The Southeast Asian journal of tropical medicine and public health* 1994, **25**(1):60-66.

33. Becher H, Müller O, Jahn A, Gbangou A, Kynast-Wolf G, Kouyaté B: Risk factors of infant and child mortality in rural Burkina Faso. *Bulletin of the World Health Organization* 2004, **82**(4):265-273.

34. Åsling-Monemi K, Pena R, Ellsberg MC, Persson LÅ: Violence against women increases the risk of infant and child mortality: a case-referent study in Nicaragua. *Bulletin of the World Health Organization* 2003, **81**(1):10-16.

35. De Francisco A, Morris J, Hall A, Schellenberg JA, Greenwood B: Risk factors for mortality from acute lower respiratory tract infections in young Gambian children. *International journal of epidemiology* 1993, **22**(6):1174-1182.

36. Antai D: Regional inequalities in under-5 mortality in Nigeria: a population-based analysis of individual-and community-level determinants. *Population health metrics* 2011, **9**(1):6.

37. Hosain G: Stillbirth in a rural area of Bangladesh. In: *11th Congress of the Federation of the Asia and Oceania Perinatal Societies Manila, Philippines: 2000*; 2000.

38. Bari W, Chowdhury RI, Islam M, Chakraborty N, Akhter H: The differentials and determinants of perinatal mortality in rural Bangladesh. *European J of Contraception and Reproductive Healthcare* 2002, **7**(4):216-222.

39. Chen LC, Rahman M, Sarder A: Epidemiology and causes of death among children in a rural area of Bangladesh. *International journal of epidemiology* 1980, **9**(1):25-34.

40. McGuire JW: Basic health care provision and under-5 mortality: a cross-national study of developing countries. *World Development* 2006, **34**(3):405-425.

41. Marmot M: Social determinants of health inequalities. *The Lancet* 2005, **365**(9464):1099-1104.

42. WHO: Perinatal mortality: a listing of available information. In. Edited by WHO. Geneva; 1996.

43. Kusiako T, Ronsmans C, Van der Paal L: Perinatal mortality attributable to complications of childbirth in Matlab, Bangladesh. *Bulletin of the World Health Organization* 2000, **78**(5):621-627.

44. West KP, Shamim AA, Mehra S, Labrique AB, Ali H, Shaikh S, Klemm RD, Wu LS, Mitra M, Haque R: Effect of Maternal Multiple Micronutrient vs Iron–Folic Acid Supplementation on Infant Mortality and Adverse Birth Outcomes in Rural Bangladesh: The JiVitA-3 Randomized Trial. *JAMA* 2014, **312**(24):2649-2658.

45. Pervin J, Moran A, Rahman M, Razzaque A, Sibley L, Streatfield PK, Reichenbach LJ, Koblinsky M, Hruschka D, Rahman A: Association of antenatal care with facility delivery and perinatal survival–a population-based study in Bangladesh. *BMC pregnancy and childbirth* 2012, **12**(1):111.

46. Blencowe H, Lawn J, Vandelaer J, Roper M, Cousens S: Tetanus toxoid immunization to reduce mortality from neonatal tetanus. *International Journal of Epidemiology* 2010, **39**(suppl 1):i102-i109.

47. JORGE MACHADO C, Hill K: Maternal, neonatal and community factors influencing neonatal mortality in Brazil. *Journal of biosocial science* 2005, **37**(02):193-208.

48. Doctor HV: The Effect of living standards on childhood mortality in Malawi. 2004.

49. Quamrul HC, Rafiqul I, Kamal H: Socio-economic determinants of neonatal, post neonatal, infant and child mortality. *International Journal of Sociology and Anthropology* 2010, **2**(6):118-125.

50. Mathews T, MacDorman MF, Statistics NCfH: Infant mortality statistics from the 2004 period linked birth, infant death data set, vol. 55: US Department of Health & Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2007.

51. Mondal N, Hossain K, Ali K: Factors influencing infant and child mortality: A case study of Rajshahi District, Bangladesh. *Journal of Human Ecology* 2009, **26**(1):31-39.

52. Chowdhury AH, Islam SS, Abdul Karim D: Covariates of Neonatal and Post-Neonatal Mortality in Bangladesh. *Global Journal of Human-Social Science Research* 2013, **13**(4).

53. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International: Bangladesh Demographic and Health Survey 2004. In. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.; 2005.

54. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International: Bangladesh Demographic and Health Survey 2007. In. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International; 2009.

55. Statistics Sierra Leone (SSL), International. I: Sierra Leone Demographic and Health Survey 2013. In. Freetown, Sierra Leone and Rockville, Maryland, USA: SSL and ICF International; 2014.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0 Introduction

A critical review of the relevant extant literature and the theoretical framework of the thesis are presented in this chapter. Collection of important literature directly related to the study was done through sources such as Journal Storage (JSTOR), Google search engine, Google Scholar search engine, PubMED, Health Inter-Network Access to Research Initiative (HINARI), CAB direct, edited books and reports. Access of many published articles was obtained through the Western Sydney University library and through my supervisors' assistance. The literature search was executed by including keywords and MeSH terms such as: perinatal mortality/death, stillbirth, infant mortality, under-5 mortality, child mortality and child survival. The search also included terms such as multivariate analysis of childhood mortality and determinants of infant and child mortality. Studies that examine, neonatal, post-neonatal, infant, Child and under-5 mortality, child health and survival abound in the demographic and public health literature. There have been diverse findings on the causes and determinants of infant and child deaths in many studies on infant and child mortality. The extant literature reveals that child health outcomes are generally poor in South Asia and sub-Saharan Africa. These two sub-regions, incidentally, have been found to be the major global contributors to statistics on childhood mortality. The rest of this chapter is organised as follows: The global overview of stillbirth, perinatal, infant and child mortality is presented in section 2.1. This is followed by an overview of stillbirth, perinatal, infant and child mortality in South Asia. Section 2.3 presents an overview of stillbirth, perinatal, infant and child mortality in Bangladesh. This is then followed by risk factors for stillbirth, perinatal, infant and child mortality, as well as the risks associated with stillbirth, perinatal, infant and child mortality. This is then followed by the theoretical framework that informs this study. This section comprises one model, namely, the Mosley-Chen model. A summary concludes this chapter.

2.1 Global overview of stillbirth, perinatal, infant and child mortality

Despite the fact that stillbirths are very real to families who experience a death, they are invisible in many societies and on the worldwide policy agenda. The global focus has remained on survival after live birth, in spite of 30 years of attention to interventions on child survival [1, 2], more than 20 years of attention to safe motherhood [3, 4] and recent increases in attention to newborn baby survival [5-7]. Stillbirths do not persist in only low-income countries. There has only been a one percent decrease per annum for the past 15 years in the United Kingdom and the United States and two-thirds of all perinatal deaths in the United Kingdom are due to stillbirths [8-10]. Stillbirths exceed deaths from sudden infant death syndrome by a factor of 10 in high-income countries [11]; however, they receive less attention in programmes and funding for research [12]. In least developed African countries, such as Malawi and Zambia, stillbirth rates of between 40 per 1000 live births and 50 per 1000 live births are common. Among middle-income and lesser-developed countries in Latin America, stillbirth rates generally range between 15 and 25 per 1000 live births. Stillbirth rates among Middle Eastern countries range between 10 and 20 per 1000 live births. In many developing countries, stillbirth rates have remained steady or declined slightly over the last decades [13, 14].

A past research found that neonatal mortality rates had ranged from 42.6 per 1000 in Mali to 1.2 per 1000 in Singapore in 2013 [15]. Despite a decline in neonatal mortality rates in Africa, there has not been a similar decline in stillbirth rates [16]. Whilst modest declines in stillbirths had been reported in Latin America and the Caribbean [17], in the United States and other developed countries, there had been impressive declines in stillbirth rates over the last several decades, a possible consequence of improved antenatal and delivery care [13, 14, 18, 19].

A distinction has been drawn by a past study [20], between risk factors of stillbirth or characteristics associated with, but not obviously causal, such as obesity or advanced age of a mother and causes, which are defined as factors (such as a placental abruption or extensive

foetal infection), which if present, could plausibly kill the foetus. In developing countries, the most common risk factors for stillbirths include limited access to antenatal care, lack of skilled delivery attendants, low socioeconomic status, poor nutrition, prior history of stillbirths and advanced age of a mother [20]. Apart from the important exceptions of limited access to antenatal care and lack of skilled delivery assistance, there is not much difference between the risk factors for still birth in developing countries and elsewhere [21-23]. Cigarette smoking has been found to be associated with stillbirth in mid-level countries such as those in South America and in many developed countries [24].

Globally, under-five mortality rates have ranged from 152.5 per 1000 livebirths in Guinea-Bissau to 2.3 per 1000 in Singapore in 2013 [15]. Sub-Saharan Africa was home to the ten countries with the highest under-5 mortality rate in 2013. Fifty five countries achieved under-5 mortality rates lower than 10 per 1000 livebirths in 2013, and nine of them were developing countries [15]. In 2013, 26 countries accounted for 80% of child deaths worldwide. The countries included Afghanistan, Angola, Brazil, Burkina Faso, Cameroon, Chad, China, Cote d'Ivoire, Democratic Republic of the Congo, Ethiopia, Ghana, India, Indonesia, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Pakistan, Philippines, Somalia, Sudan, Tanzania, and Uganda [15].

Findings from a cohort study on maternal education in relation to early and late child health outcomes in Brazil [25] supported the hypothesis that maternal education has an effect on child health, which has been found to be partly independent of other socio-economic factors.

A study in Brazil [26] that utilized multilevel techniques to analyse trends in infant mortality, found that infant mortality was positively associated with proportion of low birth weight newborns and number of hospital beds per 1000 inhabitants. However, infant mortality was found to be negatively associated with rate of caesarean operations, and number of hospitals

per 10,000 inhabitants. In addition, this Brazilian study found that individual and community-level characteristics had significant effects in the reduction of infant mortality rates.

A past study which examined the effects of access to health care on infant mortality in Indonesia [27] found that the odds of infant death could be reduced by almost two percent by just an addition of one doctor. These odds, according to this Indonesian study, could be reduced up to 15% by an addition of just one maternity clinic. A slight increase in distance to a health facility was found to a corresponding increase in risk of mortality among the children [27]. From a theoretical point of view, one would have expected a reduction in infant and child mortality rates with increase in the availability of health personnel; in contrast, a past researcher [27] found that increase in the number of health personnel tended to increase risk of child mortality among children in Indonesia.

Several factors have been known to influence infant and child mortality. One such factor is maternal education, which importance in childrearing had long been established by a past study on maternal education and child survival in developing countries [28]. This study found maternal education to have a significant effect on infant and child mortality through the impact of intervening factors such as reproductive health patterns and equitable care for children.

A past study in India [29] found that apart from the effect of maternal education on child mortality, the average level of education of women in an enumeration area is also strongly associated with child mortality. Disparities in maternal level of education among various ethnic groups has been found to be a function of ethnic differentials in the risk of under-5 mortality in Nigeria [30]; and another past study in Nigeria also highlighted the significant role that maternal education plays in protecting against infant mortality.

Competition for resources between the newborn and the previous sibling was found in a past study [31], to be the pathway through which short birth intervals increase the mortality risk among children. Children of young mothers, children of high parity and children whose

previous siblings died or were breastfed for short durations were found to be at the greatest risk of dying if their births were followed by a short birth interval [31]. Schell and colleagues [32] conducted a research on socio-economic determinants of infant mortality, using data from 152 low-, middle- and high-income countries, and found that relative significance of key determinants of health varied substantially between income levels, thereby making extrapolation of health strategies from high- to low-income countries difficult.

Additionally, other researchers such as Omariba and colleagues [33], Harttgen and Misselhorn [34] Griffiths and colleagues [35] and Sastry [36] had all used multilevel modelling to examine the relationship between community characteristics, household attributes, and child survival in a number of South Asian, Latin American and South American countries, and established a significant relationship between child mortality and a number of community-level variables.

From the foregoing, the global debate on infant and child mortality is unlimited. Despite the numerous past researches on infant and child mortality the world over, the burden remains an issue for policy and research in developing countries. This thesis attempted to build on the insights (understanding of the individual and household-level determinants of child mortality) derived from the reviewed literature to contribute to the global discourse on infant and child mortality. In addition, the thesis sought to advance the existing knowledge by exploring multilevel analytical techniques to produce more robust analyses of factors associated with infant and child mortality in Bangladesh.

2.2 Overview of stillbirth, perinatal, infant and child mortality in South Asia

South Asian countries have the world's largest population and highest burden of stillbirth, with rates generally ranging from 25 to 40 per 1000 live births [37]. In a regional comparison, stillbirth rates remain highest in sub-Saharan Africa, followed by southern Asia and Latin America [38]. About two-thirds of neonatal deaths arise in the African and southeast Asian regions of the WHO. Additionally, South Asia is home to countries with the largest absolute

numbers of perinatal deaths, because of the large populations in this region; India alone contributes a quarter of neonatal deaths [7].

Globally, 18 million babies are estimated to be born with low birthweights every year - half in south Asia [39]. Although these low-birthweight babies constitute only about 14% of children born, they account for 60–80% of neonatal deaths in this region [40].

Females have a well described biological survival advantage over males in the neonatal period [41]. There has been reduced care seeking for girls compared with boys, especially in South Asia [42].

Despite a decline in the global under-5 mortality rates, the figure still remains unacceptable high in Sothern Asia with a rate of 51per 1000 live births in 2015, second only to Sub-Saharan Africa, with 83 per 1000 live births in the same year [43].

2.3 Overview of stillbirth, perinatal, infant and child mortality in Bangladesh

In Bangladesh, perinatal mortality rates declined from 65 per 1000 live births in 2004 to 50 per 1000 live births in 2011 [44, 45]. According to the 2011 BDHS, these perinatal rates ranged from a highest of 71 per 1000 live births among first pregnancy women to a lowest of 36 per 1000 live births among women from households of the highest wealth quintiles [45]. Bangladesh has maintained a consistently high rate of change of neonatal mortality of around -4.7% to -5.5% since 1990, slightly higher than in neighbouring India (-3.0% to -4.3%), although the pace of child mortality change in India has improved during the past 13 years, reaching -4.5% from 2012 to 2013. Bangladesh was among the 55 countries which achieved under-5 mortality rates lower than 10 per 1000 livebirths in 2013 [15].

2.4 Risk factors for stillbirth, perinatal, infant and child mortality

Assessing the risk factors for childhood mortality in developing countries has been found to be a difficult task [46]. Many past studies have identified various risk factors for infant and child mortality. However, recognition of the effects of various risk factors is difficult to accomplish, and the pathway of influence through which the various risk factors operate can prove complex. This has created an endless debate as to what to constitute risk factors of infant and child mortality, especially in developing countries. Bio-demographic and socio-economic factors have resulted in big differentials in the risks of mortality among infants and children.

2.4.1 Stillbirth and perinatal mortality

In order to address the problem of perinatal mortality, it is crucial to understand the factors associated with stillbirth, which contributes over 50% of perinatal deaths in developing countries [47]. The origin of about one third of stillbirths could neither be known nor explained [47]. The stillbirth ratio, just as the perinatal mortality rate, is a crucial indicator of the quality of antenatal and obstetric care [48]. However, studies have not distinctively differentiated the frequency of and risk factors for macerated against fresh stillbirths. Identifying the quality of antenatal and obstetric care available to the pregnant women and prioritizing appropriate intervention strategies could be enhanced by understanding the distribution of fresh and macerated stillbirths and deaths within the immediate postpartum period. Macerated stillbirths are often associated with insults that occur in utero during the antenatal period, while fresh stillbirths and early neonatal deaths or mortality (ENNM) may suggest problems with the care available during labour and at delivery [17, 48, 49].

Past research has found that a lack of antenatal care was associated with increased risk of stillbirth and ENNM [50, 51]. Additionally, rural residence has been found to be associated with increased risk of all stillbirth and ENNM, irrespective of whether analysis was done using traditional methods (gestational age-specific mortality) or with gestational age as a time

varying factor [50]. A study in Zimbabwe revealed that fresh or macerated stillbirths and ENNM were more likely to be delivered breech, but less likely to be delivered by Caesarean section [50]. In the Zimbabwe study, caesarean section appeared to protect against stillbirth in that population; and fresh stillbirths and ENNM were also associated with delivery by instrumentation [50].

Some past studies have revealed that a lack of prenatal care was consistently and strongly associated with stillbirths and ENNM [17, 52], and older mothers were found to be a greater risk for stillbirth, but lower risk for neonatal death [50]. Furthermore, an association has been found between preterm recent stillbirths and low birth weight; and this may be attributable, in part, to reluctance on the part of doctors to deliver preterm foetuses at risk of stillbirth earlier because of poor survival or lack of newborn care facilities [53].

2.4.2 Infant and child mortality

A reported trial of micronutrient supplementation during pregnancy in rural China found that neonatal mortality reduced by 54% among mothers who received standard iron and folic acid supplementation compared to mothers who received only folic acid [54]. This protective influence of iron and folic acid supplementation on child mortality was also highlighted in a study in Indonesia [55], showing its importance among pregnant women in developing countries. Tetanus toxoid vaccinations have been found to have a protective effect on infant/child deaths in past research [56, 57].

Some socio-demographic factors have been known to be associated with infant and child mortality. A past study in Nicaragua revealed that the risk of death in infancy or before five years of age was more than six times greater if the mother had been exposed to both physical and sexual violence by a current or former partner at any point in the mother's life [58]. There is also evidence in the extant literature that children of older mothers have better survival compared to those of younger mothers [59].

2.5 Theoretical framework

This research adapts the Mosley-Chen conceptual model used to analyse child survival in developing countries [60] to analyse factors associated with stillbirth, infant and child mortality in Bangladesh. The framework, first proposed by Mosley and Chen in 1984, incorporated social and biological factors which are likely to be associated with the survival of an infant. The adapted version of the Mosley and Chen framework is shown in Figure 2.1 below. Some selected potential predictors of stillbirth, infant and child mortality were identified for the purpose of this research. These possible predictors are a range of socio-demographic characteristics associated with a child and their parents; grouped into three broad levels, namely: 1) individual-level variables – variables from the mother, father, child and mother-child dyad, 2) household-level variable – income/wealth and 3) community-level variables – type of residence (urban/rural) and geographical region [60, 61].

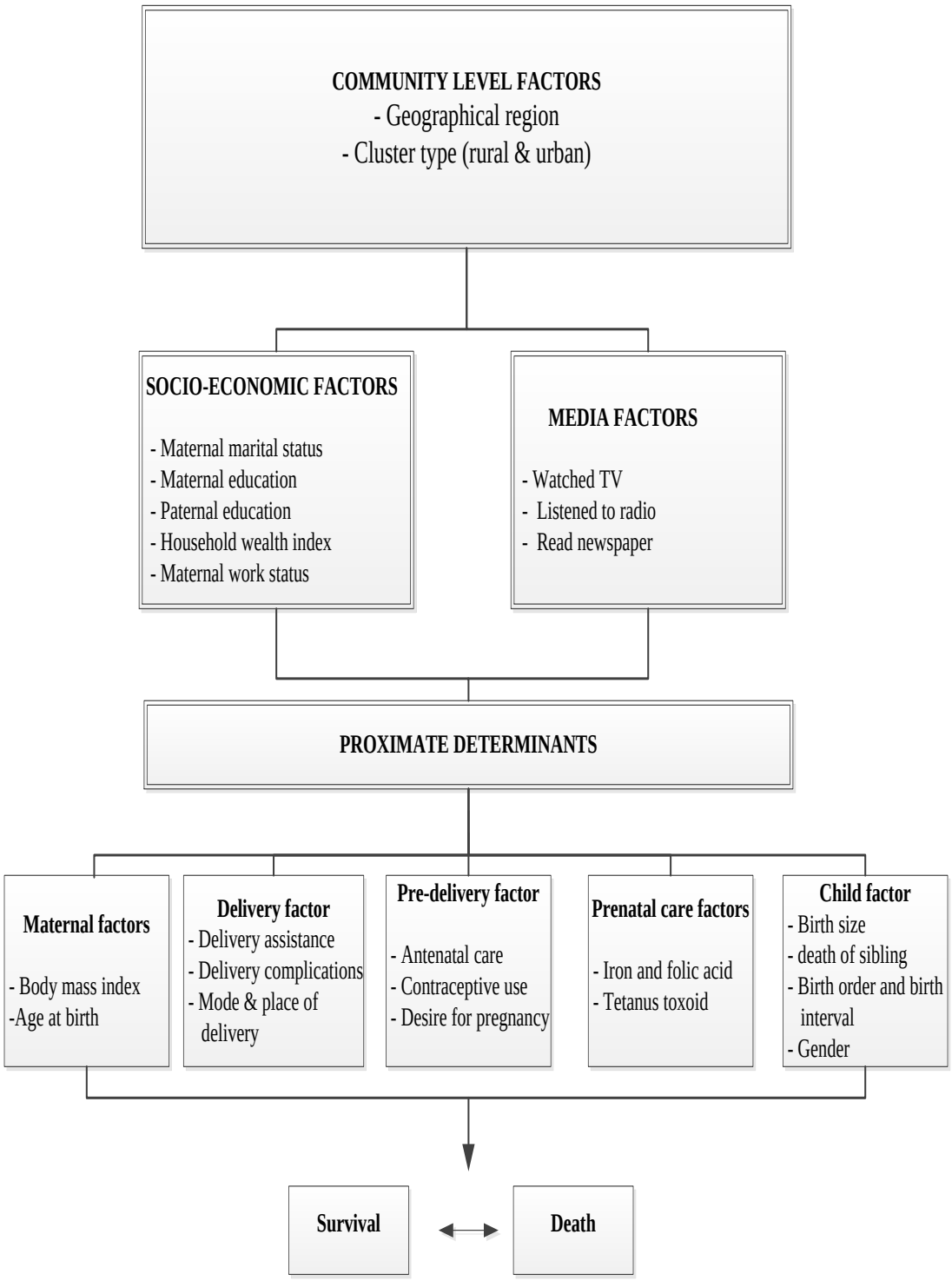


Figure 2.1: Conceptual framework for analysing factors associated with death of children < 5 years in Bangladesh.

2.5.1 Individual-level variables

Three elements determine the 'productivity' of members of a household. These elements are: skills (typically determined by level of education), health and time. The 'product' of interest in this research is a healthy survival child. Therefore, the childbearing and childrearing adult, which is usually the mother, is usually considered separately from other adults such as the father.

There is usually a strong correlation between level of education and occupation among fathers, particularly in urban settings. Consequently, a strong correlation exists between level of education and household income. The assets and marketable commodities consumed by a household are strongly determined by the level of education of the father. Consequently, there is usually a correlation between health effects and level of education of fathers (or other non-childbearing, economically productive adult members in a household) due to the operations and the proximate determinants through the income effects. Furthermore, the level of education of a father might influence attitudes, and therefore preferences in choice of consumer goods, including child care services, particularly in situations where more educated fathers are married to less educated mothers.

However, the health, nutritional status and reproductive pattern of a mother may influence the health and survival of the child, as a result of biological links between the mother and infant during pregnancy and lactation [60]. A child's survival may be affected by a mother's educational level, because of the mother's responsibility for the care of her child through the most vulnerable stages of its life.

Additionally, the time spent by the mother in attending prenatal care services, preparation of food and other chores are important for the production of a healthy child. Other economically productive activities that may or may not be related to the health of the child can take a great portion of a mother's time. However, in traditional societies where there is a sharp division of labour by sex, a mother has maximum time to take care of her child. The individual-level

factors consist of attributes from the mothers, fathers and children. These attributes are discussed below.

Mother's education

Caldwell [62] reported that maternal education is an important predictor of child survival in low- and middle-income countries including Bangladesh and this has been confirmed by other previous studies conducted in developing countries [28, 31, 63-65]. These studies revealed that educated mothers could understand health care practices and hazards related to contraception, nutrition than uneducated mothers. The study conducted by Anyamele in 2009 [66] concluded that mothers who had completed formal education reported improved child survival than those mothers with no schooling. However, any minimal level of maternal education is needed in order to achieve positive effects in child survival [67]. A study conducted in India by Madise et al [68] found that infant mothers with higher levels of education (secondary school or higher) have huge influence on their child's health.

Maternal age

Studies conducted in Pakistan and Bangladesh [69, 70] has shown a strong relationship between maternal age at birth and child survival. Another study conducted in Nigeria by Ezeh et al [71] found that neonates born to mothers aged younger than 20 years reported significantly higher risk of mortality compared to those born to mothers aged 20–29 years, 30–39 years, and 40–49 years. However, these findings contradict those reported by Mahmood [72] who argued that neonates and post-neonates of older mothers aged 30–39 years were more likely to die than those of younger mothers. While other studies conducted in Swaziland [73] and Tanzania [74] showed no significant association between maternal age and neonatal mortality.

Child's sex

Several studies that examined the relationship between child's sex and child mortality have shown mortality differential by sex. The studies indicated that female neonate were less likely to die during the neonatal period compared with male neonate [71, 75]. Higher rate of mortality among male neonates may be related to high vulnerability of infectious disease [76], and late development of early foetal lung maturity during the first week of life [77]. Also, in the post-neonatal and child periods, studies revealed that during the post-neonatal and child mortality periods, females were at a greater risk of dying when compared with males [78-80]. These findings argued that behavioural altitude through neglect and inadequate parental care of female children was one of the major contributors [81]. However, other researchers have argued that the effect of sex discrimination against females or males mostly in developing countries was the major negligible on child survival [28] and its effect was strongly weak in children born to educated parents [31].

Birth order

Several studies conducted in developing countries indicated that first born and a high birth order infants are associated with childhood mortality [82, 83]. A study carried out in Malaysia by Davanzo et al [84] indicated that first-born children are at a disadvantage due to biological effects of primiparity and young maternal age. However, a comparative studies on infant and early childhood mortality conducted by Hobcraft et al [82], reported a 20% decrease risk of dying among first-born if mothers who delayed their first birth until they are 18 years or older.

Birth interval

Past studies have indicated that child spacing improve survival of child under 5 years of age [71, 85]. A number of studies have suggested pathways through which a short child-spacing interval may affect childhood survival. Some of these suggestions are, inadequate time for physical and nutritional recovery [86] and behavioural effects associated with competition among siblings [75, 82] have also been frequently reported as an obvious pathway for how a short birth interval may affect child survival. In addition, Davanzo et al [84], a study conducted in Malaysia indicated that inadequate attention to a child and disease transmission may be one of the possible contributors to the effect of closely spaced children. However, in this thesis and to avoid any collinearity, birth order and birth interval were combined together in the analyses because the effect of birth order may be mediated by the birth interval between children as indicated in previous studies carried out in Zimbabwe and Indonesia which combined birth order and birth interval in their analyses of childhood mortality [87].

Mother's perceived birth size

In any epidemiological studies, the birth weight of a child is the best predictor for childhood mortality but in the most demographic and health survey datasets, more than half of the birth weight information collected are either missing or not completed due to recall bias which are usually associated with cross-sectional design. Hence, in this thesis, mother perceived birth size was used as a proxy for birth weight at birth because past study showed a strong relationship between mean birth weights and perceived newborn size by the mother [55]. During neonatal and post-neonatal periods, perceived newborn size by the mother is generally considered as a factor that is associated with childhood mortality. This association has been consistently reaffirmed by past reviews [88-91]. A cross-sectional design conducted in Indonesia in 2008 reported that small or very small-sized neonates were significantly more likely to die than average or larger-sized neonates [13]. Similarly, another cross-sectional study

carried out in five Asian countries (India, Indonesia, Nepal, Bangladesh, and the Philippines) in 2008 also indicated that smaller than average neonates reported an increased risk of neonatal deaths than average or larger-sized neonates in four of the five countries with data on perceived newborn size [92].

Mode of delivery

In low- and middle-income countries, several studies have indicated that strong association between mode of delivery and childhood mortality [55, 69, 71, 93]. However, this association was not consistent in the studies. For example, studies conducted in Egypt and Swaziland indicated a non-significant relationship between the mode of delivery and neonatal mortality [73, 93]. A recent study that examine the relationship between caesarean section and perinatal mortality in South Western Nigeria indicated that nearly 84% of early neonatal deaths occurred in pregnant mothers who delivered their newborns by emergency caesarean section [94]. This may be attributed to the fact that pregnant mothers presented to a health facility after experiencing labour at home or from elsewhere, with life-threatening complications for emergency caesarean section [95].

Place of birth

Previous studies have shown that children whose mothers are from poor household and with no schooling were significantly more likely to be delivered at home are more likely to die compared with those delivered at health facilities [96, 97]. Evidence from the BDHS showed that home delivery in Bangladesh remains high. As an example, this four BDHSs (2004, 2007, and 2011 and 2014) showed that at about 60% of mothers delivered their babies at home [1-4 in C3] because of inadequate health facilities, insufficient skilled health professionals, and a lack of modern medical equipment, which have undermined the Bangladesh healthcare system, particularly among rural dwellers [98].

Assistance during delivery

According to the BDHS, the percentage of assisted by trained birth attendants (doctor, nurse, and midwife) has increased and ranged from 15,7% in 2004 to 54% in 2014. Overall in 2014, about Forty-six percent of births were assisted by untrained birth attendants, such as traditional birth attendants, and relatives or other persons. Past studies have suggested a strong correlation between untrained birth attendants and childhood mortality [99, 100].

Father's education

Father Education has been shown to be a strong predictor for neonatal, infant, and child mortality [69, 70]. In Bangladesh, as in many low- and middle-income countries, the father is the head of the family and decision maker, as well as the main income earner. Fathers who completed secondary or more level of education are significantly more likely to gain better paid work than father with no schooling. Educated father are significantly more likely to improve access to healthcare facilities, healthy nutrition, housing environment, and a good life style for the family.

Mother's work status

Findings that reported the association between mother's work status and childhood mortality has been inconsistent. For example, a cross-sectional study conducted in Jordan by Sullivan et al [101] revealed that the mother's work status is associated to childhood mortality. This finding was contradicted by another cross-sectional study conducted in Malaysia by Davanzo et al which showed no significant relationship between the mother's work status and childhood mortality [14].

2.5.2 Household-level variables

The health and mortality of a child depends upon a variety of goods, services and assets at the household level. The health of the child may be influenced by income effects in a number of ways; the first relates to food: There must be the stable availability of a basic minimum food

supply of sufficient variety to ensure adequate amounts of all nutrients; the second relates to water: Adequate quantity and quality of water are essential for drinking and food preparation; the third relates to housing: Quality of housing requires separate rooms for cooking and for storing food and water; the fourth relates to fuel/energy: An adequate supply of fuel would ensure proper food preparation and sterilization of stored food (particularly in urban areas); the fifth relates to transportation: Access to markets for consumption goods and food and to places of income-generating employment is essential; the sixth relates to information: Households can obtain information about proper nutrition through the radio, television, newspapers/magazines, books and other informal channels. Household wealth effect is strongly correlated with a range of goods and services, as well as assets at the household level. This in turn affects child health and mortality. Household-level factors considered in the study included household wealth index, Tetanus Toxoid (TT) vaccination, iron folic acid supplementation and access to mass media.

Household wealth index

Household wealth is strongly associated with childhood mortality including infant and under-five mortality [46, 69, 102, 103]. In developing countries, household wealth is usually very difficult to estimate because a lot of factors influence household income. These factors varies from access to healthcare facilities, food availability, improved water supply, improved sanitation facilities, access to modern stoves and cleaner energy, and housing conditions. The complex nature of determining household wealth in low- and middle-income countries, have prompted the use of household assets as a proxy to measure household economic status [104, 105].

In this study, a household wealth index variable was constructed using household assets because BDHS data sets contain no data on income or on household consumption expenditure. As a result, the household wealth index was calculated using household assets. In the BDHS

data sets, Household wealth index was constructed using principal components analysis (PCA) to determine the weights for the index based on information collected about several household assets and facilities [45]. Weights were assigned to two housing characteristics (availability of electricity and type of toilet facility) and six household assets (possession of a radio, television, refrigerator, bicycle, motorcycle/scooter and car). The household wealth index measures the economic status of the household. As a measure of household wealth index, in this study, we pooled the wealth index factor scores in each data. The pooled original household wealth index factor scores were then categorised into five quintiles: poorest, poorer, middle, richer and richest. This was then divided into three categories: the bottom 40% of households were referred to as poor households, the next 40% as the middle households and the top 20% as rich households.

Tetanus Toxoid (TT) vaccination

TT vaccination during pregnancy is one of the components of Antennal care. Vaccination of mothers against tetanus prior to birth can prevent transmission of neonatal tetanus and also to ensure clean delivery and cord care practices in order to reduce infection. According to the WHO and in order to prevent neonatal and maternal tetanus, at least two vaccinations during pregnancy could be enough to protect the women against tetanus throughout her childbearing years. Past study indicated that vaccinations women of childbearing age with at least two doses of tetanus toxoid are estimated to reduce mortality from neonatal tetanus by 94 percent [106].

Iron folic acid (IFA) supplementation

Iron-deficiency is the most common nutritional deficiency globally. It is highly prevalent and most severe in pregnant women, infants, and children, because of the high iron requirements for infant growth and pregnancy [55, 107, 108]. Approaches to controlling iron deficiency anaemia in pregnancy, include iron supplementation, nutrition education to diversify diets, fortification of foods with iron, deworming or combinations of these interventions [109]. Past

studied showed that mothers consuming any iron-folic acid supplements in pregnancy, there was a protective effect for child deaths beyond the neonatal period with a 26% reduction in post-neonatal deaths. A recent pooled analysis of longitudinal birth cohort studies has reported that 16% of childhood stunting can be attributed to low birth weight [107]. In addition, two new meta-analyses [110, 111] have reported that iron/folic acid supplements reduce the prevalence of low birthweight by 20%. These observations combined suggest that antenatal iron/folic acid supplementation is likely to reduce childhood stunting, although this has never been assessed directly in a trial. Adequate iron status early in pregnancy is critical for brain development [112, 113]. Improvements in antenatal iron/folic acid distribution programs could be driven by evidence that starting supplements early in pregnancy significantly reduces child mortality. In this study, the use of iron supplementation will provide intervention that offers a new way to accelerate reductions in child mortality and help countries reach their child survival MDG, potentially saving millions of lives.

Access to the mass media

The media play a significant role in reducing childhood mortality especially in educating women about prenatal and postnatal care. The Government of Bangladesh relied heavily on the mass media to educate mothers and communities about prenatal check-ups and vaccinations. Past studies from Bangladesh, Indonesia, India and Nigeria revealed that women who had any exposure to mass media were more likely to utilise antenatal care and postnatal care compared to those women who had no mass media exposure [114-117]. Limited or non-access to the mass media could lead to lack of exposure to information and health knowledge about pregnancy and postnatal care. Mass media improve women's empowerment, educate mothers and provide available information would enhance women's knowledge of the importance of

healthcare services factors including prenatal and postnatal check-ups, at least two tetanus toxoid vaccinations, and consumption of the recommended IFA supplementation.

2.5.3 Community-level variables

One of the major features of community-level variables is ecological setting of households. This includes climate, soil, rainfall, temperature and seasonality. In rural subsistence settings, the variables mentioned above can have a strong influence on child survival by affecting the quantity and variety of food crops produced. The availability of income-generating employment, the access to and use of medical facilities and the time mothers can stay at home in childcare, can all be influenced by ecological variables.

These potential factors used in the current study to identify risk factors associated with child mortality are discussed below for the benefit of readers unfamiliar with this concept of child mortality. Community-setting attributes that were considered were the type of residence and geographical zone that may affect access to healthcare institutions, and social and economic infrastructure.

Place of residence

The respondent's living location plays a vital role in reducing childhood mortality especially in developing countries including Bangladesh. Past studies indicated that children born to mothers who lived in rural areas are significantly more likely to die compared to those children whose mothers lived in urban areas [70, 71]. This finding could be attributed to the fact that children born to mothers that lived in rural areas have limited access to health facilities and maternal healthcare services which may result to high probability of childhood mortality.

Geographical region

Bangladesh is made up of seven geographical regions but for the purpose of this study, only six regions were used and they included six geographical zone covering groups of divisions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet). This study utilised data from four recent DHS datasets (2004, 2007, 2011 and 2014) and in 2004 data set, the region called Rajshahi was not created and hence, it was deleted from all this study analysis in order reduce statistical bias. A study conducted in Bangladesh by Abir et al [118] suggested that under-5 mortality in Bangladesh was significantly higher in infants from the Barisal region compared with infants from the Khulna region. There is geographical disparity in the patterns of deaths of children < 5 years old could relate to the fact that developed geographical regions are more likely to have better health care services which could improve child survival.

2.6.1 Independent variables

The independent variables, as depicted in the conceptual framework above, consist of variables at three levels: individual, household and community levels.

In this research, the individual-level factors considered included: maternal working status, father's occupation, maternal educational level, father's educational level, maternal literacy level, maternal age, maternal marital status, maternal religion, maternal BMI, birth order of the child, birth interval, child's sex, child's age, perceived size of the baby at birth, place of delivery of the baby, type of delivery assistance offered, antenatal clinic visits, timing of postnatal check-up, whether the child developed fever or diarrhoea in the past 2 weeks and whether the child developed ARI in the past 2 weeks.

Because of the practical importance to have narrower age intervals at younger rather than at older ages within the sample, child's age was categorised as 6-11 months, 12-17 months and 18-23 months. ARI was defined as having symptoms of cough accompanied by short, rapid

breathing. Any child whose stool was watery, bloody and contained mucus was considered to have had contracted diarrhoea.

Household-level factors considered in the study included wealth index, source of water and access to mass media. Household wealth index was calculated as a score of household assets such as ownership of means of transport, ownership of durable goods and household facilities, which was weighted by using the Principal Components Analysis method [105]. The index was divided into 5 categories (quintiles), namely poorest, poorer, middle, richer and richest. In this study, the wealth index was re-categorised into 3, namely poor, middle and rich. Community-level factors considered in the study included type of place of residence (urban or rural) and geographical or administrative region.

2.6.1 Outcome variables

The outcome variables in this study were the risks of stillbirth, perinatal, infant and child mortality. The risk of stillbirth is defined as the probability of birth of an infant that has died in the mother's womb, strictly, after having survived through at least, the first 28 weeks of pregnancy. The risk of perinatal death is defined as the probability of stillbirths and deaths in the first week of life. The risk of infant death is defined as the probability of dying between birth and the first birthday (0-11 months); while the risk of child death is defined as the probability of dying between age one and the fifth birthday (12-59 months). Overall, under-five mortality is the probability of dying between birth and the fifth birthday (0-59 months).

2.7 Summary

In this chapter, a critical review of the relevant extant literature and the theoretical framework of the thesis have been presented. Collection of important literature directly related to the study was carried out by exploring the different search engines. A global overview of stillbirth, perinatal, infant and child mortality was presented. This was followed by an overview of

stillbirth, perinatal, infant and child mortality in South Asia. South Asia has been known to be home the largest absolute numbers of perinatal deaths, because of the large populations in this region. The study carried out an overview of stillbirth, perinatal, and infant mortality in Bangladesh. A past research revealed that Bangladesh was among the 55 countries which achieved under-5 mortality rates lower than 10 per 1000 livebirths in 2013.

The section that followed presented the theoretical framework of the study. The Mosley and Chen conceptual model was adapted and modified. Covariates in the study were categorised into individual-level, household-level and community-level variables. The next chapter discusses the methodology applied in the study.

References

1. Wang, H., et al., *Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015.* The Lancet, 2016. **388**(10053): p. 1725-1774.
2. Lawn, J.E., et al., *Stillbirths: rates, risk factors, and acceleration towards 2030.* The Lancet, 2016. **387**(10018): p. 587-603.
3. Black, R.E., S.S. Morris, and J. Bryce, *Where and why are 10 million children dying every year?* . The Lancet, 2003. **361**: p. 2226-2234.
4. Rohde, J., et al., *30 years after Alma-Ata: has primary health care worked in countries?* The Lancet, 2008. **372**(9642): p. 950-961.
5. Ronsmans, C., W.J. Graham, and L.M.S.S.s. group, *Maternal mortality: who, when, where, and why.* The Lancet, 2006. **368**(9542): p. 1189-1200.
6. Rosenfield, A. and D. Maine, *Maternal mortality-a neglected tragedy: Where is the M in MCH?* The Lancet, 1985. **326**(8446): p. 83-85.
7. Shiffman, J., *Issue attention in global health: the case of newborn survival.* The Lancet, 2010. **375**(9730): p. 2045-2049.
8. Knippenberg, R., et al., *Systematic scaling up of neonatal care in countries.* The Lancet, 2010. **365**(9464): p. 1087-1098.
9. Lawn, J.E., S. Cousens, and J. Zupan, *4 million neonatal deaths: when? Where? Why?* The Lancet, 2005. **365**(9462): p. 891-900.
10. Ananth, C.V., et al., *A comparison of foetal and infant mortality in the United States and Canada.* International journal of epidemiology, 2009. **38**(2): p. 480-489.
11. MacDorman, M.F., S. Kirmeyer, and E. Wilson, *Fetal and perinatal mortality, United States, 2005.* National vital statistics reports, 2007. **56**(3).

12. Flenady, V., et al., *Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis.* The Lancet, 2011. **377**(9774): p. 1331-1340.
13. Smith, G.C. and R.C. Fretts, *Stillbirth.* The Lancet, 2007. **370**(9600): p. 1715-1725.
14. Frøen, J.F., et al., *Stillbirths: why they matter.* The Lancet, 2011. **377**(9774): p. 1353-1366.
15. Martin, J.A. and D.L. Hoyert. *The national fetal death file*. in *Seminars in Perinatology*. 2002. Elsevier.
16. Goldenberg, R.L., R. Kirby, and J. Culhane, *Stillbirth: a review.* The journal of maternal-fetal & neonatal medicine, 2004. **16**(2): p. 79-94.
17. Wang, H., et al., *Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013.* The Lancet, 2014. **384**(9947): p. 957-979.
18. Organization, W.H., *Perinatal mortality: a listing of available information.* 1996.
19. Conde-Agudelo, A., J.M. Belizán, and J.L. Díaz-Rossello, *Epidemiology of fetal death in Latin America.* Acta obstetricia et gynecologica Scandinavica, 2000. **79**(5): p. 371-378.
20. Ananth, C.V., et al., *Stillbirths in the United States, 1981–2000: an age, period, and cohort analysis.* American Journal of Public Health, 2005. **95**(12): p. 2213.
21. Martin, J.A. and N.C.f.H. Statistics, *Births: final data for 2002*. Vol. 52. 2003: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.
22. McClure, E., M. Nalubamba-Phiri, and R. Goldenberg, *Stillbirth in developing countries.* International Journal of Gynecology & Obstetrics, 2006. **94**(2): p. 82-90.
23. Cnattingius, S., et al., *Prepregnancy weight and the risk of adverse pregnancy outcomes.* New England Journal of Medicine, 1998. **338**(3): p. 147-152.

24. Künzel, W., et al., *Maternal and perinatal health in Mali, Togo and Nigeria.* European Journal of Obstetrics & Gynecology and Reproductive Biology, 1996. **69**(1): p. 11-17.

25. Fretts, R.C., *Etiology and prevention of stillbirth.* American journal of obstetrics and gynecology, 2005. **193**(6): p. 1923-1935.

26. Goldenberg, R.L., *Factors influencing perinatal outcomes.* Annals of the New York Academy of Sciences, 2004. **1038**(1): p. 227-234.

27. Victoria, C.G., et al., *Maternal education in relation to early and late child health outcomes: findings from a Brazilian cohort study.* Social science & medicine, 1992. **34**(8): p. 899-905.

28. Zanini, R.R., et al., *Infant mortality trends in the State of Rio Grande do Sul, Brazil, 1994-2004: a multilevel analysis of individual and community risk factors.* Cadernos de Saúde Pública, 2009. **25**(5): p. 1035-1045.

29. Frankenberg, E., *The effects of access to health care on infant mortality in Indonesia.* Health Transition Review, 1995: p. 143-163.

30. Cleland, J.G. and J.K. Van Ginneken, *Maternal education and child survival in developing countries: the search for pathways of influence.* Social science & medicine, 1988. **27**(12): p. 1357-1368.

31. Kravdal, Ø., *Child mortality in India: the community-level effect of education.* Population studies, 2004. **58**(2): p. 177-192.

32. Antai, D., *Inequalities in under-5 mortality in Nigeria: do ethnicity and socioeconomic position matter?* Journal of Epidemiology, 2011. **21**(1): p. 13-20.

33. Whitworth, A. and R. Stephenson, *Birth spacing, sibling rivalry and child mortality in India.* Social Science & Medicine, 2002. **55**(12): p. 2107-2119.

34. Schell, C.O., et al., *Socioeconomic determinants of infant mortality: a worldwide study of 152 low-, middle-, and high-income countries.* Scandinavian journal of public health, 2007. **35**(3): p. 288-297.

35. Omariba, D. and M.H. Boyle, *Family structure and child mortality in Sub-Saharan Africa: cross-national effects of polygyny.* Journal of Marriage and Family, 2007. **69**(2): p. 528-543.

36. Harttgen, K. and M. Misselhorn, *A multilevel approach to explain child mortality and undernutrition in South Asia and Sub-Saharan Africa*. 2006, Discussion papers//Ibero America Institute for Economic Research.

37. Griffiths, P., et al., *A tale of two continents: a multilevel comparison of the determinants of child nutritional status from selected African and Indian regions.* Health & place, 2004. **10**(2): p. 183-199.

38. Sastry, N., *Community characteristics, individual and household attributes, and child survival in Brazil.* Demography, 1996. **33**(2): p. 211-229.

39. Lawn, J., K. Shibuya, and C. Stein, *No cry at birth: global estimates of intrapartum stillbirths and intrapartum-related neonatal deaths.* Bulletin of the World Health Organization, 2005. **83**(6): p. 409-417.

40. Zupan, J., *Perinatal mortality in developing countries.* New England Journal of Medicine, 2005. **352**(20): p. 2047-2048.

41. Unicef, *Childhood under threat: the state of the world's children 2005*, in *Childhood under threat: the state of the world's children 2005*. 2004, UNICEF.

42. Bang, A., M. Reddy, and M. Deshmukh, *Child mortality in Maharashtra.* Economic and Political Weekly, 2002: p. 4947-4965.

43. Ulizzi, L. and L. Zonta, *Sex differential patterns in perinatal deaths in Italy.* Human biology, 2002. **74**(6): p. 879-888.

44. Victora, C.G., et al., *Applying an equity lens to child health and mortality: more of the same is not enough.* The Lancet, 2003. **362**(9379): p. 233-241.

45. UNICEF, U., *Levels and trends in child mortality.* New York: UNICEF, 2011.

46. National Institute of Population Research and Training (NIPORT) Dhaka, B. and B. Mitra and Associates Dhaka, *Bangladesh DHS 2004*. 2005, ORC Macro Calverton, Maryland USA.

46. National Institute of Population and Training and D. Mitra and Associates, Bangladesh,, *Bangladesh DHS 2011*. 2013, MEASURE DHS, ICF International, Calverton, Maryland, USA

48. Rodgers, G.B., *Income and inequality as determinants of mortality: an international cross-section analysis.* International journal of epidemiology, 2002. **31**(3): p. 533-538.

49. Cnattingius, S. and O. Stephansson. *The epidemiology of stillbirth*. in *Seminars in perinatology*. 2002. Elsevier.

50. Kambarami, R., *Levels and risk factors for mortality in infants with birth weights between 500 and 1,800 grams in a developing country: a hospital based study.* The Central African journal of medicine, 2001. **48**(11-12): p. 133-136.

51. Osman, N.B., et al., *Perinatal outcome in an obstetric cohort of Mozambican women.* Journal of Tropical Pediatrics, 2001. **47**(1): p. 30-38.

52. Feresu, S.A., et al., *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 and childbirth, 2005. **5**(1): p. 9.

53. Joseph, K., *Incidence-based measures of birth, growth restriction, and death can free perinatal epidemiology from erroneous concepts of risk.* Journal of clinical epidemiology, 2004. **57**(9): p. 889-897.

54. Galvan, J., *Prenatal care utilization and foetal outcomes at Harare Maternity Hospital, Zimbabwe.* 2001.

55. Stringer, E.M., et al., *Determinants of stillbirth in Zambia.* Obstetrics & Gynecology, 2011. **117**(5): p. 1151-1159.

56. Zeng, L., et al., *Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial.* Bmj, 2008. **337**: p. a2001.

57. Titaley, C.R., et al., *Iron and folic acid supplements and reduced early neonatal deaths in Indonesia.* Bulletin of the World Health Organization, 2010. **88**(7): p. 500-508.

58. Gitta, S.N., et al., *Risk factors for neonatal tetanus--Busoga region, Uganda, 2002-2003.* MMWR Morb Mortal Wkly Rep, 2006. **55**(Suppl 1): p. 25-30.

59. Chai, F., et al., *Neonatal tetanus incidence in China, 1996–2001, and risk factors for neonatal tetanus, Guangxi Province, China.* International journal of epidemiology, 2004. **33**(3): p. 551-557.

60. Åsling-Monemi, K., et al., *Violence against women increases the risk of infant and child mortality: a case-referent study in Nicaragua.* Bulletin of the World Health Organization, 2003. **81**(1): p. 10-16.

61. Konseiga, A., E.M. Zulu, and Y. Yé, *Assessing the effect of mother's migration on childhood mortality in the informal settlements of Nairobi*, in *Discussion Paper No. 2295*. 2006, The Institute for the Study of Labor: Bonn, Germany.

62. Mosley, W.H. and L.C. Chen, *An analytical framework for the study of child survival in developing countries.* Population and development review, 1984: p. 25-45.

63. Hector, D., et al., *Factors affecting breastfeeding practices. Applying a conceptual framework.* New South Wales public health bulletin, 2005. **16**(4): p. 52-55.

64. Caldwell, J.C., *Education as a factor in mortality decline an examination of Nigerian data.* Population studies, 1979: p. 395-413.

65. Uthman, O., *Environmental factors, neighbourhood deprivation, and under-five mortality in Nigeria: an exploratory spatial data analysis.* The Internet Journal of Pediatrics and Neonatology, 2008. **9**(1).

66. Buor, D., *Mothers' education and childhood mortality in Ghana.* Health Policy, 2003. **64**(3): p. 297-309.

67. Das Gupta, M., *Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India.* Population studies, 1990. **44**(3): p. 489-505.

68. Anyamele, O.D., *Urban and rural differences across countries in child mortality in sub-Saharan Africa.* Journal of health care for the poor and underserved, 2009. **20**(4A): p. 90-98.

69. Hobcraft, J.N., J.W. McDonald, and S.O. Rutstein, *Socio-economic factors in infant and child mortality: a cross-national comparison.* Population studies, 1984. **38**(2): p. 193-223.

70. Mani, K., S.N. Dwivedi, and R.M. Pandey, *Determinants of under-five mortality in Rural Empowered Action Group States in India: An application of Cox frailty model.* International Journal of MCH and AIDS, 2012. **1**(1): p. 60.

71. Agha, S., *The determinants of infant mortality in Pakistan.* Social science & medicine, 2000. **51**(2): p. 199-208.

72. Mondal, N.I., K. Hossain, and K. Ali, *Factors influencing infant and child mortality: A case study of Rajshahi District, Bangladesh.* Journal of Human Ecology, 2009. **26**(1): p. 31-39.

73. Ezeh, O.K., et al., *Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey.* BMC Public Health, 2014. **14**(1): p. 521.

74. Mahmood, M.A., *Determinants of neonatal and post-neonatal mortality in Pakistan.* The Pakistan Development Review, 2002: p. 723-744.

75. Zwane, E. and S. Masango, *Factors influencing neonatal mortality: an analysis using the Swaziland Demographic Health Survey 2007.* Journal of Public Health in Africa, 2012. **3**(2): p. 18.

76. Ajaari, J., et al., *Impact of place of delivery on neonatal mortality in rural Tanzania.* International Journal of MCH and AIDS, 2012. **1**(1): p. 49.

77. Rutstein, S.O., *Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys.* International Journal of Gynecology & Obstetrics, 2005. **89, Supplement 1**(0): p. S7-S24.

78. Alonso, V., V. Fuster, and F. Luna, *Causes of neonatal mortality in Spain (1975–98): influence of sex, rural–urban residence and age at death.* Journal of Biosocial Science, 2006. **38**(04): p. 537-551.

79. Khoury, M.J., et al., *Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome.* American journal of obstetrics and gynecology, 1985. **151**(6): p. 777-782.

80. Chen, L.C., E. Huq, and S. d'Souza, *Sex bias in the family allocation of food and health care in rural Bangladesh.* Population and development review, 1981: p. 55-70.

81. Bhuiya, A. and K. Streatfield, *Mothers' education and survival of female children in a rural area of Bangladesh.* Population Studies, 1991. **45**(2): p. 253-264.

82. Arokiasamy, P., *Regional patterns of sex bias and excess female child mortality in India.* Population, 2004. **59**(6): p. 947-982.

83. Subramanian, S., et al., *The mortality divide in India: the differential contributions of gender, caste, and standard of living across the life course.* American Journal of Public Health, 2006. **96**(5): p. 818-825.

84. Hobcraft, J.N., J.W. McDonald, and S.O. Rutstein, *Demographic determinants of infant and early child mortality: a comparative analysis.* Population studies, 1985. **39**(3): p. 363-385.

85. Rutstein, S.O., *Factors associated with trends in infant and child mortality in developing countries during the 1990s.* Bulletin of the World Health Organization, 2000. **78**(10): p. 1256-1270.

86. DaVanzo, J., W.P. Butz, and J.-P. Habicht, *How biological and behavioural influences on mortality in Malaysia vary during the first year of life.* Population studies, 1983. **37**(3): p. 381-402.

87. Arokiasamy, P. and A. Gautam, *Neonatal mortality in the empowered action group states of India: trends and determinants.* Journal of biosocial science, 2008. **40**(2): p. 183.

88. Boerma, J.T. and G.T. Bicego, *Preceding birth intervals and child survival: searching for pathways of influence.* Studies in family planning, 1992. **23**(4): p. 243-256.

89. Kembo, J. and J.K. Van Ginneken, *Determinants of infant and child mortality in Zimbabwe: Results of multivariate hazard analysis.* Demographic Research, 2009. **21**: p. 367-384.

90. Onwuanaku, C.A., et al., *The effects of birth weight and gender on neonatal mortality in north central Nigeria.* BMC research notes, 2011. **4**(1): p. 562.

91. Uthman, O.A., *Effect of low birth weight on infant mortality: analysis using Weibull hazard model.* Int J of Epidemiol, 2008. **6**(1): p. 8.

92. Ballot, D.E., T.F. Chirwa, and P.A. Cooper, *Determinants of survival in very low birth weight neonates in a public sector hospital in Johannesburg.* BMC pediatrics, 2010. **10**(1): p. 30.

93. Manda, S.O., *Birth intervals, breastfeeding and determinants of childhood mortality in Malawi.* Social Science & Medicine, 1999. **48**(3): p. 301-312.

94. Fort, A.L., M.T. Kothari, and N. Abderrahim, *DHS Working Papers.* Calverton, MD, USA: Macro International, 2008: p. 1-47.

95. Seedhom, A.E. and N.N. Kamal, *Some determinants of neonatal mortality in a rural area, El-Minia governorate, Egypt, 2008.* Egypt J Community Med, 2010. **28**(2).

96. Ezechi, O., et al., *Caesarean section and perinatal mortality in South Western Nigeria.* Nepal Journal of Obstetrics and Gynaecology, 2015. **4**(1): p. 46-48.

97. Sunday-Adeoye, I. and C. Kalu, *Pregnant Nigerian women's view of cesarean section.* Nigerian journal of clinical practice, 2011. **14**(3): p. 276-279.

98. Koblinsky, M., et al., *Going to scale with professional skilled care.* The Lancet, 2006. **368**(9544): p. 1377-1386.

99. Ronsmans, C., et al., *Professional assistance during birth and maternal mortality in two Indonesian districts.* Bulletin of the World Health Organization, 2009. **87**(6): p. 416-423.

100. Welcome, M.O., *The Nigerian health care system: Need for integrating adequate medical intelligence and surveillance systems.* Journal of Pharmacy and Bioallied Sciences, 2011. **3**(4): p. 470.

101. Gill, C.J., et al., *Effect of training traditional birth attendants on neonatal mortality (Lufwanyama Neonatal Survival Project): randomised controlled study.* Bmj, 2011. **342**: p. d346.

102. Satishchandra, D., et al., *Impact of training of traditional birth attendants on the newborn care.* Indian journal of pediatrics, 2009. **76**(1): p. 33-36.

103. Sullivan, J., A. Adlakha, and C. Suchindran. *Infant mortality levels, time trends and determinants in Jordan: a summary of findings*. in *52nd Annual Meeting of the Population Association of America, Pittsburgh, Pennsylvania: April*. 1983.

104. Okposio, M.M., M.O. Unior, and F.O. Ukpeteru, *Sociodemographic Determinants of Mortality in Hospitalized Under-Five Children at a Secondary Health Care Centre in the Niger Delta.* 2012.

105. Collison, D., et al., *Income inequality and child mortality in wealthy nations.* Journal of Public Health, 2007. **29**(2): p. 114-117.

106. Montgomery, M.R., et al., *Measuring living standards with proxy variables.* Demography, 2000. **37**(2): p. 155-174.

107. Filmer, D. and L.H. Pritchett, *Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India*.* Demography, 2001. **38**(1): p. 115-132.

108. Blencowe, H., et al., *Tetanus toxoid immunization to reduce mortality from neonatal tetanus.* International Journal of Epidemiology, 2010. **39**(suppl 1): p. i102-i109.

109. Dibley, M.J., et al., *Iron and folic acid supplements in pregnancy improve child survival in Indonesia.* The American journal of clinical nutrition, 2012. **95**(1): p. 220-230.

110. Stoltzfus, R.J., *Defining iron-deficiency anemia in public health terms: a time for reflection.* The Journal of nutrition, 2001. **131**(2): p. 565S-567S.

111. Stoltzfus, R.J. and M.L. Dreyfuss, *Guidelines for the use of iron supplements to prevent and treat iron deficiency anemia*. Vol. 2. 1998: Ilsi Press Washington^ eDC DC.

112. Christian, P., et al., *Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low-and middle-income countries.* International journal of epidemiology, 2013. **42**(5): p. 1340-1355.

113. Pena-Rosas, J.P., et al., *Daily oral iron supplementation during pregnancy.* Cochrane Database Syst Rev, 2012. **12**(12): p. CD004736.

114. Imdad, A. and Z.A. Bhutta, *Routine iron/folate supplementation during pregnancy: effect on maternal anaemia and birth outcomes.* Paediatric and perinatal epidemiology, 2012. **26**(s1): p. 168-177.

115. Beard, J.L., *Why iron deficiency is important in infant development.* The Journal of nutrition, 2008. **138**(12): p. 2534-2536.

116. Singh, P.K., et al., *Determinants of maternity care services utilization among married adolescents in rural India.* PloS one, 2012. **7**(2): p. e31666.

117. Islam, M. and J. Odland, *Determinants of antenatal and postnatal care visits among Indigenous people in Bangladesh: a study of the Mru Community.* Rural Remote Health, 2011. **11**(2): p. 1672.

118. Titaley, C.R., M.J. Dibley, and C.L. Roberts, *Factors associated with non-utilisation of postnatal care services in Indonesia.* Journal of epidemiology and community health, 2009. **63**(10): p. 827-831.

119. Agho, K., et al., *Population attributable risk estimates for factors associated with non-use of postnatal care services among women in Nigeria.* BMJ open, 2016. **6**(7): p. e010493.

120. Abir, T., et al., *Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011.* BMJ open, 2015. **5**(8): p. e006722.

CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter presents methodology for answering the different research questions. The chapter seeks to achieve a couple of inter-related aims. Firstly, it describes the sources of data used in answering the various research questions of the study. These sources were 2004, 2007, 2011 and 2014 Bangladesh DHS. Secondly, the chapter describes the study outcomes and study variables used in answering these research questions.

3.1 Bangladesh Demographic and Health Surveys

The BDHS was a two-stage cluster sampling. At first BDHS was stratified by urban and rural location. This was followed by a two stage sampling procedures. In the first stage, geographical areas (usually defined as enumeration areas (EAs) from a recently completed population census) were systematic sampled with probability proportional to the EA size. In the second stage, systematic sampling of equal probability and fixed size across the EAs were carried.

BDHS is a periodic survey conducted in Bangladesh to serve as a source of population and health data for policymakers, program managers, and the research community. In general, the aims of the BDHS are to provide information to meet the monitoring and evaluation needs of health and family planning programs, and to provide program managers and policymakers involved in these programs with the information they need to plan and implement future interventions. More specifically, the objectives of the survey are to provide up-to-date information on fertility and childhood mortality levels; fertility preferences; awareness, approval, and use of family planning methods; breastfeeding practices; nutrition levels; maternal and child health; awareness of HIV/AIDS and other sexually transmitted diseases; knowledge of tuberculosis; and domestic violence. Members of the Bangladesh Demographic and Health Surveys Technical Review Committee (TRC), consisting of professionals from

Dhaka University, BRAC University, Jahangeernagar University, National Institute of Population Research and Training (NIPORT), Population Council, Ministry of Health, Icddr,b, Macro International as well as researchers and professionals working in the Health Nutrition and Population Sector contributed to the major part of the survey. In addition, for designing and implementing the survey, a Technical Task Force (TTF) was formed and the TTF included the NIPORT, Icddr,b, BRAC University, USAID/Bangladesh, Macro International, and Mitra and Associates {1-3]

3.1.1 Bangladesh Demographic and Health Survey 2004

The 2004 Bangladesh Demographic and Health Survey (2004 BDHS) was a nationally representative survey of 11,440 women age 10-49 and 4,297 men age 15-54 from 10,500 households covering 361 sample points (clusters) throughout Bangladesh, 122 in urban areas and 239 in the rural areas. The survey was the fourth in a series of national-level population and health surveys conducted as part of the global Demographic and Health Surveys (DHS) program. It was designed to provide data to monitor the population and health situation in Bangladesh as a follow-up to the 1993- 1994, 1996-1997 and 1999-2000 BDHS surveys. The survey utilized a multistage cluster sample based on the 2001 Bangladesh Census and was designed to produce separate estimates for key indicators for each of the six divisions of the country—Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet. Data collection took place over a five-month period from 1 January to 25 May 2004. Previous surveys included only ever-married women and currently married men. This survey was first DHS survey in Bangladesh to also include never-married and formerly married men, i.e., the sample for the survey was ever-married women aged 10-49 years and all men aged 15-54 years. The survey obtained detailed information on fertility levels, marriage, fertility preferences, awareness and use of family planning methods, breastfeeding practices, nutritional status of women and young children, childhood mortality and causes of death of children under five, maternal and child

health, awareness and behaviour regarding HIV/AIDS, and other sexually transmitted infections (STIs). In the previous surveys, anthropometric measurements (height and weight) were restricted to mothers who had a child under five years, and their young children. In the 2004 BDHS, all children under five in the household and all interviewed women had their height and weight measured. In addition, the 2004 BDHS collected information on the level of arsenic in drinking water. The 2004 BDHS was conducted under the authority of the National Institute for Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare. It was implemented by Mitra and Associates, a Bangladeshi research firm located in Dhaka. Technical assistance was provided by ORC Macro through the MEASURE DHS program. Financial support for the survey was provided by the U.S. Agency for International Development (USAID)/Bangladesh.

3.1.2 Bangladesh Demographic and Health Survey 2007

The 2007 Bangladesh Demographic and Health Survey (BDHS) was a nationally representative sample survey designed to provide information on basic national indicators of social progress including fertility, childhood mortality, contraceptive knowledge and use, maternal and child health, nutritional status of mothers and children, awareness of AIDS, and domestic violence. In addition to presenting the main findings from the 2007 BDHS on fertility, family planning, maternal & child health and nutrition, this report highlighted the major changes that took place in

Bangladesh's demographic and health situation since the previous BDHS surveys. Results of the 2007

BDHS showed that the fertility declines have continued in recent years, with the total fertility rate (TFR) dropping to 2.7 children per woman. However, differentials in fertility by administrative divisions were substantial. The TFR was highest in Sylhet division (3.7) and lowest in Khulna (2.0). Similar differentials were observed by wealth quintile. The poorest

women had an average of 3.2 children—one child more than women from the richest households (2.2 children). BDHS data also indicated that 17 percent of married women have an unmet need for family planning, and that if unmet need of women could be addressed, the current contraceptive prevalence rate in Bangladesh would reach to 73 percent to achieve a replacement level of fertility. The findings of this report together with other national surveys were very important in assessing the achievements of health, Health Nutrition and Population Sector Program (HNPSP). Information obtained from the 2007 BDHS could be used to review the progress of HNPSP, Millennium Development Goals (MDGs) and Poverty Reduction Strategy (PRS) of Bangladesh.

3.1.3 Bangladesh Demographic and Health Survey 2011

The 2011 Bangladesh Demographic and Health Survey (BDHS) was the sixth survey of its kind conducted in Bangladesh. This survey was implemented through a collaborative effort of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. The financial support for the survey was provided by the United States Agency for International Development (USAID), Bangladesh.

The 2011 BDHS was a nationwide sample survey of men and women of reproductive age that provided information on childhood mortality levels; fertility preferences; use of family planning methods; and maternal, child, and newborn health. Included are breastfeeding practices; nutrition levels, including the presence of anaemia and iodine deficiency; knowledge and attitudes toward HIV/AIDS and other sexually transmitted infections; and community-level data on accessibility and availability of health and family planning services. The special feature of this survey was its provision of biomarker indices of adult male and female populations, which were instrumental in determining the increasing risk of non-communicable diseases.

Members of the Technical Review Committee (TRC), consisting of experts from government, Non-government, and international organizations as well as researchers and professionals working in the health, nutrition, and population sectors, contributed their expert opinion in various phases of the survey implementation. A Technical Working Group (TWG) was also formed with the representatives from NIPORT; Icddr,b; USAID, Bangladesh; ICF International; and Mitra and Associates for designing the survey questionnaires and implementing the survey.

The preliminary results of the 2011 BDHS, with its key indicators, were released through a dissemination seminar in April 2012. The final report brought more comprehensive analysis of the survey results. Along with the key results, detailed findings and possible interpretations were presented. The report was an outcome of contributions from professionals at NIPORT, National Institute of Preventive and Social Medicine (NIPSOM), Mitra and Associates, Dhaka University, Jahangirnagar University, Icddr,b, MEASURE Evaluation, Population Council, Social Marketing Company (SMC), Save the Children, and Eminence.

3.1.3 Bangladesh Demographic and Health Survey 2014

The 2014 2014 BDHS was implemented under the authority of the National Institute of Population Research and Training (NIPORT), Bangladesh Ministry of Health and Family Welfare. The survey was conducted by Mitra and Associates from June to November 2014. Funding was provided by the United States Agency for International Development (USAID)/Bangladesh. ICF International provided technical assistance through The DHS Program, a USAID-funded project.

The BDHS) 2014 is the seventh national-level demographic and health survey. It was designed to provide information to address the monitoring and evaluation needs of the Health, Population and Nutrition Sector Development Program (HPNSDP), and to provide managers

and policy makers involved in this program with the information that they need to effectively plan and implement future interventions in the country. The survey generated evidences on basic national indicators of social progress, including fertility, childhood mortality, fertility preferences and fertility regulation, maternal and child health, nutritional status of mothers and children, and awareness and attitude towards HIV/AIDS.

In addition to presenting the main findings from BDHS 2014 on fertility, family planning, maternal and child health and nutrition, this report highlights the major changes that have taken place in Bangladesh's demographic and health situation since 1993-94.

The findings of the BDHS 2014 report and its policy and programmatic implications were meant to be instrumental in monitoring and evaluation of HPNSDP, and in designing the next HPN sector programme in Bangladesh.

3.1 Data sources for answering the first research question

Datasets from the 2004, 2007, 2011and 2014 BDHS were obtained [1-4]. The BDHS data sets were based on two-stage stratified cluster sampling. Level-1 was individuals (ever-married women aged 15−49) who were nested within clusters (level-2). Comprehensive details of survey methodology, sampling procedure, and questionnaires are available in the respective BDHS reports. The data obtained were from 20,439 ever-married women of reproductive age, consisting of 11,601 women from the 2004 survey (i.e., ever-married and aged 15-49 years), 10,996 women from the 2007 survey (i.e., ever-married and aged 15-49 years) and 11,601 women from the 2011 survey (i.e., ever-married and aged 12-49 years). All the surveys reported very high response rates of about 98%. Our analyses were restricted to ever-married women aged 15-49 years yielding the weighted sample of 20,922 (2004: 7002 women; 2007: 6057 women and 2011: 7863 women).

3.1.1 Study Outcome for answering the first research question

The outcome variable of this study was stillbirth, defined as the death of a foetus of 27 weeks or more gestation [1-4]. The outcome was recorded as a binary variable in the data sets coded as 1 for 'stillbirth' and 0 for 'No stillbirth'.

3.1.2 Study variables for answering the first research question

Study variables included socio-demographic and economic characteristics of respondents, which were classified into four categories: community, socioeconomic, infant and health service factors. The community factors were cluster type (urban and rural) and geographical region, covering groups of divisions, namely Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet. The socioeconomic factors included number of children ever born, age of mother's at the time of the interview, mother's working status, mother's marital status, mother's body mass index (BMI), parents' highest level of education, mother's access to the media (television, radio and newspaper). Source of drinking water and type of toilet facility constituted the environmental factors. The infant factors involved sex of the infant, mother's age at index infant's birth, previous multiple births, desire for pregnancy, previous death of a sibling and combined birth rank and interval. This study combined previous birth order and birth interval because the impact of birth order may be mediated by the birth interval between children [5, 6].

The socioeconomic factor comprised household wealth index, which measures the economic status of the household. This variable was constructed by assigning weights to three housing characteristics, namely, availability of electricity, type of floor and type of wall; and six household assets, namely radio, television, fridge, bicycle, motorcycle and car, using the survey data and principal components analysis [7]. The wealth index was used to rank all households across the three surveys. The household wealth index variable was categorized into five quintiles: poorest, poorer, middle, richer and richest. It was then divided into three categories:

the bottom 40% of households was referred to as poor households, the next 40% as the middle households and the top 20% as rich households.

3.2 Data sources for answering the second research question

This study utilized data from the four most recent DHS datasets (2004, 2007, 2011 and 2014) for Bangladesh [1-4]. The study involved a total sample of 27540 women; 6287 from the 2004 BDHS, 5473 from the 2007 BDHS, 8986 from the 2011 BDHS, and 8069 from the 2014 BDHS. The four surveys averaged a response rate of 98%.

3.2.1 Study Outcome for answering the second research question

The outcome variable of this study was perinatal mortality, which was categorised into (i) stillbirth and early neonatal and (ii) stillbirth and neonatal. The outcome was recorded as a binary variable in the data sets, coded as 1 for 'perinatal' and 0 for 'No perinatal'.

3.2.2 Study variables for answering the second research question

The Mosley and Chen framework of factors influencing child survival in developing countries [5] was also used as the basis for selecting potential risk factors for perinatal mortality in Bangladesh. This study examined the outcome variables against all selected potential risk variables. These variables were organised into four distinct groups; namely, community; household, individual and health services factors. The community level factors assessed were residence type and geographical zone. The residence type was categorized into two groups in the analysis (urban, rural), and geographical zone covering groups of divisions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet). The household factor used was the wealth index variable which measures the economic status of the households. The household wealth index was constructed by assigning weights to three housing characteristics (i.e. availability of

electricity and type of floor and wall) and six household assets (i.e. possession of a radio, television, fridge, bicycle, motorcycle and car) using the survey data and principle components analysis. The wealth index was used to rank all households across the three surveys. Household wealth index variable was categorized into five quintiles (poorest, poorer, middle, richer and richest), however this index was divided into three categories. The bottom 40% of households was arbitrarily referred to as poor households, the next 40% as the middle households and the top 20% as rich households. The individual level factors consisted of maternal, child and paternal characteristics: Maternal (religion, number of children under that age of five, education, watches TV, listens to radio, read newspapers, age, body mass index and desire for pregnancy); Child (sex of the baby, combined birth place and mode of delivery, delivery assistance and a combination of birth order and birth interval); and paternal education. The health services factors were: delivery complications, desire for previous pregnancies and contraceptive use.

3.3 Data sources for answering the third research question

This study utilized data from the three most recent DHS datasets (2004, 2007 and 2011) for Bangladesh [1-3]. It is worthy of note that the most recent BDHS did not collect data on tetanus toxoid vaccination in pregnant women, and hence was not included in this analysis. The study involved a total sample of 16722 women; 5364 from the 2004 BDHS, 4872 from the 2007 BDHS and 6485 from the 2011 BDHS. The three surveys averaged a response rate of 97%.

3.3.1 Study Outcome for answering the third research question

The outcome variable for this current study was child mortality, which comprises neonatal (death within 0-28 days), post-neonatal (between 1 and 11 months) and under-5 (between 12 and 59 months) mortalities.

3.3.2 Main exposure variables and study factors for answering the third research question

This study examined antenatal care (health care services offered to pregnant women by trained officials) as the main exposure variable. Antenatal care (ANC) services may include offering maternal health education, physical examination on pregnant women, iron and folic acid supplementation (IFA) as well as tetanus toxoid (TT) vaccinations. The influence of the different combinations of other aspects of ANC, iron and folic acid supplementation and TT vaccinations on child mortality was analysed so as to assess the individual effects of these services.

The study adapted the Mosley and Chen [5] model to evaluate the association of other factors with child mortality. We identified three main variables in this current study: (i) Community-level factors [type of residence (rural/urban) and administrative region] (ii) Socio-economic determinants (maternal marital status, maternal religion, maternal age at the time of the survey, maternal age at the time of birth of the child, parents' working status, maternal body mass index (BMI), parents' level of education, household wealth index, maternal access to the mass media: radio, television and newspaper/magazine) (iii) Proximate determinants (gender or sex of baby, birth rank and interval, maternal desire for pregnancy (iv) Pregnancy or delivery health-care service (patronage of ANC services, place and mode of delivery of baby and type of delivery assistance).

All households across the three surveys were ranked by using the *household wealth index*, which was constructed (utilising the survey data and applying the principal components analysis [6]) by apportioning weights to three characteristics of households; namely, the type of floor, the type of wall and access to electricity, and six assets in the household; namely, possession of a radio, television, bicycle, motor cycle, car and refrigerator.

3.4 Data sources for answering the fourth research question

The data used in this study were derived from the 2004, 2007, 2011 and 2014 surveys. In total, information on 22969 women was obtained from these surveys. On average, the response rate was over 98% [1-4].

The analyses used survival information from 22,969 singleton live-born infants of the most recent birth of the mother within three years prior to her being interviewed. The analyses used the most recent birth because only those births had detailed information about the use of perinatal health services. The most recent birth was also used in order to limit the potential for differential recall of events from mothers who had delivered at very different durations prior to the interview. However, multiple births were excluded from our analysis, given that previous studies have shown a strong correlation between multiple births and childhood mortality [7]. This analysis was restricted to ever-married women aged 15-49 years and to births within 5 years in order to minimise recall bias about birth and death dates reported by mothers.

3.4.1 Study Outcomes for answering the fourth research question

The main outcomes of this study were childhood mortality examined in four different time periods. The mortality outcomes investigated in four different time periods were post-neonatal death defined as death of an infant from 1 month through 11 months of life [8] and infant death, defined as death of an infant after birth through 11 months of life. The other two outcomes were child death defined as death between 12 and 59 months of life and under-five children death, defined as death of a child after birth through 59 months of life.

3.4.2 Potential risk factors

The Mosley and Chen framework of factors influencing child survival in developing countries [5] was the basis for selecting potential risk factors for childhood mortality in Bangladesh. The study outcome variables were examined against all selected potential risk variables, and these variables were organised into four distinct groups which included community; household,

individual and health services factors. The community level factors assessed were residence type and geographical zone. The residence type was categorized into two groups, namely, urban and rural. Geographical region consisted of the different administrative divisions of Bangladesh, namely, the Barisal, Chittago, Dhaka, Khulna, Rajshahi and Sylhet regions. The household factor used was the wealth index variable which measures the economic status of the households. The household wealth index was constructed by assigning weights to three housing characteristics (i.e. availability of electricity and type of floor and wall) and six household assets (i.e. possession of a radio, television, fridge, bicycle, motorcycle and car) using the survey data and principle components analysis. The wealth index was used to rank all households across the three surveys. Household wealth index variable was categorized into five quintiles (poorest, poorer, middle, richer and richest), however this index was divided into three categories. The bottom 40% of households was arbitrarily referred to as poor households, the next 40% as the middle households and the top 20% as rich households. The individual level factors consisted of maternal, child and paternal characteristics: Maternal (religion, number of children under that age of five, education, mother watched television, mother listened to the radio, mother read newspapers, age, body mass index and desire for pregnancy); child (sex of the baby, combined birth place and mode of delivery, delivery assistance and a combination of birth order and birth interval); and paternal education. The health services factors were: delivery complications, desire for previous pregnancies, contraceptive use and number of antenatal clinic visits. The categorisation of the covariates used in this study is described below.

Table 3.1:
Categorisation of covariates used in the study.

COVARIATES	CATEGORISATION
Community level factors	
Year	(1=2004; 2=2007; 3=2011; 4=2014)
Residence	(0=Rural;1=Urban)
Geographical region	(1=Barisal;2=Chittagong;3=Dhaka;4=Khulna;) 5=Rajshahi;6=Sylhet)
Socio-economic factors	
Household Wealth index	(1=Poor;2=Middle;3=Rich)
Mother's education	(1=No education;2=Primary,3=Secondary or higher
Partner's education	(1=No education;2=Primary;3=Secondary or higher)
Mother's marital status	(1=Currently married;2=Formerly married)
Maternal Working status	(1=Not working; 2=Working)
Parents employment status	(1=fatheronlyworking;2=Bothworking;3=neither working)
Media factors	
Reading newspapers	(0=No; 1=Yes/Some)
Watching TV	(0=No; 1= Yes/Some)
Listening to radio	(0=No; 1= Yes/Some)
Maternal factors	
Mother's age at birth (in years)	(1= <20; 2=20-29 ; 3=30-39; 4=40^{+})
Mother's age (in years)	(1=15-24; 2=25-34; 3=35-49)
Maternal BMI	(1= <=18.5;2=19-25;3=25+)
Delivery factors	
Combined Place and mode of delivery	(1=Health facilities without caesarean;2=Health facility with caesarean; 3= home)
Delivery assistance	(1=Noone,2=Doctor/obstetrician-gynaecologist;

	3= nurse/midwife; 4=TBA; 5= other untrained personnel)
Pre-delivery factors	
Antenatal clinic visits	(1=Not used; 2=used)
Contraceptive use	(1=N0; 2=Yes)
Desire for pregnancy	(1=Then;2=Later;3=Not at all)
Prenatal factors	
IFA supplements	(1=N0; 2=Yes)
TT-vaccination	(1=Never;2=one TT;3=2^{+} TT)
Child factors	
Sex of child	1=Male; 2=Female
Previous death of sibling	(1=N0; 2=Yes)
Birth interval and rank	1= 2 or 3 child, interval > 2; 2= First child; 3=2 or 3 child, interval <= 2;4=4 or more child, interval > 2;5=4 or more child, interval <= 2)

IFA =Iron Folic Acid supplementation

3.5 Summary

In this chapter, the methodology for answering the research questions was presented. The datasets used in the study were extracted from the Bangladesh Demographic and Health Surveys, which are released approximately every five years. The 2004, 2007, 2011 and 2014 versions of this population-based survey were utilized in the study. The outcome variables used in answering the various research questions were stillbirth and perinatal mortality, antenatal care service, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy as well as under-5 mortality. Independent variables used in the study were mainly chosen on the basis of the Mosely-Chen model for the study of the determinants of child survival in low-income and middle-income countries. These variables include individual-, household- and community-level factors such as characteristics of the child and mother, household wealth index, type of residence (rural/urban), as well as administrative region. The next chapter presents the statistical analyses used to answer three of the four research questions.

References

1. National Institute of Population Research and Training (NIPORT) Dhaka B, Mitra and Associates Dhaka, Bangladesh: Bangladesh Demographic and Health Survey (DHS) 2004. ORC Macro Calverton, Maryland USA; 2005.
2. National Institute of Population Research and Training (NIPORT) Dhaka B, Mitra and Associates Dhaka, Bangladesh: Bangladesh DHS, 2007. Macro International, Calverton, Maryland, USA; 2009.
3. National Institute of Population and Training, Mitra and Associates Dhaka, Bangladesh: Bangladesh DHS 2011. MEASURE DHS, ICF International, Calverton, Maryland, USA, 2013.
4. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International: Bangladesh Demographic and Health Survey 2014. In. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International; 2016.
5. Mosley WH, Chen LC: An analytical framework for the study of child survival in developing countries. Population and development review 1984:25-45.
6. Filmer D, Pritchett LH: Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India. Demography 2001, 38:115-132.
7. Uthman OA, Uthman MB, Yahaya I. A population-based study of effect of multiple birth on infant mortality in Nigeria. BMC pregnancy and childbirth 2008, 8(1):41.
8. Lawn JE, Cousens S, Zupan J: 4 million neonatal deaths: When? Where? Why? The Lancet 2005, 365(9462):891-900.

CHAPTER 4

STATISTICAL ANALYSES

4.0 Introduction

This chapter presents the multilevel modelling mathematical statistical approaches and analyses employed in answering the four research questions of this thesis. The statistical software package STATA versions 13 and 14 (Stata Corporation, College Station, USA) was used for all statistical analyses of this study. The "svy" command was used to adjust for sampling weights and the cluster survey design.

4.1 Multilevel Logistic Regression Modelling Approach

We used multilevel logistic regression to model the risk of a child dying by following similar method employed by Rabe-Hesketh & Skrondal[1]. The probability of a child dying is defined as $P_{ijk} = \Pr(y_{ijk=1})$, where $y_{ijk=1}$ indicates that the ith child of the jth household living in the kth community that recorded deaths and the logit transformation of P_{ijk} is modelled as a linear function of the covariates in the model.

$$\mathrm{Log}\left[P_{ijk}/(1-P_{ijk})\right] = X'_{ijk}\beta_1 + X'_{jk}\beta_2 + X'_{k}\beta_3 + \mu_{jk} + \nu_k \qquad (4.1)$$

Where μ_{jk} is the household-level and ν_k is the community-level that are each normally distributed with zero mean and variance σ_u^2 and σ_v^2, respectively. Assuming that the observation are independent once condition on μ_{jk} and ν_k, which capture any observed effect common on children from the same household and the community. The strength of unobserved family and community effects with the intra-cluster correlation coefficient for the households (ρ_j) and community ρ_k can be summarised.

The first estimate that reduced form model shown in equation (4.1) that includes only the background child(X_{ijk}), household (X_{ij}) and community (X_i) covariates, Adding intermediate child(W_{ijk}), household (W_{ij}) covariate to the model, we have:

$$\mathrm{Log}\left[P_{ijk}/(1-P_{ijk})\right] = W'_{ijk}\gamma_1 + W'_{jk}\gamma_2 + X'_{ijk}\beta_1 + X'_{jk}\beta_2 + X'_{k}\beta_3 + \mu_{jk} + \nu_k \qquad (4.2)$$

By comparing the estimates contained from equation (4.1) and (4.2), we can examine how background factors affects mortality directly and indirectly. In particular, the results based on equation (4.1) shows the total effect of each background factors on mortality. Equation (4.2) shows how the background factors operate through the intermediate variables that are added to

the model. The mathematical equations described there were applied to stillbirths, perinatal and childhood mortality separately.

4.2 Analyses employed in answering the first research question

Frequency tabulations were first conducted to describe the distributions of data used in this study, followed by prevalence estimates using the Taylor series linearization method to examine the impact of all potential predictors on stillbirth without adjusting for other covariates. The rate of stillbirths was calculated as the number of stillbirths per 1,000 births.

Individual risk factors were identified employing multilevel logistic regression analysis. Odds ratios (OR) and 95% confidence intervals (CI) were generated to quantify the relationship between each potential risk factor and the outcome. Multilevel logistic regression which adjusts for cluster variability was employed to identify the independent risk factors for stillbirth. A two stage model was performed by following a similar conceptual model approach to that employed by Chowdhury et al [2]. In the first modelling stage, community and socioeconomic factors were entered into the baseline model to assess their relationship with the dependent variables. A manually processed stepwise backwards elimination was performed, and variables that were significant at 5% significance level were retained in the model (model 1). Second, child factors were examined with the community and socioeconomic factors that were significantly associated with stillbirth, and those variables with p-values < 0.05 were retained (model 2). A similar procedure was used for media factors in the third stage as before, those variables with p-values < 0.05 were retained (model 3).

The odd ratios and 95% confidence intervals obtained from adjusted multilevel logistic regression models (which adjusts for clustering) were used to identify significant risk factors for stillbirth.

4.3 Analyses employed in answering the second research question

The perinatal mortality rate was calculated by utilizing a similar method described by Rutstein and Rojas [3]. The crude odds ratios (ORs) for factors associated with perinatal death were determined by univariate analyses, which were performed using multilevel logistic regression model. Further, multivariable analysis was carried out to examine the association between the potential independent variables and the study outcome. Multilevel logistic models were fitted using STATA survey commands to adjust for the cluster sampling design, weights, and the calculation of standard errors.

A two-stage modelling scheme was employed. In the first stage, community, socio-economic and child demographic factors were entered into the baseline model to assess their relationship with the dependent variables. A manually processed stepwise backwards elimination was performed, and variables that were significant at 5% significance level were retained in the model. Second, health services factors were examined with the community, socio-economic and child demographic factors that were significantly associated with perinatal mortality, and those variables with *p*-values < 0.05 were retained. Collinearity was tested and reported in the final model. Odds ratios and 95% confidence intervals (CIs) were calculated to assess the adjusted risk factors that affected the study outcome; and those with $p < 0.05$ were retained in the final model.

4.4 Analyses employed in answering the third research question

Frequency tabulations were used to describe characteristics of the study populations. A multilevel logistic regression model was used to perform bivariate analysis to determine the adjusted and unadjusted odds ratios (ORs) for the determinants of neonatal, post-neonatal and under-5 mortality. In addition, the independent effect of each variable after other covariates were controlled for was examined by multivariate analysis.

The modelling was performed in 2 stages. Firstly, a significance level of 0.05 was used to remove all factors not significant among the various variables (community-level and socio-economic). This was done by performing a backward stepwise elimination procedure. Regardless of their level of significance, the year of the survey and maternal age at birth of the child were retained in the final model [4]. Secondly, ANC, mode of delivery, place of delivery and type of skilled delivery assistance were assessed, after significant community and socio-economic variables were controlled for. The type of skilled delivery assistance has been known to have a protective effect [5]. Consequently, this variable was retained in the final model, regardless; other non-significant variables were removed. ANC was found to be correlated with both IFA and TT vaccination. Hence, ANC was replaced by IFA and TT vaccination in the final model. The study then examined the effect of a combination of any form of ANC and IFA, as well as a combination of IFA and TT vaccination on neonatal, post-neonatal and Under-5 mortality. The OR and 95% CI for neonatal, post-neonatal and under-5 mortality were determined for each factor.

4.5 Analyses employed in answering the fourth research question

Initially, neonatal, postneonatal, infant, child and under-5 mortality rates by year of survey were estimated using a method similar to that described by Rutstein and Rojas [3]. The unadjusted ORs for factors associated with neonatal, postneonatal, infant, and child and under-5 mortality were examined using multilevel modelling. This was followed by multivariable analyses used to assess the independent effect of each factor after controlling for other related factors. Multilevel models were fitted using STATA survey commands to adjust for the variability of clustering.

In the multivariable analysis models, a stepwise backwards elimination process was used to identify factors that were significantly associated with the study outcomes, using a 5%

significance level. In order to minimise or avoid statistical error in our analyses, we repeated the backward elimination process by using a different approach: first, only variables among community, household and individual level variables with p-value < 0.20 identified in the univariate analysis were entered for the backward elimination process. Second, the backward elimination was double-checked by including all community, household, individual and health services variables; and those with p-value < 0.05 were retained in the final model. Third, any collinearity in the final model was tested and reported. The odd ratios (OR) and 95% confidence intervals (CIs) were calculated for each variable, and were used to measure the adjusted risk factors impact on the study outcomes.

4.6 Summary

This chapter has presented the statistical analyses that informed the study of this thesis. STATA statistical software package was used in analysing all four research questions. Both univariate and multivariate regression analyses were employed in the study. The next chapter presents the results of the various research questions.

References

1. Rabe-Hesketh S, Skrondal A. Multilevel modelling of complex survey data. Journal of the Royal Statistical Society: Series A (Statistics in Society) 2006;169(4):805-27.

2. Chowdhury AH, Islam SS, Abdul Karim D: Covariates of Neonatal and Post-Neonatal Mortality in Bangladesh. *Global Journal of Human-Social Science Research* 2013, **13**(4).

3. Rutstein SO: Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys. *International Journal of Gynecology & Obstetrics* 2005, **89,** Supplement 1(0):S7-S24.

4. Alam N: Teenage motherhood and infant mortality in Bangladesh: Maternal age-dependent effect of parity one. *Journal of biosocial science* 2000, **32**(02):229-236.

5. World Health Organization: The World health report: 2005: make every mother and child count: overview. 2005.

CHAPTER 5

PREVALENCE AND FACTORS ASSOCIATED WITH STILLBIRTH

5.0 Introduction

In this chapter, results of the first research question are presented. Community-level factors, socio-economic and child determinants, as well as media factors that were significantly associated with stillbirth in Bangladesh are assessed. The chapter presents the basic characteristics of the study samples, and also presents a forest plot of the rates of stillbirth over the four study periods. Further, the chapter highlights the factors associated with stillbirth (both univariate and multivariate analyses).

5.1. Basic characteristics of the study participants

Frequencies of the potential determinants of stillbirths are presented in Table 5.1. The majority of mothers were from rural areas in all four study periods.

Table 5.1:
Characteristics of variables (n = 29,094), Bangladesh, 2004-2014

VARIABLE	n	n*	%*	2004 (n=6395)	2007 (n=5409)	2011 (n=9021)	2014 (n=8269)
COMMUNITY LEVEL FACTORS							
Cluster type							
Urban	8965	6423	22.1	21.4	20.2	22.1	25.3
Rural	19850	22670	77.9	78.6	79.8	77.9	74.7
Geographic region							
Barisal	3313	1685	5.8	6.1	6.3	5.6	5.6
Chittagong	5876	6472	22.2	23.3	22.3	22.9	21.6
Dhaka	5406	9354	32.2	32.5	31.5	31.0	35.0
Khulna	3296	2605	9.0	10.1	9.6	9.0	7.5
Rajshahi	4124	4608	15.8	19.2	21.3	13.1	10.3
Sylhet	3986	2815	9.7	8.7	9.1	10.6	9.8
SOCIOECONOMIC DETERMINANTS							
Mother's Age (years)							
15-24	14271	14576	50.1	50.4	51.7	50.4	48.5
25-34	11890	11953	41.1	39.5	38.9	41.1	43.7
35-49	2634	2558	8.8	10.0	9.4	8.5	7.8

Mother working status							
Not working	23132	23095	79.4	82.2	71.5	89.0	71.9
Working	5679	5995	20.6	17.8	28.5	10.9	28.1
Mother BMI (kg/m^2)							
<=18	6329	6360	21.9	28.9	23.4	20.9	16.5
19-25	18595	19064	65.5	64.6	68.0	65.6	64.5
25+	3724	3515	12.1	5.2	8.5	13.5	18.2
Maternal marital status							
Currently married	28282	28572	98.2	97.9	97.9	98.3	98.5
Formerly married	533	522	1.8	2.1	2.1	1.7	1.5
Maternal highest level of education							
No schooling	12235	12712	43.7	59.8	49.1	38.8	33.0
Primary	12775	12939	44.5	33.6	38.3	49.3	51.7
Secondary or more	3785	3428	11.8	6.6	12.3	11.9	15.4
Paternal highest level of education							
No schooling	13898	14440	49.6	58.3	55.0	46.5	42.9
Primary	9608	9697	33.3	29.6	28.2	35.3	37.4
Secondary or more	5291	4940	17.0	12.1	16.7	18.1	19.7
Wealth Index							
Rich	5763	5118	17.6	12.7	14.7	18.3	22.5
Middle	11526	11684	40.2	46.9	38.4	40.3	35.9
Poor	11526	12291	42.3	40.4	46.9	41.4	41.6
CHILD DETERMINANTS							
Sex							
Female	13861	14019	48.2	49.2	50.0	47.6	46.9
Male	14538	14666	50.4	50.8	50.0	49.8	51.0
Mothers age at child's birth (years)							
less than 20	9069	9377	32.2	33.3	34.5	31.2	31.1
20 - 29	15074	15159	52.1	50.4	50.4	53.2	53.4
30 - 39	3953	3847	13.2	14.8	14.2	12.2	12.5
40+	303	302	1.0	1.6	0.9	0.9	0.8
Birth rank and birth interval							
2nd/3rd birth rank, more than 2 years interval	10675	10935	37.6	34.9	35.3	39.1	39.5
1st birth rank	9948	9996	34.4	29.2	34.9	34.5	37.9
2nd/3rd birth rank, less than or equal to 2 years interval	1924	1907	6.6	8.2	7.1	6.0	5.6
4th birth rank, more than 2 years interval	5178	5200	17.9	21.9	18.5	17.6	14.7
4th birth rank, less than or equal to 2 years interval	1090	1056	3.6	5.9	4.3	2.8	2.3
Previous Death of Sibling							
No	28067	28352	97.5	95.2	96.7	98.2	98.9
Yes	748	742	2.6	4.8	3.3	1.8	1.1

Number of children born							
1	7990	7999	27.5	21.1	26.7	28.2	32.2
2	8732	8868	30.5	27.2	29.6	31.5	32.4
3	5278	5412	18.6	19.6	17.6	19.2	17.8
4+	6733	6732	23.1	32.1	26.1	20.6	17.1
Number of children under-five years							
1-2	17873	18113	62.3	53.7	60.2	64.5	67.8
3 or more	10942	10981	37.7	46.3	39.8	35.6	32.2
MEDIA FACTORS							
Mother watched television every week							
Yes	16123	16080	55.3	51.1	52.2	58.0	57.5
No	12688	13011	44.7	48.9	47.8	41.9	42.5
Mother listened to the radio every week							
Yes	5158	5385	18.5	43.7	24.8	9.5	4.8
No	23650	23703	81.5	56.3	75.2	90.4	95.2
Mother read newspaper							
Yes	4501	4115	14.1	14.5	13.4	14.7	13.7
No	24291	24960	85.8	85.5	86.6	85.2	86.1

Weighted for sampling probability. n Weighted 'n'

The majority of mothers (32.2%) were from the Dhaka administrative region, whilst the minority (5.8%) were from the Barisal region. Almost half of mothers belonged to the youngest age group (15-24 years), and only 8.8% of them were aged between 35 and 49 years. Close to two-thirds (65.5%) of mothers had a body mass index (BMI) of between 19 and 25 kg/m^2, and only 12.1% of them had a BMI of 25kg/m^2 or more. A very large majority (98.1%) of mothers were currently married. While mothers with no schooling and those with only primary education were almost equally represented (43.7% and 45.5% respectively), only 11.8% of them had secondary education or higher. Only about 17 out of every 100 households were rich, and 40 out of every 100 were poor. Female and male children were almost equally represented (49.2% and 50.8% respectively). More than half (52.1%) of mothers were aged 20-29 years, and about a third (32.2%) of them were aged less than 20 years when they gave birth. Only one out of every 100 mothers was older than 40 years when they gave birth. More than one-third

(37.6%) of children of mothers were second or third born with more than one year interval between them and the previous sibling; and only about four out of every 100 (3.6%) children were fourth born with less than one year between them and their previous sibling. A large majority (97.5%) of children did not have dead previous siblings. The majority of mothers (30.5%) had two children, followed by mothers who had one child (27.5%). About one out of every five (23.1%) mothers had more than four children. More than 50% of mothers watched television every week. However, only a small proportion of them listened to the radio (18.5%) or read newspapers (14.1%).

Figure 5.1 shows a forest plot of stillbirths from 2004 to 2014. It indicates that the overall stillbirth rate over the 10-year period was 28.2% [95% CI: (21.1, 34.3).

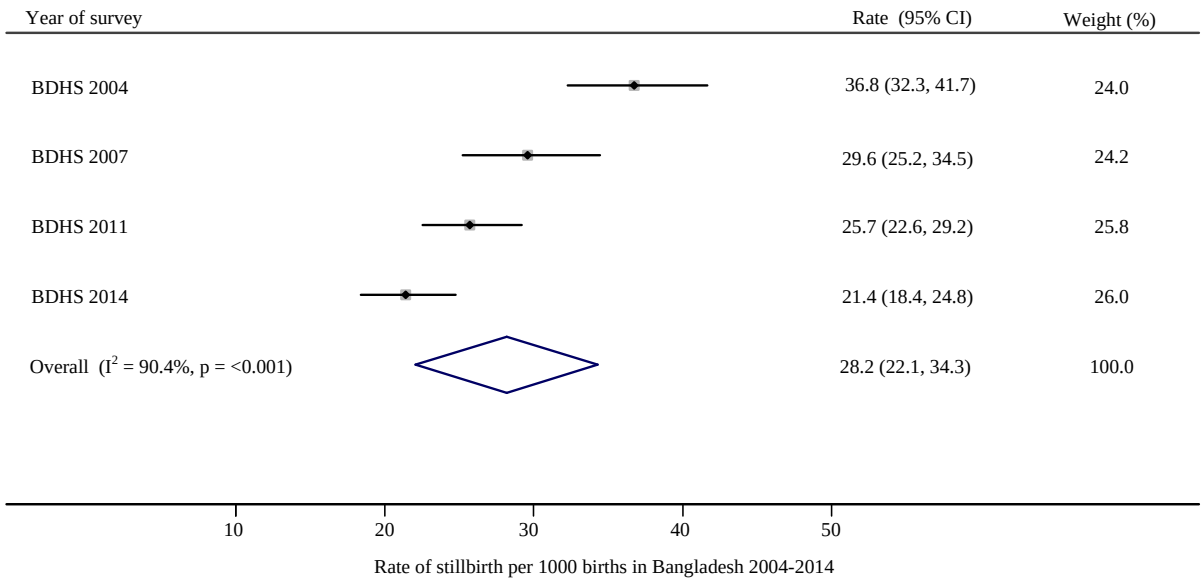


Figure 5.1: Rate of stillbirth per 1000 births in Bangladesh, 2004-2014

5.2 Prevalence and odds ratios of stillbirth: results of univariate analysis

Table 5.2 summarises the prevalence and the unadjusted odds ratios with their 95% confidence interval (CI) stillbirth.

Stillbirth was most prevalent in 2004 [Prevalence (Pr) = 3.68; 95% confidence interval (CI): (3.08, 5.38)]. Compared to 2004, the odds of stillbirth was significantly lower in 2014 [Unadjusted odds ratio (UOR) = 0.56; 95% CI: (0.45, 0.68), p < 0.001]. Prevalence of stillbirth was higher in rural areas [Pr = 2.92, 95% CI: (2.63, 3.23); and, compared to infants in urban areas, rural infants had about 36 times more odds of stillbirth than their urban counterparts [UOR = 1.36; 95% CI: (1.13, 1.65), p = 0.001]. Among the administrative regions of Bangladesh, stillbirth was found to most prevalent in the Rajshahi region [Pr = 3.23; 95% CI: (2.60, 4.00)].

The odds of stillbirth were significantly highest among infants in the Sylhet region compared to those in the Barisal region [UOR = 1.27; 95% CI: (1.03, 1.60), p = 0.024].

Prevalence of stillbirth was highest among mothers who were aged between 35 and 49 years, compared to mothers of the other age brackets [Pr = 5.73; 95% CI: (5.26, 6.23)]; and compared to the youngest mothers (aged 15-24 years), the odds of experiencing a stillbirth was significantly higher among mothers aged 35-49 years [unadjusted odd ratios (UOR) = 0.81; 95% CI: (0.72, 0.90), p < 0.001].

Table 5.2
Prevalence and unadjusted odd ratios and their 95% confidence intervals of stillbirth in Bangladesh, 2004-2014

VARIABLE	Prevalence (Pr) [95%[CI]	Unadjusted odds ratio			
		OR	(95% CI)		p-value
COMMUNITY LEVEL FACTORS					
Year of survey					
2004	3.68 [3.08,4.38]	1.00			
2007	2.96 [2.41,3.63]	0.77	0.62	0.95	0.013
2011	2.58 [2.22,2.99]	0.67	0.55	0.81	<0.001
2014	2.14 [1.79,2.55]	0.56	0.45	0.68	<0.001
Cluster type					
Urban	2.23 [1.89,2.64]	1.00			
Rural	2.92 [2.63,3.23]	1.36	1.13	1.65	0.001
Geographic region					
Barisal	2.68 [2.11,3.38]	1.00			
Chittagong	2.51 [2.05,3.08]	0.93	0.65	1.35	0.717
Dhaka	2.62 [2.17,3.17]	1.02	0.71	1.45	0.923
Khulna	2.3 [1.79,2.96]	0.87	0.57	1.33	0.517

Rajshahi	3.23 [2.60,4.00]	1.26	0.87	1.83	0.225
Sylhet	3.16 [2.53,3.94]	1.27	0.85	1.90	0.241
SOCIOECONOMIC DETERMINANTS					
Mother's age (years)					
15-24	2.76 [2.44,3.13]	1.00			
25-34	2.73 [2.37,3.15]	0.99	0.85	1.15	0.908
35-49	2.97 [2.21,4.00]	1.09	0.85	1.40	0.518
Mother working status					
Not working	2.75 [2.49,3.04]	1.00			
Working	2.82 [2.33,3.41]	1.03	0.86	1.22	0.773
Mother BMI (kg/m^2)					
<=18	2.88 [2.39,3.47]	1.00			
19-25	2.79 [2.51,3.11]	0.97	0.82	1.15	0.740
25+	2.33 [1.81,3.00]	0.81	0.62	1.06	0.124
Maternal marital status					
Currently married	2.71 [2.47,2.97]	1.00			
Formerly married	5.89 [3.78,9.08]	2.28	1.56	3.32	<0.001
Maternal highest level of education					
No schooling	3.32 [2.93,3.76]	1.00			
Primary	2.44 [2.12,2.81]	0.72	0.62	0.84	<0.001
Secondary or more	1.96 [1.50,2.55]	0.57	0.44	0.75	<0.001
Paternal highest level of education					
No schooling	3.17 [2.81,3.57]	1.00			
Primary	2.71 [2.33,3.15]	0.84	0.72	0.99	0.033
Secondary or more	1.66 [1.30,2.13]	0.51	0.40	0.65	<0.001
Wealth Index					
Rich	1.74 [1.38,2.19]	1.00			
Middle	2.87 [2.49,3.31]	1.71	1.35	2.17	<0.001
Poor	3.09 [2.72,3.52]	1.85	1.46	2.35	<0.001
CHILD DEMOGRAPHICS					
Gender					
Female	1.41 [1.15,1.71]	1.00			
Male	1.35 [1.12,1.63]	0.97	0.79	1.19	0.783
Mothers age at child's birth (years)					
less than 20	1.51 [1.20,1.89]	1.00			
20 - 29	1.36 [1.11,1.67]	0.90	0.72	1.12	0.339
30 - 39	1.18 [0.83,1.68]	0.79	0.56	1.11	0.167
40+	0.8 [0.30,2.14]	0.50	0.14	1.80	0.288
Birth rank and birth interval					
2nd/3rd birth rank, more than 2 years interval	1.08 [0.85,1.36]	1.00			
1st birth rank	1.58 [1.29,1.92]	1.47	1.16	1.87	0.002
2nd/3rd birth rank, less than or equal to 2 years interval	1.58 [1.04,2.41]	1.49	0.99	2.23	0.054
4th birth rank, more than 2 years interval	9.24 [8.26,10.32]	9.91	8.05	12.20	<0.001
4th birth rank, less than or equal to 2 years interval	1.82 [1.12,2.92]	1.79	1.09	2.92	0.021
Previous Death of Sibling					

No	2.75 [2.51,3.01]	1.00			
Yes	3.56 [2.03,6.15]	1.31	0.88	1.96	0.185
Number of children born					
1	3.40 [2.97,3.89]	1.00			
2	2.02 [1.67,2.45]	0.57	0.47	0.69	<0.001
3	2.00 [1.54,2.60]	0.58	0.46	0.73	<0.001
4+	2.44 [1.96,3.02]	0.70	0.57	0.85	<0.001
Number of children under-five years					
1-2	3.23 [2.94,3.55]	1.00			
3+	2.00 [1.63,2.46]	0.61	0.52	0.71	<0.001
MEDIA FACTORS					
Mother watched television every week					
Yes	2.41 [2.12,2.73]	1.00			
No	3.21 [2.83,3.64]	1.36	1.18	1.58	<0.001
Mother listened to the radio every week					
Yes	3.00 [2.46,3.66]	1.00			
No	2.71 [2.46,3.00]	0.90	0.76	1.08	0.267
Mother read newspaper					
Yes	1.83 [1.40,2.41]	1.00			
No	2.92 [2.66,3.21]	1.61	1.27	2.05	<0.001

OR = odds ratio

Stillbirth was higher among formerly married mothers than among currently married ones [Pr = 5.89; 95% CI: (3.78, 9.08)]. Compared to mothers who were currently married, the odds of stillbirth were significantly higher among formerly married mothers [UOR = 2.28; 95% CI: (1.56, 3.32), $p < 0.001$]. Prevalence of stillbirth was highest among mothers who had no schooling, compared to those who had primary education and those who had secondary education or higher [Pr = 3.32; 95% CI: (2.93, 3.76)]. The odds of stillbirth was significantly lower among mothers who had secondary education or higher, compared to those who had no schooling [UOR = 0.57; 95% CI: (0.44, 0.75), $p < 0.001$]. The same pattern was observed for paternal education. Mothers from rich households reported the least occurrence of stillbirth [Pr = 1.74; 95% CI: (1.38, 2.19)]. Compared to rich households, the odds of stillbirth was significantly higher among poor households [UOR = 1.85; 95% CI: (1.46, 2.35), $p < 0.001$]. Prevalence of stillbirth was higher for female infants than for males [Pr = 1.41; 95% CI: (1.15, 1.71)]. The odds of stillbirth were significantly lower for males compared to females, although this result was not statistically significant [UOR = 0.97; 95% CI: (9.79, 1.19), $p = 0.783$].

Prevalence of stillbirth was highest among infants whose previous siblings had died [Pr= 3.56; 95% CI: (2.03, 6.15)]. The odds of stillbirth were significantly higher among infants whose previous siblings had died compared to those whose previous siblings had not, although this was not statistically significant [UOR = 1.31; 95% CI: (0.88, 1.96), p < 0.185]. Stillbirth was most prevalent among mothers who had 1-2 children aged under five years than those who had three or more children aged under five years [Pr = 3.23; 95% CI: (2.94, 3.55)]. The odds of stillbirth were significantly lower among mothers who had three or more under-5 children compared to those who had between one and three under-5 children [UOR = 0.61; 95% CI: (0.52, 0.71), p < 0.001)]. Prevalence of stillbirth was significantly highest among mothers who had one child only [Pr = 3.40; 95% CI: (2.97, 3.89)]. The odds of stillbirth were significantly lower among mothers who had two children, compared to those who had one child only [UOR = 0.57; 95% CI: (0.47, 0.69), p < 0.001].

Stillbirth was most prevalent among mothers who did not watch television [P = 3.21; 95% CI: (2.83, 3.64)], and, compared to mothers watched television every week, the odds of stillbirth were significantly higher among those who did not watch television [UOR = 1.36; 95% CI: (1.18, 1.58), p < 0.001]. Stillbirth was more prevalent among mothers who did not read newspapers than those who did every week [Pr = 2.92; 95% CI: (2.66, 3.21)]. Mothers who did not read any newspapers had significantly higher odds of stillbirth compared to those who did every week [UOR = 1.61; 95% CI: (1.27, 2.05), p < 0.001].

The section that follows presents the factors associated with stillbirth when other covariates are adjusted for.

5.3 Factors associated with stillbirth: multivariate analyses

Table 5.3 summarises the factors associated with stillbirth when other covariates are adjusted for.

In all three models, the odds of stillbirth were significantly higher in the 2007 survey compared to the 2004 survey [adjusted odds ratio (AOR) = 0.79; 95% confidence interval (CI): (0.64, 0.98), p-value (P) = 0.031 (model 1), AOR = 0.77; 95% CI: (0.62, 0.95), P = 0.015 (model 2), and AOR = 0.81, 95% CI: (0.66, 1.00), P = 0.045 (model 3)].

Table 5.3
Risk factors for stillbirth: adjusted odds ratio (AOR)

Characteristic	Model 1				Model 2				Model 3			
	AOR	[95%CI)		Pvalue	AOR	[95%CI)		Pvalue	AOR	[95%CI)		Pvalue
Year of survey												
2004	1.00				1.00				1.00			
2007	0.79	0.64	0.98	0.031	0.77	0.62	0.95	0.015	0.81	0.66	1.00	0.045
2011	0.72	0.59	0.87	0.001	0.55	0.45	0.68	<0.001	0.54	0.44	0.66	<0.001
2014	0.62	0.50	0.76	<0.001	0.47	0.37	0.58	<0.001	0.47	0.38	0.59	<0.001
Maternal highest level of education												
No schooling	1.00				1.00				1.00			
Primary	0.83	0.71	0.97	0.021	0.62	0.52	0.74	<0.001	0.66	0.55	0.80	<0.001
Secondary or more	0.77	0.58	1.03	0.075	0.52	0.38	0.72	<0.001	0.59	0.43	0.82	0.002
Maternal marital status												
Currently married	1.00											
Formerly married	2.12	1.45	3.09	<001								
Wealth Index												
Rich	1.00				1.00				1.00			
Middle	1.54	1.20	1.97	0.001	1.53	1.17	2.01	0.002	1.30	1.01	1.66	0.040
Poor	1.59	1.23	2.05	<0.001	1.66	1.25	2.19	<0.001	1.47	1.13	1.90	0.004
Number of children born												
1					1.00				1.00			
2					0.57	0.46	0.69	<0.001	0.56	0.46	0.69	<0.001
3					0.50	0.39	0.63	<0.001	0.49	0.39	0.63	<0.001
4+					0.50	0.40	0.63	<0.001	0.53	0.43	0.66	<0.001
Number of children under-five years												
1-2					1.00				1.00			
3 or more					0.74	0.63	0.89	0.001	0.74	0.63	0.88	0.001
Mother read newspaper												
Yes									1.00			
No									1.34	1.02	1.76	0.037

Model 1- community and socioeconomic factors associated with stillbirth.
Model 2- model 1 plus child factors associated with stillbirth
Model 3- model 2 plus Media factors associated with stillbirth
AOR – Adjusted Odds ratio

The odds of stillbirth were significantly lower among mothers who had only primary education compared to those who had no schooling in all three models [UOR = 0.83; 95% CI: (0.71,

0.97), p = 0.021 (model1), AOR = 0.62; 95% CI: (0.52, 0.74), p < 0.001 (model 2), and AOR = 0.66; 95% CI: (0.55, 0.80), p < 0.001 (model 3)]. Compared to currently married mothers, formerly married mothers had a significantly higher likelihood of stillbirth [UOR = 2.12; 95% CI (1.45, 3.09), p< 0.001 (model 1)]. In all three models, the odds of stillbirth were significantly higher among infants from poor households compared to those from rich households [AOR = 1.59; 95% CI: (1.23, 2.05), p < 0.001 (model 1), AOR = 1.66; 95% CI (1.25, 2.19), p < 0.001 (model 2) and UOR = 1.47; 95% CI: (1.13, 1.90), p= 0.004 (model 3)].

In models 2, mothers with four or more children were significantly less likely to have a stillbirth, compared to those who had only one child [AOR = 0.50; 95% CI: (0.40, 0.63), p < 0.001], whilst in model 3, mothers with three children were significantly less likely to have a stillbirth, compared to those who had only one child [AOR = 0.49; 95% CI: (0.40, 0.63), p < 0.001]. The odds of stillbirth were significantly lower among mothers who had three or more under-5 children, compared to those who had between one and two under-5 children in models 2 and 3 [AOR = 0.74; 95% CI: (0.63, 0.89), p = 0.001].

In model 3, mothers who did not read newspapers were significantly more likely to experience stillbirth, compared to those who read newspapers every week [AOR = 1.34; 95% CI: (1.02, 1.76), p = 0.037].

5.4 Summary

This chapter presented the factors associated with stillbirth in Bangladesh. Parents with no formal education were significantly more likely to experience stillbirth, compared to those who had secondary education or higher. The odds of stillbirth were significantly higher in poor households, compared to rich households. The next chapter presents factors associated with perinatal mortality.

CHAPTER 6

PREVALENCE AND PREDICTORS OF PERINATAL MORTALITY

6.0 Introduction

In this chapter, results of the second research question are presented. Community, socio-economic and proximate factors that are significantly associated with perinatal mortality in Bangladesh are assessed. The chapter presents characteristics of the samples, and also presents the prevalence and unadjusted odds ratios with 95% confidence intervals of perinatal mortality (stillbirth and early neonatal). Prevalence and the unadjusted odds ratios with 95% confidence intervals of perinatal mortality (stillbirth and neonatal) are also highlighted in this section. Further, the chapter highlights the factors associated with perinatal mortality (stillbirth and early neonatal) and factors associated with perinatal mortality (stillbirth and neonatal).

6.1 Basic characteristics of the variables

The basic characteristics of the study variables are shown in Figure 6.1. A total sample of 27540 mothers was featured in this study, 6287 from 2004, 5473 from 2007, 8986 from 2011 and 8069 from 2014. The study variables were categorised into community level factors, socio-economic determinants, media factors, child determinants and service factors. Community level factors were type of residence (urban/rural) and geographical region (Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet).

There was a weighted total of 6212 urban mothers, constituting a weighted proportion of 22.1%. The proportion of urban mothers was 19.4%, 20.2%, 22.1% and 25.3% in 2004, 2007, 2011 and 2014 respectively. The weighted total of mothers who resided in rural areas was 21328, representing 77.9%. The proportion of rural mothers in 2004, 2007, 2011 and 2014 was 80.6%, 79.8%, 77.9% and 74.7% respectively. The greatest proportion of mothers in all the four surveys was from the Dhaka administrative region, with a weighted average proportion of

32.2%, whilst the lowest proportion was from the Barisal region, with a weighted average proportion of 5.8%.

Table 6.1:
Characteristics of the study variables (n = 27,540)

VARIABLE	n	n*	%*	2004 (n=6287)	2007 (n=5473)	2011 (n=8986)	2014 (n=8069)
COMMUNITY LEVEL FACTORS							
Cluster type							
Urban	8242	6212	22.1	19.4	20.2	22.1	25.3
Rural	17759	21328	77.9	80.6	79.8	77.9	74.7
Geographical region							
Barisal	3313	1685	5.8	5.8	6.3	5.6	5.6
Chittagong	5876	6472	22.2	22.3	22.3	22.9	21.6
Dhaka	5406	9354	32.2	30.7	31.5	31.0	35.0
Khulna	3296	2605	9.0	10.2	9.6	9.0	7.5
Rajshahi	4124	4608	15.8	22.3	21.3	13.1	10.3
Sylhet	3986	2815	9.7	8.7	9.1	10.6	9.8
SOCIOECONOMIC DETERMINANTS							
Maternal marital status							
Currently married	25519	27041	98.2	97.9	97.9	98.3	98.5
Formerly married	482	499	1.8	2.1	2.1	1.7	1.5
Mother's Age (years)							
15-24	13102	13920	50.1	50.4	51.7	50.4	48.5
25-34	10571	11239	41.1	39.5	38.9	41.1	43.7
35-49	2308	2375	8.8	10.0	9.4	8.5	7.8
Mother working status							
Not working	20648	21719	79.4	82.2	71.5	89.0	71.9
working	5351	5818	20.6	17.8	28.5	10.9	28.1
Mother BMI (kg/m^2)							
<=18	5597	5967	21.9	28.9	23.4	20.9	16.5
19-25	16905	18090	65.5	64.6	68.0	65.6	64.5
25+	3350	3337	12.1	5.2	8.5	13.5	18.2
Maternal highest level of education							
No schooling	10930	11969	43.7	59.8	49.1	38.8	33.0
Primary	11524	12246	44.5	33.6	38.3	49.3	51.7
Secondary or more	3527	3309	11.8	6.6	12.3	11.9	15.4
Paternal highest level of education							
No schooling	12413	13588	49.6	58.3	55.0	46.5	42.9
Primary	8690	9178	33.3	29.6	28.2	35.3	37.4
Secondary or more	4880	4756	17.0	12.1	16.7	18.1	19.7
Wealth Index							
Rich	5123	4860	17.6	12.7	14.7	18.3	22.5
Middle	10568	11178	40.2	46.9	38.4	40.3	35.9
Poor	10310	11502	42.3	40.4	46.9	41.4	41.6

MEDIA FACTORS							
Mother watched TV every week							
Yes	14775	15421	55.3	51.1	52.2	58.0	57.5
No	11224	12116	44.7	48.9	47.8	41.9	42.5
Mother listened to the radio every week							
Yes	5019	5305	18.5	43.7	24.8	9.5	4.8
No	20975	22229	81.5	56.3	75.2	90.4	95.2
Mother read newspaper							
Yes	4054	3902	14.1	14.5	13.4	14.7	13.7
No	21930	23621	85.8	85.5	86.6	85.2	86.1
CHILD DETERMINANTS							
Sex							
Female	12547	13285	48.2	49.2	50.0	47.6	46.9
Male	13137	13899	50.4	50.8	50.0	49.8	51.0
Mothers age at child's birth (years)							
less than 20	8442	9030	32.2	33.3	34.5	31.2	31.1
20 - 29	13478	14281	52.1	50.4	50.4	53.2	53.4
30 - 39	3493	3589	13.2	14.8	14.2	12.2	12.5
40+	271	284	1.0	1.6	0.9	0.9	0.8
Birth rank and birth interval							
2nd/3rd birth rank, more than 2 years interval	9776	10455	37.6	34.9	35.3	39.1	39.5
1st birth rank"	9164	9556	34.4	29.2	34.9	34.5	37.9
2nd/3rd birth rank, less than or equal to 2 years interval	1677	1777	6.6	8.2	7.1	6.0	5.6
4th birth rank, more than 2 years interval	4453	4787	17.9	21.9	18.5	17.6	14.7
4th birth rank, less than or equal to 2 years interval	931	965	3.6	5.9	4.3	2.8	2.3
Previous Death of Sibling							
No	25318	26832	97.5	95.2	96.7	98.2	98.9
Yes	683	708	2.6	4.8	3.3	1.8	1.1
Number of children under-five							
1-2	16467	17365	62.3	53.7	60.2	64.5	67.8
3 or more	9534	10175	37.7	46.3	39.8	35.6	32.2
HEALTH SERVICE FACTORS							
Delivery complications							
None	19087	20537	75.0	77.1	81.8	65.2	79.5
Any complications	6907	6992	25.0	22.9	18.2	34.7	20.5
Birth attendance							
TBA/others	19887	21648	78.8	87.7	82.6	73.6	75.3
health professional	6114	5892	21.2	12.3	17.5	26.5	24.7
Contraceptive use							
No	9710	10411	37.8	44.54	43.81	35.05	30.7
Yes	16291	17129	62.2	55.46	56.19	64.95	69.3
Number ANC							
None	6428	7123	25.9	34.4	32.2	28.9	12.0
1-3 times	7991	8524	30.5	30.6	32.3	33.1	26.5
4+ times	4861	4670	16.6	11.9	16.3	19.4	17.4
Combined place and mode of delivery							

Health facilities without caesarean	1981	1831	6.6	6.4	5.9	6.5	7.4
Health facilities with caesarean	2577	2574	9.3	3.2	6.8	11.7	12.9
Home	17690	19097	68.8	90.4	85.0	73.0	36.9

BMI: Body mass index. TV: Television. TBA: Traditional birth attendant. ANC: Antenatal care.

Over the four survey periods, a large proportion of mothers (98.2%) were currently married, with only 1.2% being formerly married. The majority of mothers (50.1%) were aged between 15 and 24 years, whilst mothers aged 35-49 years formed the minority (8.8%), with mothers aged 25-34 years lying in between (41.1%). Non-working mothers were almost four times more than working mothers (79.4% against 20.6%). The majority of mothers had a body mass index (BMI) of between 19 and 25 kgm^{-2}, whilst 12.1% of them had a BMI higher than 25 kgm^{-2}. The proportion of mothers with no formal education (43.7%) was almost equal to that of mothers with primary education (44.5%). Only 11.8% of the mothers had secondary education or higher. Almost one half of fathers (49.6%) had no schooling, and only 17% of them had secondary education or higher. The majority of mothers (42.3%) came from poor households, while only 17.6% were from rich households.

A relatively higher proportion of mothers (55.3%) reported watching television every week, as against 44.7% of them who did not watch television at all. A higher proportion of mothers (81.5%) did not listen to the radio every week, while 18.5% did. In the same fashion, a high proportion of mothers did not read the newspaper every week whilst 14.1% of them did.

Female (48.2%) and male (50.8%) were almost equally represented. The majority of infants (37.6%) were either second or third born, with two years interval, whilst only 3.6% were fourth born, with an interval of one year or less. A large majority of infants (97.5%) had no previous dead sibling, with only 2.6% had previous dead siblings. Three-quarters (75%) of mothers did not experience any delivery complications whilst a quarter (25%) experienced delivery complications. Nearly 80% of mothers delivered with assistance from traditional birth attendants (TBA) and other non-health personnel, with only 21.2% delivering with the aid of

health professionals. Mothers who used contraceptives were more than those who did not (62.2% against 37.8%). The majority of pregnant mothers (30.5%) had between one and three antenatal care visits whilst 25.9% of them had none. Most mothers (68.8%) delivered their babies at home, 6.6% of them delivered their babies at a health facility without caesarean operation, whilst 9.3% delivered at a health facility through a caesarean section.

6.2 Perinatal mortality (stillbirth and early neonatal)

Table 6.2 summarizes the prevalence and the unadjusted odds ratios with their 95% confidence interval (CI) of perinatal mortality (stillbirth and early neonatal)

Table 6.2:
Prevalence and unadjusted odd ratios and their 95% confidence intervals of Perinatal mortality (stillbirth and early neonatal)

VARIABLE	Prevalence & 95%[CI]	Unadjusted odd ratio			
		OR	(95% CI)		p-value
COMMUNITY LEVEL FACTORS					
Year of survey					
2004	6.50 [5.77,7.33]	1.00			
2007	5.67 [4.87,6.59]	0.91	0.78	1.06	0.232
2011	5.02 [4.51,5.58]	0.76	0.66	0.87	<0.001
2014	4.36 [3.84,4.95]	0.66	0.57	0.77	<0.001
Cluster type					
Urban	4.62 [4.09,5.21]	1.00			
Rural	5.47 [5.08,5.88]	1.14	1.01	1.28	0.032
Geographical Region					
Barisal	5.16 [4.29,6.19]	1.00			
Chittagong	4.37 [3.77,5.07]	0.90	0.73	1.11	0.330
Dhaka	5.04 [4.42,5.75]	1.02	0.83	1.26	0.832
Khulna	5.22 [4.38,6.21]	1.02	0.80	1.28	0.895
Rajshahi	6.51 [5.62,7.53]	1.23	0.99	1.52	0.065
Sylhet	5.75 [4.87,6.79]	1.28	1.03	1.60	0.024
SOCIOECONOMIC DETERMINANTS					
Mother's age (years)					
15-24	5.73 [5.26,6.23]	1.00			
25-34	4.71 [4.25,5.23]	0.81	0.72	0.90	<0.001
35-49	5.37 [4.33,6.65]	0.86	0.72	1.04	0.125
Maternal marital status					
Currently married	5.21 [4.89,5.56]	1.00			
Formerly married	8.80 [6.22,12.32]	1.64	1.20	2.25	0.002
Mother working status					
not working	5.18 [4.82,5.56]	1.00			
working	5.67 [4.95,6.48]	1.08	0.95	1.23	0.229
Mother BMI in kg/m^2					
<=18.5	5.35 [4.69,6.10]	1.00			
18-25	5.23 [4.83,5.67]	0.98	0.86	1.11	0.742
25+	5.27 [4.25,6.52]	0.93	0.77	1.11	0.412
Maternal highest level of education					
No schooling	5.84 [5.32,6.40]	1.00			
Primary	5.12 [4.67,5.60]	0.84	0.76	0.94	0.002
Secondary or more	3.85 [3.17,4.66]	0.61	0.50	0.73	<0.001
Paternal highest level of education					
No schooling	5.82 [5.32,6.36]	1.00			
Primary	5.30 [4.75,5.92]	0.86	0.77	0.97	0.012
Secondary or more	3.62 [3.05,4.30]	0.57	0.49	0.68	<0.001
Wealth Index					

Rich	3.70 [3.17,4.31]	1.00			
Middle	5.50 [4.98,6.07]	1.43	1.23	1.67	<0.001
Poor	5.73 [5.20,6.30]	1.54	1.32	1.80	<0.001
Mother watched television every week					
Yes	4.94 [4.52,5.40]	1.00			
No	5.70 [5.20,6.23]	1.14	1.03	1.27	0.012
Mother listened to the radio every week					
Yes	5.83 [5.08,6.67]	1.00			
No	5.16 [4.81,5.52]	0.86	0.76	0.98	0.024
Mother read newspaper					
Yes	4.10 [3.46,4.85]	1.00			
No	5.48 [5.12,5.86]	1.41	1.20	1.65	<0.001
CHILD DEMOGRAPHICS					
Sex					
Female	3.60 [3.22,4.03]	1.00			
Male	4.23 [3.84,4.67]	1.18	1.05	1.33	0.007
Mothers age at child's birth (years)					
less than 20	4.82 [4.29,5.41]	1.00			
20 - 29	3.48 [3.10,3.91]	0.71	0.62	0.80	<0.001
30 - 39	3.59 [2.92,4.40]	0.78	0.64	0.94	0.008
40+	2.90 [1.44,5.78]	0.73	0.39	1.34	0.305
Birth rank and birth interval					
2nd/3rd birth rank, more than 2 years interval	3.03 [2.62,3.50]	1.00			
1st birth rank	4.92 [4.41,5.49]	1.67	1.45	1.92	<0.001
2nd/3rd birth rank, less than or equal to 2 years interval	4.68 [3.72,5.86]	1.55	1.22	1.97	<0.001
4th birth rank, more than 2 years interval	10.93[9.89,12.07]	4.15	3.61	4.78	<0.001
4th birth rank, less than or equal to 2 years interval	5.15 [3.67,7.17]	1.73	1.29	2.32	<0.001
Previous Death of Sibling					
No	5.04 [4.72,5.38]	1.00			
Yes	14.35[11.26,18.10]	3.37	2.74	4.16	<0.001
Number of children under-five years					
1-2	6.63 [6.21,7.07]	1.00			
3 or more	3.05 [2.60,3.57]	0.45	0.39	0.50	<0.001
Birth attendance					
Traditional birth attendant/others	5.65 [5.28,6.03]	1.00			
Health professional	3.91 [3.37,4.54]	0.66	0.58	0.76	<0.001
HEALTH SERVICE FACTORS					
Delivery complications					
None	6.20 [5.80,6.62]	1.00			
Any complications	2.51 [2.11,2.97]	0.37	0.32	0.44	<0.001
Contraceptive use					
No	7.45 [6.85,8.11]	1.00			
Yes	3.92 [3.57,4.30]	0.47	0.43	0.53	<0.001
Number ANC					

None	3.37 [2.92,3.88]	1.00			
1-3 times	2.62 [2.25,3.05]	0.76	0.63	0.90	0.002
4+ times	2.73 [2.24,3.34]	0.76	0.62	0.93	0.009
Combined place and mode of delivery					
Health facilities without Caesarean	5.45 [4.39,6.75]	1.00			
Health facilities with Caesarean	3.1 [2.45,3.91]	0.57	0.43	0.75	<0.001
Home	4.15 [3.79,4.55]	0.77	0.63	0.94	0.012

CI: Confidence interval. BMI: Body mass index., OR = odds ratio

Perinatal mortality (stillbirth and early neonatal) (PMEN) was most prevalent in 2004 [Prevalence (Pr) = 6.50; 95% confidence interval (CI): (5.77, 7.33)]. Compared to 2004, the odds of PMEN was significantly lower in 2014 [Unadjusted odds ratio (UOR) = 0.66; 95% CI: (0.57, 0.77), p < 0.001]. Prevalence of PMEN was higher in rural areas [Pr = 5.47, 95% CI: (5.08, 5.88); and, compared to infants in urban areas, rural infants had about 14 times more odds of PMEN than their urban counterparts [UOR = 1.14; 95% CI: (1.01, 1.28), p = 0.032]. Among the administrative regions of Bangladesh, PMEN was found to most prevalent in the Rajshahi region [Pr = 6.51; 95% CI: (5.62, 7.53)]. The odds of PMEN were significantly highest among infants in the Sylhet region compared to those in the Barisal region [UOR = 1.28; 95% CI: (1.03, 1.60), p = 0.024].

Prevalence of PMEN was highest among mothers who were aged between 15 and 24 years, compared to mothers of the other age brackets [Pr = 5.73; 95% CI: (5.26, 6.23)]; and compared to mothers in this age bracket, the odds of experiencing a PMEN was significantly lowest among mothers aged 25-34 years [UOR = 0.81; 95% CI: (0.72, 0.90), p < 0.001]. PMEN was higher among formerly married mothers than among currently married ones [Pr = 8.80; 95% CI: (6.22, 12.32)]. Compared to infants whose mothers were currently married, the odds of PMEN were significantly higher among those whose mothers were formerly married [UOR = 1.64; 95% CI: (1.20, 2.25), p = 0.002]. Prevalence of PMEN was highest among mothers who had no schooling, compared to those who had primary education and those who had secondary education or higher [Pr = 5.82; 95% CI: (5.32, 6.36)]. The odds of PMEN was lower among

mothers who had secondary education or higher, compared to those who had no schooling [UOR = 0.57; 95% CI: (0.49, 0.68), p < 0.001]. The same pattern was observed for paternal education. Mothers from rich households reported the least occurrence of PMEN [Pr = 3.70; 95% CI: (3.17, 4.31)]. Compared to infants from rich households, the odds of PMEN was significantly higher among those from poor households [UOR = 1.54; 95% CI: (1.32, 1.80), p < 0.001]. PMEN was most prevalent among mothers who did not watch television [Pr = 5.70; 95% CI: (5.20, 6.23)], and compared to infants whose mothers watched television every week, the odds of PMEN was significantly higher among those whose mothers did not watch television [UOR = 1.14; 95% CI: (1.03, 1.27), p = 0.012]. Prevalence of PMEN was higher among mothers who did listen to the radio every week than among those who did not [Pr = 5.83; 95% CI: (5.08, 6.67)]. The odds of PMEN were significantly lower among mothers who did not listen to the radio compared to those who did every week [UOR = 0.86; 95% CI: (0.76, 0.98), p = 0.024]. PMEN was more prevalent among mothers who did not read magazines/newspapers than among those who did every week [Pr = 5.48; 95% CI: (5.12, 5.86)]. Infants whose mothers did not read magazines/newspapers had significantly higher odds of PMEN compared to those whose mothers did every week [UOR = 1.41; 95% CI: (1.20, 1.65), p < 0.001].

Prevalence of PMEN was higher for male infants than for females [Pr = 4.23; 95% CI: (3.84, 4.67)]. The odds of PMEN were significantly higher among males compared to females [UOR = 1.18; 95% CI: (1.05, 1.33), p = 0.007]. PMEN was most prevalent among mothers who were aged less than 20 years at the time of the birth of that infant [Pr = 4.82; 95% CI: (4.29, 5.41)]. Compared to infants whose mothers were aged less than 20 years when they were born, those whose mothers were aged 20-29 years had significantly lower odds of PMEN [UOR = 0.71; 95% CI: (0.62, 0.80), p < 0.001]. Prevalence of PMEN was highest among infants whose previous siblings had died [Pr = 14.35; 95% CI: (11.26, 18.10)]. The odds of PMEN was

significantly higher among infants whose previous siblings had died compared to those whose previous siblings did not [UOR = 3.37; 95% CI: (2.74, 4.16), p < 0.001]. Perinatal mortality (stillbirth and early neonatal) was more prevalent among mothers who had 1-2 children aged under five years than those who had three or more children aged under five years [Pr = 6.63; 95% CI: (6.21, 7.07)]. The odds of PMEN was significantly lower among mothers who had three or more under-5 children compared to those who had between one and three children [UOR = 0.45; 95% CI: (0.39, 0.50), p < 0.001)]. Prevalence of PMEN was higher among infants who were delivered with assistance from traditional birth attendants or other non-health personnel than among those who were delivered by a trained medical professional [Pr = 5.65; 95% CI: (5.28, 6.03)]. The odds of PMEN was significantly lower among infants who were delivered by trained health professionals compared to those who were delivered by traditional birth attendants or other untrained personnel [UOR = 0.66; 95% CI: (0.58, 0.76), p < 0.001]. Prevalence of PMEN was higher among mothers who had no delivery complications than those who had [Pr = 6.20; 95% CI: (5.80, 6.62)], and the odds of PMEN were significantly lower among mothers who had delivery complications [UOR = 0.37; 95% CI: (0.32, 0.44), p < 0.001]. Prevalence of PMEN was higher among mothers who used contraceptives than those who did not [Pr = 7.45; 95% CI: (6.85, 8.11)]. Mothers who used contraceptives had significantly lower odds of PMEN compared to those did not [UOR = 0.47; 95% CI: (0.43, 0.53), p < 0.001]. Prevalence of PMEN was higher among infants whose mothers did not attend any antenatal care (ANC) service than among those whose mothers did [Pr = 3.37; 95% CI: (2.92, 3.88)], and the odds of PMEN were significantly lower among infants whose mothers had four or more ANC visits compared to those whose mothers had none [UOR = 0.76; 95% CI: (0.62, 0.93), p = 0.009]. PMEN was more prevalent among infants who were delivered at a health facility without caesarean operation than those who were delivered at a health facility with caesarean operation or who were delivered at home [Prr = 5.45; 95% CI: (4.39, 6.75)] and the odds of

PMEN were significantly lower among infants who were delivered at home compared to those who were delivered at a health facility without a caesarean operation [UOR = 0.77; 95% CI: (0.63, 0.94), p = 0.012].

The section that follows presents the prevalence and unadjusted odds ratios of variables associated with perinatal mortality (stillbirth and neonatal mortality) (PMN).

6.3 Perinatal mortality (stillbirth and neonatal)

The prevalence and unadjusted odds ratios of variables associated with perinatal mortality (stillbirth and neonatal) are summarised in Table 6.3.

Perinatal mortality (stillbirth and neonatal) (PMN) was most prevalent in 2004 [Prevalence (Pr) = 7.50; 95% confidence interval (CI): (6.72, 8.36)]. Compared to 2004, the odds of PMN was significantly lower in 2014 [Unadjusted odds ratio (UOR) = 0.65; 95% CI: (0.56, 0.74), p < 0.001]. Prevalence of PMN was higher in rural areas [Pr = 6.24, 95% CI: (5.83, 6.68); and, compared to infants in urban areas, rural infants had about 14 times more odds of PMN [UOR = 1.19; 95% CI: (1.06, 1.33), p = 0.003]. Among the administrative regions of Bangladesh, PMN was found to most prevalent in the Rajshahi region [Pr = 7.24; 95% CI: (6.26, 8.36)]. The odds of PMN were significantly highest among infants in the Sylhet region compared to those in the Barisal region [UOR = 1.37; 95% CI: (1.11, 1.68), p = 0.003].

Table 6.3:
Prevalence and unadjusted odd ratios and their 95% confidence intervals of Perinatal mortality (stillbirth and neonatal)

VARIABLE	Prevalence & 95%[CI]	Unadjusted odd ratio			
		OR	(95% CI)		p-value
COMMUNITY LEVEL FACTORS					
Year of survey					
2004	7.5[6.72,8.36]	1.00			
2007	6.54 [5.64,7.58]	0.91	0.79	1.05	0.194
2011	5.6 [5.07,6.18]	0.75	0.66	0.86	<0.001
2014	4.87 [4.31,5.49]	0.65	0.56	0.74	<0.001
Cluster type					
Urban	5.08 [4.53,5.69]	1.00			
Rural	6.24 [5.83,6.68]	1.19	1.06	1.33	0.003
Geographical Region					
Barisal	5.58 [4.70,6.61]	1.00			
Chittagong	5.12 [4.45,5.87]	0.98	0.80	1.19	0.811
Dhaka	5.72 [5.06,6.45]	1.09	0.89	1.34	0.401
Khulna	5.72 [4.82,6.76]	1.05	0.83	1.31	0.701
Rajshahi	7.24 [6.26,8.36]	1.28	1.04	1.58	0.020
Sylhet	6.52 [5.54,7.66]	1.37	1.11	1.68	0.003
SOCIOECONOMIC DETERMINANTS					
Mother's Age (years)					
15-24	6.52 [6.03,7.05]	1.00			
25-34	5.31 [4.82,5.84]	0.80	0.72	0.89	<0.001
35-49	6.1 [4.99,7.44]	0.87	0.73	1.04	0.134
Maternal marital status					
Currently married	5.91 [5.56,6.29]	1.00			
Formerly married	9.82 [7.11,13.41]	1.66	1.24	2.23	0.001
Maternal working status					
Not working	5.89 [5.51,6.29]	1.00			
Working	6.36 [5.61,7.20]	1.07	0.95	1.21	0.268
Mother BMI (kg/m^2)					
<=18.5	6.37 [5.66,7.17]	1.00			
18-25	5.93 [5.49,6.39]	0.93	0.83	1.05	0.253
25+	5.5 [4.46,6.77]	0.83	0.70	0.99	0.040
Maternal highest level of education					
No schooling	6.72 [6.17,7.32]	1.00			
Primary	5.76 [5.28,6.27]	0.81	0.73	0.89	<0.001
Secondary or more	4.14 [3.44,4.97]	0.57	0.48	0.68	<0.001
Paternal highest level of education					
No schooling	6.75 [6.21,7.33]	1.00			
Primary	5.88 [5.30,6.52]	0.84	0.75	0.93	0.001
Secondary or more	3.94 [3.33,4.65]	0.55	0.47	0.64	<0.001

Wealth Index					
Rich	3.94 [3.39,4.57]	1.00			
Middle	6.2 [5.65,6.80]	1.51	1.30	1.75	<0.001
Poor	6.63 [6.06,7.25]	1.67	1.44	1.94	<0.001
Mother watched television every week					
Yes	5.48 [5.03,5.96]	1.00			
No	6.61 [6.07,7.20]	1.20	1.08	1.32	<0.001
Mother listened to the radio every week					
Yes	6.54 [5.77,7.41]	1.00			
No	5.86 [5.49,6.25]	0.87	0.77	0.98	0.024
Mother read newspaper					
Yes	4.53 [3.85,5.33]	1.00			
No	6.23 [5.84,6.64]	1.47	1.27	1.71	<0.001
CHILD DEMOGRAPHICS					
Sex					
Female	4.32 [3.90,4.79]	1.00			
Male	4.95 [4.52,5.42]	1.17	1.04	1.30	0.007
Mothers age at child's birth (years)					
Less than 20	5.65 [5.07,6.28]	1.00			
20 - 29	4.13 [3.73,4.57]	0.71	0.63	0.80	<0.001
30 - 39	4.33 [3.60,5.20]	0.80	0.67	0.95	0.011
40+	3.4 [1.76,6.44]	0.68	0.38	1.22	0.195
Birth rank and birth interval					
2nd/3rd birth rank, more than 2 years interval	3.55 [3.12,4.04]	1.00			
1st birth rank	5.67 [5.12,6.29]	1.62	1.42	1.86	<0.001
2nd/3rd birth rank, less than or equal to 2 years interval	5.98 [4.80,7.42]	1.66	1.34	2.06	<0.001
4th birth rank, more than 2 years interval	11.54 [10.49,12.68]	3.71	3.24	4.23	<0.001
4th birth rank, less than or equal to 2 years interval	6.8 [5.08,9.06]	1.93	1.49	2.50	<0.001
Previous Death of Sibling					
No	5.65 [5.31,6.01]	1.00			
Yes	18.76 [15.24,22.87]	1.40	1.21	1.59	<0.001
Number of children under-five years					
1-2	7.48 [7.03,7.97]	1.00			
3 or more	3.51 [3.04,4.05]	0.45	0.40	0.51	<0.001
Birth attendance					
Traditional birth attendants/others	6.41 [6.02,6.83]	1.00			
Health professional	4.39 [3.82,5.04]	0.65	0.57	0.74	<0.001
HEALTH SERVICE FACTORS					
Delivery complications					
None	7.05 [6.62,7.50]	1.00			
Any complications	2.78 [2.36,3.28]	0.36	0.31	0.42	<0.001
Maternal contraceptive use					

No	8.54 [7.90,9.23]	1.00			
Yes	4.39 [4.01,4.79]	0.46	0.42	0.51	<0.001
Number of antenatal care clinic visits					
None	3.98 [3.49,4.53]	1.00			
1-3 times	2.94 [2.55,3.39]	0.71	0.60	0.84	<0.001
4+ times	2.92 [2.40,3.54]	0.69	0.57	0.84	<0.001
Combined place and mode of delivery					
Health facilities without Caesarean	6.19 [5.07,7.53]	1.00			
Health facilities with Caesarean	3.54 [2.84,4.41]	0.57	0.44	0.75	<0.001
Home	4.93 [4.53,5.37]	0.82	0.68	0.99	0.040

OR = odds ratio

Prevalence of PMN was highest among mothers who were aged between 15 and 24 years, compared to mothers of the other age brackets [Pr = 6.52; 95% CI: (6.03, 7.05)]; and compared to mothers in this age bracket, the odds of experiencing a PMN was significantly lower among mothers aged 25-34 years compared to mothers of the other age brackets [UOR = 0.80; 95% CI: (0.72, 0.89), p < 0.001]. PMN was higher among infants of formerly married mothers than among those of currently married ones [Pr = 9.82; 95% CI: (7.11, 13.41)]. Compared to infants whose mothers were currently married, the odds of PMN were significantly higher among those whose mothers were formerly married [UOR = 1.66; 95% CI: (1.24, 2.23), p = 0.001]. Prevalence of PMN was highest among mothers who had no schooling, compared to those who had primary education and those who had secondary education or higher [Pr = 6.75; 95% CI: (6.17, 7.32)]. The odds of PMN were lower among mothers who had secondary education or higher, compared to those who had no schooling [UOR = 0.57; 95% CI: (0.48, 0.68), p < 0.001]. The same pattern was observed for paternal education. Mothers from rich households reported the least occurrence of PMN [Pr = 3.94; 95% CI: (3.17, 4.31)]. Compared to infants from rich households, the odds of PMN were significantly higher among those from poor households [UOR = 1.67; 95% CI: (1.44, 1.94), p < 0.001]. PMN was most prevalent among mothers who did not watch television [Pr = 6.61; 95% CI: (6.07, 7.20)], and compared to infants whose mothers watched television every week, the odds of PMN was significantly higher among those whose mothers did not watch television [UOR = 1.20; 95% CI: (1.08, 1.32), p < 0.001].

Prevalence of PMN was higher among mothers who did listen to the radio every week than among those who did not [Pr = 6.54; 95% CI: (5.77, 7.41)]. The odds of PMN were significantly lower among mothers who did not listen to the radio compared to those who did every week [UOR = 0.87; 95% CI: (0.77, 0.98), p = 0.024]. PMN was more prevalent among mothers who did not read magazines/newspapers than among those who did every week [Pr = 6.23; 95% CI: (5.84, 6.64)]. Infants whose mothers did not read magazines/newspapers had significantly higher odds of PMN compared to those whose mothers did every week [UOR = 1.47; 95% CI: (1.27, 1.71), p < 0.001].

Prevalence of PMN was higher for male infants than for females [Pr = 4.95; 95% CI: (4.52, 5.42)]. The odds of PMN were significantly higher among males compared to females [UOR = 1.17; 95% CI: (1.04, 1.30), p = 0.007]. PMN was most prevalent among mothers who were aged less than 20 years at the time of the birth of that infant [Pr = 5.65; 95% CI: (5.07, 6.28)]. Compared to infants whose mothers were aged less than 20 years when they were born, those whose mothers were aged 20-29 years had significantly lower odds of PMN [UOR = 0.71; 95% CI: (0.63, 0.80), p < 0.001]. Prevalence of PMN was highest among infants whose previous siblings had died [Pr = 18.76; 95% CI: (15.24, 22.87)]. The odds of PMN were significantly higher among infants whose previous siblings had died compared to those whose previous siblings did not [UOR = 1.40; 95% CI: (1.21, 1.59), p < 0.001]. Perinatal mortality (stillbirth and neonatal) was more prevalent among mothers who had 1-2 children aged under five years than those who had three or more children aged under five years [Pr = 7.48; 95% CI: (7.03, 7.97)]. The odds of PMN was significantly lower among mothers who had three or more under-5 children compared to those who had between one and three children [UOR = 0.45; 95% CI: (0.40, 0.51), p < 0.001)]. Prevalence of PMN was higher among infants who were delivered with assistance from traditional birth attendants or other non-health personnel than among those who were delivered by a trained medical professional [Pr = 6.41; 95% CI: (6.02, 6.83)].

The odds of PMN was significantly lower among infants who were delivered by trained health professionals compared to those who were delivered by traditional birth attendants or other untrained personnel [UOR = 0.65; 95% CI: (0.57, 0.74), $p < 0.001$].

Prevalence of PMN was higher among mothers who had no delivery complications than those who had [Pr = 7.05; 95% CI: (6.62, 7.50)], and the odds of PMN were significantly lower among mothers who had delivery complications [UOR = 0.36; 95% CI: (0.31, 0.42), $p < 0.001$].

Prevalence of PMN was higher among mothers who did not use contraceptives than those who did not [Pr = 8.54; 95% CI: (7.90, 9.23)]. Mothers who used contraceptives had significantly lower odds of PMN compared to those did not [UOR = 0.46; 95% CI: (0.23, 0.51), $p < 0.001$].

Prevalence of PMN was higher among infants whose mothers did not attend any antenatal care (ANC) service than among those whose mothers did [Pr = 3.98; 95% CI: (3.49, 4.53)], and the odds of PMN were significantly lower among infants whose mothers had four or more ANC visits compared to those whose mothers had none [UOR = 0.69; 95% CI: (0.57, 0.84), $p < 0.001$]. PMEN was more prevalent among infants who were delivered at a health facility without caesarean operation than those who were delivered at a health facility with caesarean operation or who were delivered at home [Pr = 6.19; 95% CI: (5.07, 7.53)] and the odds of PMN were significantly lower among infants who were delivered at a health facility with caesarean operation compared to those who were delivered at a health facility without a caesarean operation [UOR = 0.57; 95% CI: (0.44, 0.75), $p < 0.001$].

Figure 6.1 shows the variation of the two versions of perinatal mortality (per 1000 live births) for the various DHS years.

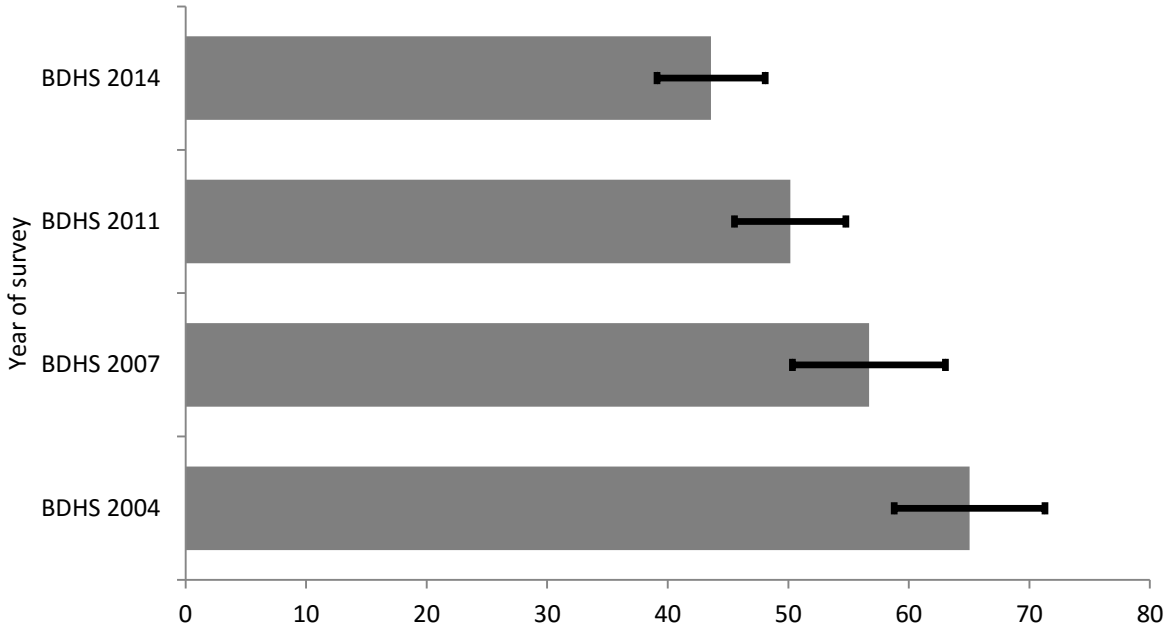


Figure 6.1: Perinatal mortality (stillbirth and early neonatal) rate and 95%CI per 1,000 live births

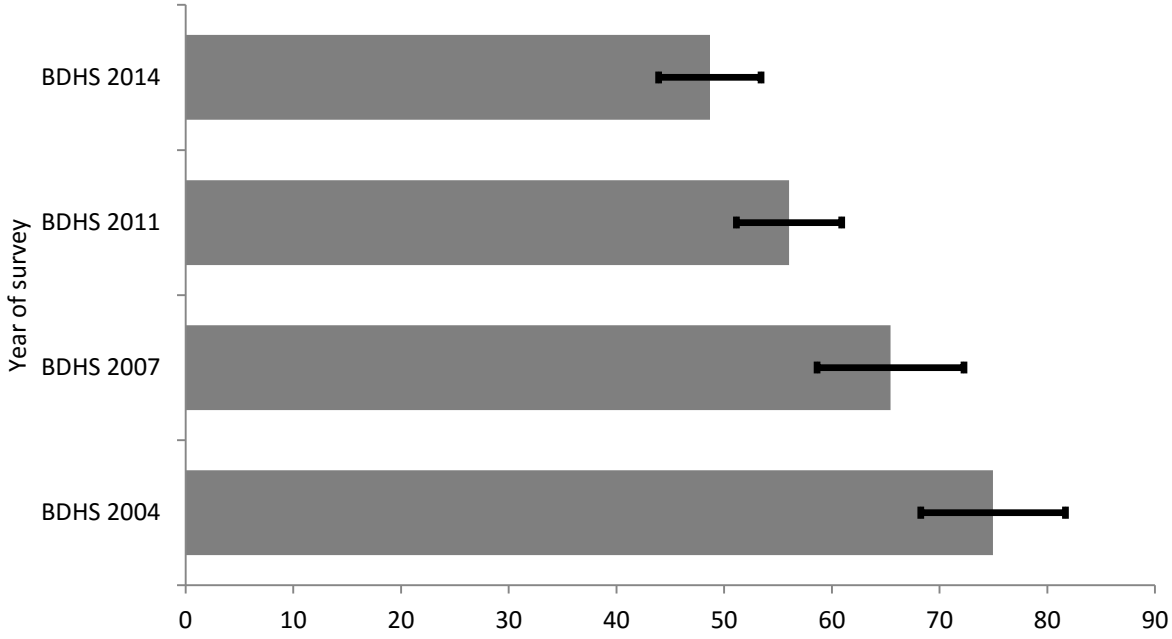


Figure 6.2: Perinatal mortality (stillbirth and neonatal) rate and 95%CI per 1,000 live births

Prevalence of PMN was highest among mothers who were aged between 15 and 24 years, compared to mothers

The perinatal mortality (stillbirth and early neonatal) rate was highest (65 per 1000 live births) in 2004, and the lowest perinatal mortality (stillbirth and early neonatal) rate was lowest (44 per 1000 live births) in 2014. In a similar fashion, the highest perinatal mortality (stillbirth and neonatal) rate (75 per 1000 live births) was in 2004, and the lowest (49 per 1000 live births) was in 2014.

The next two sections present factors associated with both PMEN and OMN; that is, the dependence of PMEN and PMN on certain variables when other covariates are adjusted for.

6.4 Factors associated with Perinatal mortality (stillbirth and early neonatal)

Factors associated with perinatal mortality (stillbirth and early neonatal) are shown in Table 6.4.

Table 6.4:
Factors associated with Perinatal mortality (stillbirth and early neonatal): Adjusted odd ratios (AOR)

VARIABLE	Model 1				Model 2			
	AOR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.91	0.78	1.07	0.242	0.90	0.77	1.05	0.166
2011	0.39	0.32	0.46	<0.001	0.43	0.36	0.51	<0.001
2014	0.34	0.28	0.41	<0.001	0.36	0.30	0.44	<0.001
Maternal BMI (kg/m^2)								
<=18.5	1.00							
18-25	1.04	0.90	1.20	0.628				
25+	1.34	1.06	1.69	0.016				
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.87	0.75	1.01	0.062	0.92	0.80	1.06	0.261
Secondary or more	0.66	0.52	0.85	0.001	0.75	0.60	0.94	0.014
Wealth Index								
Rich	1.00							
Middle	1.29	1.06	1.56	0.012				
Poor	1.39	1.13	1.71	0.002				
Sex								
Female	1.00				1.00			

Male	1.22	1.08	1.38	0.001	1.21	1.07	1.36	0.002
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	1.85	1.60	2.14	<0.001	1.72	1.48	1.99	<0.001
2nd/3rd birth rank, less than or equal to 2 years interval	1.31	1.03	1.68	0.030	1.24	0.97	1.59	0.083
4th birth rank, more than 2 years interval	0.75	0.61	0.93	0.007	0.75	0.61	0.92	0.007
4th birth rank, less than or equal to 2 years interval	0.87	0.63	1.19	0.384	0.86	0.63	1.18	0.355
Previous death of sibling								
No	1.00				1.00			
Yes	4.78	3.72	6.13	<0.001	4.31	3.36	5.53	<0.001
HEALTH SERVICE FACTORS								
Delivery complications								
None					1.00			
Any complications					0.62	0.53	0.73	<0.001
Contraceptive use								
No					1.00			
Yes					0.54	0.48	0.61	<0.001

Model 1: Community, socio-economic and child factors associated with perinatal mortality
Model 2: Model 1 plus health services factors associated with perinatal mortality
AOR – Adjusted Odds rati

Table 6.4 summarises the factors associated with perinatal mortality (stillbirth and early neonatal) when other covariates are adjusted for. In both models, the odds of PMEN were significantly lower in 2014 compared to 2004 [adjusted odds ratio (AOR) = 0.34; 95% confidence interval (CI): (0.28, 0.41), $p < 0.001$] (model1) and [AOR = 0.36; 95% CI: (0.30, 0.44), $p < 0.001$] (model 2).

Compared to infants whose mothers had a body mass index (BMI) of 18.5 kgm^{-2} or less, the odds of PMEN were significantly higher [AOR = 1.34; 95% CI: (1.06, 1.69), $p = 0.016$] (model1). Infants whose mothers had secondary education or higher had significantly lower odds of PMEN compared to those whose mothers had no schooling [AOR = 0.66; 95% CI: (0.52, 0.85), $p = 0.001$] (model 1) and [AOR = 0.75; 95% CI: (0.60, 0.94), $p = 0.014$] (model 2). The odds of PMEN were significantly higher among infants from poor households compared to those from rich households (model1) [AOR = 1.39; 95% CI: (1.13, 1.71), $p = 0.002$]. Male infants were found to have significantly higher odds of PMEN compared to their

female counterparts (both models) [AOR = 1.22; 95% CI: (1.08, 1.38), p = 0.001] (model1) and [AOR = 1.21; 95% CI: (1.07, 1.36), p = 0.002] (model 2). For both models, infants whose previous siblings died had significantly higher odds of PMEN compared to those whose previous siblings did not [AOR = 4.78; 95% CI: (3.72, 6.13), p < 0.001] (model1) and [AOR = 4.31; 95% CI: (3.36, 5.53), p < 0.001] (model 2).

The odds of PMEN were significantly lower among infants whose mothers did not have any complications during their delivery compared to those whose mothers had (model 2) [AOR = 0.62; 95% CI: (0.53, 0.73), p < 0.001]. Further, the odds of PMEN were significantly lower among infants whose mothers used contraceptives compared to those whose mothers did not (model 2) [AOR = 0.54; 95% CI: (0.48, 0.61), p < 0.001].

6.5 Factors associated with Perinatal mortality (stillbirth and neonatal)

Factors associated with perinatal mortality (stillbirth and neonatal) (PMN) are summarised in Table 6.5.

Table 6.5:
Factors associated with Perinatal mortality (stillbirth and neonatal): Adjusted odds ratios (AOR)

VARIABLE	Model 1				Model 2			
	AOR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.93	0.81	1.08	0.349	0.90	0.78	1.04	0.162
2011	0.45	0.38	0.53	<0.001	0.49	0.42	0.58	<0.001
2014	0.39	0.33	0.46	<0.001	0.40	0.34	0.48	<0.001
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.83	0.73	0.95	0.007	0.91	0.79	1.04	0.160
Secondary or more	0.66	0.52	0.82	<0.001	0.77	0.62	0.97	0.029
Wealth Index								
Rich	1.00				1.00			
Middle	1.30	1.09	1.56	0.004	1.18	0.99	1.42	0.068
Poor	1.40	1.16	1.69	<0.001	1.21	1.00	1.47	0.048
Sex								
Female	1.00				1.00			
Male	1.18	1.06	1.32	0.003	1.20	1.07	1.34	0.002
Birth rank and birth interval								

2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	1.78	1.55	2.04	<0.001	1.69	1.47	1.93	<0.001
2nd/3rd birth rank, less than or equal to 2 years interval	1.39	1.12	1.74	0.003	1.33	1.07	1.66	0.012
4th birth rank, more than 2 years interval	0.71	0.59	0.86	<0.001	0.72	0.59	0.87	0.001
4th birth rank, less than or equal to 2 years interval	0.91	0.68	1.20	0.496	0.91	0.68	1.21	0.528
Previous Death of Sibling								
No	1.00				1.00			
Yes	5.51	4.40	6.91	<0.001	5.04	4.01	6.32	<0.001
HEALTH SERVICE FACTORS								
Delivery complications								
None	1.00				1.00			
Any complications	0.36	0.31	0.42	<0.001	0.58	0.50	0.68	<0.001
Contraceptive use								
No	1.00				1.00			
Yes	0.46	0.42	0.51	<0.001	0.54	0.48	0.60	<0.001

Model 1: Community, socio-economic and child factors associated with perinatal mortality
Model 2: Model 1 plus health services factors associated with perinatal mortality

In both models, the odds of PMN were significantly lower in 2014 compared to 2004 [adjusted odds ratio (AOR) = 0.39; 95% confidence interval (CI): (0.33, 0.46), $p < 0.001$] (model1) and [AOR = 0.40; 95% CI: (0.34, 0.48), $p < 0.001$] (model 2).

The odds of PMN among infants whose mothers had secondary education or higher were significantly lower compared to those whose mothers had no schooling [AOR = 0.66; 95% CI: (0.52, 0.82), $p = 0.001$] (model 1) and [AOR = 0.77; 95% CI: (0.62, 0.97), $p = 0.029$] (model 2). In both model 1 and model 2, the odds of PMN were significantly higher among infants from poor households compared to those from rich households [AOR = 1.40; 95% CI: (1.16, 1.69), $p < 0.001$] (model 1) and [AOR = 1.21; 95% CI: (1.00, 1.47), $p = 0.048$] (model 2). Male infants were found to have significantly higher odds of PMN compared to their female counterparts (both models) [AOR = 1.18; 95% CI: (1.06, 1.32), $p = 0.003$] (model1) and [AOR = 1.20; 95% CI: (1.07, 1.34), $p = 0.002$] (model 2). For both models, infants whose previous siblings died had significantly higher odds of PMN compared to those whose previous siblings

did not [AOR = 5.51; 95% CI: (4.40, 6.91), p < 0.001] (model1) and [AOR = 5.04; 95% CI: (4.01, 6.32), p < 0.001] (model 2).

In both models, the odds of PMN were significantly lower among infants whose mothers did not have any complications during their delivery compared to those whose mothers had [AOR = 0.36; 95% CI: (0.31, 0.42), p < 0.001] (model1), and [AOR = 0.58; 95% CI: (0.50, 0.68), p < 0.001] (model 2). Further, in both models, the odds of PMN were significantly lower among infants whose mothers used contraceptives compared to those whose mothers did not [AOR = 0.46; 95% CI: (0.42, 0.51), p < 0.001] (model 1), and [AOR = 0.54; 95% CI: (0.48, 0.60), p < 0.001] (model 2).

6.5 Summary

In this chapter, the prevalence and factors associated with perinatal mortality (stillbirth and early neonatal) and perinatal mortality (stillbirth and neonatal) were presented. Both classes of perinatal mortality were most prevalent in the Dhaka administrative region of Bangladesh. Some of the other factors for which both classes of perinatal mortality were prevalent included: rural mothers, compared to urban ones; younger mothers, compared to older ones; parents who had no formal education compared to those who had secondary education or higher; mothers who did patronise electronic and print media; and mothers who did not attend any antenatal clinics.

Factors which were associated with perinatal mortality included: mothers with a BMI of 25kg/m^2 or more, uneducated mothers, poor households, and mothers who did not use contraceptives.

The next chapter presents the impact of antenatal care, iron and folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh.

CHAPTER 7

THE EFFECT OF ANTENATAL CARE, IRON FOLIC ACID SUPPLEMENTATION AND TETANUS TOXOID VACCINATION DURING PREGNANCY ON CHILD MORTALITY

7.0 Introduction

In this chapter, results of the third research question are presented. Community, socio-economic and proximate factors that were associated with antenatal care service patronage, intake of iron and folic acid supplementation by mothers in Bangladesh are assessed. This report does not include data from the 2014 Bangladesh DHS. This is because information such as tetanus toxoid vaccination by women during pregnancy was not collected.

7.1 Basic characteristics of the study participants

As shown in Table 7.1, there was a variation in child deaths among the administrative regions of Bangladesh, with the lowest and highest deaths occurring in the Barisal (6.4%) and Dhaka (32.9%) regions respectively. More than 90% of the Bangladeshi mothers were both married and belonged to the Islamic faith. Nearly 50% of mothers interviewed belonged to the youngest age bracket (15-24 years), whilst less than 2% of mothers were aged 40 years or older at the time of birth of the child. The majority of mothers (80.8%) were unemployed, and more than two-thirds of them had a BMI of between 18 and 25 kg/m^2. Less than 1 in 5 families had both parents in paid employment in the 12 months preceding the survey. Nearly 50% of parents had no schooling, and about the same proportion of mothers were from poor households. Close to 60% of mothers watched television every week. However, more than three-quarters of them had no access to the radio or newspaper. Male and female children were almost equally represented, and more than one-third of children were either 2nd or 3rd born with more than two years interval. Almost 7 in every 10 women desired for pregnancy at the time of the surveys; and two-thirds of mothers attended ANC clinics. Only about one-third of mothers gave their children IFA supplements while more than 50% of children received 2 or more TT vaccinations. More than three-quarters of mothers gave birth at home and close to one-third delivered their babies with assistance from Traditional Birth Attendants (TBAs).

Table 7.1:
Characteristics of the study participants (n = 16722), Bangladesh, 2004-2011

VARIABLE	n*	%*
Year of survey		
2004	5364	32.1
2007	4872	29.1
2011	6485	38.8
COMMUNITY-LEVEL FACTORS		
Cluster type		
Urban	3739	22.4
Rural	12983	77.6
Geographical region		
Barisal	1067	6.4
Chittagong	3697	22.1
Dhaka	5497	32.9
Khulna	1804	10.8
Rajshahi	3377	20.2
Sylhet	1278	7.6
SOCIOECONOMIC DETERMINANTS		
Maternal marital status		
Married	16367	97.9
Formerly Married	354	2.1
Maternal religion		
Islam	15382	92.0
Others	1339	8.0
Mother's Age at interview (years)		
15-24	8273	49.5
25-34	6772	40.5
35-49	1670	10.0
Mothers age at child's birth (years)		
Less than 20	5019	30.0
20 - 29	8921	53.4
30 - 39	2560	15.3
40+	221	1.3
Maternal working status		
Not working	13509	80.8
Working	3210	19.2
Maternal BMI (kg/m^2)		
<=18.5	3929	23.5
18-25	11019	65.9
25+	1708	10.2
Parents employment status		
Father only working	13119	78.5
Both working	2998	17.9
Neither working	604	3.6
Maternal highest level of education		

No schooling	7818	46.8
Primary	7010	41.9
Secondary or more	1882	11.3
Paternal highest level of education		
No schooling	8512	50.9
Primary	5331	31.9
Secondary or more	2861	17.1
Wealth Index		
Rich	2921	17.5
Middle	5991	35.8
Poor	7810	46.7
Mother watched television every week		
Yes	9484	56.7
No	7234	43.3
Mother listened to the radio every week		
Yes	4259	25.5
No	12458	74.5
Mother read newspaper		
Yes	2620	15.7
No	14099	84.3
PROXIMATE DETERMINANTS		
Sex		
Female	8173	48.9
Male	8549	51.1
Birth rank and birth interval		
2nd/3rd birth rank, more than 2 years interval	6438	38.5
1st birth rank	5241	31.4
2nd/3rd birth rank, less than or equal to 2 years interval	1110	6.6
4th birth rank, more than 2 years interval	3267	19.5
4th birth rank, less than or equal to 2 years interval	665	4.0
Desire for pregnancy		
Then	11625	69.5
Later	2598	15.5
Not at all	2497	14.9
Pregnancy or delivery health-care service		
Use of Antenatal care		
Not used	6679	39.9
Used	10035	60.0
Iron and folic acid supplements		
No	11039	66.0
Yes	5476	32.8
Tetanus toxoid vaccination during pregnancy		

Never	3573	21.4
One TT	3731	22.3
2+ TT	9385	56.1
Combined place and mode of delivery		
Health facilities without caesarean	1153	6.9
Health facilities with caesarean	1482	8.9
Home	13663	81.7
Delivery assistance		
None	195	1.2
Doctor/Obstetrician-Gynaecologist	2561	15.3
Nurse/midwife	1054	6.3
TBA	5505	32.9
Other untrained personnel	5986	35.8

*Weighted for the sampling probability.

7.2 Factors associated with neonatal, postnatal and child mortality

The results of a univariate analysis of how community-level factors, socioeconomic and proximate determinants are associated with neonatal, postnatal and child mortalities are presented in Table 7.2. Compared to the year 2004, the odds of neonatal and postnatal mortalities were significantly higher in 2011. However, the odds of child mortality were significantly lower in 2011 compared to 2004. Compared to infants of younger mothers (aged 15-24 years), the likelihood of postnatal and child mortalities was significantly higher among those whose mothers were aged 35 49 years. Whilst postnatal mortality was significantly associated with formerly infants/children of married mothers, child mortality was significantly associated with those of married mothers. Postnatal and child mortalities were found to be significantly associated with infants/children of older mothers (aged 40+ years), compared to those of younger mothers (aged <20 years). The likelihood of neonatal, postnatal and child mortalities was significantly more likely among 4^{th}- born infants/children with interval of 2 years or less and those whose parents worked in the 12 months preceding the survey. The likelihood of all three categories of mortality was found to be significantly higher among infants/children whose mothers had no schooling, never had TT vaccination and delivered with no assistance from a health professional. Postnatal and child mortalities were found to be significantly associated with infants/children from poor households, from households with no

access to television and/or newspaper/magazine and those who did not receive any IFA supplements. The likelihood of neonatal mortality was significantly higher among males whilst females were significantly associated with child mortality.

Multivariate analysis revealed that there was a decline in the likelihood of postnatal and child mortalities between 2004 and 2011 (Table 7.2). Neonatal, postnatal and child mortalities were significantly associated with infants/children whose mothers had no schooling. The likelihood of postnatal and child mortalities was significantly higher among infants/children whose mothers were formerly married. Child mortality was significantly associated with 4^{th}-born children with an interval of 2 years or less and children whose mothers were employed. Child mortality was significantly higher among children of older mothers (aged 40+ years), whilst neonatal mortality was significantly associated with infants whose mothers had a BMI of 25kg/m^2 or higher.

Table 7.2:
Community and Socio-economic factors associated with neonatal, postnatal and child mortality, Bangladesh, 2004-2011

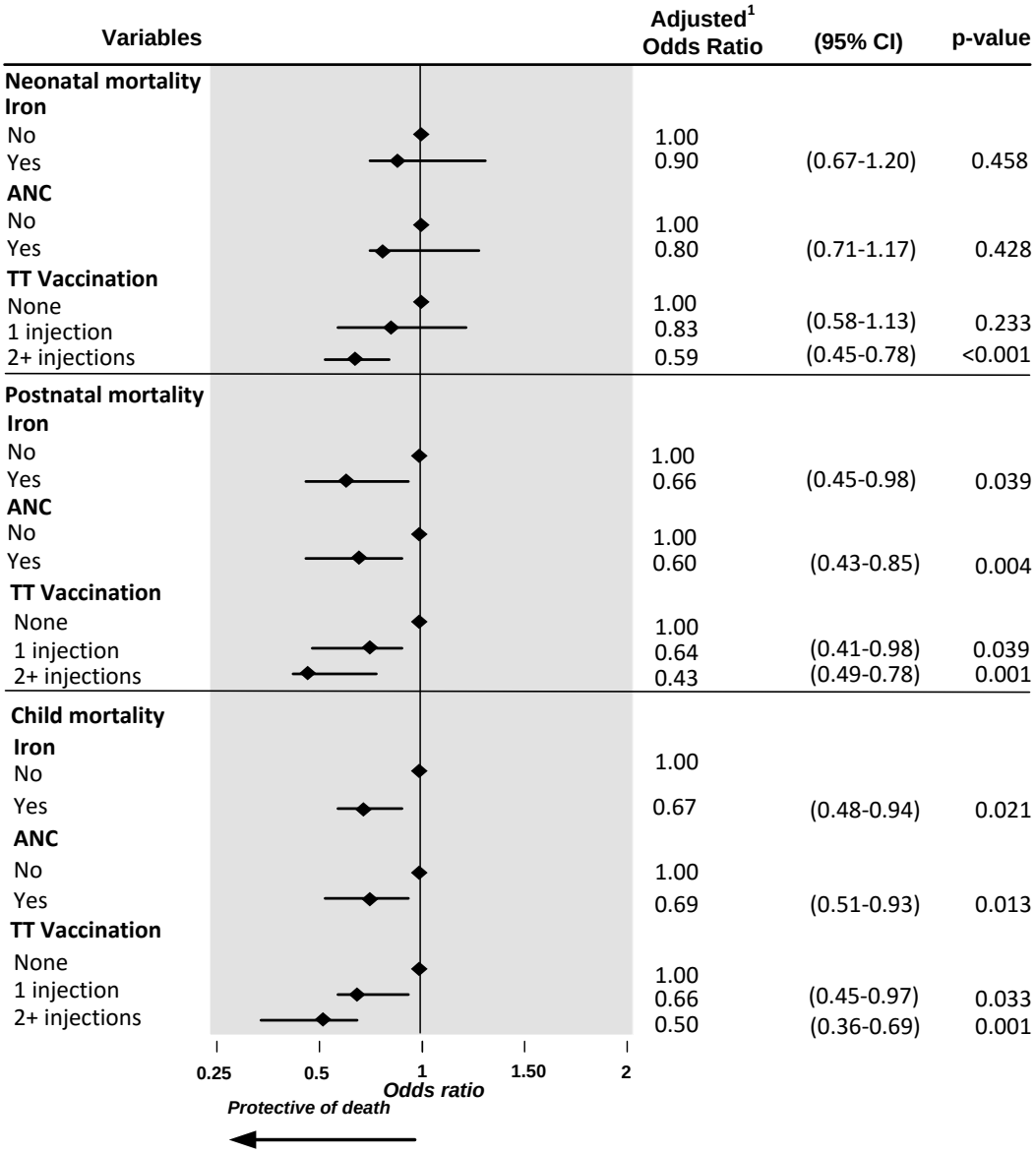
VARIABLE	Neonatal		Postnatal		Child	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Year of survey						
2004	1.00		1.00		1.00	
2007	0.81 (0.61, 1.08)	0.152	0.74 (0.51,1.08)	0.120	0.71 (0.51,0.99)	0.042
2011	0.84 (0.64, 1.11)	0.227	0.58 (0.39,0.86)	0.007	0.64 (0.45,0.90)	0.011
Cluster type						
Urban						
Rural						
Region						
Barisal					1.000	
Chittagong					0.90 (0.55,1.48)	0.680
Dhaka					0.85 (0.51,1.40)	0.519
Khulna					0.37 (0.18, 0.76)	0.007
Rajshahi					0.80 (0.47,1.36)	0.419
Sylhet					1.24 (0.75, 2.03)	0.396
Maternal marital status						
Married			1.00		1.000	
Formerly Married			2.97 (1.57, 5.63)	0.001	3.08 (1.82,5.23)	<0.001
Maternal highest level of education						
No education	1.00		1.00		1.000	
Primary	0.70 (0.53, 0.91)	0.007	0.64 (0.44, 0.94)	0.023	0.75 (0.54,1.04)	0.082
Secondary or more	0.48 (0.31, 0.75)	0.001	0.19 (0.07, 0.52)	0.001	0.15 (0.06, 0.42)	<0.001
Mother working status						
Not working					1.000	
Working					1.75 (1.28, 2.41)	0.001
Mothers age at child's birth (years)						

Less than 20			1			
20 - 29			1.14 (0.67, 1.93)	0.632		
30 - 39			1.45 (0.75, 2.81)	0.271		
40+			3.03 (1.18, 7.77)	0.021		
Mother BMI (kg/m^2)						
<=18.5	1.00					
18-25	0.99 (0.76, 1.31)	0.966				
25+	1.66 (1.11, 2.46)	0.013				
Birth rank and birth interval						
2nd/3rd birth rank, more than 2 years interval	1.00		1.00		1.000	
1st birth rank	1.85 (1.38, 2.48)	<0.001	1.25 (0.72, 2.15)	0.425	1.00 (0.68, 1.48)	0.980
2nd/3rd birth rank, less than or equal to 2 years interval	2.17 (1.43, 3.31)	<0.001	0.92 (0.41, 2.08)	0.843	0.97 (0.52, 1.82)	0.934
4th birth rank, more than 2 years interval	1.25 (0.89, 1.77)	0.202	1.44 (0.89, 2.33)	0.142	1.40 (0.97, 2.03)	0.071
4th birth rank, less than or equal to 2 years interval	1.99 (1.20, 3.29)	0.007	3.42 (1.98, 5.92)	<0.001	2.99 (1.88, 4.76)	<0.001

OR = odds ratio

Table 7.3 shows results of multivariate analyses of the effect of different combinations of any form of ANC, IFA supplementation and TT vaccinations. The likelihood of neonatal death was significantly higher among neonates whose mothers were given no IFA supplements and had less than two TT vaccinations compared to those whose mothers had IFA supplements and who had two or more TT vaccinations. Infants whose mothers received no IFA supplements and had less than two TT vaccinations were not significantly protected from postnatal death while those whose mothers had IFA supplements and two or more TT vaccinations were. The likelihood of infants dying in the postnatal period was found to be significantly higher among mothers who did not have any ANC visits and did not receive any IFA supplements compared to those who had ANC visits and took IFA supplements. Children whose mothers had IFA supplementation and had two or more TT vaccinations were significantly better protected against child mortality than those whose mothers did not receive any IFA supplements and had two or less TT vaccinations. Children whose mothers attended ANC clinics and received IFA supplements were significantly less likely to die compared to those whose mothers did not attend any ANC clinics and did not receive any IFA supplements.

Figure 7.1 shows the effect of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination during pregnancy on neonatal, post-neonatal and child mortality. Children whose mothers did not have any TT vaccinations were significantly more likely to die compared to those whose mothers had 2 or more TT vaccinations. The likelihood of postnatal mortality was significantly higher among infants whose mothers did not take any iron supplements, whose mothers attended no ANC clinics and received no TT vaccinations. Child mortality was found to be significantly higher among children whose mothers received no iron supplements, did not attend any ANC clinics and received no TT vaccination.



[1] Adjusted for cluster type, region; maternal marital status, mother's Age at interview, mothers age at child's birth, mother working status, mother BMI, Parents employment status; maternal highest level of education; paternal highest level of education; household wealth Index; watches television every week; listens to radio every week; read newspaper; sex of the baby; Previous birth rank and birth interval, desire for pregnancies

TT – tetanus toxoid

ANC – antenatal care

Figure 7.1: Impact of antenatal care, iron folic acid supplementation and tetanus toxoid vaccination on child mortality, Bangladesh, 2004-2011

.

Table 7.3:
The effect of different combinations of iron supplementation, tetanus toxoid vaccination and antenatal care on neonatal, post-neonatal and child mortality, as determined by multivariate analysis, Bangladesh, 2004-2011

Variable	Number of live births	Number of deaths	Unadjusted		Adjusted	
			OR (95% CI)	P-value	AOR (95% CI)	P-value
Neonatal Mortality (0-28 days)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5492	117	1.00		1.00	
No IFA supplements with >=2 TT injections	5725	93	0.65 (0.49, 0.86)	0.003	0.62 (0.47, 0.83)	0.001
IFA supplements with < 2 TT injections	1813	33	0.84 (0.58, 1.22)	0.364	0.77 (0.51, 1.15)	0.202
IFA supplements with >=2 TT injections	3660	66	0.71 (0.52, 0.96)	0.027	0.60 (0.42, 0.86)	0.005
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5663	114	1.00		1.00	
ANC without IFA supplements	5577	96	0.85 (0.65, 1.12)	0.257	0.98 (0.73, 1.32)	0.908
IFA supplements alone	1015	22	0.96 (0.59, 1.57)	0.865	0.96 (0.58, 1.59)	0.879
ANC including IFA supplements	4458	78	0.82 (0.61, 1.10)	0.189	0.90 (0.65, 1.25)	0.523
Postnatal Mortality (1- 11 months)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5422	70	1.00		1.00	
No IFA supplements with >=2 TT injections	5687	39	0.56 (0.38, 0.82)	0.003	0.56 (0.38, 0.83)	0.004
IFA supplements with < 2 TT injections	1791	22	0.83 (0.51, 1.36)	0.469	0.76 (0.45, 1.28)	0.302
IFA supplements with >=2 TT injections	3638	23	0.40 (0.25, 0.66)	<0.001	0.37 (0.22, 0.63)	<0.001
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5586	78	1.00		1.00	
ANC without IFA supplements	5546	31	0.40 (0.27, 0.60)	<0.001	0.66 (0.43, 1.01)	0.057
IFA supplements alone	1002	14	0.89 (0.49, 1.60)	0.692	0.82 (0.45, 1.50)	0.516
ANC including IFA supplements	4427	31	0.40 (0.26, 0.62)	<0.001	0.51 (0.32, 0.81)	0.005
Child Mortality (1-4 years)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5397	95	1.00		1.00	

No IFA supplements with >=2 TT injections	5669	56	0.59 (0.43, 0.82)	0.002	0.59 (0.42, 0.83)	0.002
IFA supplements with < 2 TT injections	1789	24	0.69 (0.43, 1.09)	0.111	0.66 (0.41, 1.07)	0.094
IFA supplements with >=2 TT injections	3625	35	0.48 (0.32, 0.71)	<0.001	0.45 (0.29, 0.70)	<0.001
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5562	101	1.00		1.00	
ANC without IFA supplements	5527	50	0.46 (0.33, 0.65)	<0.001	0.77 (0.54, 1.11)	0.161
IFA supplements alone	998	17	0.84 (0.49, 1.42)	0.512	0.79 (0.46, 1.36)	0.400
ANC including IFA supplements	4416	42	0.43 (0.30, 0.62)	<0.001	0.57 (0.38, 0.84)	0.005

AOR – Adjusted Odds ratio; OR = odds ratio

7.3 Summary

This chapter presented characteristics of the respondents. Majority of them were rural dwellers, married, not employed, did not attend any antenatal clinics, did not take any iron and folic acid supplements, and belonged to the Islamic faith. Factors associated with neonatal, postnatal and child mortalities were also presented. Formerly married mothers were more associated with postnatal and child mortalities. The odds of neonatal, postnatal and child mortality were higher among mothers who had no formal education. Mothers with BMI higher than 25kg/m2 have been shown to be associated with neonatal mortality, so are $2^{nd}/3^{rd}$ rank neonates with two years birth interval or less. The odds of neonatal, postnatal and child mortalities were significantly lower among mothers who had IFA supplements together with two or more TT vaccinations compared to those who had no IFA supplements and no TT vaccinations. Mothers who attended antenatal care clinics and also had IFA were less likely to experience neonatal, postnatal and child mortality. Chapter 8 presents the factors associated with under-5 mortality.

CHAPTER 8

PREVALENCE AND FACTORS ASSOCIATED WITH UNDER-5 MORTALITY

8.0 Introduction

In this chapter, results of the fourth research question are presented. This is a peer-reviewed publication in BMJ Open journal [1]. That publication covered BDHS for the years 2004, 2007 and 2011. This chapter incorporates the most recent BDHS (2014). Prevalence of neonatal, post-neonatal, child and under-5 mortality are discussed. Further, community-level factors, socio-economic determinants, media factors, proximate determinants, and health services factors that are significantly associated with neonatal mortality, post-neonatal mortality, infant mortality, child mortality and under-5 mortality in Bangladesh are assessed.

8.1 Basic characteristics of the study participants

Table 8.1 summarises the basic characteristics of the study variables. A total sample of 22969 mothers was featured in this study. The study variables were categorised into community level factors, socio-economic determinants, media factors, child determinants and service factors. Community level factors were type of residence (urban/rural) and geographical region (Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet).

There was a weighted total of 5462 urban mothers, constituting a weighted proportion of 23.8%. The proportion of urban mothers was 20.6%, 21.1%, 24.7% and 27.6% in 2004, 2007, 2011 and 2014 respectively. The weighted total of mothers who resided in rural areas was 17507, representing 76.2%. The proportion of rural mothers in 2004, 2007, 2011 and 2014 was 79.4%, 78.9%, 75.3% and 72.4% respectively. The greatest proportion of mothers in all the four surveys was from the Dhaka administrative region, with a weighted average proportion of 34.7%, whilst the lowest proportion was from the Barisal region, with a weighted average proportion of 6.4%.

Over the four survey periods, a large proportion of mothers (98%) were currently married, with only 2% being formerly married. A large majority of mothers (91.9%) belonged to the Islamic faith. Approximately half of mothers (49%) were aged between 15 and 24 years, whilst mothers

aged 35-49 years formed the minority (9.5%), with mothers aged 25-34 years lying in between (41.5%). More than half of mothers (53.8%) got their first child when they were aged 20-29 years. Non-working mothers were almost four times more than working mothers (78.4% against 21.6%).

Table 8.1:
Characteristics of variables (n = 22969)

VARIABLE	n	n*	%*	Prevalence (%)			
				2004	2007	2011	2014
THE MOST RECENT BIRTH WITHIN THE LAST 5 YEARS							
COMMUNITY LEVEL FACTORS							
Cluster type							
Urban	7407	5462	23.8	20.6	21.1	24.7	27.6
Rural	15027	17507	76.2	79.4	78.9	75.3	72.4
Geographical region							
Barisal	2919	1476	6.4	6.2	6.4	6.6	6.5
Chittagong	4718	5154	22.4	20.6	20.9	24.3	23.3
Dhaka	4656	7979	34.7	30.9	31.8	35.4	39.7
Khulna	2981	2352	10.2	11.2	10.2	10.9	8.8
Rajshahi	3691	4107	17.9	23.8	22.9	15.2	11.7
Sylhet	3469	1902	8.3	7.4	7.8	7.7	10.0
SOCIOECONOMIC DETERMINANTS							
Maternal marital status							
Married	21982	22514	98.0	97.5	97.7	98.3	98.4
Formerly Married	452	455	2.0	2.5	2.3	1.7	1.6
Religion							
Islam	20498	21116	91.9	91.8	91.4	92.6	91.8
Others	1934	1848	8.0	8.2	8.6	7.4	8.2
Mother's Age (years)							
15-24	10819	11262	49.0	49.6	49.9	49.0	47.8
25-34	9377	9527	41.5	40.0	39.5	41.7	44.1
35-49	2221	2174	9.5	10.3	10.6	9.3	8.1
Mothers age at child's birth (years)							
less than 20	6530	6903	30.1	30.6	30.0	28.9	30.2
20 - 29	12147	12357	53.8	51.7	53.4	56.0	55.0
30 - 39	3480	3436	15.0	16.0	15.3	14.0	14.0
40+	277	273	1.2	1.7	1.3	1.1	0.8
Maternal working status							
Not working	17805	17997	78.4	81.6	69.7	88.4	71.8
working	4627	4970	21.6	18.4	30.3	11.5	28.2
Mother's BMI (kg/m^2)							
<=18.5	4837	4933	21.5	28.3	23.3	19.7	16.1
18-25	14421	15031	65.4	65.0	67.4	65.6	64.2
25+	3060	2896	12.6	5.7	9.3	14.7	19.0
Mother's occupation							

Non-agriculture	2817	2760	12.0	12.6	14.5	9.1	12.7
Agriculture	1528	1906	8.3	5.8	15.7	0.4	12.8
Not working	17820	18011	78.4	81.5	69.8	88.5	72.0
Husband's occupation							
Non-agriculture	16649	16486	71.8	67.3	68.4	73.6	76.4
Agriculture	5149	5838	25.4	29.8	28.5	23.9	20.8
Not working	636	644	2.8	2.9	3.1	2.6	2.7
Both Parents' employment							
Father only working	17287	17479	76.1	79.2	67.3	86.2	69.8
Both working	4247	4560	19.9	17.9	29.7	9.2	25.0
Neither working	900	930	4.0	2.9	3.1	4.6	5.2
Maternal highest level of education							
No schooling	9312	9851	42.9	57.8	47.6	37.0	32.5
Primary	9962	10218	44.5	34.7	38.9	50.2	51.4
Secondary or more	3145	2888	12.6	7.5	13.3	12.8	16.1
Paternal highest level of education							
No schooling	10497	11135	48.5	56.7	53.1	44.5	42.0
Primary	7538	7678	33.4	29.7	28.7	36.1	37.6
Secondary or more	4383	4138	18.0	13.6	18.0	19.3	20.4
Wealth Index							
Rich	4809	4302	18.7	13.6	15.2	20.3	24.3
Middle	8734	8988	39.1	44.9	35.5	40.2	36.0
Poor	8891	9679	42.1	41.5	49.4	39.6	39.7
MEDIA FACTORS							
Mother watched television every week							
Yes	13094	13242	57.7	53.8	56.7	61.4	60.2
No	9337	9724	42.3	46.2	43.3	38.6	39.9
Mother listened to radio every week							
Yes	4374	4548	19.8	44.8	25.5	10.0	4.6
No	18055	18417	80.2	55.1	74.5	90.0	95.4
Mother read newspaper							
Yes	3819	3545	15.4	16.1	15.7	16.2	14.8
No	18599	19409	84.5	83.9	84.3	83.8	85.0
PROXIMATE DETERMINANTS							
Sex							
Male	11550	11852	51.6	51.0	51.1	51.7	52.9
Female	10884	11117	48.4	49.0	48.9	48.3	47.1
Previous death of sibling							
No	21941	22468	97.8	96.1	97.4	98.4	99.1
Yes	493	501	2.2	4.0	2.6	1.6	0.9
Number of children under-5							
1–2	15655	16138	70.3	63.9	69.5	71.8	74.7
3+	6779	6831	29.7	36.1	30.5	28.2	25.3
Breastfeeding							
Never	2411	2487	10.8	1.3	1.4	1.7	35.9
Yes	20023	20481	89.2	98.7	98.6	98.3	64.1
Birth rank and birth interval							
2nd/3rd birth rank, more than 2 years interval	8701	8991	39.1	36.4	38.5	41.3	40.9
1st birth rank	7422	7584	33.0	27.8	31.4	33.7	37.5

2nd/3rd birth rank, less than or equal to 2 years interval	1439	1466	6.4	7.4	6.6	6.1	5.7
4th birth rank, more than 2 years interval	4043	4120	17.9	23.1	19.5	16.0	13.7
4th birth rank, less than or equal to 2 years interval	829	808	3.5	5.3	4.0	2.9	2.3
HEALTH SERVICE FACTORS							
Desire for previous pregnancy							
Then	14330	14689	64.0	68.6	69.5	70.6	49.0
Later	3242	3213	14.0	15.9	15.5	15.4	9.9
Not at all	2843	2968	12.9	15.5	14.9	14.1	7.5
Contraceptive use							
No	8433	8611	37.5	41.8	41.6	35.4	32.8
Yes	14001	14358	62.5	58.2	58.4	64.6	67.2
Delivery complications							
None	15404	16027	69.8	58.2	67.5	69.7	75.9
Any complications	7029	6940	30.2	41.8	32.5	30.3	24.1
Birth attendance							
TBA/other untrained/none	15154	15967	69.5	86.4	78.4	69.6	45.8
Health professional	7280	7002	30.5	13.7	21.6	30.4	54.2
Number of ANC visits							
None	7158	7582	33.0	44.2	39.8	36.5	14.4
1-3 times	8394	8700	37.9	39.8	39.5	40.7	32.0
4+ times	4846	4572	19.9	15.9	20.6	22.7	19.9
Tetanus toxoid during pregnancy							
Never	3581	3573	21.4	14.9	17.5	29.7	NA
One TT	3660	3731	22.3	21.3	22.7	22.9	NA
2+ TT	9230	9385	56.1	63.7	59.7	47.2	NA
Combined place and mode of delivery							
Health facility without Caesarean	1844	1633	7.1	6.9	7.7	6.9	7.7
Health facility with Caesarean	2563	2463	10.7	3.9	8.5	13.3	15.7
Home	17473	18297	79.7	89.2	83.7	73.4	74.2

*Weighted for the sampling probability

n* weighted 'n'

The majority of mothers (65.4%) had a body mass index (BMI) of between 18 and 25 kgm^{-2}, whilst 12.6% of them had a BMI higher than 25 kg/m^2. More than three-quarters (78.4%) of mothers were unemployed, and just 8.3% worked in an agricultural industry. Whilst only 2.8% of fathers were unemployed, as high as seven in every ten of them worked in industries that were not agriculture-related. Only 12.6% of mothers had secondary education or higher with about 43% (42.9%) having no schooling. Almost one half of fathers (48.5%) had no schooling, and only 18% of them had secondary education or higher. More than three-quarters (76.1%) of

households had only fathers in paid employment; 42.3% of the households were poor, with only 18.7% being rich.

A relatively higher proportion of mothers (57.7%) reported watching television every week, as against 44.7% of them who did not watch television at all. A higher proportion of mothers (80.2%) did not listen to the radio every week, while 19.8% did. In the same fashion, a high proportion of mothers (84.5%) did not read the newspaper every week whilst 15.4% of them did.

Female (48.4%) and male (51.6%) were almost equally represented. The majority of children (39.1%) were either second or third born, with two years interval, whilst only 3.5% were fourth born, with an interval of one year or less. A large majority of children (97.8%) had no previous dead sibling, with only 2.2% having previous dead siblings. Whilst about 89% of mothers reported ever breastfeeding their infants, about 11% of them never did. More than two-thirds of mothers (64%) had desired for pregnancy whilst about 13% never had any desire for a pregnancy. The majority of mothers (62.5%) had used contraceptives, whilst 37.5% never did. About seven in every ten mothers (69.8) had never experienced any delivery complications, whilst about 30% (30.2%) of them reported experiencing some delivery complications. Nearly 70% of mothers delivered with assistance from traditional birth attendants (TBA) and other non-health personnel, with only 30.5% delivering with assistance from health professionals. The majority of pregnant mothers (37.9%) had between one and three antenatal care visits whilst 19.9% of them had none. More than half of the mothers received at least two tetanus toxoid vaccinations during their pregnancy, whilst 21.4% of them never had. Most mothers (79.7%) delivered their babies at home, and 7% of them delivered their babies at a health facility without caesarean operation.

8.2 Prevalence of neonatal, post-neonatal and infant mortality

Table 8.2 summarises the prevalence and the unadjusted odds ratios with their 95% confidence interval (CI) of neonatal, post-neonatal and infant mortality.

Among the administrative regions of Bangladesh, neonatal mortality was found to most prevalent in the Sylhet region [Prevalence (P) = 2.99; 95% confidence interval (CI): (2.33, 3.83), p-value (p) = 0.001]. Similarly, the Sylhet region reported the most prevalent of infant mortality [P = 4.32; 95% CI: (3.49, 5.34)]. Neonatal mortality, post-neonatal mortality and infant mortality were all significantly more prevalent among formerly married mothers than among currently married ones [P = 3.43; 95% CI: (1.93, 6.02), p = 0.024 (neonatal), P = 2.02; 95% CI: (1.09, 3.71), p = 0.002 (post-neonatal) and P = 5.46; 95% CI: (3.53, 8.34), p < 0.001(infant)]. Neonatal mortality, post-neonatal mortality and infant mortality were all also significantly most prevalent among mothers of the relatively oldest age bracket (35-49 years) [P = 2.32; 95% CI: (1.71, 3.15), p = 0.024 (neonatal), P = 1.49; 95% CI: (1.03, 2.17), p < 0.001 (post-neonatal) and P = 3.82; 95% CI: (3.03, 4.80), p = 0.003(infant)]. Post-neonatal mortality and infant mortality were both significantly most prevalent among mothers who were aged forty or older when they gave birth [P = 2.68; 95% CI: (1.23, 5.73), p < 0.001 (post-neonatal), and P = 5.23; 95% CI: (2.99, 8.93), p < 0.001(infant)]. In addition, post-neonatal mortality and infant mortality were both significantly more prevalent among working mothers than non-working ones [P = 1.14; 95% CI: (0.86, 1.52), p = 0.004 (post-neonatal), and P = 3.24; 95% CI: (2.74, 3.82), p = 0.003(infant)]. Prevalence of post-neonatal mortality was significantly highest among mothers who worked in an agricultural-related industry [P = 1.33; 95% CI: (0.95, 1.84), p = 0.011]; and infant mortality was most prevalent among mothers who worked in an agricultural sector [P = 3.42; 95% CI: (2.79, 4.18), p = 0.023. Prevalence of post-neonatal mortality and infant mortality were significantly higher in households where both parents were in paid employment [P = 1.13; 95% CI: (0.83, 1.52), p = 0.044 (post-neonatal) and [P = 3.14;

95% CI: (2.63, 3.74), p = 0.040 (infant)]. 0.71; 95% CI: (0.62, 0.80), p < 0.001]. Neonatal mortality, post-neonatal mortality and infant mortality were all significantly most prevalent among mothers who had no formal education [P = 2.06; 95% CI: (1.78, 2.40), p = 0.011 (neonatal), [P = 1.21; 95% CI: (0.99, 1.49), p < 0.001 (post-neonatal), and P = 3.28; 95% CI: (2.91, 3.69), p < 0.001(infant)]. Prevalence of neonatal, post-neonatal and infant mortalities among fathers who had no formal education followed a similar pattern. Post-neonatal mortality and infant mortality were both significantly most prevalent among mothers of poor households [P = 1.01; 95% CI: (0.80, 1.27), p = 0.026 (post-neonatal), and P = 3.04; 95% CI: (2.66, 3.46), p = 0.003(infant)].

Post-neonatal mortality and infant mortality were both significantly more prevalent among mothers who did not watch any television than those who did [P = 1.07; 95% CI: (0.85, 1.33), p = 0.001 (post-neonatal), and P = 3.09; 95% CI: (2.72, 3.51), p < 0.001(infant)]. Post-neonatal mortality was significantly more prevalent among mothers who did not read any newspapers than those who did [P = 0.89; 95% CI: (0.75, 1.06), p < 0.001]. Similarly, infant mortality was significantly more prevalent among mothers who did not read newspapers than those who did [P = 2.74; 95% CI: (2.49, 3.02), p = 0.003].

Neonatal mortality, post-neonatal mortality and infant mortality were significantly more prevalent among mothers who had previously lost a child before the current birth than those who did not [P = 10.36; 95% CI: (7.79, 13.65), p < 0.001 (neonatal), [P = 5.99; 95% CI: (3.99, 8.91), p < 0.001 (post-neonatal), and P = 16.35; 95% CI: (13.07, 20.26), p < 0.001(infant)]. Furthermore, prevalence of neonatal, post-neonatal and infant mortalities was highest among mothers who had 1-2 children than those who had three or more children [P = 2.39; 95% CI: (2.13, 2.68), p < 0.01 (neonatal), [P = 1.04; 95% CI: (0.87, 1.24), p < 0.001 (post-neonatal), and P = 3.43; 95% CI: (3.11, 3.77), p < 0.001(infant)]. Neonatal mortality, post-neonatal mortality and infant mortality were all significantly most prevalent among mothers who had

fourth birth rank children with two years birth interval or less [P = 3.01; 95% CI: (1.86, 4.82), p < 0.001 (neonatal), [P = 2.81; 95% CI: (1.76, 4.45), p < 0.001 (post-neonatal), and P = 5.82; 95% CI: (4.18, 8.03), p < 0.001(infant)]. Post-neonatal was significantly most prevalent among mothers who did not desire for a pregnancy [P = 1.31; 95% CI: (0.91, 1.88), p = 0.010]. It was also significantly more prevalent among mothers who did not experience any delivery complications than those who did [P = 0.89; 95% CI: (0.74, 1.07), p = 0.016]. Neonatal mortality, post-neonatal mortality and infant mortality were all significantly more prevalent among mothers who did not use any contraceptives than those who did [P = 3.10; 95% CI: (2.72, 3.54), p < 0.001 (neonatal), [P = 1.29; 95% CI: (1.04, 1.59), p < 0.001 (post-neonatal), and P = 4.39; 95% CI: (3.94, 4.89), p < 0.001(infant)]. Neonatal mortality was significantly more prevalent among mothers who delivered their babies with assistance from a health professional than those who were assisted by traditional birth attendants or other non-health personnel [P = 2.13; 95% CI: (1.77, 2.56), p = 0.028], whilst post-neonatal mortality was significantly more prevalent among mothers who delivered their babies with assistance from a traditional birth attendant or other non-health personnel than those who were assisted by a health professional [P = 0.92; 95% CI: (0.77, 1.11), p = 0.003]. Post-neonatal mortality and infant mortality were both significantly most prevalent among mothers who did not attend any antenatal clinics than those who did [P = 1.27; 95% CI: (1.01, 1.59), p < 0.001 (post-neonatal), and P = 3.38; 95% CI: (2.93, 3.90), p = 0.001(infant)]. Post-neonatal mortality was significantly most prevalent among mothers who delivered their babies at home [P = 0.88; 95% CI: (0.74, 1.05), p = 0.021], whilst neonatal mortality was significantly most prevalent among mothers who delivered their babies at a health facility without caesarean operation [P = 2.50; 95% CI: (1.77, 3.52), p = 0.012].

Table 8.2:
Prevalence and 95% confidence intervals of Neonatal, post-neonatal and infant mortality, Bangladesh (2004-2014)

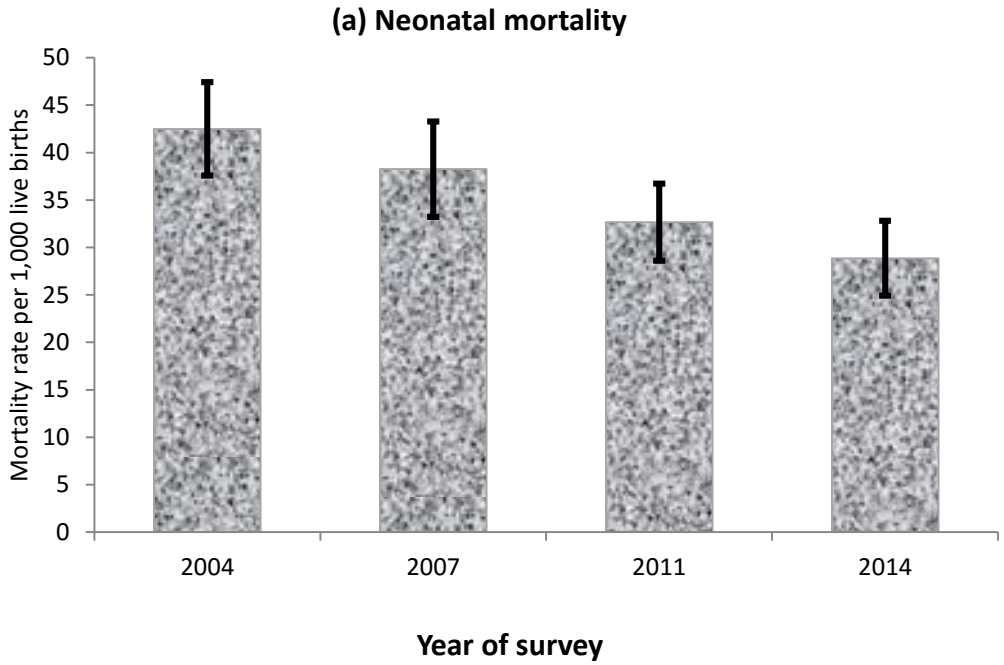
VARIABLE	Neonatal Mortality (0-30 days), n=413		p-value	Post-neonatal mortality (1–11 months), n=182		p-value	Infant mortality (0–11 months), n=595		p-value
	%	(95% CI)		%	(95% CI)		%	(95% CI)	
COMMUNITY LEVEL FACTORS									
Cluster type									
Urban	1.60	[1.28,2.00]		0.79	[0.58,1.08]		2.39	[2.00,2.86]	
Rural	1.86	[1.64,2.12]	0.259	0.79	[0.65,0.97]	0.975	2.65	[2.38,2.96]	0.331
Geographical region									
Barisal	1.40	[1.01,1.95]		0.85	[0.59,1.24]		2.26	[1.76,2.88]	
Chittagong	1.43	[1.14,1.81]		0.70	[0.49,1.01]		2.13	[1.77,2.57]	
Dhaka	1.83	[1.47,2.26]		0.86	[0.63,1.17]		2.68	[2.24,3.21]	
Khulna	1.47	[1.10,1.98]	0.001	0.46	[0.23,0.92]	0.069	1.93	[1.49,2.51]	<0.001
Rajshahi	1.98	[1.53,2.56]		0.69	[0.46,1.04]		2.68	[2.17,3.29]	
Sylhet	2.99	[2.33,3.83]		1.33	[0.91,1.94]		4.32	[3.49,5.34]	
SOCIOECONOMIC DETERMINANTS									
Maternal marital status									
Married	1.77	[1.58,1.98]		0.77	[0.64,0.91]		2.53	[2.30,2.78]	
Formerly Married	3.43	[1.93,6.02]	0.024	2.02	[1.09,3.71]	0.002	5.46	[3.53,8.34]	<0.001
Maternal religion									
Islam	1.83	[1.63,2.06]		0.79	[0.67,0.95]		2.63	[2.39,2.89]	
Others	1.44	[0.96,2.14]	0.354	0.76	[0.41,1.41]	0.900	2.20	[1.56,3.09]	0.326
Mother's Age (years)									
15-24	1.96	[1.67,2.29]		0.60	[0.46,0.78]		2.56	[2.24,2.92]	
25-34	1.50	[1.24,1.80]	0.024	0.86	[0.67,1.11]	<0.001	2.35	[2.03,2.73]	0.003
35-49	2.32	[1.71,3.15]		1.49	[1.03,2.17]		3.82	[3.03,4.80]	
Mothers age at child's birth (years)									
less than 20	1.91	[1.56,2.34]		0.61	[0.44,0.86]		2.53	[2.13,3.00]	
20-29	1.58	[1.35,1.85]	0.065	0.70	[0.55,0.89]	<0.001	2.28	[2.00,2.61]	<0.001
30-39	2.31	[1.78,2.99]		1.31	[0.94,1.82]		3.62	[2.96,4.41]	
40+	2.55	[1.11,5.75]		2.68	[1.23,5.73]		5.23	[2.99,8.98]	

Maternal working status									
Not working	1.72	[1.52,1.95]		0.69	[0.57,0.85]		2.41	[2.17,2.68]	
Working	2.09	[1.68,2.60]	0.114	1.14	[0.86,1.52]	0.004	3.24	[2.74,3.82]	0.003
Mother's BMI (kg/m^2)									
<=18.5	1.60	[1.25,2.06]		0.89	[0.64,1.24]		2.49	[2.03,3.05]	
18-25	1.88	[1.64,2.15]	0.547	0.80	[0.65,0.98]	0.466	2.67	[2.39,2.99]	0.682
25+	1.81	[1.34,2.43]		0.60	[0.36,1.01]		2.41	[1.87,3.10]	
Mother's occupation									
Non-agriculture	2.09	[1.59,2.75]		1.33	[0.95,1.84]		2.72	[1.94,3.80]	
Agriculture	1.81	[1.17,2.77]	0.507	0.91	[0.50,1.68]	0.011	3.42	[2.79,4.18]	0.023
Not working	1.73	[1.53,1.96]		0.69	[0.57,0.85]		2.42	[2.18,2.69]	
Husband's occupation									
Non-agriculture	1.71	[1.49,1.95]		0.75	[0.62,0.92]		2.46	[2.21,2.75]	
Agriculture	2.08	[1.69,2.57]	0.249	0.88	[0.63,1.25]	0.732	2.97	[2.48,3.54]	0.204
Not working	1.62	[0.86,3.04]		0.87	[0.30,2.53]		2.50	[1.44,4.32]	
Both Parents' employment									
Father only working	1.72	[1.52,1.96]		0.70	[0.57,0.86]		2.42	[2.18,2.70]	
Both working	2.01	[1.60,2.53]	0.367	1.13	[0.83,1.52]	0.044	3.14	[2.63,3.74]	0.040
Neither working	2.20	[1.34,3.58]		0.85	[0.36,2.00]		3.05	[2.00,4.64]	
Maternal highest level of education									
No schooling	2.06	[1.78,2.40]		1.21	[0.99,1.49]		3.28	[2.91,3.69]	
Primary	1.74	[1.47,2.06]	0.011	0.54	[0.41,0.73]	<0.001	2.28	[1.97,2.64]	<0.001
Secondary or more	1.11	[0.75,1.65]		0.22	[0.10,0.49]		1.34	[0.94,1.90]	
Paternal highest level of education									
No schooling	2.07	[1.79,2.40]		1.11	[0.90,1.37]		3.18	[2.82,3.58]	
Primary	1.72	[1.40,2.10]	0.010	0.66	[0.49,0.89]	<0.001	2.38	[2.01,2.81]	<0.001
Secondary or more	1.23	[0.89,1.69]		0.18	[0.10,0.36]		1.41	[1.06,1.89]	
Wealth Index									
Rich	1.38	[1.04,1.83]		0.58	[0.38,0.91]		1.96	[1.55,2.49]	
Middle	1.75	[1.47,2.09]	0.058	0.66	[0.49,0.89]	0.026	2.41	[2.07,2.81]	0.003
Poor	2.03	[1.72,2.39]		1.01	[0.80,1.27]		3.04	[2.66,3.46]	
MEDIA FACTORS									
Mother watched television every week									
Yes	1.63	[1.41,1.89]		0.59	[0.46,0.76]		2.22	[1.96,2.52]	
No	2.03	[1.72,2.39]	0.054	1.07	[0.85,1.33]	0.001	3.09	[2.72,3.51]	<0.001

Mother listened to radio every week									
Yes	2.13	[1.72,2.65]		0.92	[0.65,1.28]		3.05	[2.53,3.67]	
No	1.72	[1.51,1.95]	0.085	0.76	[0.63,0.92]	0.345	2.48	[2.23,2.75]	0.054
Mother read newspaper									
Yes	1.54	[1.15,2.05]		0.25	[0.13,0.49]		1.79	[1.38,2.33]	
No	1.85	[1.64,2.08]	0.247	0.89	[0.75,1.06]	<0.001	2.74	[2.49,3.02]	0.003
PROXIMATE DETERMINANTS									
Sex									
Male	1.66	[1.41,1.96]		0.70	[0.55,0.90]		2.63	[2.31,2.99]	
Female	1.93	[1.65,2.25]	0.210	0.89	[0.71,1.11]	0.152	2.55	[2.23,2.91]	0.758
Previous death of sibling									
No	1.61	[1.43,1.81]		0.68	[0.56,0.81]		2.28	[2.07,2.52]	
Yes	10.36	[7.79,13.65]	<0.001	5.99	[3.99,8.91]	<0.001	16.35	[13.07,20.26]	<0.001
Number of children under-5									
1–2	2.39	[2.13,2.68]		1.04	[0.87,1.24]		3.43	[3.11,3.77]	
3+	0.41	[0.28,0.61]	<0.001	0.20	[0.12,0.34]	<0.001	0.61	[0.45,0.84]	<0.001
Breastfeeding									
Never	10.30	[8.89,11.91]		1.39	[0.95,2.03]		11.69	[10.20,13.36]	
Yes	0.77	[0.64,0.91]	<0.001	0.72	[0.60,0.87]	<0.001	1.49	[1.30,1.69]	<0.001
Birth rank and birth interval									
2nd/3rd birth rank, more than 2 years interval	1.29	[1.06,1.57]		0.63	[0.46,0.85]		1.92	[1.62,2.26]	
1st birth rank	2.06	[1.71,2.48]		0.54	[0.38,0.77]		2.61	[2.21,3.08]	
2nd/3rd birth rank, less than or equal to 2 years interval	2.59	[1.79,3.73]	<0.001	0.73	[0.37,1.44]	<0.001	3.32	[2.40,4.56]	<0.001
4th birth rank, more than 2 years interval	1.92	[1.52,2.42]		1.23	[0.92,1.64]		3.15	[2.61,3.78]	
4th birth rank, less than or equal to 2 years interval	3.01	[1.86,4.82]		2.81	[1.76,4.45]		5.82	[4.19,8.03]	
Desire for previous pregnancy									
Then	2.00	[1.75,2.29]		0.80	[0.65,0.99]		2.80	[2.50,3.13]	
Later	1.45	[1.06,1.97]	0.144	0.56	[0.36,0.89]	0.010	2.01	[1.56,2.59]	0.052
Not at all	1.71	[1.25,2.33]		1.31	[0.91,1.88]		3.02	[2.38,3.83]	
Delivery complications									
None	1.82	[1.60,2.07]		0.89	[0.74,1.07]		2.71	[2.44,3.01]	
Any complications	1.75	[1.41,2.17]	0.744	0.54	[0.37,0.78]	0.016	2.29	[1.90,2.75]	0.118
Contraceptive use									
No	3.10	[2.72,3.54]		1.29	[1.04,1.59]		4.39	[3.94,4.89]	
Yes	1.02	[0.84,1.24]	<0.001	0.49	[0.38,0.64]	<0.001	1.51	[1.29,1.77]	<0.001

Birth attendance									
TBA/other untrained/none	1.65	[1.44,1.90]		0.92	[0.77,1.11]		2.58	[2.31,2.88]	
Health professional	2.13	[1.77,2.56]	0.028	0.49	[0.33,0.72]	0.003	2.63	[2.23,3.08]	0.848
Number of ANC visits									
None	2.11	[1.76,2.53]		1.27	[1.01,1.59]		3.38	[2.93,3.90]	
1-3 times	1.79	[1.51,2.13]	0.233	0.63	[0.46,0.85]	<0.001	2.42	[2.09,2.80]	0.001
4+ times	1.64	[1.24,2.16]		0.52	[0.34,0.79]		2.16	[1.71,2.73]	
Combined place and mode of delivery									
Health facility without caesarean	2.50	[1.77,3.52]		0.57	[0.29,1.13]		3.07	[2.27,4.13]	
Health facility with caesarean	2.35	[1.76,3.13]	0.012	0.38	[0.20,0.71]	0.021	2.73	[2.10,3.55]	0.441
Home	1.65	[1.45,1.87]		0.88	[0.74,1.05]		2.53	[2.28,2.80]	
Total	1.80	[1.61,2.01]		0.79	[0.67,0.94]		2.59	[2.36,2.84]	

Figure 8.1 (a-c) shows the variation of neonatal mortality, post-neonatal mortality and infant mortality with the different years of survey. The figures show a significant decline in the mortality rates.



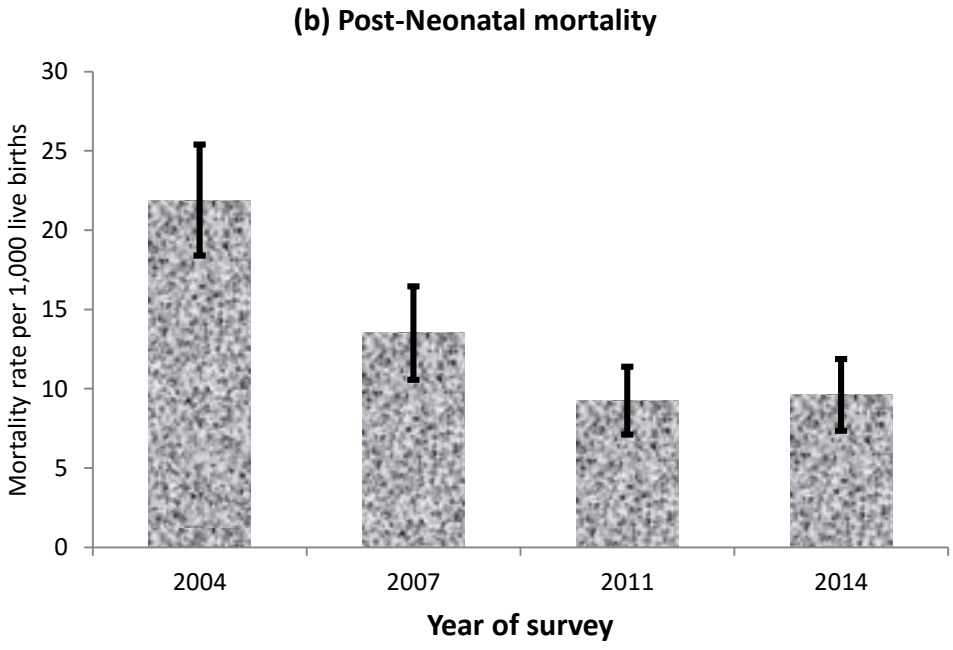


Figure 8.1: Neonatal (a), post-neonatal (b), and infant (c) mortality rates per 1000 live births in Bangladesh (2004-2014)

8.3 Prevalence of child and under-5 mortality

Table 8.3 summarises the prevalence of child mortality and under-5 mortality over for DHS periods (2004, 2007, 2011 and 2014). Among Bangladesh's geographical region, under-5 mortality was significantly most prevalent among mothers who lived in the Sylhet region [P = 4.61; 95% CI: (3.77, 5.61), p < 0.001]. Both child mortality and under-5 mortality were significantly more prevalent among formerly married mothers [P = 2.01; 95% CI: (0.99, 4.03), p < 0.001 (child), and P = 7.47; 95% CI: (5.17, 10.67), p < 0.001(under-5)]. Under-5 mortality was significantly most prevalent among mothers who were aged 35-49 years at the time of the surveys [P = 4.41; 95% CI: (3.55, 5.45), p = 0.001]. It was also significantly most prevalent among mothers who were aged 40 years or older at the birth of the child [P = 5.65; 95% CI: (3.19, 9.82), p < 0.001]. Prevalence of both child mortality and under-5 mortality was significantly among working mothers than non-working ones [P = 0.53; 95% CI: (0.34, 0.83), p = 0.014 (child), and P = 3.77; 95% CI: (3.22, 4.40), p < 0.001(under-5)]. Child mortality and under-5 mortality were significantly most prevalent among mothers who worked in a non-

agricultural sector [P = 0.64; 95% CI: (0.38, 1.06), p = 0.026 (child), and P = 4.06; 95% CI: (3.38, 4.87), p = 0.003 (under-5)]. The prevalence of under-5 mortality was highest in households where both parents were employed [P = 3.64; 95% CI: (3.10, 4.27), p = 0.006]. Child mortality and under-5 mortality were significantly most prevalent among mothers who had no formal education [P = 0.39; 95% CI: (0.28, 0.55), p = 0.042 (child) and P = 3.67; 95% CI: (3.28, 4.11), p < 0.001 (under-5)].

Table 8.3:
Prevalence and 95% confidence intervals (CI) of child and under-five mortality, Bangladesh (2004-2014)

VARIABLE	Child Mortality (1-4 years), n=74		P-value	Under-five mortality (0-5 years), n=669		P-value
	%	(95% CI)		%	(95% CI)	
COMMUNITY LEVEL FACTORS						
Cluster type						
Urban	0.27	[0.15,0.47]		2.66	[2.25,3.15]	
Rural	0.34	[0.25,0.46]	0.476	2.99	[2.70,3.31]	0.243
Geographical region						
Barisal	0.29	[0.14,0.59]		2.55	[2.01,3.22]	
Chittagong	0.48	[0.29,0.77]		2.61	[2.18,3.12]	
Dhaka	0.25	[0.14,0.45]		2.94	[2.47,3.49]	
Khulna	0.20	[0.09,0.46]	0.300	2.13	[1.66,2.74]	<0.001
Rajshahi	0.36	[0.21,0.64]		3.04	[2.50,3.69]	
Sylhet	0.29	[0.14,0.58]		4.61	[3.77,5.61]	
SOCIOECONOMIC DETERMINANTS						
Maternal marital status						
Married	0.29	[0.22,0.38]		2.82	[2.58,3.09]	
Formerly Married	2.01	[0.99,4.03]	<0.001	7.47	[5.17,10.67]	<0.001
Maternal religion						
Islam	0.33	[0.25,0.43]		2.95	[2.70,3.23]	
Others	0.29	[0.11,0.74]	0.803	2.49	[1.80,3.43]	0.318
Mother's Age (years)						
15-24	0.24	[0.16,0.38]		2.80	[2.47,3.18]	
25-34	0.36	[0.24,0.52]	0.062	2.71	[2.36,3.11]	0.001
35-49	0.59	[0.32,1.10]		4.41	[3.55,5.45]	
Mothers age at child's birth (years)						
less than 20	0.23	[0.13,0.41]		2.76	[2.35,3.25]	
20 - 29	0.33	[0.23,0.47]	0.277	2.61	[2.30,2.95]	<0.001
30 - 39	0.49	[0.29,0.83]		4.11	[3.42,4.92]	
40+	0.42	[0.06,2.91]		5.65	[3.19,9.82]	
Maternal working status						
Not working	0.27	[0.19,0.37]		2.68	[2.42,2.96]	
Working	0.53	[0.34,0.83]	0.014	3.77	[3.22,4.40]	<0.001
Mother's BMI (kg/m^2)						

<=18.5	0.36	[0.21,0.63]		2.85	[2.36,3.45]	
18-25	0.30	[0.22,0.42]	0.836	2.98	[2.68,3.31]	0.835
25+	0.36	[0.16,0.81]		2.77	[2.16,3.54]	
Mother's occupation						
Non-agriculture	0.64	[0.38,1.06]		4.06	[3.38,4.87]	
Agriculture	0.46	[0.19,1.12]	0.026	3.18	[2.29,4.41]	0.003
Not working	0.27	[0.19,0.37]		2.69	[2.43,2.97]	
Husband's occupation						
Non-agriculture	0.28	[0.20,0.39]		2.75	[2.47,3.05]	
Agriculture	0.39	[0.24,0.63]	0.223	3.35	[2.83,3.97]	0.132
Not working	0.74	[0.21,2.52]		3.24	[1.95,5.34]	
Both Parents' employment						
Father only working	0.27	[0.19,0.38]		2.69	[2.43,2.98]	
Both working	0.50	[0.31,0.79]	0.110	3.64	[3.10,4.27]	0.006
Neither working	0.51	[0.15,1.74]		3.56	[2.39,5.28]	
Maternal highest level of education						
No schooling	0.39	[0.28,0.55]		3.67	[3.28,4.11]	
Primary	0.34	[0.22,0.51]	0.042	2.62	[2.28,3.01]	<0.001
Secondary or more	0.04	[0.01,0.30]		1.38	[0.98,1.94]	
Paternal highest level of education						
No schooling	0.37	[0.26,0.52]		3.55	[3.17,3.97]	
Primary	0.33	[0.21,0.53]	0.312	2.71	[2.31,3.17]	<0.001
Secondary or more	0.19	[0.09,0.41]		1.60	[1.21,2.12]	
Wealth Index						
Rich	0.21	[0.09,0.47]		2.17	[1.71,2.75]	
Middle	0.34	[0.22,0.51]	0.465	2.75	[2.38,3.17]	0.002
Poor	0.36	[0.24,0.53]		3.40	[3.00,3.85]	
MEDIA FACTORS						
Mother watched television every week						
Yes	0.25	[0.17,0.37]		2.47	[2.19,2.79]	
No	0.42	[0.30,0.61]	0.054	3.52	[3.11,3.97]	<0.001
Mother listened to radio every week						
Yes	0.40	[0.24,0.68]		3.46	[2.89,4.12]	
No	0.30	[0.23,0.41]	0.323	2.78	[2.52,3.07]	0.035
Mother read newspaper						
Yes	0.19	[0.07,0.52]		1.98	[1.52,2.57]	
No	0.35	[0.27,0.46]	0.239	3.09	[2.82,3.38]	0.001
PROXIMATE DETERMINANTS						
Sex						
Male	0.28	[0.19,0.42]		2.92	[2.58,3.30]	
Female	0.37	[0.26,0.53]	0.350	2.91	[2.57,3.29]	0.977
Previous death of sibling						
No	0.24	[0.18,0.32]		2.52	[2.29,2.77]	
Yes	4.17	[2.51,6.84]	<0.001	20.52	[16.87,24.71]	<0.001
Number of children under-5						
1–2	0.45	[0.34,0.58]		3.88	[3.54,4.24]	
3+	0.03	[0.01,0.12]	<0.001	0.64	[0.47,0.87]	<0.001
Breastfeeding						
Never	0.75	[0.43,1.32]		12.44	[10.88,14.20]	
Yes	0.27	[0.20,0.37]	0.001	1.76	[1.56,1.98]	<0.001
Birth rank and birth interval						
2nd/3rd birth rank, more than 2 years interval	0.30	[0.19,0.46]		2.21	[1.90,2.58]	
1st birth rank	0.17	[0.09,0.29]		2.77	[2.36,3.25]	
2nd/3rd birth rank, less than or equal to 2 years interval	0.66	[0.29,1.47]	0.005	3.97	[2.95,5.32]	<0.001

4th birth rank, more than 2 years interval	0.45	[0.26,0.76]		3.59	[3.02,4.26]	
4th birth rank, less than or equal to 2 years interval	0.83	[0.36,1.89]		6.65	[4.91,8.95]	
Desire for previous pregnancy						
Then	0.27	[0.19,0.38]		3.07	[2.76,3.42]	
Later	0.49	[0.27,0.86]	0.166	2.50	[1.99,3.14]	0.160
Not at all	0.41	[0.21,0.78]		3.43	[2.74,4.30]	
Delivery complications						
none	0.41	[0.31,0.54]		3.12	[2.83,3.44]	
any complications	0.13	[0.06,0.26]	0.002	2.41	[2.02,2.89]	0.012
Contraceptive use						
No	0.64	[0.47,0.87]		3.81	[3.34,4.34]	
Yes	0.13	[0.08,0.22]	<0.001	2.59	[2.30,2.92]	<0.001
Birth attendance						
TBA/other untrained/none	0.38	[0.28,0.51]		2.95	[2.66,3.27]	
Health professional	0.20	[0.11,0.37]	0.069	2.83	[2.41,3.31]	0.652
Number of ANC visits						
None	0.42	[0.29,0.63]		3.81	[3.34,4.34]	
1-3 times	0.31	[0.19,0.48]	0.184	2.72	[2.38,3.12]	<0.001
4+ times	0.19	[0.08,0.44]		2.35	[1.87,2.94]	
Combined place and mode of delivery						
Health facility without caesarean	0.26	[0.10,0.65]		3.32	[2.50,4.41]	
Health facility with caesarean	0.15	[0.06,0.39]	0.177	2.88	[2.23,3.71]	0.651
Home	0.36	[0.27,0.48]		2.89	[2.63,3.18]	
Total	0.32	[0.25,0.42]		2.91	[2.67,3.18]	

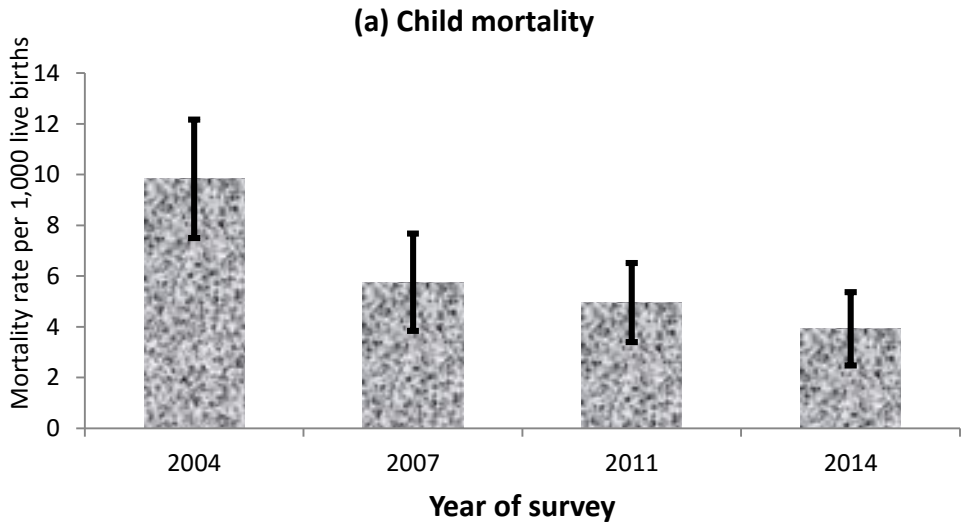
Under-5 mortality was significantly most prevalent in poor households [P = 3.40; 95% CI: (3.00, 3.85), p = 0.002], and in households where fathers had no formal education [P = 3.55; 95% CI: (3.17, 3.97), p < 0.001].

Under-5 mortality was significantly more prevalent among mothers who did not watch television [P = 3.52; 95% CI: (3.11, 3.97), p < 0.001], who did not listen to the radio [P = 3.46; 95% CI: (2.89, 4.12), p = 0.035], and who did not read any newspapers [P = 3.09; 95% CI: (2.82, 3.38), p = 0.001].

Child mortality and under-5 mortality were significantly more prevalent among mothers who had previously lost a child before the current birth than those who did not [P = 4.17; 95% CI: (2.51, 6.84), p < 0.001 (child), and P = 20.52; 95% CI: (16.87, 24.71), p < 0.001(under-5)]. Furthermore, prevalence of child mortality and under-5 mortality was highest among mothers who had 1-2 under-5 children than those who had three or more [P = 0.45; 95% CI: (0.34, 0.58), p < 0.01 (child), and P = 3.88; 95% CI: (3.54, 4.24), p < 0.001(under-5)]. Child and

under-5 mortalities were significantly more prevalent among mothers who had never breastfed their children [P = 0.75; 95% CI: (0.43, 1.32), p = 0.001 (child), and P = 12.44; 95% CI: (10.88, 14.20), p < 0.001(under-5)]. Child mortality, and under-5 mortality were both significantly most prevalent among mothers who had fourth birth rank children with two years birth interval or less [P = 0.83; 95% CI: (0.36, 1.39), p = 0.005 (child), and P = 6.65; 95% CI: (4.91, 8.95), p < 0.001(under-5)]. Both child mortality and under-5 mortality were significantly more prevalent among mothers who did not experience any delivery complications than those who did [P = 0.41; 95% CI: (0.31, 0.54), p = 0.002 (child), and P = 3.12; 95% CI: (2.83, 3.44), p = 0.012 (under-5)]. Child mortality and under-5 mortality were both significantly more prevalent among mothers who did not use any contraceptives than those who did [P = 0.64; 95% CI: (0.47, 0.87), p < 0.001 (child), and P = 3.81; 95% CI: (3.34, 4.34), p < 0.001 (under-5)]. Under-5 mortality was significantly most prevalent among mothers who did not attend any antenatal clinics than those who did [P = 3.81; 95% CI: (3.34, 4.34), p < 0.001].

Figure 8.2 (a and b) presents the variation of child and under-5 mortality rates for 2004, 2007, 2011 and 2014.



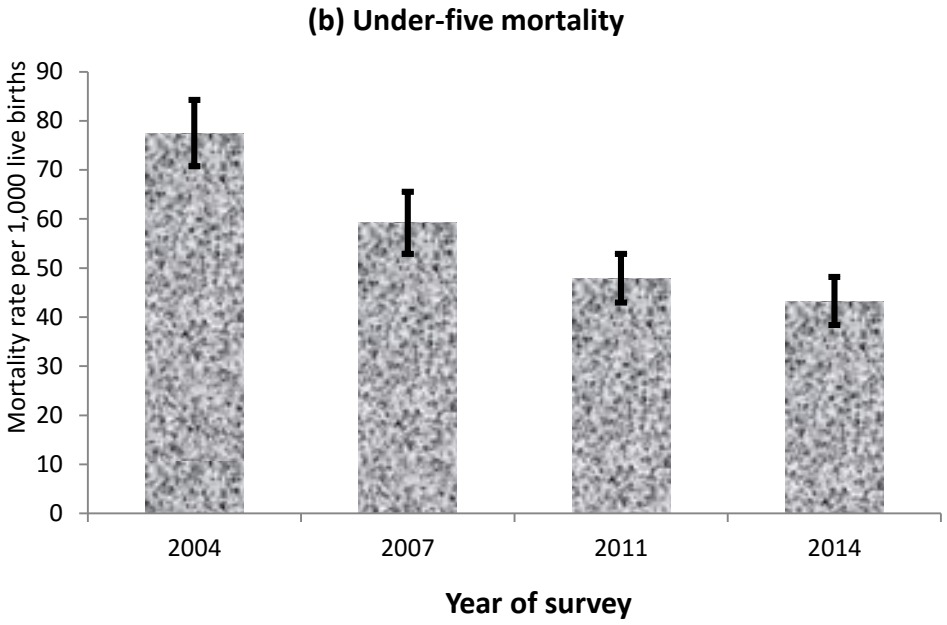


Figure 3.2: Child (a) and under-5 (b) mortality rates per 1000 live births in Bangladesh (2004-2014)

Figure 8.2 highlights the gradual decline in mortality rates between 2004 and 2014.

8.4 Factors associated with neonatal mortality

Table 8.4 summarises univariate and multivariate analyses of factors associated with neonatal mortality in Bangladesh.

The odds of neonatal mortality were significantly lower in 2014, compared to 2004 [adjusted odds ratio (AOR) = 0.02; 95% confidence interval (CI): (0.01, 0.03), $p < 0.001$]. Univariate analysis revealed that the odds of neonatal deaths were significantly higher in the Sylhet region, compared to the Barisal region [Unadjusted odds ratio (OR) = 1.95; 95% CI: (1.34, 2.84), $p < 0.001$]. This result was confirmed when other covariates were adjusted for [AOR = 2.38; 95% CI: (1.49, 3.80), $p < 0.001$]. Further, univariate analysis showed that neonates born to formerly married mothers had significantly higher odds of dying, compared to those who were born to married mothers [UOR = 2.01; 95% CI: (1.21, 3.35), $p = 0.007$]. Univariate analysis showed that the odds of neonatal mortality were higher among mothers of the oldest age bracket (35-

49 years), compared to those of the youngest age bracket (14-24 years), although this result was statistically insignificant [OR = 1.27; 95% CI: (0.94, 1.72), p < 0.120]. However, when other covariates were adjusted for, neonatal death was significantly less likely to occur in mothers of the oldest age bracket compared to those of the youngest bracket [AOR = 0.28; 95% CI: (0.14, 0.55), p < 0.001]. Compared to mothers who had no formal education, the odds of neonatal mortality were significantly lower among those mothers who had secondary education or higher [AOR = 0.61; 95% CI: (0.42, 0.88), p = 0.009].

Mothers who reported the death of a child before their current pregnancy had significantly higher odds of neonatal death, compared to those who did not have a child dying before their pregnancy [AOR = 3.82; 95% CI: (2.35, 6.23), p < 0.001]. The odds of neonatal death were significantly lower among mothers who had more than three under-5 children, compared to those who between one and two children [AOR = 0.14; 95% CI: (0.09, 0.22), p < 0.001].

Table 8.4:
Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with neonatal mortality

VARIABLE	OR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.80	0.60	1.06	0.121	0.69	0.48	0.99	0.044
2011	0.82	0.63	1.06	0.134	0.67	0.47	0.94	0.022
2014	0.83	0.63	1.08	0.164	0.02	0.01	0.03	<0.001
Cluster type								
Urban	1.00							
Rural	1.11	0.89	1.37	0.356				
Geographical region								
Barisal	1.00				1.00			
Chittagong	1.11	0.76	1.64	0.588	1.41	0.88	2.27	0.155
Dhaka	1.35	0.92	1.96	0.121	1.67	1.04	2.66	0.032
Khulna	1.03	0.66	1.58	0.909	1.48	0.87	2.52	0.153
Rajshahi	1.37	0.93	2.03	0.111	1.98	1.23	3.20	0.005
Sylhet	1.95	1.34	2.84	<0.001	2.38	1.49	3.80	<0.001
Maternal marital status								
Married	1.00							
Formerly Married	2.01	1.21	3.35	0.007				
Maternal religion								
Islam	1.00							
Others	0.89	0.62	1.28	0.530				
Mother's Age (years)								
15-24	1.00				1.00			
25-34	0.82	0.67	1.02	0.074	0.46	0.32	0.66	<0.001
35-49	1.27	0.94	1.72	0.120	0.28	0.14	0.55	<0.001
Mothers age at child's birth (years)								
less than 20	1.00				1.00			
20 - 29	0.86	0.68	1.08	0.190	1.73	1.21	2.47	0.003

30 - 39	1.27	0.96	1.69	0.093	3.36	1.82	6.23	<0.001
40+	1.56	0.75	3.23	0.229	3.34	1.06	10.52	0.040
Maternal working status								
Not working	1.00							
Working	1.23	0.98	1.54	0.081				
Mother's BMI (kg/m^2)								
<=18.5	1.00							
18-25	1.09	0.85	1.39	0.511				
25+	1.15	0.82	1.61	0.412				
Mother's occupation								
Non-agriculture	1.00							
Agriculture	0.93	0.61	1.40	0.720				
Not working	1.32	1.01	1.73	0.043				
Husband's occupation								
Non-agriculture	1.00							
Agriculture	1.16	0.92	1.45	0.208				
Not working	1.07	0.60	1.92	0.822				
Both Parents' employment								
Father only working	1.00							
Both working	1.20	0.95	1.53	0.129				
Neither working	1.28	0.81	2.02	0.291				
Maternal highest level of education								
No schooling	1.00							
Primary	0.76	0.62	0.94	0.010				
Secondary or more	0.51	0.36	0.73	<0.001				
Paternal highest level of education								
No schooling	1.00				1.00			
Primary	0.78	0.63	0.98	0.030	0.80	0.61	1.05	0.109
Secondary or more	0.56	0.42	0.76	<0.001	0.61	0.42	0.88	0.009
Wealth Index								
Rich	1.00							
Middle	1.28	0.96	1.70	0.089				

Poor	1.39	1.05	1.84	0.021				
MEDIA FACTORS								
Mother watched television every week	1.00							
Yes	1.12	0.92	1.36	0.274				
No								
Mother listened to radio every week	1.00							
Yes	0.82	0.65	1.04	0.103				
No								
Mother read newspaper	1.00							
Yes	1.25	0.95	1.66	0.115				
No								
PROXIMATE DETERMINANTS								
Female	1.00							
Male	1.21	1.00	1.48	0.054				
Previous death of sibling								
No	1.00				1.00			
Yes	6.82	4.99	9.33	<0.001	3.82	2.35	6.23	<0.001
Number of children under-5								
1–2	1.00				1.00			
3+	0.17	0.12	0.25	<0.001	0.14	0.09	0.22	<0.001
Breastfeeding								
Never	1.00				1.00			
Yes	0.06	0.05	0.08	<0.001	0.01	0.01	0.02	<0.001
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	1.52	1.19	1.93	0.001	1.25	0.88	1.77	0.209
2nd/3rd birth rank, less than or equal to 2 years interval	1.80	1.23	2.63	0.003	2.67	1.65	4.32	<0.001
4th birth rank, more than 2 years interval	1.42	1.06	1.89	0.018	1.05	0.69	1.60	0.806
4th birth rank, less than or equal to 2 years interval	2.34	1.52	3.60	<0.001	2.04	1.09	3.83	0.027
Desire for previous pregnancy								
Then	1.00							
Later	0.79	0.59	1.07	0.126				

Not at all	0.94	0.70	1.26	0.681				
Delivery complications								
none	1.00							
any complications	0.87	0.70	1.08	0.203				
Contraceptive use								
No	1.00				1.00			
Yes	0.30	0.25	0.37	<0.001	0.28	0.22	0.37	<0.001
Birth attendance								
TBA/other untrained/none	1.00							
Health professional	1.25	1.02	1.53	0.030				
Number of ANC visits								
None	1.00							
1-3 times	0.82	0.66	1.03	0.089				
4+ times	0.74	0.56	0.97	0.029				
Combined place and mode of delivery								
Health facility without caesarean	1.00							
Health facility with caesarean	1.00	0.67	1.49	0.990				
Home	0.72	0.52	1.00	0.047				

OR: Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

Compared to mothers who never breastfed their children, the likelihood of neonatal death was significantly lower among those who did [AOR = 0.01; 95% CI: (0.01, 0.02), p < 0.001]. The likelihood of death was significantly higher among second/third neonates, with a birth interval of two years or less, compared to second/third neonates with a birth interval of more than two years [AOR = 2.67; 95% CI: (1.65, 4.32), p < 0.001]. Mothers who used contraceptives were significantly less likely to experience a neonatal death, compared to those who did not [AOR = 0.28; 95% CI: (0.22, 0.37), p < 0.001].

8.5 Factors associated with post-neonatal mortality

Table 5 presents the unadjusted and adjusted odds ratios of factors associated with post-neonatal mortality in Bangladesh, taking into consideration, the 2004, 2007, 2011 and 2014 Bangladesh Demographic and Health Surveys. The odds of a post-neonatal death were significantly lower in 2014, compared to 2004 [AOR = 0.16; 95% CI: (0.09, 0.29), p < 0.001]. Univariate analysis showed that the odds of post-neonatal death were significantly higher among formerly married mothers, compared to currently married ones [OR = 3.47; 95% CI: (1.91, 6.29), p < 0.001]. Further, univariate analysis revealed that the likelihood of post-neonatal death was significantly higher among mothers belonging to the oldest age bracket (35-49 years), compared to mothers of the youngest age bracket [OR = 2.61; 95% CI: (1.74, 3.92), p < 0.001]. Multivariate analysis showed that the odds of post-neonatal death was significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors [AOR = 2.09; 95% CI: (1.45, 3.00), p < 0.001]. Compared to mothers who had no formal education, the likelihood of post-neonatal death was significantly lower among mothers who had secondary education or higher [AOR = 0.38; 95% CI: (0.18, 0.79), p = 0.010]. Mothers who reported the death of a child before their current pregnancy had significantly higher odds of experiencing post-neonatal death, compared to those who did not have a child

dying before their pregnancy [AOR = 2.45; 95% CI: (1.49, 4.05), $p < 0.001$]. The odds of post-neonatal death were significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children [AOR = 0.16; 95% CI: (0.09, 0.27), $p < 0.001$].

Table 8.5:
Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with post-neonatal mortality

VARIABLE	OR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.67	0.46	0.97	0.035	0.64	0.44	0.95	0.025
2011	0.46	0.31	0.68	<0.001	0.53	0.35	0.80	0.002
2014	0.30	0.19	0.48	<0.001	0.16	0.09	0.29	<0.001
Cluster type								
Urban	1.00							
Rural	1.07	0.78	1.47	0.661				
Geographical region								
Barisal	1.00				1.00			
Chittagong	0.82	0.49	1.39	0.466	0.83	0.48	1.43	0.509
Dhaka	1.05	0.64	1.74	0.835	1.00	0.59	1.68	0.998
Khulna	0.37	0.18	0.78	0.009	0.43	0.20	0.92	0.029
Rajshahi	0.70	0.39	1.24	0.221	0.67	0.37	1.22	0.193
Sylhet	1.47	0.89	2.43	0.128	1.37	0.81	2.32	0.240
Maternal marital status								
Married	1.00							
Formerly Married	3.47	1.91	6.29	<0.001				
Maternal religion								
Islam	1.00							
Others	1.09	0.66	1.80	0.745				
Mother's Age (years)								
15-24	1.00							
25-34	1.35	0.97	1.87	0.073				
35-49	2.61	1.74	3.92	<0.001				
Mothers age at child's birth (years)								
less than 20	1.00							

20 - 29	1.14	0.79	1.66	0.483				
30 - 39	2.17	1.42	3.31	<0.001				
40+	4.73	2.19	10.21	<0.001				
Maternal working status								
Not working	1.00							
Working	1.95	1.43	2.66	<0.001				
Mother's BMI (kg/m^2)								
<=18.5	1.00							
18-25	0.91	0.64	1.29	0.587				
25+	0.68	0.40	1.17	0.166				
Mother's occupation								
Non-agriculture	1.00				1.00			
Agriculture	1.25	0.70	2.23	0.442	1.26	0.69	2.29	0.452
Not working	2.31	1.63	3.27	<0.001	2.09	1.45	3.00	<0.001
Husband's occupation								
Non-agriculture	1.00							
Agriculture	1.07	0.76	1.50	0.717				
Not working	0.97	0.39	2.38	0.943				
Both Parents' employment								
Father only working	1.00							
Both working	1.89	1.37	2.60	<0.001				
Neither working	1.28	0.62	2.63	0.499				
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.44	0.32	0.60	<0.001	0.74	0.51	1.05	0.095
Secondary or more	0.20	0.10	0.40	<0.001	0.38	0.18	0.79	0.010
Paternal highest level of education								
No schooling	1.00							
Primary	0.64	0.46	0.88	0.007				
Secondary or more	0.24	0.13	0.44	<0.001				
Wealth Index								
Rich	1.00							

Middle	1.27	0.80	2.03	0.304				
Poor	2.05	1.32	3.16	0.001				
MEDIA FACTORS								
Mother watched television every week								
Yes	1.00							
No	1.95	1.45	2.62	<0.001				
Mother listened to radio every week								
Yes	1.00							
No	0.89	0.63	1.28	0.540				
Mother read newspaper								
Yes	1.00							
No	2.94	1.64	5.29	<0.001				
PROXIMATE DETERMINANTS								
Sex								
Female	1.00							
Male	0.78	0.58	1.04	0.096				
Previous death of sibling								
No	1.00				1.00			
Yes	9.26	6.18	13.89	<0.001	2.45	1.49	4.05	<0.001
Number of children under-5								
1–2	1.00				1.00			
3+	0.23	0.14	0.38	<0.001	0.16	0.09	0.27	<0.001
Breastfeeding								
Never	1.00				1.00			
Yes	0.50	0.35	0.73	<0.001	0.25	0.15	0.42	<0.001
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	0.91	0.60	1.36	0.635	0.79	0.52	1.20	0.266
2nd/3rd birth rank, less than or equal to 2 years interval	1.14	0.58	2.25	0.705	1.37	0.69	2.75	0.370
4th birth rank, more than 2 years interval	2.30	1.57	3.35	<0.001	1.36	0.89	2.07	0.152
4th birth rank, less than or equal to 2 years interval	4.66	2.84	7.66	<0.001	3.59	2.01	6.39	<0.001
Desire for previous pregnancy								

Then	1.00							
Later	0.83	0.53	1.31	0.427				
Not at all	1.57	1.08	2.28	0.019				
Delivery complications								
none	1.00							
any complications	0.42	0.31	0.57	<0.001				
Contraceptive use								
No	1.00				1.00			
Yes	0.50	0.34	0.73	<0.001	0.44	0.32	0.60	<0.001
Birth attendance								
TBA/other untrained/none	1.00							
Health professional	0.47	0.33	0.69	<0.001				
Number of ANC visits								
None	1.00							
1-3 times	0.43	0.31	0.61	<0.001				
4+ times	0.40	0.26	0.62	<0.001				
Combined place and mode of delivery								
Health facility without caesarean	1.00							
Health facility with caesarean	0.93	0.41	2.14	0.873				
Home	1.69	0.89	3.20	0.111				

OR: Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

Compared to mothers who never breastfed their children, the odds of post-neonatal death were significantly lower among those who did [AOR = 0.25; 95% CI: (0.15, 0.42), p < 0.001]. The likelihood of death was significantly higher among fourth rank post-neonates, with a birth interval of two years or less, compared to second/third post-neonates with a birth interval of more than two years [AOR = 3.59; 95% CI: (2.01, 6.39), p < 0.001]. Finally, mothers who used contraceptives were significantly less likely to experience a post-neonatal death, compared to those who did not [AOR = 0.44; 95% CI: (0.32, 0.60), p < 0.001].

8.6 Factors associated with infant mortality

The unadjusted and adjusted odds ratios of the factors associated with infant mortality are summarised in Table 8.6, utilising the 2004, 2007, 2011, and 2014 Bangladesh DHS data. The likelihood of infant death was significantly lower in 2014, compared to 2004 [AOR = 0.02; 95% CI: (0.01, 0.03), p < 0.001]. The odds of infant death was significantly higher in the Sylhet region, compared to the Barisal region of Bangladesh [AOR = 1.93; 95% CI: (1.34, 2.78), p < 0.001]. Further, univariate analysis revealed that the likelihood of infant death was significantly higher among mothers belonging to the oldest age bracket (35-49 years), compared to mothers of the youngest age bracket [UOR = 1.62; 95% CI: (1.27, 2.06), p < 0.001]. Multivariate analysis showed that the odds of infant death was significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors [AOR = 1.45; 95% CI: (1.12, 1.87), p = 0.004]. The odds of infant death was significantly lower among mothers who had secondary education or higher, compared to mothers who had no formal education [AOR = 0.55; 95% CI: (0.38, 0.81), p = 0.002]. Mothers who reported the death of a child before their current pregnancy were significantly more likely to experience infant death, compared to those who did not have a child dying before their pregnancy [AOR = 3.83; 95% CI: (2.66, 5.52), p < 0.001]. The likelihood of infant death was significantly lower among

mothers who had more than three under-5 children, compared to those who had between one and two children [AOR = 0.14; 95% CI: (0.10, 0.19), $p < 0.001$].

Table 8.6:
Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with Infant mortality

VARIABLE	OR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.74	0.59	0.94	0.011	0.66	0.50	0.87	0.003
2011	0.67	0.54	0.84	<0.001	0.59	0.45	0.77	<0.001
2014	0.62	0.49	0.77	<0.001	0.02	0.01	0.03	<0.001
Cluster type								
Urban	1.00							
Rural	1.10	0.92	1.31	0.312				
Geographical region								
Barisal	1.00				1.00			
Chittagong	1.00	0.73	1.37	0.997	1.12	0.77	1.62	0.548
Dhaka	1.24	0.91	1.67	0.169	1.34	0.93	1.94	0.112
Khulna	0.77	0.53	1.11	0.159	0.89	0.57	1.39	0.615
Rajshahi	1.11	0.81	1.53	0.520	1.33	0.90	1.95	0.148
Sylhet	1.78	1.32	2.40	<0.001	1.93	1.34	2.78	<0.001
Maternal marital status								
Married	1.00							
Formerly married	2.50	1.69	3.71	<0.001				
Maternal religion								
Islam	1.00							
Others	0.95	0.71	1.28	0.732				
Mother's Age (years)								
15-24	1.00							
25-34	0.95	0.80	1.14	0.593				
35-49	1.62	1.27	2.06	<0.001				
Mothers age at child's birth (years)								
less than 20	1.00							

20 - 29	0.93	0.77	1.13	0.463				
30 - 39	1.51	1.19	1.91	0.001				
40+	2.40	1.41	4.07	0.001				
Maternal working status								
Not working	1.00							
Working	1.44	1.19	1.73	<0.001				
Mother's BMI (kg/m^2)								
<=18.5	1.00							
18-25	1.02	0.84	1.26	0.813				
25+	0.99	0.74	1.31	0.926				
Mother's occupation								
Non-agriculture	1.00				1.00			
Agriculture	1.02	0.73	1.43	0.915	1.04	0.72	1.52	0.822
Not working	1.61	1.30	2.00	<0.001	1.45	1.12	1.87	0.004
Husband's occupation								
Non-agriculture	1.00							
Agriculture	1.13	0.93	1.36	0.210				
Not working	1.04	0.63	1.70	0.883				
Both Parents' employment								
Father only working	1.00							
Both working	1.40	1.16	1.70	0.001				
Neither working	1.28	0.87	1.90	0.208				
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.64	0.54	0.76	<0.001	0.80	0.64	1.00	0.053
Secondary or more	0.39	0.29	0.54	<0.001	0.55	0.38	0.81	0.002
Paternal highest level of education								
No schooling	1.00							
Primary	0.73	0.61	0.88	0.001				
Secondary or more	0.45	0.35	0.59	<0.001				
Wealth Index								
Rich	1.00							

Middle	1.28	1.00	1.63	0.046				
Poor	1.57	1.24	1.99	<0.001				
MEDIA FACTORS								
Mother watched television every week								
Yes	1.00							
No	1.33	1.13	1.57	0.001				
Mother listened to radio every week								
Yes	1.00							
No	0.84	0.69	1.03	0.088				
Mother read newspaper								
Yes	1.00							
No	1.55	1.21	2.00	0.001				
PROXIMATE DETERMINANTS								
Sex								
Female	1.00							
Male	1.06	0.90	1.25	0.498				
Previous death of sibling								
No	1.00				1.00			
Yes	8.15	6.30	10.54	<0.001	3.83	2.66	5.52	<0.001
Number of children under-5								
1–2	1.00				1.00			
3+	0.19	0.14	0.25	<0.001	0.14	0.10	0.19	<0.001
Breastfeeding								
Never	1.00				1.00			
Yes	0.11	0.09	0.13	<0.001	0.01	0.01	0.01	<0.001
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	1.33	1.08	1.64	0.007	1.11	0.87	1.42	0.407
2nd/3rd birth rank, less than or equal to 2 years interval	1.60	1.15	2.23	0.006	2.42	1.64	3.58	<0.001
4th birth rank, more than 2 years interval	1.70	1.35	2.14	<0.001	1.13	0.85	1.51	0.406
4th birth rank, less than or equal to 2 years interval	3.12	2.25	4.32	<0.001	3.01	1.94	4.65	<0.001
Desire for previous pregnancy								

Then	1.00							
Later	0.80	0.62	1.03	0.085				
Not at all	1.12	0.89	1.42	0.325				
Delivery complications								
none	1.00							
any complications	0.74	0.62	0.90	0.002				
Contraceptive use								
No	1.00				1.00			
Yes	0.32	0.27	0.38	<0.001	0.32	0.26	0.39	<0.001
Birth attendance								
TBA/other untrained/none	1.00							
Health professional	0.96	0.81	1.15	0.672				
Number of ANC visits								
None	1.00							
1-3 times	0.67	0.55	0.81	<0.001				
4+ times	0.60	0.48	0.76	<0.001				
Combined place and mode of delivery								
Health facility without caesarean	1.00							
Health facility with caesarean	0.99	0.69	1.42	0.954				
Home	0.90	0.68	1.20	0.483				

OR: Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

The odds of infant death were significantly lower among mothers who breastfed their children, compared to those who never did [AOR = 0.01; 95% CI: (0.01, 0.01), p < 0.001]. The odds of death was significantly higher among fourth rank infants with a birth interval of two years or less, compared to second/third infants with a birth interval of more than two years [AOR = 3.01; 95% CI: (1.94, 4.65), p < 0.001]. Additionally, mothers who used contraceptives were significantly less likely to experience an infant death, compared to those who did not [AOR = 0.32; 95% CI: (0.26, 0.39), p < 0.001].

8.7 Factors associated with child mortality

Table 8.7 summarises the unadjusted and adjusted odds ratios of the factors associated with child mortality, making use of data from the 2004, 2007, 2011, and 2014 Bangladesh DHS. Univariate analysis revealed that the likelihood of child death was significantly higher among formerly married mothers compared to currently married ones [OR = 7.30; 95% CI: (3.59, 14.84), p < 0.001]. Child death was significantly likely among mothers belonging to the oldest age bracket (35-49 years), compared to mothers of the youngest age bracket [OR = 2.46; 95% CI: (1.26, 4.81), p = 0.008]. Multivariate analysis showed that the likelihood of child death was significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors [AOR = 2.73; 95% CI: (1.56, 4.79), p < 0.001]. The odds of child death was significantly lower among mothers who had secondary education or higher, compared to mothers who had no formal education [AOR = 0.13; 95% CI: (0.02, 1.00), p = 0.050].

The likelihood of child death among mothers who reported the previous death of a child, was significantly higher, compared to those who did not have a previous death of a child [AOR = 8.46; 95% CI: (4.50, 15.93), p < 0.001]. The odds of child death were significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children [AOR = 0.06; 95% CI: (0.02, 0.26), p < 0.001].

Table 8.7:
Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with child mortality

VARIABLE	OR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.83	0.43	1.60	0.583	0.81	0.41	1.59	0.539
2011	0.73	0.39	1.37	0.321	1.10	0.57	2.15	0.771
2014	0.64	0.33	1.25	0.193	0.44	0.18	1.07	0.069
Cluster type								
Urban	1.00							
Rural	1.42	0.83	2.44	0.203				
Geographical region								
Barisal	1.00							
Chittagong	1.64	0.72	3.77	0.242				
Dhaka	0.94	0.38	2.34	0.893				
Khulna	0.73	0.25	2.14	0.570				
Rajshahi	1.30	0.53	3.19	0.566				
Sylhet	1.06	0.41	2.74	0.901				
Maternal marital status								
Married	1.00							
Formerly married	7.30	3.59	14.84	<0.001				
Maternal religion								
Islam	1.00							
Others	0.82	0.33	2.04	0.668				
Mother's Age (years)								
15-24	1.00							
25-34	1.38	0.82	2.33	0.224				
35-49	2.46	1.26	4.81	0.008				
Mothers age at child's birth (years)								
less than 20	1.00							

20 - 29	1.33	0.73	2.43	0.354				
30 - 39	2.14	1.07	4.30	0.032				
40+	1.58	0.21	12.02	0.660				
Maternal working status								
Not working	1.00							
Working	2.14	1.31	3.50	0.002				
Mother's BMI (kg/m^2)								
<=18.5	1.00							
18-25	1.11	0.61	2.02	0.741				
25+	1.14	0.51	2.58	0.751				
Mother's occupation								
Non-agriculture	1.00				1.00			
Agriculture	1.56	0.66	3.66	0.311	1.51	0.62	3.68	0.370
Not working	2.68	1.56	4.60	<0.001	2.73	1.56	4.79	<0.001
Husband's occupation								
Non-agriculture	1.00							
Agriculture	1.38	0.82	2.34	0.226				
Not working	1.67	0.52	5.41	0.389				
Both Parents' employment								
Father only working	1.00							
Both working	2.13	1.29	3.54	0.003				
Neither working	1.31	0.40	4.22	0.656				
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.68	0.42	1.10	0.113	1.12	0.66	1.91	0.667
Secondary or more	0.07	0.01	0.54	0.010	0.13	0.02	1.00	0.050
Paternal highest level of education								
No schooling	1.00							
Primary	0.82	0.49	1.38	0.458				
Secondary or more	0.49	0.23	1.05	0.068				
Wealth Index								
Rich	1.00							

Middle	1.84	0.87	3.88	0.111				
Poor	1.86	0.88	3.92	0.102				
MEDIA FACTORS								
Mother watched television every week	1.00							
Yes	1.66	1.04	2.67	0.035				
No								
Mother listened to radio every week	1.00							
Yes	0.82	0.47	1.43	0.480				
No								
Mother read newspaper	1.00							
Yes	2.67	1.07	6.63	0.035				
No								
PROXIMATE DETERMINANTS								
Female	1.00							
Male	0.66	0.41	1.07	0.092				
Previous death of sibling								
No	1.00				1.00			
Yes	13.71	7.75	24.25	<0.001	8.46	4.50	15.93	<0.001
Number of children under-5								
1–2 times	1.00				1.00			
3+ times	0.07	0.02	0.27	<0.001	0.06	0.02	0.26	<0.001
Breastfeeding								
Never	1.00				1.00			
Yes	0.40	0.23	0.71	0.001	0.35	0.16	0.75	0.007
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00							
1st birth rank	0.68	0.36	1.28	0.232				
2nd/3rd birth rank, less than or equal to 2 years interval	1.63	0.71	3.77	0.252				
4th birth rank, more than 2 years interval	1.25	0.66	2.36	0.498				
4th birth rank, less than or equal to 2 years interval	2.85	1.23	6.59	0.015				
Desire for previous pregnancy								
Then	1.00							

Later	1.43	0.76	2.68	0.262				
Not at all	1.39	0.71	2.71	0.335				
Delivery complications								
none	1.00				1.00			
any complications	0.32	0.16	0.65	0.002	0.40	0.19	0.84	0.014
Contraceptive use								
No	1.00				1.00			
Yes	0.21	0.12	0.36	<0.001	0.21	0.12	0.36	<0.001
Birth attendance								
TBA/other untrained/none	1.00							
Health professional	0.57	0.32	1.00	0.051				
Number of ANC visits								
None	1.00							
1-3. times	0.64	0.38	1.09	0.100				
4+ times	0.37	0.17	0.80	0.012				
Combined place and mode of delivery								
Health facility without caesarean	1.00							
Health facility with caesarean	0.72	0.21	2.50	0.606				
Home	1.27	0.51	3.17	0.610				

OR: Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

The odds of child death were significantly lower among mothers who breastfed their children, compared to those who never did [AOR = 0.35; 95% CI: (0.16, 0.75), p = 0.007]. Univariate analysis revealed that the odds of death was significantly higher among fourth rank children with a birth interval of two years or less, compared to second/third infants with a birth interval of more than two years [OR = 2.85; 95% CI: (1.23, 6.59), p = 0.015]. Multivariate analysis showed that the likelihood of child death was significantly lower among mothers who had delivery complications, compared to those who had none [AOR = 0.40; 95% CI: (0.19, 0.84), p = 0.014]; and, mothers who used contraceptives were significantly less likely to experience a child death, compared to those who did not [AOR = 0.21; 95% CI: (0.12, 0.36), p < 0.001].

8.8 Factors associated with under-5 mortality

The unadjusted and adjusted odds ratios of factors associated with under-5 mortality are summarised in Table 8.8. The odds of under-5 death was significantly lower in 2014, compared to 2004 [AOR = 0.02; 95% CI: (0.01, 0.03), p < 0.001]. The likelihood of under-5 death was significantly higher in the Sylhet region, compared to the Barisal region of Bangladesh [AOR = 1.72; 95% CI: (1.22, 2.44), p = 0.002]. Further, univariate analysis revealed that the odds of under-5 death were significantly higher among formerly married mothers compared to currently married mothers [OR = 3.04; 95% CI: (2.15, 4.30), p < 0.001]; and also the likelihood of under-5 death was significantly higher among mothers belonging to the oldest age bracket (35-49 years), compared to mothers of the youngest age bracket [OR = 1.70; 95% CI: (1.35, 2.13), p < 0.001]. Multivariate analysis showed that the odds of under-5 death were significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors [AOR = 1.61; 95% CI: (1.27, 2.04), p < 0.001]. The odds of under-5 death was significantly lower among mothers who had secondary education or higher,

compared to mothers who had no formal education [AOR = 0.65; 95% CI: (0.42, 1.00), p = 0.050].

Table 8.8:
Unadjusted and adjusted odds ratios (95% confidence intervals) for factors associated with under-five mortality

VARIABLE	OR	(95% CI)		p-value	AOR	(95% CI)		p-value
Year of survey								
2004	1.00				1.00			
2007	0.75	0.60	0.93	0.009	0.67	0.52	0.87	0.002
2011	0.68	0.55	0.83	<0.001	0.61	0.47	0.78	<0.001
2014	0.62	0.50	0.77	<0.001	0.02	0.01	0.03	<0.001
Cluster type								
Urban	1.00							
Rural	1.13	0.95	1.33	0.170				
Geographical region								
Barisal	1.00				1.00			
Chittagong	1.07	0.80	1.43	0.647	1.16	0.82	1.64	0.401
Dhaka	1.21	0.91	1.61	0.199	1.25	0.89	1.77	0.195
Khulna	0.76	0.54	1.08	0.129	0.84	0.56	1.28	0.428
Rajshahi	1.13	0.84	1.53	0.421	1.29	0.90	1.85	0.159
Sylhet	1.70	1.28	2.27	<0.001	1.72	1.22	2.44	0.002
Maternal marital status								
Married	1.00							
Formerly married	3.04	2.15	4.30	<0.001				
Maternal religion								
Islam	1.00							
Others	0.94	0.70	1.24	0.644				
Mother's Age (years)								
15-24	1.00							
25-34	0.99	0.84	1.17	0.907				
35-49	1.70	1.35	2.13	<0.001				
Mothers age at child's birth (years)								
less than 20	1.00							

20 - 29	0.96	0.80	1.16	0.694				
30 - 39	1.57	1.25	1.96	<0.001				
40+	2.33	1.40	3.90	0.001				
Maternal working status								
Not working	1.00							
Working	1.51	1.27	1.79	<0.001				
Mother's BMI (kg/m^2)								
<=18.5	1.00				1.00			
18-25	1.03	0.85	1.25	0.745	1.29	1.02	1.63	0.030
25+	1.00	0.76	1.31	0.995	1.23	0.87	1.73	0.235
Mother's occupation								
Non-agriculture	1.00				1.00			
Agriculture	1.07	0.78	1.47	0.671	1.06	0.75	1.51	0.747
Not working	1.72	1.41	2.10	<0.001	1.61	1.27	2.04	<0.001
Husband's occupation								
Non-agriculture	1.00							
Agriculture	1.16	0.97	1.38	0.113				
Not working	1.10	0.70	1.74	0.672				
Both Parents' employment								
Father only working	1.00							
Both working	1.48	1.23	1.77	<0.001				
Neither working	1.29	0.89	1.87	0.181				
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.64	0.54	0.75	<0.001	0.88	0.70	1.11	0.277
Secondary or more	0.36	0.26	0.49	<0.001	0.65	0.42	1.00	0.050
Paternal highest level of education								
No schooling	1.00				1.00			
Primary	0.74	0.62	0.88	0.001	0.90	0.73	1.13	0.367
Secondary or more	0.45	0.35	0.58	<0.001	0.64	0.45	0.91	0.014
Wealth Index								
Rich	1.00							

Middle	1.33	1.06	1.68	0.015				
Poor	1.60	1.28	2.01	<0.001				
MEDIA FACTORS								
Mother watched television every week								
Yes	1.00							
No	1.37	1.17	1.59	<0.001				
Mother listened to radio every week								
Yes	1.00							
No	0.84	0.70	1.01	0.065				
Mother read newspaper								
Yes	1.00							
No	1.63	1.28	2.08	<0.001				
PROXIMATE DETERMINANTS								
Sex								
Female	1.00							
Male	1.01	0.86	1.18	0.932				
Previous death of sibling								
No	1.00				1.00			
Yes	9.16	7.21	11.65	<0.001	4.74	3.37	6.66	<0.001
Number of children under-5								
1–2	1.00				1.00			
3+	0.17	0.13	0.23	<0.001	0.12	0.09	0.17	<0.001
Breastfeeding								
Never	1.00				1.00			
Yes	0.12	0.10	0.14	<0.001	0.01	0.01	0.02	<0.001
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	1.00				1.00			
1st birth rank	1.24	1.02	1.52	0.030	1.02	0.81	1.29	0.857
2nd/3rd birth rank, less than or equal to 2 years interval	1.61	1.18	2.20	0.003	2.42	1.68	3.49	<0.001
4th birth rank, more than 2 years interval	1.64	1.32	2.04	<0.001	1.04	0.79	1.37	0.782
4th birth rank, less than or equal to 2 years interval	3.11	2.29	4.23	<0.001	2.98	1.97	4.50	<0.001
Desire for previous pregnancy								

Then	1.00							
Later	0.86	0.68	1.08	0.201				
Not at all	1.15	0.92	1.43	0.217				
Delivery complications								
none	1.00							
any complications	0.69	0.58	0.83	<0.001				
Contraceptive use								
No	1.00				1.00			
Yes	0.31	0.26	0.36	<0.001	0.29	0.24	0.36	<0.001
Birth attendance								
TBA/other untrained/none	1.00							
Health professional	0.91	0.77	1.08	0.294				
Number of ANC visits								
None	1.00							
1-3	0.66	0.55	0.79	<0.001				
4+	0.58	0.46	0.72	<0.001				
Combined place and mode of delivery								
Health facility without caesarean	1.00							
Health facility with caesarean	0.97	0.68	1.36	0.844				
Home	0.93	0.71	1.23	0.627				

OR: Odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval

The likelihood of an under-5 child whose previous sibling had died was significantly higher than one whose previous sibling had not [AOR = 4.74; 95% CI: (3.37, 6.66), $p < 0.001$]. The likelihood of under-5 death was significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children [AOR = 0.12; 95% CI: (0.09, 0.17), $p < 0.001$]. Under-5 children who had been breastfed before had a significantly lower likelihood of death than those who had never been breastfed [AOR = 0.01; 95% CI: (0.01, 0.02), $p < 0.001$]. The odds of under-5 death was significantly higher among fourth rank children with a birth interval of two years or less, compared to second/third infants with a birth interval of more than two years [AOR = 2.98; 95% CI: (1.97, 4.50), $p < 0.001$]. Univariate analysis showed that the likelihood of under-5 death was significantly lower among mothers who had delivery complications, compared to those who had none [OR = 0.69; 95% CI: (0.58, 0.83), $p < 0.001$]. Mothers who used contraceptives were significantly less likely to experience an under-5 death, compared to those who did not [AOR = 0.29; 95% CI: (0.24, 0.36), $p < 0.001$]. Univariate analysis also revealed that under-5 death was significantly lower among mothers who had four or more antenatal care clinic visits compared to those who had none Univariate analysis revealed that the odds of death was significantly higher among fourth rank children with a birth interval of two years or less, compared to second/third infants with a birth interval of more than two years [OR = 2.85; 95% CI: (1.23, 6.59), $p = 0.015$]. Multivariate analysis showed that the likelihood of child death was significantly lower among mothers who had delivery complications, compared to those who had none [AOR = 0.40; 95% CI: (0.19, 0.84), $p = 0.014$]; and, mothers who used contraceptives were significantly less likely to experience a child death, compared to those who did not [OR = 0.58; 95% CI: (0.46, 0.72), $p < 0.001$].

8.9 Summary

This chapter presented factors associated with under-5 mortality, among other issues. Prominent factors for which the odds of under-5 mortality are significantly higher include mothers with a BMI of 18-25kg/m^2, formerly married mothers, parents with no formal education, children who had not been breastfed, and mothers who had not used contraceptives. In the next chapter, a discussion of findings of the whole thesis is presented.

CHAPTER 9

DISCUSSION

9.0 Introduction

This chapter presents discussions of the results of the various research questions. It assesses factors that were significantly associated with stillbirth, prenatal and under-5 mortality in Bangladesh. It also discusses the impact of antenatal care, iron and folic acid supplementation and tetanus toxoid on child mortality in Bangladesh.

9.1 Factors associated with stillbirth in Bangladesh

The analyses showed that factors associated with stillbirths in Bangladesh included parental level of education, maternal age at child's birth and previous birth rank and interval. Factors associated with stillbirths in Bangladesh constitute a major challenge in ensuring optimum pregnancy outcomes in this country. Successful prevention strategies could have far-reaching effects on the health and well-being of the wider population.

A previous study in Norway [1] found that stillbirth rates were greater for Norwegian women with fewer years of education but not for Pakistani women living in Norway. Thus, there may be other confounders influencing stillbirth such as maternal age, parity and maternal place of birth. In our first model, we found that fathers with no schooling had an increased risk of stillbirth. This finding is also supported by other previous studies which show that parents with only a technical or primary education have a higher risk of stillbirth than parents with a higher level of educational [2]. Other studies [1, 3-5] also report a higher rate of stillbirth in parents with little or no schooling. These findings are consistent with the current study in which the rate of stillbirths was higher in mothers with no schooling. A lower level of education may relate to a lower family income which may act as a hindrance to the decision to seek early medical care.

The risk of stillbirth was significantly lower in mothers who had three or more children compared to mothers with those who had just one child. This finding is contrary to findings from previous studies [6, 7], and may reflect the fact that mothers with many children tend to be more experienced and more likely to take precautions to prevent complications during pregnancy that could lead to stillbirth.

In this study, the odds of stillbirth were significantly higher in poor households compared to rich households. This is consistent with findings from other researchers, which indicated that women in disadvantaged populations have stillbirth rates far in excess of those living without such disadvantage [7, 8]. Poverty could be the overriding factor preventing access to care and obstacles are deeply rooted in the experience of being poor, disadvantaged, and vulnerable [9].

Alongside household poverty, limited or lack of formal education, formerly married mothers were found to have higher odds of stillbirth compared to currently married ones. This is consistent with previous studies which found that in almost all geographical areas, socio-economic status, lack of education and lack of a partner, were linked to increased stillbirth rates [10-12].

The main strength of the study is that the BDHS are nationally-representative and used standardised methods to achieve high response rates. Our study, however, has some limitations. Firstly, it was based on ever-married women and therefore excluded unmarried women who had foetus of gestation over 27 weeks. In Bangladesh, the probability of a woman having a child without being married is very small as there are strong social and religious norms against unmarried mothers. Secondly, the diagnosis of stillbirth was based on self-report from the mother and was subject to recall and misclassification bias. As most births occurred in rural areas, there was no healthcare provider to measure heartbeat or conduct a physical examination.

In most communities and hospitals in low and middle income countries, depressed live-born infants are often misclassified as stillbirths, due to the fact that stillbirth is more culturally acceptable and culpability may be minimised. In addition, formal verbal autopsies are not conducted on stillbirths. Furthermore, no information on labour, delivery or other factors such as tobacco gestational diabetes or genetic abnormalities that may have been associated with stillbirth was included in the BDHS data.

In Bangladesh, the proportion of rural women giving birth at home remains high and with stillbirths predominantly occurring at full term, this indicates the possible chance of survival of an infant if improved standard pregnancy and childbirth care were available. Significant risk factors for stillbirths in this study included advanced age of mothers and parental education. The government of Bangladesh and other stakeholders should implement strategies to improve access to and use of prenatal and emergency obstetric care to minimise the occurrence of stillbirth in Bangladesh, especially in groups who have been identified to be at higher risk.

9.2 Factors associated with perinatal mortality in Bangladesh

Findings from this study showed that the risk factors were consistent across both perinatal mortality (stillbirth and early neonatal) and perinatal mortality (stillbirth and neonatal), and related to household wealth index, maternal level of education, maternal BMI, previous death of a sibling, mother's delivery complications and mothers use of contraceptives.

In this study, it was found that the odds of perinatal death were significantly higher among infants whose mothers had no formal education compared to those whose mothers had secondary education or higher. This finding is consistent with past studies which have shown that there are high risks of mortality among children aged less than five years whose mothers had no schooling [13-16]. Educated mothers have a higher likelihood of better knowledge about child health and modern healthcare services; thus, the mother's education is a key determinant of poor child health [17]. Improved maternal healthcare-seeking behaviours [18,

19] such as immunisation and feeding practices, may in turn positively influence child survival. Educated mothers are additionally more likely to reside in socially and economically developed areas that have well-equipped medical facilities, and good water and sanitation infrastructure [20].

Previous studies have shown that the risks of infant and under-5 mortalities were significantly higher for male children than for female children [13, 21]; this is consistent with a finding in this study where males had significantly higher odds of perinatal death, compared to females. Biological factors [22-24] may be possible explanations to the increased risk of male deaths. The high rate of infant and under-5 deaths among male children may be due to late development of foetal lung maturity in the first week of life [25], resulting in a higher incidence of respiratory diseases in male children compared with female ones.

In this study, the odds of perinatal death were found to be significantly higher in poor households, compared to rich ones; consistent with results from a past study [13, 26].

This study found that perinatal death was significantly more likely among infants whose mothers had a BMI higher than 25kg/m^2. This is consistent with findings from previous studies [7, 27-30] which found an association between maternal overweight/obesity and the risk of stillbirth and infant mortality. The mechanisms behind the associations between maternal BMI above the normal range and stillbirth and infant mortality are probably multifactorial. Inflammation and infection have been associated with stillbirth, and obesity may contribute to dysregulation of inflammatory responses and increase the risk of infection, leading to foetal loss [31]. Adipose tissue in obese individuals mainly releases pro-inflammatory cytokines (e.g., tumour necrosis factor α, interleukin-6, leptin), while adipose tissue in lean individuals secretes anti- inflammatory adipokines (adiponectin, transforming growth factor β, interleukin-10) [32].

In this study, it was found that infants born to mothers who had delivery complications were significantly more likely to die compared to those whose mothers did not have any delivery complications. This is in disagreement with findings from previous studies [33, 34]. This descrepancy could be due to chance, as a result of recall bias [35].

A recent study in Afghanistan established a close association between family planning practice and infant mortality [36]. A similar finding was made in this study. Infants whose mothers did not use any contraceptives had significantly higher odds of dying compared those whose mothers used contraceptives.

9.3 Effect of antenatal care, iron and folic acid supplementation and tetanus toxoid vaccination on child mortality in Bangladesh

In this study, it was found that the provision of any form of ANC led to a reduction of the likelihood of infant/child mortality in Bangladesh. In particular, IFA supplementation and TT vaccinations (2 components of ANC) were found to lead to a decline in infant/child mortality.

The study showed that there was a decline in child mortality (including neonatal) between 2004 and 2011. This improvement may be partly due to reduced cases of neonatal tetanus [37]. We also found that iron and folic acid supplementation posed a protective effect towards neonatal, postnatal and child mortality, which is consistent with results of a past reported trial of micronutrient supplementation during pregnancy in rural China in which neonatal mortality was reduced by 54% among mothers who received standard iron and folic acid supplementation compared to mothers who received only folic acid [38]. The protective influence of iron and folic acid supplementation was also highlighted in a study from Indonesia [39], and may be important for pregnant women in developing countries [40]. These findings suggest that

promotion and supply of iron and folic acid supplementation for pregnant women should be included in all antenatal care programmes as a crucial intervention. There are already efforts being made in Bangladesh to encourage the use of iron and folic acid supplementation in Bangladesh. The Micronutrient Initiative (MI), Bangladesh [41], is one non-governmental organisation which strives to increase the number of women receiving iron and folic acid supplements in that country.

In this study, we found a lower protective effect of TT vaccination as against iron and folic acid supplementation towards neonatal and postnatal mortality. Tetanus toxoid vaccinations were found to have a protective effect on infant/children deaths, consistent with previous research [42-44]. Women should therefore be encouraged to take these vaccinations during pregnancy.

This study also found other socio-demographic factors to be associated with neonatal, postnatal and child mortalities. These mortalities were found to be significantly associated with children whose mothers had no schooling, whose parents were employed and who came from poor households. Other factors found to influence these mortalities were households with no access to the mass media, 4^{th}-born children with intervals of less than 2 years, and children who were delivered with no assistance from qualified health professionals. In addition to ensuring good antenatal cares services, these other factors which influence child mortality should be addressed.

9.4 Factors associated with under-5 mortality in Bangladesh

According to a recent report [45], between 2000 and 2010, the global burden of mortality in children younger than 5 years decreased by two million, to which pneumonia, measles and diarrhoea contributed most to the overall reduction. This global decline is reflected in this study. This study found a steady decline in the rates of neonatal, post-neonatal, infant, child and under-5 mortality in Bangladesh between 2004 and 2011. In order to improve on this result,

accelerated reduction for the most prevalent causes of death, especially pneumonia and preterm birth complications, is required.

The study showed that the risk of post-neonatal, infant and under-5 mortality was higher in infants from the Barisal region compared with infants from the Khulna region. A low number of prenatal care visits and low birth weight have been associated with post-neonatal death [46] Access to health facilities may be lacking in some of the regions in Bangladesh, and this could result in the observed regional differences in post-neonatal deaths. More developed communities are more likely to have better sanitation connections, which improve infant survival [47]

This study showed that male neonates had a significantly higher risk of dying during the neonatal period compared with female neonates. This finding is consistent with a cross-sectional study conducted in Indonesia, Nigeria and Bangladesh, in 2009 [14, 33, 48]. An increased risk of dying in the first month of life among male neonates may be as a result of high vulnerability to infectious disease [22] and female neonates are more likely to develop early foetal lung maturity in the first week of life [25], which may result in a lower incidence of respiratory diseases in female compared with male neonates.

This study had several strengths. First, the 2004, 2007 and 2011 versions of the DHS were nationally representative surveys that used standardised methods yielding an average response rate of 98%. Second, multilevel modelling was used, which took into account the hierarchical structure of the data and the variability within the clusters, household and individual levels to better estimate the level of association of the study factors with the outcome [49]. Third, the pooled method increased the study power, predicted which risk factors for child deaths persisted over time, and allows us to safely generalise the findings to other populations with similar characteristics.

The study was limited in a number of ways. First, the survey interviewed only surviving women, and this may have led to an underestimation of mortality rates because of the association between neonatal and maternal deaths. The effect of some of the associated factors, such as delivery complications, could have also been underestimated. Second, there may be other possible determinants of post-neonatal and other mortalities that were not available in the various versions of the BDHS data sets, such as environmental and genetic factors, or that were only available for the most recent delivery of a mother occurring within the past 5 years preceding the surveys. Third, several variables in the study were not infant specific as they only reflected the most recent conditions or birth, such as mother's work status, which was recorded as employment within the 12 months preceding the survey, and lastly, reverse causality is common with cross-sectional data, such as those from the DHS.

In terms of child mortality, although much is assumed about the disadvantage of teenaged mothers, motherhood in the early 20s is also likely to be disadvantageous as compared with older motherhood [50]. In this study, mothers who were aged 15–24 years were found to pose a risk to under-5 mortality. Older mothers may be more likely to highly value continuity of prenatal care and comprehensive care more than young mothers [51], and are more likely to attend more antenatal care visits, which reduce morbidities throughout the pregnancy period. The higher mortality risk for infants of younger mothers may be related to socioeconomic factors as well as biological immaturity [52]. In addition, children whose mothers were aged 30–39 years at the time of their birth had a significantly higher risk of under-5 mortality.

Strong associations have been reported between combined parental occupation and neonatal deaths. Paternal unemployment and maternal employment outside the home were found to significantly increase the odds of neonatal death [53] In this study, we found that while unemployed mothers posed a risk to neonatal and post-neonatal mortality, employed mothers increased the odds of infant under-5 mortality. Maternal employment may have an adverse

effect on the care provided to the newborn [53] Lack of personal and timely care, including infrequent breast feeding, experienced by infants born to working mothers, may have increased the odds of neonatal death [54]. The higher risk of infant and under-5 mortality among working mothers reflects the fact that employed mothers perform other traditionally ascribed roles within the family [55].

There is evidence that points quite unambiguously to higher mortality where there are short intervals between births [56]. Other studies have found strong associations between short preceding birth interval, birth rank and the risks of neonatal death [26, 54, 57]. In this analysis, fourth rank children with an interval of 2 years or less had significantly higher odds of neonatal, post-neonatal, infant and under-5 mortality than second/third rank children with >2 years interval. In addition, it was found that second/third rank children with an interval of <2 years had significantly higher odds of child mortality compared with children of similar rank but with an interval of >2 years. These findings may be attributed to maternal depletion syndrome and resource competition between siblings, in addition to a lack of care and attention experienced by high-ranked infants [26, 58]

In a previous study [56], neonatal and post-neonatal deaths were higher if older siblings had died in respective age intervals. A pregnancy interval of <12 months after child birth raised the risk of death at ages between 1 and 2 years considerably if the child was born after a short birth interval (<15 months).

Results from a previous study [53] indicate that neonates born to women experiencing complications such as vaginal bleeding, fever or convulsions during childbirth had significantly higher odds of dying compared with neonates born to women without any complications.

A study in Bangladesh found that infants born to women without severe delivery complications had better survival rates than infants born to women with eclampsia, intrapartum haemorrhage or even prolonged labour [34]. However, in this study, it was found that infants whose mothers

had no delivery complications had significantly higher odds of post-neonatal, infant, child and under-5 mortality. These findings could be largely due to chance, because of recall bias. However, further research may be required to explain this discrepancy.

Neonatal tetanus remains an important and preventable cause of neonatal mortality globally [59]. Immunisation of pregnant women or women of childbearing age with at least two doses of TT is estimated to reduce mortality from neonatal tetanus by 94% [59]. In this study, it was found that infants whose mothers did not have TT immunisations had significantly higher odds of neonatal, post-neonatal, infant and child mortality. The association of TT immunisations with neonatal, post-neonatal, infant and child mortality may be due more to its association with education and socioeconomic status than with a direct effect of the vaccine. It was also found that there was lower under-5 mortality rate in children who were delivered at home. This result could be due to selection bias and potential bias, which may, therefore, be misleading and could send the wrong message regarding the place of delivery, especially in low-income countries including Bangladesh. Past studies have associated high mortality rates to home delivery of Babies [60]. This finding could also be attributed to the fact that women from low socioeconomic groups with pregnancy complications that could be emergency will only delivery their babies at the hospital if they have preeclampsia, water break, severe bleeding and other emergency pregnancy complications. Higher child mortality in hospital are because they deal with more high risk pregnancies, and are better at reporting.

Birth control is said to be driven by contraceptive use and other factors. A recent study has found favourable effects of contraceptive use in reducing infant deaths in second and higher order births [61]. This study found that infants whose mothers did not use any contraceptives had significantly higher odds of neonatal, post-neonatal, infant, child and under-5 mortality.

In this study, it was found that the odds of neonatal, post-neonatal, infant, child and under-5 deaths decreased significantly among mothers who had other children aged 3 years or older. This issue is a mathematical consequence of a mother losing a child, because losing a child may reduce future under-5 deaths, and this is an example of reverse causality.

9.5 Summary

This chapter presented factors significantly associated with stillbirth, perinatal and under-5 mortality in Bangladesh, as well as the impact of antenatal care, iron and folic acid supplementation and tetanus toxoid vaccination on child mortality in Bangladesh. Among the significant factors associated with stillbirth were: limited maternal level of education, lack of husband, and household poverty. Significant factors associated with perinatal mortality included high maternal BMI, limited maternal level of education, household poverty and non-use of contraceptives among mothers. The study found that the provision of any form of antenatal care led to a reduction of the likelihood of infant/child mortality in Bangladesh. Further, iron and folic acid supplementation and tetanus toxoid vaccinations (2 components of ANC) were found to lead to a decline in infant/child mortality. The next section presents the conclusions to this thesis and recommendations for future research.

References

1. Rom AL, Mortensen LH, Cnattingius S, Arntzen A, Gissler M, Andersen A-MN: A comparative study of educational inequality in the risk of stillbirth in Denmark, Finland, Norway and Sweden 1981–2000. *Journal of epidemiology and community health* 2012, **66**(3):240-246.

2. Rychtarikova J, Gourbin C, Wunsch G: Paternal Age and Child Death: The Stillbirth Case. *European Journal of Population* 2004, **20**(1):23-33.

3. Luque-Fernández MÁ, Lone NI, Gutiérrez-Garitano I, Bueno-Cavanillas A: Stillbirth risk by maternal socio-economic status and country of origin: a population-based observational study in Spain, 2007–08. *The European journal of Public health* 2012, **22**(4):524-529.

4. Auger N, Delézire P, Harper S, Platt RW: Maternal education and stillbirth: estimating gestational-age-specific and cause-specific associations. *Epidemiology* 2012, **23**(2):247-254.

5. Luo Z-C, Wilkins R, Kramer MS: Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. *Canadian Medical Association Journal* 2006, **174**(10):1415-1420.

6. Reddy UM, Ko C-W, Willinger M: Maternal age and the risk of stillbirth throughout pregnancy in the United States. *American journal of obstetrics and gynecology* 2006, **195**(3):764-770.

7. Flenady V, Koopmans L, Middleton P, Frøen JF, Smith GC, Gibbons K, Coory M, Gordon A, Ellwood D, McIntyre HD: Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *The Lancet* 2011, **377**(9774):1331-1340.

8. McClure E, Nalubamba-Phiri M, Goldenberg R: Stillbirth in developing countries. *International Journal of Gynecology & Obstetrics* 2006, **94**(2):82-90.

9. Harvey SM, Faber KS: Obstacles to prenatal care following implementation of a community-based program to reduce financial barriers. *Family Planning Perspectives* 1993:32-36.

10. Gazi R, Goodburn L, Chowdhury A: Risk factors for perinatal deaths in rural Bangladesh. *Journal of health & population in developing countries* 1999, **2**(1):70.

11. Bartlett LA, Mawji S, Whitehead S, Crouse C, Dalil S, Ionete D, Salama P, Team AMMS: Where giving birth is a forecast of death: maternal mortality in four districts of Afghanistan, 1999–2002. *The Lancet* 2005, **365**(9462):864-870.

12. Feresu SA, Harlow SD, Woelk GB: Risk factors for prematurity at Harare maternity hospital, Zimbabwe. *International journal of epidemiology* 2004, **33**(6):1194-1201.

13. Agha S: The determinants of infant mortality in Pakistan. *Social science & medicine* 2000, **51**(2):199-208.

14. Mondal N, Hossain K, Ali K: Factors influencing infant and child mortality: A case study of Rajshahi District, Bangladesh. *Journal of Human Ecology* 2009, **26**(1):31-39.

15. Buor D: Mothers' education and childhood mortality in Ghana. *Health policy* 2003, **64**(3):297-309.

16. Das Gupta M: Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India. *Population studies* 1990, **44**(3):489-505.

17. Caldwell JC: Education as a factor in mortality decline an examination of Nigerian data. *Population studies* 1979:395-413.

18. Basu AM, Stephenson R: Low levels of maternal education and the proximate determinants of childhood mortality: a little learning is not a dangerous thing. *Social science & medicine* 2005, **60**(9):2011-2023.

19. Mellington N, Cameron L: Female education and child mortality in Indonesia. *Bulletin of Indonesian Economic Studies* 1999, **35**(3):115-144.

20. Palloni A: Mortality in Latin America: emerging patterns. *Population and Development Review* 1981:623-649.

21. Ezeh OK, Agho KE, Dibley MJ, Hall JJ, Page AN: Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. *BMJ open* 2015, **5**(3):e006779.

22. Alonso V, Fuster V, Luna F: Causes of neonatal mortality in Spain (1975–98): influence of sex, rural–urban residence and age at death. *Journal of biosocial science* 2006, **38**(04):537-551.

23. DaVanzo J, Butz WP, Habicht J-P: How biological and behavioural influences on mortality in Malaysia vary during the first year of life. *Population studies* 1983, **37**(3):381-402.

24. Bhuiya A, Streatfield K: Mothers' education and survival of female children in a rural area of Bangladesh. *Population Studies* 1991, **45**(2):253-264.

25. Khoury MJ, Marks JS, McCarthy BJ, Zaro SM: Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome. *American journal of obstetrics and gynecology* 1985, **151**(6):777-782.

26. Rutstein SO: Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys. *International Journal of Gynecology & Obstetrics* 2005, **89**:S7-S24.

27. Lindam A, Johansson S, Stephansson O, Wikström A-K, Cnattingius S: High maternal body mass index in early pregnancy and risks of stillbirth and infant mortality—a

population-based sibling study in Sweden. *American Journal of Epidemiology* 2016, **184**(2):98-105.

28. Johansson S, Villamor E, Altman M, Bonamy A-KE, Granath F, Cnattingius S: Maternal overweight and obesity in early pregnancy and risk of infant mortality: a population based cohort study in Sweden. *BMJ* 2014, **349**:g6572.

29. Cnattingius S, Bergström R, Lipworth L, Kramer MS: Prepregnancy weight and the risk of adverse pregnancy outcomes. *New England Journal of Medicine* 1998, **338**(3):147-152.

30. Meehan S, Beck CR, Mair-Jenkins J, Leonardi-Bee J, Puleston R: Maternal obesity and infant mortality: a meta-analysis. *Pediatrics* 2014, **133**(5):863-871.

31. Blackwell C: The role of infection and inflammation in stillbirths: parallels with SIDS? *Frontiers in immunology* 2015, **6**.

32. Makki K, Froguel P, Wolowczuk I: Adipose tissue in obesity-related inflammation and insulin resistance: cells, cytokines, and chemokines. *ISRN inflammation* 2013, **2013**.

33. Titaley CR, Dibley MJ, Agho K, Roberts CL, Hall J: Determinants of neonatal mortality in Indonesia. *BMC Public Health* 2008, **8**(1):232.

34. Mercer A, Haseen F, Huq NL, Uddin N, Khan MH, Larson CP: Risk factors for neonatal mortality in rural areas of Bangladesh served by a large NGO programme. *Health Policy and Planning* 2006, **21**(6):432-443.

35. Abir T, Agho KE, Page AN, Milton AH, Dibley MJ: Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011. *BMJ open* 2015, **5**(8):e006722.

36. Rahmani AM, Wade B, Riley W: Evaluating the impact a proposed family planning model would have on maternal and infant mortality in Afghanistan. *The International journal of health planning and management* 2015, **30**(1):71-85.

37. Ronsmans C, Chowdhury ME, Alam N, Koblinsky M, Arifeen SE: Trends in stillbirths, early and late neonatal mortality in rural Bangladesh: the role of public health interventions. *Paediatric and perinatal epidemiology* 2008, **22**(3):269-279.

38. Zeng L, Cheng Y, Dang S, Yan H, Dibley MJ, Chang S, Kong L: Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. *Bmj* 2008, **337**.

39. Titaley CR, Dibley MJ, Roberts CL, Hall J, Agho K: Iron and folic acid supplements and reduced early neonatal deaths in Indonesia. *Bulletin of the World Health Organization* 2010, **88**(7):500-508.

40. Organization WH: Iron deficiency anaemia: assessment, prevention and control: a guide for programme managers. 2001.

41. Bangladesh [http://micronutrient.org/mi-in-the-world/asia/bangladesh/] (Accessed 18/06/2016, Sydney)

42. Tall F, Prazuck T, Roisin A, Sanou J, Nacro B, Traore A, Cot M, Lafaix C: [Risk factors for neonatal tetanus in western Burkina Faso. Case-control study]. *Bulletin de la Societe de pathologie exotique (1990)* 1990, **84**(5 Pt 5):558-561.

43. Gitta SN, Wabwire-Mangen F, Kitimbo D, Pariyo G: Risk factors for neonatal tetanus--Busoga region, Uganda, 2002-2003. *MMWR Morb Mortal Wkly Rep* 2006, **55**(Suppl 1):25-30.

44. Chai F, Prevots DR, Wang X, Birmingham M, Zhang R: Neonatal tetanus incidence in China, 1996–2001, and risk factors for neonatal tetanus, Guangxi Province, China. *International journal of epidemiology* 2004, **33**(3):551-557.

45. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, Rudan I, Campbell H, Cibulskis R, Li M *et al*: Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *The Lancet* 2012, **379**(9832):2151-2161.

46. Machado CJ, Hill K: Determinants of neonatal and post-neonatal mortality in the City of São Paulo. *Revista Brasileira de Epidemiologia* 2003, **6**(4):345-358.

47. Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS: How many child deaths can we prevent this year? *The Lancet* 2003, **362**(9377):65-71.

48. Ezeh OK, Agho KE, Dibley MJ, Hall J, Page AN: Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. *BMC Public Health* 2014, **14**(1):1.

49. Twisk JW: Applied multilevel analysis: a practical guide: Cambridge University Press; 2006.

50. Taylor JS, Cabral HJ: Are women with an unintended pregnancy less likely to breastfeed? *Journal of family practice* 2002, **51**(5):431-438.

51. O'Malley AS, Forrest CB: Beyond the examination room. *Journal of general internal medicine* 2002, **17**(1):66-74.

52. Kirchengast S, Hartmann B: Impact of maternal age and maternal somatic characteristics on newborn size. *American Journal of Human Biology* 2003, **15**(2):220-228.

53. Titaley C, Dibley M, Agho K, Roberts C, Hall J: Determinants of neonatal mortality in Indonesia. *BMC Public Health* 2008, **8**(1):232.

54. Reid A: Neonatal mortality and stillbirths in early twentieth century Derbyshire, England. *Population studies* 2001, **55**(3):213-232.

55. Ahmad-Nia S: Women's work and health in Iran: a comparison of working and non-working mothers. *Social science & medicine* 2002, **54**(5):753-765.

56. Sear R, Steele F, McGregor IA, Mace R: The effects of kin on child mortality in rural Gambia. *Demography* 2002, **39**(1):43-63.

57. Arokiasamy P, Gautam A: Neonatal mortality in the empowered action group states of India: trends and determinants. *Journal of biosocial science* 2008, **40**(02):183-201.

58. Zenger E: Siblings' neonatal mortality risks and birth spacing in Bangladesh. *Demography* 1993, **30**(3):477-488.

59. Blencowe H, Lawn J, Vandelaer J, Roper M, Cousens S: Tetanus toxoid immunization to reduce mortality from neonatal tetanus. *International Journal of Epidemiology* 2010, **39**(suppl 1):i102-i109.

60. Filippi V, Ronsmans C, Campbell OM, Graham WJ, Mills A, Borghi J, Koblinsky M, Osrin D: Maternal health in poor countries: the broader context and a call for action. *The Lancet* 2006, **368**(9546):1535-1541.

61. van Soest A, Saha U: Does family planning reduce infant mortality? Evidence from surveillance data in Matlab, Bangladesh. In.; 2012.

CHAPTER 10

SUMMARY, POLICY IMPLICATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

10.0 Introduction

In this chapter, an overview of key findings of the current study is presented. The key factors associated with stillbirth in Bangladesh are summarised. The next section summarises the factors associated with perinatal mortality in Bangladesh. Following this section is a summary of the community, socio-economic and proximate factors that were associated with antenatal care service patronage, intake of iron and folic acid supplementation by mothers in Bangladesh. The next section presents a summary of the factors associated with under-5 mortality in Bangladesh. The strengths and limitations of the current study are summarised in the next section. The section that follows summarises future research direction of this current study. Finally, the last section concludes the study.

10.1 Overview of key findings

This body of research examined the determinants of stillbirth in Bangladesh. It then assessed the factors associated with perinatal mortality in Bangladesh. Community, socio-economic and proximate factors that were associated with antenatal care service patronage, intake of iron and folic acid supplementation by mothers in Bangladesh were also examined. Finally, factors associated with under-5 mortality in Bangladesh were examined.

10.1.2 Factors associated with stillbirth in Bangladesh

Limited maternal education was significantly associated with stillbirth in Bangladesh. Formerly married mothers had a significantly higher likelihood of stillbirth, compared to currently married ones; and the odds of stillbirth were significantly higher in poor households,

compared to rich households. A reduced likelihood of stillbirth was found to be significantly associated with mothers who had three or more children, compared to those who had just one. Mothers who had three or more under-5 children were significantly less likely to experience a stillbirth, compared to those who had between one and two under-5 children.

10.1.3 Factors associated with perinatal mortality in Bangladesh

Mothers of BMI higher than 18.5kg/m2 were significantly more likely to experience a stillbirth and/or early neonatal death. The likelihood of both perinatal death (stillbirth and early neonatal) and perinatal death (stillbirth and neonatal) was significantly higher among mothers who had no schooling compared to those who had secondary education of higher. Perinatal deaths are significantly more likely to occur in poor households compared to rich households. Perinatal deaths were significantly associated with males; and infants whose previous siblings had died were significantly higher odds of perinatal death compared to those whose previous siblings had not. Furthermore, the likelihood of perinatal death was significantly higher among mothers who did not experience any delivery complications and who did not take any contraceptives.

10.1.4 Effect of different combinations of iron and folic acid supplementation, tetanus toxoid vaccination and antenatal care on neonatal, post-neonatal and child mortality

The likelihood of neonatal death was significantly higher among neonates whose mothers were given no iron and folic acid (IFA) supplements and had less than two tetanus toxoid (TT) vaccinations compared to those whose mothers had IFA supplements and who had two or more TT vaccinations. Infants whose mothers received no IFA supplements and had less than two TT vaccinations were not significantly protected from postnatal death while those who had IFA supplements and two or more TT vaccinations were.

The likelihood of infants dying in the postnatal period was found to be significantly higher among mothers who did not have any ANC visits and did not receive any IFA supplements compared to those who had ANC visits and took IFA supplements.

Children whose mothers had IFA supplementation and had two or more TT vaccinations were significantly better protected against child death than those whose mothers did not receive any IFA supplements and had two or less TT vaccinations. Children whose mothers attended ANC clinics and received IFA supplements were significantly less likely to die compared to those whose mothers did not attend any ANC clinics and did not receive any IFA supplements.

10.1.5 Factors associated with mortality

10.1.5.1 Neonatal mortality

Neonates whose mothers resided in the Sylhet region of Bangladesh were significantly associated with neonatal deaths. The odds of neonatal deaths were significantly more likely among younger mothers compared to older mothers. It was also significantly more likely among mothers who had low levels of education or who had no formal education. Mothers who had lost a child earlier on were significantly more likely to lose their neonate than those who had not. The likelihood of neonatal death was significantly among mothers who did not breastfeed their infant compared to those who did. Other factors significantly associated with neonatal deaths were: second/third rank neonates with a birth interval of less than two years, and neonates whose mothers did not use any contraceptives.

10.1.5.2 Post-neonatal mortality

The odds of post-neonatal death were significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sector. Compared to mothers who had no formal education, the likelihood of post-neonatal death was significantly lower among

mothers who had secondary education or higher. Mothers who reported the death of a child before their latest pregnancy had significantly higher odds of experiencing post-neonatal death, compared to those who did not have a child dying before their pregnancy. The odds of post-neonatal death were significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children.

10.1.5.3 Infant mortality

The odds of infant death were significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors. The odds of infant death were significantly lower among mothers who had secondary education or higher, compared to mothers who had no formal education. Mothers who reported the death of a child before their current pregnancy were significantly more likely to experience infant death, compared to those who did not have a child dying before their pregnancy. The likelihood of infant death was significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children.

The odds of infant death were significantly lower among mothers who breastfed their children, compared to those who never did. The odds of death was significantly higher among fourth rank infants with a birth interval of two years or less, compared to second/third infants with a birth interval of more than two years. Additionally, mothers who used contraceptives were significantly less likely to experience an infant death, compared to those who did not.

10.1.5.4 Child mortality

The probability of child dying was significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors. The odds of child death were significantly lower among mothers who had secondary education or higher, compared to mothers who had no formal education.

The odds of dying among children whose mothers reported the previous death of a child, was significantly higher, compared to those whose mothers did not have a previous death of a child. The odds of child death were significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children.

The odds of child death were significantly lower among mothers who breastfed their children, compared to those who never did. The likelihood of child death was significantly lower among mothers who had delivery complications, compared to those who had none; and mothers who used contraceptives were significantly less likely to experience a child death, compared to those who did not.

10.1.5.5 Under-5 mortality

The odds of under-5 death were significantly higher among unemployed mothers, compared to mothers who were employed in non-agricultural sectors. The odds of under-5 death was significantly lower among mothers who had secondary education or higher, compared to mothers who had no formal education.

Child whose previous sibling had died was significantly more likely to report under-5 death compared to the one whose previous sibling had not. The likelihood of under-5 death was significantly lower among mothers who had more than three under-5 children, compared to those who had between one and two children. Under-5 children who had been breastfed before had a significantly lower likelihood of death than those who had never been breastfed. The odds of under-5 death was significantly higher among fourth rank children with a birth interval

of two years or less, compared to second/third infants with a birth interval of more than two years. Mothers who used contraceptives were significantly less likely to experience an under-5 death, compared to those who did not. The likelihood of child death was significantly lower among mothers who had delivery complications, compared to those who had none; and, mothers who used contraceptives were significantly less likely to experience a child death, compared to those who did not.

10.2 Strengths and weaknesses of the study

This study utilized nationally-representative datasets, which offers some advantages. Firstly, Demographic and Health Survey (DHS) data allow for the generalization of findings across the whole country and consisted of large sample sizes with high response rates. Secondly, the DHS programme often adopts similar sampling methodology and comparable survey instruments over time. Therefore results from analysis of two or more DHS data points are comparable over time. Furthermore, the use of similar methodology can make results comparable across countries. The use of multilevel analysis offers an added strength to this study. Many previous studies on infant and child mortality did not account for the hierarchical structure of the mortality data. Such studies attempted fitting a single-level regression modelling, and ignored the fact that children are nested within families and families are nested within neighbourhoods or communities [1]. Thirdly, the data analysed were restricted to information of each mother's latest birth, 5 years prior to each survey. This restriction enhanced the validity of the analysis and also minimised recall bias [2, 3]. Fourthly, analysis of the effects of the different healthcare variables, namely, general ANC services, IFA supplementation and TT vaccinations and combinations of these variables while a range of other factors associated with neonatal, postnatal and child mortality was controlled for was made possible by the substantial sample sizes.

This study, however, has some limitations. Firstly, it was based on ever-married women and therefore excluded unmarried women who had foetus of gestation over 27 weeks. In Bangladesh, the probability of a woman having a child without being married is very small as there are strong social and religious norms against unmarried mothers. Secondly, the diagnosis of stillbirth was based on self-report from the mother and was subject to recall and misclassification bias. As most births occurred in rural areas, there was no healthcare provider to measure heartbeat or conduct a physical examination. In most communities and hospitals in low and middle income countries, depressed live-born infants are often misclassified as stillbirths, due to the fact that stillbirth is more culturally acceptable and culpability may be minimised. In addition, formal verbal autopsies are not conducted on stillbirths. Furthermore, no information on labour, delivery or other factors such as tobacco gestational diabetes or genetic abnormalities that may have been associated with stillbirth was included in the BDHS data. Also, reports from mothers could not be validated. That notwithstanding, child mortality has been a core feature in the various DHS programmes, and there has been careful examination of methods used in the survey for many years [4]. Second, report of usage of IFA supplementation during pregnancy by a mother was based on her recall; consequently, we could not assess any improvement in her iron status. Additionally, there could be an underestimation of these mortalities due to the fact that history of birth and infant/child survival data obtained from only surviving mothers [3].

10.3 Policy Implications

Results of this thesis have implications for policy. In Bangladesh, the proportion of rural women giving birth at home remains high and with stillbirths predominantly occurring at full term, this indicates the possible chance of survival of an infant if improved standard pregnancy and childbirth care were available. The government of Bangladesh and other stakeholders should implement strategies to improve access to and use of prenatal and emergency obstetric

care to minimise the occurrence of stillbirth in Bangladesh especially in groups who have been identified to be at higher risk.

Infant and child mortality levels as well as risks of dying young were found to be higher in some regions than in others. As a result, under-five mortality levels will continue to remain high in Bangladesh if interventions and policies are not formulated and implemented to address the regional variations in infant and child mortality in the country.

Efforts that will reduce infant and child mortality differentials between rural and urban areas must include policies that address rural area-disadvantage through equitable distributions of community infrastructures, such as health facilities, and education for women.

Risks of death was found to be higher for children whose mothers were using no contraceptive methods compared to those whose mothers were using contraception. Therefore, without concerted efforts to address the present levels of low prevalence of contraceptive use, which currently stands at 62.4% in Bangladesh [5]; infant and child mortality will continue to remain high in the country.

10.4 Recommendations

This study found that a combination of iron and folic acid was protective against neonatal, postnatal and child mortality in Bangladesh. The study also found TT vaccination to be separately protective against neonatal mortality. Future neonatal, postnatal and child care services meant to reduce neonatal, postnatal and child mortalities should include the use of iron and folic acid supplementation as well as TT vaccinations.

This study showed that birth rank and birth interval, previous death of a sibling, having other children under 5 years old and contraceptive use by mothers were the common factors associated with neonatal, post-neonatal, infant, child and under-5 deaths. Findings of this study indicate the need to implement community-based interventions, particularly educating

community health workers and traditional birth attendants about child spacing, and contraceptive use by mothers. This may contribute to a further reduction of under-5 deaths. Findings from this study could help provide a framework to design future health plans and policies tailored towards achieving effective health initiatives to enhance child survival. In particular, the government of Bangladesh and other stakeholders could use information in this thesis to help step up further efforts to minimise mortality in that country.

In Bangladesh, the proportion of rural women giving birth at home remains high and with stillbirths predominantly occurring at full term, this indicates the possible chance of survival of an infant if improved standard pregnancy and childbirth care were available. Significant risk factors for stillbirths in this study included advanced age of mothers and parental education. The government of Bangladesh and other stakeholders should implement strategies to improve access to and use of prenatal and emergency obstetric care to minimise the occurrence of stillbirth in Bangladesh, especially in groups who have been identified to be at higher risk.

Policies and programmes aimed at addressing regional variations in infant and child mortality must be formulated and their implementation must be vigorously pursued. To achieve this, while under-five mortality reduction measures which have worked to some extent in regions of Bangladesh, such the Dhaka region, must be strengthened to achieve more results in the more privileged regions, these measures could be extrapolated and applied in the less privileged regions of the country. Such measures include having hospital delivery and attending prenatal care.

To ensure proximity to health facilities in all communities across the country, the current imbalance in the distribution of health facilities between the rural areas and the urban centres must be rectified through equitable distribution of facilities across communities and regions.

The current family planning programme in the country must be strengthened and expanded to ensure that all men and women who wish to space or limit the number of their children have

the means to do so. This will bring about adequate spacing between births. Behavioural change communication could be used as a strategy to promote acceptance of family planning.

10.5 Future research directions

- Future research should examine community-based trials that will determine the long-term impact of Iron and Folic Acid (IFA) supplementations starting early in pregnancy on child mortality and such intervention trials should exclude iron content of groundwater.
- The influences of contextual determinants on infant and child mortality need to be further explored with the use of qualitative data
- Contraceptive uptake was observed in this study as an important factor that could increase the survival chances of children. Hence both qualitative and quantitative studies should be carried out to explore the barriers to the utilisation of family planning methods including its impact on women autonomy in Bangladesh.

10.6 Conclusions

The analysis of factors associated with stillbirths in Bangladesh revealed the major risk factors for stillbirth. These findings highlight the need to increase awareness and access to basic and emergency obstetric care to women of low socioeconomic status in order for Bangladesh to achieve a substantial reduction from 27 stillbirths per 1000 births in 2011 to a target of 13 stillbirths per 1000 births by the year 2020 [6].

This study also found that a combination of iron and folic acid was protective against neonatal, postnatal and child mortality in Bangladesh. The study also found TT vaccination to be separately protective against neonatal mortality. Future neonatal, postnatal and child care services meant to reduce neonatal, postnatal and child mortalities should include the use of iron and folic acid supplementation as well as TT vaccinations.

The combined 2004, 2007, 2011 and 2014 BDHS data sets examined in this study revealed the factors associated with neonatal, post-neonatal, infant, child and under-5 deaths. Findings of

the study indicate the need to implement community-based interventions, particularly educating community health workers and traditional birth attendants about child spacing, and contraceptive use by mothers. This may contribute to a further reduction of under-5 deaths. Findings from this study could help provide a framework to design future health plans and policies tailored towards achieving effective health.

References

1. Harttgen K, Misselhorn M: A multilevel approach to explain child mortality and undernutrition in South Asia and Sub-Saharan Africa. In.: Ibero-America Institute for Economic Research; 2006.

2. Hill K, Choi Y: Neonatal mortality in the developing world. *Demographic research* 2006, 14(18):429-452.

3. Mahy M: Childhood mortality in the developing world: a review of evidence from the Demographic and Health Surveys, vol. 4: MEASURE DHS+, ORC Macro; 2003.

4. Curtis SL: Assessment of the quality of data used for direct estimation of infant and child mortality in DHS-II surveys. 1995.

5. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International: Bangladesh Demographic and Health Survey 2014. In. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International; 2016.

6. Say L, Donner A, Gulmezoglu AM, Taljaard M, Piaggio G: The prevalence of stillbirths: a systematic review. *Reprod Health* 2006, 3(1).

Appendix A

Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011

Tanvir Abir, Kingsley Emwinyore Agho, Andrew Nicolas Page,
Abul Hasnat Milton, Michael John Dibley
BMJ Open; 2015 5 (8): e006722

BMJ Open

Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011

Tanvir Abir,[1] Kingsley Emwinyore Agho,[1] Andrew Nicolas Page,[1] Abul Hasnat Milton,[2] Michael John Dibley[3]

To cite: Abir T, Agho KE, Page AN, *et al*. Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011. *BMJ Open* 2015;**5**:e006722. doi:10.1136/bmjopen-2014-006722

► Prepublication history and additional material is available. To view please visit the journal (http://dx.doi.org/10.1136/bmjopen-2014-006722).

Received 23 September 2014
Revised 28 May 2015
Accepted 15 June 2015

[1]School of Science and Health, University of Western Sydney, New South Wales, Australia
[2]Faculty of Health and Medicine, Centre for Clinical Epidemiology & Biostatistics (CCEB), School of Medicine and Public Health, The University of Newcastle, Newcastle, New South Wales, Australia
[3]Sydney School of Public Health, University of Sydney, Newcastle, New South Wales, Australia

Correspondence to
Tanvir Abir;
T.Abir@uws.edu.au

ABSTRACT

Objective: The aim of this study was to identify factors associated with mortality in children under 5 years of age using a nationally representative sample of singleton births for the period of 2004–2011.

Design, setting and participants: Pooled 2004, 2007 and 2011 cross-sectional data sets of the Bangladesh Demographic and Health Surveys were analysed. The surveys used a stratified two-stage cluster sample of 16 722 singleton live-born infants of the most recent birth of a mother within a 3-year period.

Main outcome measures: Outcome measures were neonatal mortality (0–30 days), postneonatal mortality (1–11 months), infant mortality (0–11 months), child mortality (1–4 years) and under-5 mortality (0–4 years).

Results: Survival information for 16 722 singleton live-born infants and 522 deaths of children <5 years of age included: 310 neonatal deaths, 154 postneonatal deaths, 464 infant deaths, 58 child deaths and 522 under-5 deaths. Multiple variable analysis showed that, over a 7-year period, mortality reduced significantly by 48% for postneonatal deaths, 33% for infant deaths and 29% for under-5 deaths, but there was no significant reduction in neonatal deaths (adjusted OR (AOR)=0.79, 95% CI 0.59 to 1.06) or child deaths (AOR=1.00, 95% CI 0.51 to 1.94). The odds of neonatal, postneonatal, infant, child and under-5 deaths decreased significantly among mothers who used contraceptive and mothers who had other children aged 3 years or older. The risk of neonatal, postneonatal, infant, child and under-5 deaths was significantly higher in mothers who reported a previous death of a sibling.

Conclusions: Our study suggests that family planning is needed to further reduce the overall rate of under-5 deaths in Bangladesh. To reduce childhood mortality, public health interventions that focus on child spacing and contraceptive use by mothers may be most effective.

Strengths and limitations of this study

- This is the first pooled analysis of 2004, 2007 and 2011 Bangladesh Demographic and Health Surveys with an average response rate of 98%.
- Our method used multilevel modelling, which took into account the effect of clustering to better estimate the level of association of the study factors with the outcome.
- The pooled method increases the study power, predicts which risk factors for child deaths persist over time, and the findings can be safely generalised to cover populations with similar characteristics.
- The survey interviewed surviving women only, and this may have led to an underestimation of mortality rates, because of the association between neonatal and maternal deaths.
- Several variables in the study were not infant-specific as they only reflected the most recent conditions or birth, such as mother's work status, which represented the employment status within the past 12 months preceding the survey.

INTRODUCTION

Under-5 mortality is an essential indicator of the development of a country. It is also crucial evidence of a country's values and priorities. According to a recent report, substantial progress has been made towards achieving the fourth Millennium Development Goal (MGD4). The number of under-5 deaths worldwide declined from nearly 12 million in 1990 to 6.9 million in 2011.[1] This translates into 14 000 fewer children dying each day in 2011 than in 1990. Nevertheless, the figures still imply that 19 000 children aged <5 years died every day in 2011.

The same report showed evidence that, in Bangladesh, the number of infant deaths in 1990 was 351 000. According to the report, this number fell to 105 000 in 2011.[1] Successful programmes for immunisation, control of diarrhoeal diseases and for providing vitamin A supplementation are

considered to be the most important contributors to the decline in child and infant deaths, along with potential effect of overall economic and social development. Despite this decline in child and infant deaths, greater effort is still needed to improve infant survival.

The extant literature is replete with evidence that there is a negative association between socioeconomic variables of a child's parents and postneonatal mortality.[2–4] There is also evidence of a close association between the risk of an infant's death and characteristics of the mother.[5]

There have been previous studies in Bangladesh to measure factors associated with neonatal and postneonatal, child and under-5 mortality.[4 6 7] The major limitation of these studies is the issue of generalisability because of the limited number of deaths recorded in a single Bangladesh Demographic and Health Surveys (BDHSs) data set, making it difficult to investigate risk factors for child mortality that persist over time and the issue of sample size when conducting mortality research in a single district. For instance, Chowdhury *et al*[7] conducted studies on covariates of neonatal and postneonatal mortality in Bangladesh by making use of the 2007 BDHS data set, while studies conducted by Quamrul *et al*[4] and Mondal *et al*[6] on child mortality were both conducted in the Rajshahi and Natore districts of Bangladesh.

The aim of the present study was to identify specific factors that affect childhood mortality in Bangladesh at different subperiods of the first 59 months of life (neonatal, postneonatal, infant, child and under-5 mortality) by using a pooled analysis of the 2007, 2004 and 2011 versions of the BDHS.[8–10] Findings from this study may help policy-makers to redirect resources to the most vulnerable children who have a high risk of dying before the age of 5.

Written consent was obtained from all respondents and all information was collected confidentially.

METHODS

Data sources

BDHSs are nationally representative household surveys that collect data on a wide range of population, health and nutrition indicators,[11] and have been conducted approximately every 3 years since 1993–1994 with the aim of improving the health of Bangladeshi mothers and children. The BDHS data sets were based on two-stage stratified cluster sampling. Level 1 was individuals (ever-married women aged 15–49 years) who were nested within clusters (level 2). The sampling methods used in this study have been reported elsewhere.[8–10] The data used in the present study were derived from the 2004, 2007 and 2011 surveys. In total, information on 40 460 women was obtained: 11 440 (98.6%) from 2004, 11 178 (98.4%) from 2007 and 17 842 ((97.9%) from 2011. On average, the response rate was over 98%.[8–10]

Survival information was obtained from 16 722 singleton live-born infants of the most recent birth of the mother within 3 years prior to the mother being interviewed. The analyses used the most recent birth because only those births had detailed information about the use of perinatal health services. The most recent birth was also used in order to limit the potential for differential recall of events from mothers who had delivered at different durations prior to interview. Multiple births were excluded from our analysis given that previous studies have shown a strong correlation between multiple births and childhood mortality.[12] Our analysis was restricted to ever-married women aged 15–49 years and to births within 3 years in order to minimise recall bias about birth and death dates reported by mothers.

Study outcomes

The main outcomes used were childhood mortality examined in four different time periods. The time periods were neonatal death (death after birth through 30 days of life), postneonatal death, defined as death of an infant from 1 to 11 months of life[13] and infant death, defined as death of an infant after birth through 11 months of life. The other two outcomes were child death, defined as death between 12 and 59 months of life and death of children under 5 years, defined as death of a child after birth through 59 months of life.

Potential risk factors

The Mosley and Chen[14] framework of factors influencing child survival in developing countries was the basis for selecting potential risk factors for childhood mortality. The outcome variables were examined against all selected potential risk variables and these variables were organised into four distinct groups: community, household, individual and health services factors. The community level factors assessed were residence type and geographical zone. The residence type was categorised into two groups (urban and rural) and geographical zone covering groups of divisions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet). The household factor used was the wealth index variable, which measures the economic status of a household. The household wealth index was constructed by assigning weights to three housing characteristics (ie, availability of electricity, and type of floor and wall) and six household assets (ie, possession of a radio, television, fridge, bicycle, motorcycle and car), using the survey data and principle components analysis. The wealth index was used to rank all households across the three surveys. The household wealth index variable was categorised into five quintiles (poorest, poorer, middle, richer and richest), but for analyses, this index was divided into three categories. The bottom 40% of households was arbitrarily classified as poor households, the next 40% as the middle households and the top 20% as rich households.[15] The individual level factors consisted of maternal, child and paternal characteristics: maternal factors were religion,

number of children under the age of 5, education, watches TV, listens to radio, reads newspapers, age, body mass index and desire for pregnancy; child factors were sex of the baby, combined birth place and mode of delivery, delivery assistance, and a combination of birth order and birth interval; and paternal education. The health services factors were: delivery complications, desire for previous pregnancies, contraceptive use, number of antenatal clinic visits and number of tetanus toxoid (TT) vaccinations during pregnancy.

Statistical analysis

Initially, neonatal, postneonatal, infant, child and under-5 mortality rates by year of survey were estimated using a method similar to that described by Rutstein and Rojas.[16]

The unadjusted ORs for factors associated with neonatal, postneonatal, infant, and child and under-5 mortality were examined using multilevel modelling. This was followed by multivariable analyses used to assess the independent effect of each factor after controlling for other related factors. All statistical analyses were conducted using STATA/MP V.12.1 (StataCorp, College Station, Texas, USA) and multilevel models were fitted using STATA survey commands to adjust for the variability of clustering.

In the multivariable analysis models, a manual stepwise backwards elimination process was used to identify factors that were significantly associated with the study outcomes using 5% significance level. In order to minimise or avoid statistical error in our analyses, we repeated the backward elimination process by using a different approach: first, only variables among community, household and individual level variables with p value <0.20 identified in the univariate analysis were entered for backward elimination process. Second, we double-checked the backward elimination by including all community, household, individual and health services variables, and only the variables with a p value <0.05 were retained in the final model. Third, we tested for collinearity in the final model. The ORs and 95% CIs were calculated for each variable, and were used to measure the impact of the adjusted estimates on the study outcomes.

RESULTS

In the 16 722 singleton live-born infants from the most recent delivery within 3 years prior to interview date, there were 522 under-5 child deaths, of which 310 were neonatal deaths in the first 30 days of life, 154 were postneonatal deaths in ages 1–11 months and 58 deaths in ages 1–4 years. The percentage of neonatal deaths out of all under-5 deaths was 54% in 2014, 61% in 2007 and 65% in 2011. Figure 1 shows the rates of neonatal, postneonatal, infant, child and under-5 mortality rates over time. There was a steady decline in mortality rates from 2004 through to 2011, although the decline of neonatal, postneonatal, infant, child and under-5 mortality between 2007 and 2011 was not statistically significant.

The percentage of mothers who lived in rural areas decreased from 79.4% in the 2004 BDHS to 75.3% in the 2011 BDHS. Mothers who had secondary or higher level of education increased from 7.5% in the 2004 BDHS to 12.8% in the 2011 BDHS. Male and female children were nearly equally represented in the three study periods, while the percentage of mothers from poor households decreased from 56.2% in the 2004 BDHS to 36.7% in the 2011 BDHS (see online supplementary table S1).

Univariate analysis indicated that mother working status, parental (mother and father) education, previous death of sibling, other children under 5 years, combined birth rank and interval, TT vaccinations and contraceptive use, were all associated with neonatal, postneonatal and infant mortality (see online supplementary table S2).

As shown in table 1, there was a reduction in the odds of neonatal deaths in 2011 compared with 2004. Male neonates were more likely to die than female neonates in the first 30 days of life (adjusted OR (AOR)=1.27, 95% CI 1.00 to 1.61, p=0.05 for male neonates). There was a significant increase in the odds of neonatal deaths in working mothers (AOR=1.35, 95% CI 1.01 to 1.80, p=0.04) compared with non-working mothers. Mothers who had secondary education or higher had decreased odds of neonatal death (AOR=0.51, 95% CI 0.32 to 0.83, p=0.007) compared to mothers with no schooling. There were significantly higher odds of neonatal death among second or third born infants with intervals of >2 years, fourth rank infants with 2 years interval or less and mothers who reported previous death of a sibling. The odds of neonatal deaths were lower for neonates who had other siblings aged 3 years or older, those delivered at home, those whose mothers had two or more TT vaccinations and for those whose mothers had used any contraceptives.

Compared with 2004, the odds of postneonatal mortality in 2011 reduced significantly by 48%. Infants from the Barisal region had a significantly higher risk of postneonatal deaths compared to those from the Khulna region. Infants whose mothers were in paid employment had a significantly higher risk of postneonatal death. Other factors that posed significant risks to postneonatal deaths included infants who were second, third or fourth born with <2 years interval and infant mothers who reported previous death of a sibling. A decreased risk of postneonatal death was associated with mothers having other children aged 3 years or older, those having a secondary education or higher, those having any delivery complications and with those who had two or more TT vaccinations during pregnancy or who used any contraceptives.

The odds of infant mortality in 2011 had decreased by almost a third, compared with 2004. Infants whose mothers were working or who reported previous death of a sibling were at higher risk of infant mortality.

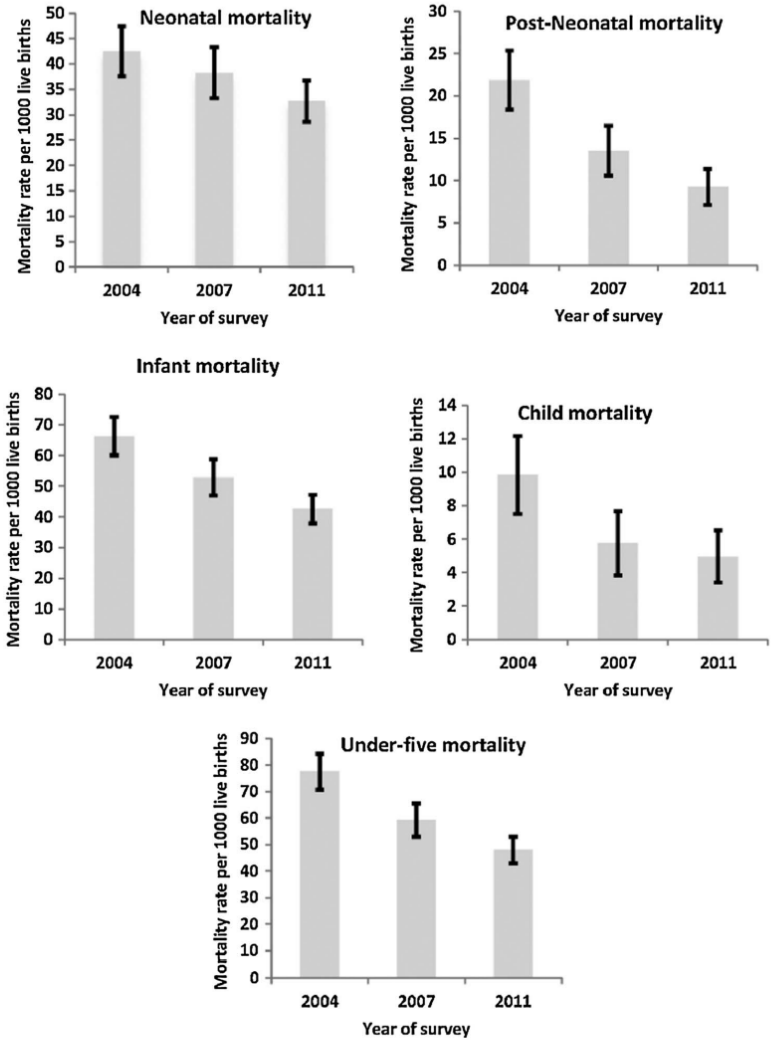


Figure 1 Neonatal, postneonatal, infant, child and under-5 mortality rates per 1000 live births in Bangladesh.

Compared with second or third born infants with intervals of >2 years, fourth rank infants with 2 years interval or less had a significantly higher risk of infant mortality. Other factors that significantly reduced the risk of infant mortality included mothers who had secondary education or higher or who had other children aged 3 years or older and infants delivered at home, as well as infants whose mothers had any delivery complications, had two or more TT vaccinations and who used any contraceptives (see table 1).

Unadjusted OR revealed that maternal marital status, previous death of a sibling, other children aged under 5 years, combined birth rank, and interval and contraceptive use, were all common factors associated with child and under-5 mortality (see online supplementary table S3).

As shown in table 2, the odds of child mortality between 2004 and 2011 were similar. The risk of child deaths was higher in children whose mothers had been formerly married. The factors that significantly reduced the risk of child mortality included first birth rank, children aged 3 years or older, mothers who had any delivery complications and mothers who used any contraceptives. Risk factors for child mortality were children with previous death of a sibling and children whose mothers desired pregnancy later.

In table 2, there was a decrease in the odds of under-5 deaths in 2011. The Khulna region had significantly lower odds for under-5 mortality compared with the Barisal region. Under-5 mortality was significantly associated with children whose mothers were in paid employment, children with previous death of a sibling,

Table 1 Risk factors for neonatal, postneonatal and infant mortality: adjusted OR

	Neonatal mortality (0–30 days)				Postneonatal mortality (1–11 months)				Infant mortality (0–11 months)			
	Adjusted				Adjusted				Adjusted			
Characteristic	OR	(95% CI)		p Value	OR	(95% CI)		p Value	OR	(95% CI)		p Value
Year of survey												
2004	1.00				1.00				1.00			
2007	0.75	0.56	1.01	0.060	0.58	0.39	0.87	0.008	0.65	0.51	0.84	0.001
2011	0.79	0.59	1.06	0.116	0.52	0.34	0.79	0.002	0.67	0.52	0.86	0.002
Region												
Barisal	–	–	–	–	1.00				1.00			
Chittagong	–	–	–	–	0.67	0.37	1.21	0.186	0.72	0.49	1.05	0.091
Dhaka	–	–	–	–	0.76	0.43	1.36	0.358	0.92	0.64	1.32	0.654
Khulna	–	–	–	–	0.33	0.14	0.77	0.010	0.53	0.34	0.83	0.006
Rajshahi	–	–	–	–	0.60	0.32	1.13	0.112	0.80	0.55	1.18	0.266
Sylhet	–	–	–	–	1.23	0.70	2.19	0.472	1.20	0.82	1.74	0.341
Sex of baby												
Female	1.00				–	–	–	–	–	–	–	–
Male	1.27	1.00	1.61	0.050	–	–	–	–	–	–	–	–
Mother working status												
Not working	1.00				1.00				1.00			
Working	1.35	1.01	1.80	0.041	1.90	1.32	2.74	0.001	1.60	1.26	2.01	<0.001
Maternal highest level of education												
No education	1.00				1.00				1.00			
Primary	0.79	0.59	1.04	0.096	0.81	0.54	1.19	0.280	0.80	0.63	1.02	0.069
Secondary or more	0.51	0.32	0.83	0.007	0.28	0.10	0.78	0.015	0.45	0.29	0.70	<0.001
Birth rank and birth interval												
2nd/3rd birth rank, >2 years interval	1.00				1.00				1.00			
1st birth rank	1.32	0.97	1.79	0.079	0.92	0.58	1.46	0.723	1.17	0.90	1.51	0.233
2nd/3rd birth rank, ≤2 years interval	3.08	1.98	4.80	<0.001	1.00	0.44	2.26	0.993	2.30	1.55	3.42	<0.001
4th birth rank, >2 years interval	0.94	0.63	1.39	0.741	1.16	0.73	1.83	0.539	1.03	0.76	1.39	0.860
4th birth rank, ≤2 years interval	2.02	1.11	3.69	0.022	3.22	1.74	5.94	<0.001	2.82	1.81	4.40	<0.001
Combined place and mode of delivery												
Health facilities without caesarean	1.00				–	–	–	–	1.00			
Health facilities with caesarean	1.30	0.79	2.15	0.302	–	–	–	–	1.32	0.85	2.06	0.220
Home	0.61	0.41	0.93	0.021	–	–	–	–	0.61	0.42	0.88	0.008
Previous death of sibling												
No	1.00				1.00				1.00			
Yes	5.24	3.38	8.12	<0.001	3.13	1.87	5.26	<0.001	4.91	3.45	6.98	<0.001
Children under-5												
1–2	1.00				1.00				1.00			
3+	0.12	0.08	0.19	<0.001	0.15	0.09	0.25	<0.001	0.12	0.09	0.17	<0.001
Delivery complications												
None	–	–	–	–	1.00				1.00			
Any complications	–	–	–	–	0.54	0.34	0.85	0.008	0.72	0.56	0.91	0.007
TT pregnancy times												
Never	1.00				1.00				1.00			
One TT	0.83	0.59	1.16	0.273	0.69	0.44	1.07	0.100	0.77	0.58	1.01	0.060
2+ TT	0.60	0.45	0.80	0.001	0.42	0.28	0.61	<0.001	0.51	0.40	0.65	<0.001
Contraceptive use												
No	1.00				1.00				1.00			
Yes	0.30	0.23	0.39	<0.001	0.49	0.35	0.70	<0.001	0.35	0.28	0.43	<0.001

Independent variables adjusted are: year of survey, cluster type; geographical region; maternal marital status; religion; mother's age; mother's age at child's birth; mother's working status; mother's BMI, maternal highest level of education; paternal highest level of education; wealth index; watches TV; listens to radio; reads newspapers; sex of child; children under-5; previous death of sibling; TT pregnancy times; birth rank and birth interval; desire for previous pregnancies; delivery complications; use of antenatal care; birth attendance; number of ANC visits; and combined place and mode of delivery.
ANC, antenatal care; BMI, body mass index; TT, tetanus toxoid.

Table 2 Risk factor for child and under-5 mortality: adjusted OR

Characteristic	Child mortality (12–59 months) Adjusted OR	(95% CI)		p Value	Under-5 mortality (0–59 months) Adjusted OR	(95% CI)		p Value
Year of survey								
2004	1.00				1.00			
2007	0.83	0.42	1.63	0.589	0.66	0.52	0.84	0.001
2011	1.00	0.51	1.94	0.999	0.71	0.56	0.90	0.004
Geographical region								
Barisal	–	–	–	–	1.00			
Chittagong	–	–	–	–	0.80	0.56	1.14	0.225
Dhaka	–	–	–	–	0.92	0.65	1.29	0.622
Khulna	–	–	–	–	0.52	0.34	0.80	0.003
Rajshahi	–	–	–	–	0.86	0.60	1.23	0.405
Sylhet	–	–	–	–	1.16	0.81	1.65	0.422
Mother working status								
Not working	–	–	–	–	1.00			
Working	–	–	–	–	1.67	1.34	2.08	<0.001
Mother's age								
15–24	–	–	–	–	1.00			
25–34	–	–	–	–	0.80	0.59	1.08	0.145
35–49	–	–	–	–	0.56	0.33	0.95	0.031
Maternal highest level of education								
No education	–	–	–	–	1.00			
Primary	–	–	–	–	0.83	0.66	1.04	0.104
Secondary or more	–	–	–	–	0.41	0.26	0.63	<0.001
Mothers age at child's birth (years)								
<20	–	–	–	–	1.00			
20–29	–	–	–	–	1.11	0.82	1.51	0.489
30–39	–	–	–	–	1.64	1.01	2.65	0.046
40+	–	–	–	–	1.87	0.84	4.16	0.126
Maternal marital status								
Married	1.00				–	–	–	–
Formerly married	2.72	1.14	6.47	0.024	–	–	–	–
Birth rank and birth interval								
2nd/3rd birth rank, >2 years interval	1.00				1.00			
1st birth rank	0.46	0.22	0.96	0.040	1.03	0.76	1.39	0.865
2nd/3rd birth rank, ≤2 years interval	1.25	0.44	3.52	0.673	2.18	1.48	3.21	<0.001
4th birth rank, >2 years interval	0.44	0.18	1.13	0.088	0.91	0.65	1.26	0.562
4th birth rank, ≤2 years interval	1.21	0.37	3.93	0.753	2.73	1.76	4.23	<0.001
Previous death of sibling								
No	1.00				1.00			
Yes	11.90	4.96	28.55	<0.001	6.00	4.28	8.40	<0.001
Children under-5								
1–2	1.00				1.00			
3+	0.05	0.01	0.22	<0.001	0.11	0.08	0.15	<0.001
Combined place and mode of delivery								
Health facilities without caesarean	–	–	–	–	1.00			
Health facilities with caesarean	–	–	–	–	1.29	0.84	1.97	0.243
Home	–	–	–	–	0.58	0.41	0.82	0.002
TT pregnancy times								
Never	–	–	–	–	1.00			
One TT	–	–	–	–	0.74	0.56	0.96	0.023
2+ TT	–	–	–	–	0.53	0.42	0.66	<0.001
Desire for previous pregnancies								
Then	1.00				–	–	–	–
Later	2.38	1.19	4.73	0.014	–	–	–	–
Not at all	1.28	0.55	2.94	0.565	–	–	–	–

Continued

Table 2 Continued

Characteristic	Child mortality (12–59 months) Adjusted OR	(95% CI)		p Value	Under-5 mortality (0–59 months) Adjusted OR	(95% CI)		p Value
Delivery complications								
None	1.00				1.00			
Any complications	0.39	0.18	0.85	0.018	0.66	0.53	0.84	0.001
Contraceptive use								
No	1.00				1.00			
Yes	0.22	0.11	0.42	<0.001	0.33	0.27	0.40	<0.001

Independent variables adjusted are: year of survey; cluster type; geographical region; maternal marital status; religion; mother's age; mother's age at child's birth; mother's working status; mother's BMI; maternal highest level of education; paternal highest level of education; wealth index; watches TV; listens to radio; reads newspapers; sex of child; children under-5; previous death of sibling; TT pregnancy times; birth rank and birth interval; desire for previous pregnancies; delivery complications; use of antenatal care; birth attendance; number of ANC visits; and combined place and mode of delivery.
ANC, antenatal care; BMI, body mass index; TT, tetanus toxoid.

infants whose mothers were aged 30–39 years at the time of their birth, fourth rank children with an interval of ≤2 years and children who were second or third born infants with intervals of ≤2 years. However, there was a significant reduction in the odds for under-5 deaths among mothers who had secondary school education or higher, mothers who had other children aged 3 years or older, children who were born at home, children whose mothers had any delivery complications, children whose mothers used any contraceptives and mothers who had one and two or more TT vaccinations.

DISCUSSION

According to a recent report,[17] between 2000 and 2010, the global burden of mortality in children younger than 5 years decreased by two million, to which pneumonia, measles and diarrhoea contributed most to the overall reduction. This global decline is reflected in this study. We found a steady decline in the rates of neonatal, postneonatal, infant, child and under-5 mortality in Bangladesh between 2004 and 2011. In order to improve on this result, accelerated reduction for the most prevalent causes of death, especially pneumonia and preterm birth complications, is required.

Our study showed that the risk of postneonatal, infant and under-5 mortality was higher in infants from the Barisal region compared with infants from the Khulna region. A low number of prenatal care visits and low birth weight have been associated with postneonatal death.[18] Access to health facilities may be lacking in some of the regions in Bangladesh, and this could result in the observed regional differences in postneonatal deaths. More developed communities are more likely to have better sanitation connections, which improve infant survival.[19]

Our study showed that male neonates had a significantly higher risk of dying during the neonatal period compared with female neonates. This finding is consistent with a cross-sectional study conducted in Indonesia, Nigeria and Bangladesh, in 2009.[6 20 21] An increased risk of dying in the first month of life among male neonates may be as a result of high vulnerability to infectious disease,[22] and female neonates are more likely to develop early fetal lung maturity in the first week of life,[23] which may result in a lower incidence of respiratory diseases in female compared with male neonates.

This present study had several strengths. First, the 2004, 2007 and 2011 versions of the DHS were nationally representative surveys that used standardised methods yielding an average response rate of 98%. Second, we used multilevel modelling, which took into account the hierarchical structure of the data and the variability within the clusters, household and individual levels to better estimate the level of association of the study factors with the outcome.[24] Third, the pooled method increased the study power, predicted which risk factors for child deaths persisted over time, and allows us to safely generalise the findings to other populations with similar characteristics.

Our study was limited in a number of ways. First, the survey interviewed only surviving women, and this may have led to an underestimation of mortality rates because of the association between neonatal and maternal deaths. The effect of some of the associated factors, such as delivery complications, could have also been underestimated. Second, there may be other possible determinants of postneonatal and other mortalities that were not available in the various versions of the BDHS data sets, such as environmental and genetic factors, or that were only available for the most recent delivery of a mother occurring within the past 5 years preceding the surveys. Third, several variables in the study were not infant specific as they only reflected the most recent conditions or birth, such as mother's work status, which was recorded as employment within the 12 months preceding the survey, and lastly, reverse causality is common with cross-sectional data, such as those from the DHS.

In terms of child mortality, although much is assumed about the disadvantage of teenaged mothers, motherhood in the early 20s is also likely to be disadvantageous

as compared with older motherhood.[25] In our study, we found mothers who were aged 15–24 years posed a risk to under-5 mortality. Older mothers may be more likely to highly value continuity of prenatal care and comprehensive care more than young mothers,[26] and are more likely to attend more antenatal care visits, which reduce morbidities throughout the pregnancy period. The higher mortality risk for infants of younger mothers may be related to socioeconomic factors as well as biological immaturity.[27] In addition, children whose mothers were aged 30–39 years at the time of their birth had a significantly higher risk of under-5 mortality.

Strong associations have been reported between combined parental occupation and neonatal deaths. Paternal unemployment and maternal employment outside the home were found to significantly increase the odds of neonatal death.[21] In our study, we found that while unemployed mothers posed a risk to neonatal and postneonatal mortality, employed mothers increased the odds of infant under-5 mortality. Maternal employment may have an adverse effect on the care provided to the newborn.[21] Lack of personal and timely care, including infrequent breast feeding, experienced by infants born to working mothers, may have increased the odds of neonatal death.[28] The higher risk of infant and under-5 mortality among working mothers reflects the fact that employed mothers perform other traditionally ascribed roles within the family.[29]

There is evidence that points quite unambiguously to higher mortality where there are short intervals between births.[30] Other studies have found strong associations between short preceding birth interval, birth rank and the risks of neonatal death.[28 31 32] In this analysis, fourth rank children with an interval of 2 years or less had significantly higher odds of neonatal, postneonatal, infant and under-5 mortality than second/third rank children with >2 years interval. In addition, we found that second/third rank children with an interval of <2 years had significantly higher odds of child mortality compared with children of similar rank but with an interval of >2 years. These findings may be attributed to maternal depletion syndrome and resource competition between siblings, in addition to a lack of care and attention experienced by high-ranked infants.[31 33]

In a previous study,[30] neonatal and postneonatal deaths were higher if older siblings had died in respective age intervals. A pregnancy interval of <12 months after child birth raised the risk of death at ages between 1 and 2 years considerably if the child was born after a short birth interval (<15 months).

Results from a previous study[21] indicate that neonates born to women experiencing complications such as vaginal bleeding, fever or convulsions during childbirth, had significantly higher odds of dying compared with neonates born to women without any complications. A study in Bangladesh found that infants born to women without severe delivery complications had better survival rates than infants born to women with eclampsia, intrapartum haemorrhage or even prolonged labour.[34] However, in our study, we found that infants whose mothers had no delivery complications had significantly higher odds of postneonatal, infant, child and under-5 mortality. These findings could be largely due to chance, because of recall bias. However, further research may be required to explain this discrepancy.

Neonatal tetanus remains an important and preventable cause of neonatal mortality globally.[35] Immunisation of pregnant women or women of childbearing age with at least two doses of TT is estimated to reduce mortality from neonatal tetanus by 94%.[35] In our study, we found that infants whose mothers did not have TT immunisations had significantly higher odds of neonatal, postneonatal, infant and child mortality. The association of TT immunisations with neonatal, postneonatal, infant and child mortality may be due more to its association with education and socioeconomic status than with a direct effect of the vaccine.

We also found that there was lower under-5 mortality rate in children who were delivered at home. This result could be due to selection bias and potential bias, which may, therefore, be misleading and could send the wrong message regarding the place of delivery, especially in low-income countries including Bangladesh. Past studies have associated high mortality rates to home delivery of babies.[36]

Birth control is said to be driven by contraceptive use and other factors. A recent study has found favourable effects of contraceptive use in reducing infant deaths in second and higher order births.[37] We found in our study that infants whose mothers did not use any contraceptives had significantly higher odds of neonatal, postneonatal, infant, child and under-5 mortality.

In this current study, we found that the odds of neonatal, postneonatal, infant, child and under-5 deaths decreased significantly among mothers who had other children aged 3 years or older. This issue is a mathematical consequence of a mother losing a child, because losing a child may reduce future under-5 deaths, and this is an example of reverse causality.

CONCLUSIONS

The combined 2004, 2007 and 2011 BDHS data sets examined in this study showed that birth rank and birth interval, previous death of a sibling, having other children under 5 years old and contraceptive use by mothers were the common factors associated with neonatal, postneonatal, infant, child and under-5 deaths. Our findings indicate the need to implement community-based interventions, particularly educating community health workers and traditional birth attendants about child spacing, and contraceptive use by mothers. This may contribute to a further reduction of under-5 deaths. Findings from this study could help provide a framework to design future health plans and policies tailored towards achieving effective health

initiatives to enhance child survival. In particular, the government of Bangladesh and other stakeholders could use our information to help step up further efforts to minimise mortality in that country.

Acknowledgements This study is part of the first author's thesis for a doctoral dissertation with the School of Science and Health at the University of Western Sydney, Australia. The authors are grateful to ICF International, Rockville, Maryland, USA, for providing the Bangladesh DHS data sets for this analysis.

Contributors TA and KEA were involved in the conception and design of this study. TA carried out the analysis and drafted the manuscript. KEA, ANP, AHM and MJD provided data analysis and interpretation advice, and revised and edited the final manuscript. All the authors read and approved the manuscript.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Ethics approval This study was based on an analysis of existing public domain survey data sets that is freely available online with all identifier information removed. The survey was approved by the Ethics Committee of the ICF Macro at Calverton in the USA and by the Ethics Committee in Bangladesh.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1. You D, New J, Wardlaw T. *Levels and trends in child mortality*. Report 2012. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation. 2010.
2. Machado CJ, Hill K. Maternal, neonatal and community factors influencing neonatal mortality in Brazil. *J Biosoc Sci* 2005;37:193–208.
3. Doctor HV. The effect of living standards on childhood mortality in Malawi. 2004.
4. Quamrul HC, Rafiqul I, Kamal H. Socio-economic determinants of neonatal, post neonatal, infant and child mortality. *Int J Sociol Anthropol* 2010;2:118–25.
5. Mathews T, MacDorman MF. *Statistics NCFH: infant mortality statistics from the 2004 period linked birth, infant death data set*. US Department of Health & Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2007.
6. Mondal N, Hossain K, Ali K. Factors influencing infant and child mortality: a case study of Rajshahi district, Bangladesh. *J Hum Ecol* 2009;26:31–9.
7. Chowdhury AH, Islam SS, Abdul Karim D. Covariates of neonatal and post-neonatal mortality in Bangladesh. *Global J Hum Soc Sci Res* 2013;13.4.
8. National Institute of Population Research and Training (NIPORT), Mitra and Associates, Macro International Inc. *Bangladesh Demographic and Health Survey 2004*. Dhaka, Bangladesh and Calverton, MD: National Institute of Population Research and Training, Mitra and Associates/Macro International; 2005.
9. National Institute of Population Research and Training (NIPORT), Mitra and Associates, Macro International Inc. *Bangladesh Demographic and Health Survey 2007*. Dhaka, Bangladesh and Calverton, MD: National Institute of Population Research and Training, Mitra and Associates/Macro International; 2009.
10. National Institute of Population Research and Training (NIPORT); Mitra and Associatesa and Macro International, *Bangladesh Demographic and Health Survey 2011*, Dhaka, Bangladesh and Calverton, Maryland, USA, 2013.
11. MEASURE DHS. *Demographic and Health Surveys: quality information to plan, monitor and improve population, health, and nutrition programs*. Calverton, Maryland: USAID, 2009.
12. Uthman OA, Uthman MB, Yahaya I. A population-based study of effect of multiple birth on infant mortality in Nigeria. *BMC Pregnancy Childbirth* 2008;8:41.
13. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: When? Where? Why? *Lancet* 2005;365:891–900.
14. Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. *Popul Dev Rev* 1984;10: 25–45.
15. Unicef. *Childhood under threat: the state of the world's children 2005*. UNICEF, 2004.
16. Rutstein SO, Rojas G. *Guide to Demographic and Health Survey (DHS) Statistics*. Calverton, Maryland, USA: ORC Macro, 2006.
17. Liu L, Johnson HL, Cousens S, *et al*. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet* 2012;379:2151–61.
18. Machado CJ, Hill K. Determinants of neonatal and post-neonatal mortality in the City of São Paulo. *Rev Bras Epidemiol* 2003;6:345–58.
19. Jones G, Steketee RW, Black RE, *et al*. How many child deaths can we prevent this year? *Lancet* 2003;362:65–71.
20. Ezeh OK, Agho KE, Dibley MJ, *et al*. Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. *BMC Public Health* 2014;14:521.
21. Titaley CR, Dibley MJ, Agho K, *et al*. Determinants of neonatal mortality in Indonesia. *BMC Public Health* 2008;8:232.
22. Alonso V, Fuster V, Luna F. Causes of neonatal mortality in Spain (1975–98): influence of sex, rural–urban residence and age at death. *J Biosoc Sci* 2006;38:537–51.
23. Khoury MJ, Marks JS, McCarthy BJ, *et al*. Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome. *Am J Obstet Gynecol* 1985;151:777–82.
24. Twisk JW. *Applied multilevel analysis: a practical guide*. Cambridge University Press, 2006.
25. Taylor JS, Cabral HJ. Are women with an unintended pregnancy less likely to breastfeed? *J Fam Pract* 2002;51:431–8.
26. O'Malley AS, Forrest CB. Beyond the examination room. *J Gen Intern Med* 2002;17:66–74.
27. Kirchengast S, Hartmann B. Impact of maternal age and maternal somatic characteristics on newborn size. *Am J Hum Biol* 2003;15:220–8.
28. Reid A. Neonatal mortality and stillbirths in early twentieth century Derbyshire, England. *Popul Stud (Camb)* 2001;55:213–32.
29. Ahmad-Nia S. Women's work and health in Iran: a comparison of working and non-working mothers. *Soc Sci Med* 2002;54: 753–65.
30. Sear R, Steele F, McGregor IA, *et al*. The effects of kin on child mortality in rural Gambia. *Demography* 2002;39:43–63.
31. Rutstein SO. Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys. *Int J Gynaecol Obstet* 2005;89:S7–S24.
32. Arokiasamy P, Gautam A. Neonatal mortality in the empowered action group states of India: trends and determinants. *J Biosoc Sci* 2008;40:183–201.
33. Zenger E. Siblings' neonatal mortality risks and birth spacing in Bangladesh. *Demography* 1993;30:477–88.
34. Mercer A, Haseen F, Huq NL, *et al*. Risk factors for neonatal mortality in rural areas of Bangladesh served by a large NGO programme. *Health Policy Plan* 2006;21:432–43.
35. Blencowe H, Lawn J, Vandelaer J, *et al*. Tetanus toxoid immunization to reduce mortality from neonatal tetanus. *Int J Epidemiol* 2010;39:i102–9.
36. Filippi V, Ronsmans C, Campbell OM, *et al*. Maternal health in poor countries: the broader context and a call for action. *Lancet* 2006;368:1535–41.
37. van Soest A, Saha U. Does family planning reduce infant mortality? Evidence from surveillance data in Matlab, Bangladesh. CentER Discussion Paper Series No. 2012-019. 2012. (accessed on 12 Jun 2014).

Appendix B

The impact of antenatal care, iron–folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh

---

Tanvir Abir, Felix Akpojene Ogbo , Garry John Stevens, Andrew Nicolas Page, Abul Hasnat Milton, Kingsley Emwinyore Agho
PLoS One, 12(11):e0187090, 2017, PMID:29091923, 14 pages

PLOS ONE

RESEARCH ARTICLE

The impact of antenatal care, iron–folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh

Tanvir Abir[1], Felix Akpojene Ogbo[2], Garry John Stevens[3], Andrew Nicolas Page[2], Abul Hasnat Milton[4], Kingsley Emwinyore Agho[1]*

1 School of Science and Health, Western Sydney University, Penrith, New South Wales, Australia, **2** Translational Health Research Institute (THRI), School of Medicine, Western Sydney University, Penrith, New South Wales, Australia, **3** Humanitarian and Development Research Initiative (HADRI), Western Sydney University, School of Social Science and Psychology, Penrith, New South Wales, Australia, **4** Centre for Clinical Epidemiology & Biostatistics (CCEB), School of Medicine and Public Health, Faculty of Health and Medicine, The University of Newcastle, Callaghan, New South Wales, Australia

* k.agho@westernsydeny.edu.au

OPEN ACCESS

Citation: Abir T, Ogbo FA, Stevens GJ, Page AN, Milton AH, Agho KE (2017) The impact of antenatal care, iron–folic acid supplementation and tetanus toxoid vaccination during pregnancy on child mortality in Bangladesh. PLoS ONE 12(11): e0187090. https://doi.org/10.1371/journal.pone.0187090

Editor: Jacobus P. van Wouwe, TNO, NETHERLANDS

Received: May 16, 2017

Accepted: October 15, 2017

Published: November 1, 2017

Data Availability Statement: The study used the Bangladesh Demographic and Health Survey (BDHS) data sets. The surveys were approved by the Ethics Committee of the ICF International, USA and the National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Bangladesh. We obtained approval from Measure DHS to download and use the data for this study. The data sets are available to apply for online at https://dhsprogram.com/data/available-datasets.cfm.

Abstract

Background

Appropriate antenatal care (ANC) is an important preventive public health intervention to ensure women's and newborn health outcomes. The study aimed to investigate the impact of ANC, iron–folic acid (IFA) supplementation and tetanus toxoid (TT) vaccination during pregnancy on child mortality in Bangladesh.

Method

A cross-sectional study of three datasets from the Bangladesh Demographic and Health Surveys for the years 2004, 2007 and 2011 were pooled and used for the analyses. A total weighted sample of 16,721 maternal responses (5,364 for 2004; 4,872 for 2007 and 6,485 for 2011) was used. Multivariate logistic models that adjusted for cluster and sampling weights were used to examine the impact of ANC, IFA supplementation and TT vaccination during pregnancy on the death of a child aged 0–28 days (neonatal), 1–11 months (post-neonatal) and 12–59 months (child).

Results

Multivariable analyses revealed that the odds of postnatal and under-5 mortality was lower in mothers who had ANC [Odds Ratio (OR) = 0.60, 95% confidence interval (95% CI): 0.43–0.85], IFA supplementation [OR = 0.66, 95% CI: (0.45–0.98)] and ≥2 TT vaccinations (OR = 0.43, 95% CI: 0.49–0.78) for post-natal mortality; and for under-5 mortality, any form of ANC (OR = 0.69, 95% CI: 0.51–0.93), IFA supplementation (OR = 0.67, 95% CI: 0.48–0.94) and ≥2 TT vaccinations (OR = 0.50, 95% CI: 0.36–0.69). When combined, TT

Funding: This study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests: The authors have declared that no competing interests exist.

vaccination with IFA supplementation, and TT vaccination without IFA supplementation were protective across all groups.

Conclusion

The study found that ANC, IFA supplementation, and TT vaccination during pregnancy reduced the likelihood of child mortality in Bangladesh. The findings suggest that considerable gains in improving child survival could be achieved through ensuring universal coverage of ANC, promoting TT vaccination during pregnancy and IFA supplementation among pregnant women in Bangladesh.

Introduction

Child mortality is an important public health issue worldwide, and often reflects a country's developmental status because it serves as a good indicator for antenatal care, delivery and early postnatal care as well as the health status of children [1]. Globally, the risk of child mortality is highest during the early neonatal period (the first six days of life), accounting for 15% of all under-five mortality (U5M), highlighting the significance of appropriate antenatal care, safe delivery practices and effective postnatal care. In 2015, approximately 2.6 million neonatal deaths were reported, despite a 42% decrease since 1990 [1]. Global policy attention and scale up efforts such as the Millennium Development Goals (MDGs) that focused on key aspects of improving child survival and health have played a major role in the reduction of childhood-related diseases (including diarrhoea, tetanus and measles), with subsequent impact on child mortality [1, 2]. Despite this improvement, child mortality remains a major health issue in resource-constraint communities in sub-Saharan Africa and South Asia countries, including Bangladesh [1].

Notably, most of the neonatal deaths are due to preventable diseases (such as infections and intrapartum-related complications) [1] in which appropriate access to basic and affordable interventions such as perinatal care could play a major role [3]. Studies have shown that mothers can increase the survival and health of their babies by attending antenatal care (ANC), being immunised against tetanus, and being provided with iron-folic acid (IFA) supplementation and health promotion messages such as exclusive breastfeeding [2, 4, 5].

In Bangladesh, small-scale studies have investigated the efficacy of ANC attendance and IFA supplementation in the prevention of U5M. For example, West et al. revealed that multiple antenatal micronutrients and IFA supplementation did not decrease all-cause infant mortality, but reduced the prevalence of stillbirths and preterm births [6]. In addition, Pervin et al. reported that ANC was associated with improved perinatal survival in a regional area of Bangladesh [7]. The limitation of these studies is that they were conducted in regional areas of Bangladesh, and the findings may be limited in informing country-wide interventions at the national level. A recent population-based study reported improvement in the utilisation of appropriate ANC (more than four visits) in Bangladesh between 1994 and 2014, with associated inequities across the socio-demographic scale and regional areas of Bangladesh [8]. The study did not examine the impact of ANC, IFA supplementation and tetanus toxoid (TT) vaccination during pregnancy on child mortality, which is the focus of the current study.

Maternal TT vaccination during pregnancy was incorporated into the World Health Organisation's Expanded Program on Immunization (EPI) in the mid-1970s to prevent child mortality from tetanus and has become a standard approach to ANC [9]. Although the impact of

ANC TT vaccination on child mortality has been documented [9–11], a recent systematic review indicated that only a few studies provided supporting evidence for the initiative, reflecting the dearth of data in many developing countries [9]. The paucity of evidence base for ANC TT vaccination and child mortality warrants investigation in a resource-poor country such as Bangladesh to continue advocacy for initiatives to improve child survival and extend the longevity of life.

This study aimed to investigate the impact of ANC, IFA supplementation and TT vaccination during pregnancy on child mortality in Bangladesh, using the Bangladesh Demographic and Health Survey Data (BDHS, 2004–2011). Evidence from this study will inform stakeholders in Bangladesh to advocate and intensify efforts for preventive health programmes to ensure improvement in child health outcomes.

Methods

Data sources

Data sets from the BDHS for the years 2004, 2007 and 2011 were pooled and used for the analyses. [12–14]. The BDHS collects socio-demographic characteristics, maternal and child health information from a nation-wide representative sample of households. The data were collected by the National Institute of Population Research and Training (NIPRT), with technical support from Inner City Fund (ICF) International and Measure DHS, using a two-stage sampling method and standardised household questionnaires. Maternal and child health information were obtained from eligible women aged 15–49 years in each household surveyed. A total weighted sample of 16,721 maternal responses (5,364 for 2004; 4,872 for 2007 and 6,485 for 2011) was used for this study, with an average response rate of 98%. The 2014 BDHS datasets were not incorporated into the analyses because information on TT vaccination during pregnancy was not collected from respondents. Additional information on the BDHS methodological strategy for data collection has been described in detail elsewhere [12–14].

Study outcome

The outcome variable for the study was child mortality, which comprises neonatal (death within 0–28 days), post-neonatal (death from 1 to 11 months) and child (death between 12 and 59 months) mortalities.

Main exposure variables

The main variables for the study comprise ANC, IFA supplementation and TT vaccination during pregnancy. ANC services may include offering maternal health education, physical examination of the pregnant woman, IFA supplementation and TT vaccination. The impact of each exposure variable and different combinations of ANC, IFA supplementation and TT vaccination on child mortality was investigated in the study.

Study factors

The study adapted the Mosley and Chen model for determinants of child mortality [15]. We identified four main variables in the current study: (i) Community-level factors [place of residence (rural/urban) and administrative region]; (ii) Socio-economic determinants (maternal marital status, maternal religion, maternal age at the time of the survey, maternal age at the time of birth of the child, parents' working status, maternal body mass index (BMI), parents' level of education, household wealth index, maternal access to the mass media: radio, television and newspaper/magazine); (iii) Proximate determinants (gender of baby, birth rank and

interval, maternal desire for pregnancy); and (iv) Pregnancy or delivery at health-care service, use of ANC services, including IFA supplementation, use of TT during pregnancy; place and mode of delivery of baby and type of delivery assistance received.

All households across the three surveys were ranked by using the household wealth index, which was constructed by NIPRT and Measure DHS by apportioning weights to three characteristics of households. These included: the type of floor and wall; access to electricity; and six household assets; namely, possession of radio, television, bicycle, motorcycle, car and fridge.

Statistical analysis

Frequency tabulations were used to describe characteristics of the study population. Logistic regression models were used to perform analysis to determine the unadjusted and adjusted odds ratios (ORs) for determinants of neonatal, post-neonatal and U5M. In addition, the independent effect of each variable after other covariates were controlled for, was investigated in multivariate analyses.

The modelling was performed in 2 stages. Firstly, a significance level of 0.05 was used to remove all factors not significant among the various variables (community-level and socio-economic). This was done by performing a backward stepwise elimination procedure. Regardless of their level of significance, the year of the survey and maternal age at birth of the child were retained in the final model [16]. Secondly, ANC, mode of delivery, place of delivery and type of skilled delivery assistance were assessed, after controlling for significant community and socio-economic variables. The type of skilled delivery assistance has been known to have a protective effect on child mortality [17]. Consequently, this variable was retained in the final model, regardless, other non-significant variables were removed. ANC was found to be correlated with both IFA supplementation and TT vaccination. Hence, the study then examined the effect of a combination of any form of ANC and IFA supplementation, as well as a combination of IFA and TT vaccination on neonatal, post-neonatal and under-5 mortality.

The ORs and corresponding 95% confidence interval for neonatal, post-neonatal and U5M, and each study factor were examined and reported. The statistical software package Stata version 12 (Stata Corporation, College Station, USA) was used for all statistical analyses. The 'svy' command was used to adjust for sampling weights and the cluster survey design.

Ethics approval

The study was based on the analyses of existing survey datasets that are available to apply for online, with all identifier information removed. The surveys were approved by the Ethics Committee of the ICF International, USA and the National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Bangladesh. We obtained approval from Measure DHS to download and use the data for this study.

Results

Characteristics of the study population

The study was based on a total weighted sample of 16,722 eligible women. As shown in Table 1, there was a variation in child mortality in the administrative regions of Bangladesh, with the lowest and highest mortality occurring in the Barisal (6.4%) and Dhaka (32.9%) regions, respectively. Less than 1 in 5 families had both parents in paid employment in the 12 months preceding the survey, and nearly 50% of mothers had no schooling and were from poor households. More than three-quarters of mothers gave birth at home, and nearly one-third delivered their babies with assistance from traditional birth attendants.

Table 1. Characteristics of the study participants (n = 16722) in Bangladesh (2004–2011).

Variable	n*	%*
Year of survey		
2004	5364	32.1
2007	4872	29.1
2011	6485	38.8
Community		
Place of residence		
Urban	3739	22.4
Rural	12983	77.6
Region		
Barisal	1067	6.4
Chittagong	3697	22.1
Dhaka	5497	32.9
Khulna	1804	10.8
Rajshahi	3377	20.2
Sylhet	1278	7.6
Socioeconomics		
Maternal marital status		
Married	16367	97.9
Formerly Married (divorced/separated/widowed)	354	2.1
Religion		
Islam	15382	92.0
Other	1339	8.0
Mother's age at interview		
15–24 years	8273	49.5
25–34 years	6772	40.5
35–49 years	1670	10.0
Mother's age at child's birth		
less than 20 years	5019	30.0
20–29 years	8921	53.4
30–39 years	2560	15.3
40+ years	221	1.3
Mother working status		
Not working	13509	80.8
Working	3210	19.2
Mother BMI		
≥ 18,5	3929	23.7
18–25	11019	65.9
25+	1708	10.4
Parents employment status		
Father only working	13119	78.5
Both working	2998	17.9
Neither working	604	3.6
Maternal education		
No education	7818	46.8
Primary	7010	41.9
Secondary or above	1882	11.3
Paternal education		
No education	8512	50.9

(*Continued*)

Table 1. (*Continued*)

Variable	n*	%*
primary	5331	31.9
Secondary or above	2861	17.2
Household wealth Index		
Rich	2921	17.5
Middle	5991	35.8
Poor	7810	46.7
Watches television every week		
Yes	9484	56.7
No	7234	43.3
Listens to radio every week		
Yes	4259	25.5
No	12458	74.5
Read newspaper		
Yes	2620	15.7
No	14099	84.3
Proximate		
Gender		
Female	8173	48.9
Male	8549	51.1
Birth rank and birth interval		
2nd/3rd birth rank, more than 2 years interval	6438	38.5
1st birth rank"	5241	31.4
2nd/3rd birth rank, less than or equal to 2 years interval	1110	6.6
4th birth rank, more than 2 years interval	3267	19.5
4th birth rank, less than or equal to 2 years interval	665	4.0
Desire for pregnancies		
Current	11625	69.5
Later	2598	15.6
Not at all	2497	14.9
Pregnancy or delivery health-care service		
Use of antenatal care		
Not used	6679	39.9
Used	10035	60.1
IFA Supplements		
No	11039	66.2
Yes	5476	32.8
TT vaccination during pregnancy		
Never	3573	21.4
One TT	3731	22.3
2+ TT	9385	56.3
[$]Combined place and mode of delivery		
Health facilities without Caesarean	1153	6.9
Health facilities with Caesarean	1482	8.9
Home	13663	81.7
[$]Delivery assistance		
None	195	1.2
Doctor	2561	15.3

(*Continued*)

Table 2. Multivariate analysis of community and socio-economic factors associated with neonatal, postnatal and child mortality in Bangladesh (2004–2011).

Variable	Neonatal mortality		Postnatal mortality		Child mortality	
	AOR (95% CI)	P-value	AOR (95% CI)	P-value	AOR (95% CI)	P-value
Year of survey						
2004			1.00		1.00	
2007			0.74 (0.51,1.08)	0.120	0.71 (0.51,0.99)	0.042
2011			0.58 (0.39,0.86)	0.007	0.64 (0.45,0.90)	0.011
Place of residence						
Urban						
Rural						
Region						
Barisal					1.00	
Chittago					0.90 (0.55,1.48)	0.680
Dhaka					0.85 (0.51,1.40)	0.519
Khulna					0.37 (0.18, 0.76)	0.007
Rajshahi					0.80 (0.47,1.36)	0.419
Sylhet					1.24 (0.75, 2.03)	0.396
Maternal marital status						
Married			1.00		1.00	
Formerly Married			2.97 (1.57, 5.63)	0.001	3.08 (1.82,5.23)	<0.001
Maternal education						
No education	1.00		1.00		1.00	
Primary	0.70 (0.53, 0.91)	0.007	0.64 (0.44, 0.94)	0.023	0.75 (0.54,1.04)	0.082
Secondary or more	0.48 (0.31, 0.75)	0.001	0.19 (0.07, 0.52)	0.001	0.15 (0.06, 0.42)	<0.001
Mother employment status						
Not working					1.00	
Working					1.75 (1.28, 2.41)	0.001
Mothers age at child's birth						
Less than 20 years			1.00			
20–29 years			1.14 (0.67, 1.93)	0.632		
30–39 years			1.45 (0.75, 2.81)	0.271		
40+ years			3.03 (1.18, 7.77)	0.021		
Mother BMI						
≥ 18,5	1.00					
18–25	0.99 (0.76, 1.31)	0.966				
25+	1.66 (1.11, 2.46)	0.013				
Birth rank and birth interval						
2nd/3rd birth rank, more than 2 years interval	1.00		1.00		1.00	
1st birth rank"	1.85 (1.38, 2.48)	<0.001	1.25 (0.72, 2.15)	0.425	1.00 (0.68, 1.48)	0.980
2nd/3rd birth rank, less than or equal to 2 years interval	2.17 (1.43, 3.31)	<0.001	0.92 (0.41, 2.08)	0.843	0.97 (0.52, 1.82)	0.934
4th birth rank, more than 2 year interval	1.25 (0.89, 1.77)	0.202	1.44 (0.89, 2.33)	0.142	1.40 (0.97, 2.03)	0.071
4th birth rank, less than or equal to 2 years interval	1.99 (1.20, 3.29)	0.007	3.42 (1.98, 5.92)	<0.001	2.99 (1.88, 4.76)	<0.001

BMI: Body mass index; AOR: Adjusted Odds ratio; Only significant data shown.

https://doi.org/10.1371/journal.pone.0187090.t002

neonatal mortality was reduced by 54% in mothers who received regular IFA supplementation compared to mothers who received only folic acid [22]. The benefits of IFA supplementation for neonatal mortality and pregnant women were highlighted in a study from Indonesia, [23] and other developing countries [24], respectively. These findings suggest that the provision of

Table 1. (*Continued*)

Variable	n*	%*
Nurse/midwife	1054	6.3
TBA	5505	32.9
Other untrained personnel	5986	35.8

*Weighted for the sampling probability;
IFA: iron–folic acid supplementation; TT: tetanus toxoid; TBA: traditional birth attendance;
$Variables with missing data

https://doi.org/10.1371/journal.pone.0187090.t001

Factors associated with neonatal, postnatal and child mortality

Neonatal mortality was significantly associated with high maternal BMI ($25kgm^{-2}$ or higher) compared to low maternal BMI ($18.5kgm^{-2}$ or lower) (Table 2). Mothers with education were less likely to experience neonatal, postnatal and child deaths compared to mothers with no schooling. Postnatal mortality was significantly associated with infants of older mothers (aged $\geq$ 40 years) compared to those of younger mothers (aged <20 years). Employed mothers were significantly more likely to experience child mortality compared to mothers not in employment. The odds of a mother experiencing child mortality were higher among 4^{th} born infants/children where there was an interval of 2 years or less with the preceding child.

The likelihood of a mother experiencing neonatal mortality was significantly higher among mothers who received no IFA supplements and had less than two TT vaccinations compared to those who had no IFA supplements but had more than two ANC TT vaccinations (Table 3). The odds of postnatal and child mortality were significantly higher among infants/children whose mothers received no IFA supplements and had less than 2 ANC TT vaccinations compared to those whose mothers received more than two ANC TT vaccinations, irrespective of whether they also received IFA supplementation. Mothers who had ANC visits and received IFA supplements were significantly less likely to experience postnatal and child deaths compared to those who had no ANC visits and received no IFA supplements.

Neonates whose mothers received no ANC TT vaccinations were significantly more likely to die compared to those whose mothers had more than two ANC TT vaccinations (Fig 1). The likelihood of postnatal and child mortality was significantly higher among infants/children whose mothers attended no ANC clinics, did not receive IFA supplements and TT vaccinations during pregnancy.

Discussion

In the current study, we found that the provision of any form of ANC intervention led to a reduction of the likelihood of postnatal and child mortality (but not neonatal mortality) in Bangladesh. In particular, IFA supplementation and TT vaccinations during pregnancy, two key components of ANC were found to be protective against infant/child mortality, reflecting the importance of ANC in improving maternal and child health outcomes.

Our study showed that there was a decline in child mortality between 2004 and 2011, consistent with findings from the GBD study 2015 [1] and United Nations MDG 2015 report [18]. The improvement in child health may be due to a number of global and national initiatives, including the WHO EPI [19], MDGs, national government policies and involvement of non-governmental organisations [20, 21]. We also found that IFA supplementation had a protective effect against neonatal, postnatal and child mortality. This finding is consistent with results of a reported trial of micronutrient supplementation during pregnancy in rural China in which

Table 3. Effects of iron-folic acid supplementation, tetanus toxoid vaccination during pregnancy and antenatal care on neonatal, postnatal and child mortality in Bangladesh (2004–2011).

Variable	Number of live births	Number of deaths	Unadjusted		Adjusted	
			OR (95% CI)	P value	AOR (95% CI)	P value
Neonatal Mortality (0–28 days)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5492	117	1.00		1.00	
No IFA supplements with ≥ 2 TT injections	5725	93	0.65 (0.49, 0.86)	0.003	0.62 (0.47, 0.83)	0.001
IFA supplements with < 2 TT injections	1813	33	0.84 (0.58, 1.22)	0.364	0.77 (0.51, 1.15)	0.202
IFA supplements with ≥ 2 TT injections	3660	66	0.71 (0.52, 0.96)	0.027	0.60 (0.42, 0.86)	0.005
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5663	114	1.00		1.00	
ANC without IFA supplements	5577	96	0.85 (0.65, 1.12)	0.257	0.98 (0.73, 1.32)	0.908
IFA supplements alone	1015	22	0.96 (0.59, 1.57)	0.865	0.96 (0.58, 1.59)	0.879
ANC including IFA supplements	4458	78	0.82 (0.61, 1.10)	0.189	0.90 (0.65, 1.25)	0.523
Postnatal Mortality (1–11 months)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5422	70	1.00		1.00	
No IFA supplements with ≥ 2 TT injections	5687	39	0.56 (0.38, 0.82)	0.003	0.56 (0.38, 0.83)	0.004
IFA supplements with < 2 TT injections	1791	22	0.83 (0.51, 1.36)	0.469	0.76 (0.45, 1.28)	0.302
IFA supplements with ≥ 2 TT injections	3638	23	0.40 (0.25, 0.66)	<0.001	0.37 (0.22, 0.63)	<0.001
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5586	78	1.00		1.00	
ANC without IFA supplements	5546	31	0.40 (0.27, 0.60)	<0.001	0.66 (0.43, 1.01)	0.057
IFA supplements alone	1002	14	0.89 (0.49, 1.60)	0.692	0.82 (0.45, 1.50)	0.516
ANC including IFA supplements	4427	31	0.40 (0.26, 0.62)	<0.001	0.51 (0.32, 0.81)	0.005
Child Mortality (1–4 years)						
Combination of IFA supplementation and TT vaccination						
No IFA supplements with < 2 TT injections	5397	95	1.00		1.00	
No IFA supplements with ≥ 2 TT injections	5669	56	0.59 (0.43, 0.82)	0.002	0.59 (0.42, 0.83)	0.002
IFA supplements with < 2 TT injections	1789	24	0.69 (0.43, 1.09)	0.111	0.66 (0.41, 1.07)	0.094
IFA supplements with ≥ 2 TT injections	3625	35	0.48 (0.32, 0.71)	<0.001	0.45 (0.29, 0.70)	<0.001
Combination of ANC and IFA supplementation						
No ANC and no IFA supplements	5562	101	1.00		1.00	
ANC without IFA supplements	5527	50	0.46 (0.33, 0.65)	<0.001	0.77 (0.54, 1.11)	0.161
IFA supplements alone	998	17	0.84 (0.49, 1.42)	0.512	0.79 (0.46, 1.36)	0.400
ANC including IFA supplements	4416	42	0.43 (0.30, 0.62)	<0.001	0.57 (0.38, 0.84)	0.005

IFA: Iron-folic acid supplementation; TT: tetanus toxoid; ANC: Antenatal care; AOR: Adjusted Odds ratio

https://doi.org/10.1371/journal.pone.0187090.t003

IFA supplementation to pregnant women should be promoted and supported at all levels of the healthcare system in Bangladesh. Efforts are being made by many organisations in Bangladesh to encourage routine use of IFA supplementation for pregnant women. For example, the Micronutrient Initiative (MI) in Bangladesh is one of the non-governmental organisation which strives to increase the number of pregnant women receiving appropriate IFA supplements [25]. A key aspect of the MI is to ensure that pregnant women in hard-to-reach areas receive micronutrient supplements to improve women and newborn survival and health.

In the study, we found a protective effect against neonatal, postnatal and child mortality from ANC TT vaccination (two or more vaccinations) compared to IFA supplementation

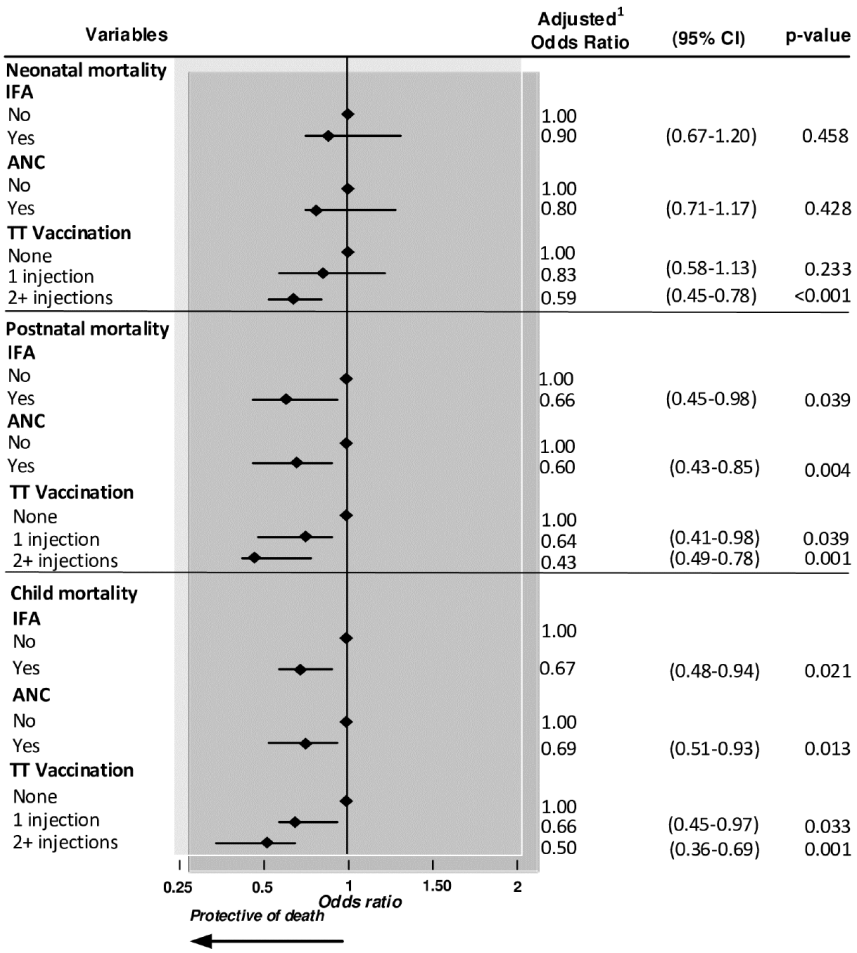


Fig 1. Impact of antenatal care, iron-folic acid supplementation and tetanus toxoid vaccination on child mortality in Bangladesh (2004–2011). Adjusted for place of residence, region; maternal marital status, mother's age at interview, mothers age at child's birth, mother working status, mother BMI, parents employment status; maternal highest level of education; paternal highest level of education; household wealth Index; watches television every week; listens to radio every week; read newspaper; sex of the baby; previous birth rank and birth interval, and desire for pregnancies. TT—tetanus toxoid; IFA—Iron-folic acid supplementation; ANC—antenatal care.

https://doi.org/10.1371/journal.pone.0187090.g001

alone, consistent with published reports [26–28]. This finding suggests that pregnant women should, therefore, be encouraged to take TT vaccinations in combination with IFA supplementation, which is part of the standard approach to ANC. In Bangladesh, a recent report has indicated that infant mortality rate fell from 87 per 1,000 in 1990 to 43 per 1,000 live births in 2011, and U5M rate declined substantially from 151 per 1,000 to 53 per 1,000 live births over the same period. These improvements have been attributed to improved coverage of effective childhood initiatives to prevent or treat the common causes of U5M and improvements in the socioeconomic status of the Bangladeshi populations [29]. The interventions that played

significant roles in reducing U5M in Bangladesh included improved coverage of childhood immunisation; effective treatment of diarrhoeal diseases and upper respiratory tract infections; improvements in breastfeeding status; and strategic implementation of integrated management of childhood illness. Other important contributing factors to reduced U5M included improved female education, increased health system strengthening and investment and strong political will to improve maternal and child health in the country [29].

Sustainable Development Goal–3.2 (SDG–3.2) aims to end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-5 mortality to at least as low as 25 deaths per 1,000 live births by 2030 [30]. Although the number of under-5 mortality has decreased in Bangladesh since 1990, accelerated and sustained progress would be made by implementing timely, evidenced-based and context-specific interventions [1, 18]. Those initiatives may include increasing universal access to appropriate ANC [31]; promoting childhood immunisation [32]; access to potable water and sanitary environment; exclusive breastfeeding [33, 34] and implementation of Global strategic initiatives such as the drowning prevention intervention [21].

The study showed that higher maternal educational level was associated with a lower likelihood of neonatal, postnatal and child mortality, consistent with evidence from Nigeria [35]. The analyses also indicated that maternal employment was associated with a higher likelihood of child mortality. Detail information on the determinants of child mortality in Bangladesh has been described elsewhere [36]. In addition to ensuring that women have appropriate ANC services in Bangladesh, other key aspects of the SDGs—Goal 1, 2 and 4, which advocate for ending poverty, no hunger and improving quality education, respectively—would have a positive impact on child survival and health in Bangladesh. Furthermore, evidence has shown that people who adhere to recommended treatment or health messages have better health outcomes compared to those who do not comply with treatment or health messages [37–39]. Therefore, health, education, socio-economic and other government and non-government agencies in Bangladesh must work together towards the achievement of the SDGs and should draw on experiences and capability from the MDGs implementation to further accelerate reductions in child mortality.

The study has several strengths. First, it was based on nationally representative surveys and utilised three different Bangladesh DHS datasets, consisting of a large sample size. Second, the data analysed were restricted to information of each mother's latest birth, five years prior to each survey. This restriction enhanced the validity of the analysis and also minimised recall bias, consistent with previous reports [40, 41]. Third, the substantial sample size made it possible to examine the effects of the main preventive interventions on mortality; notably, ANC services, IFA supplementation and TT vaccinations, and the combination of these factors, while controlling for community, socio-economic and proximate factors.

Some limitations of our study are worthy of note. First, reports from mothers could not be validated. That notwithstanding, child mortality has been a core feature in the various DHS programmes, and there has been a careful examination of methods used in the survey for many years [42]. Second, report of usage of IFA supplementation during pregnancy and other ANC services by a mother was based on her recall; consequently, we could not assess any improvement in her iron status or information on other services that the mother may have received during the antenatal visits. This may lead to under- or over-estimation of the association between the exposure variables and outcome measures. Third, there could be an underestimation of these mortalities because both the history of birth and infant/child survival data were obtained only from surviving mothers [41]. Fourth, data on the cause of death were not available, information that would have provided an opportunity for targeted and context-

specific intervention. Nonetheless, detailed information on cause-specific mortality in Bangladesh has been reported in detail elsewhere [43].

Conclusion

Our study found that a combination of IFA supplementation and ANC TT vaccination were protective against postnatal and child mortality in Bangladesh. The study also found that a minimum of two ANC TT vaccinations was protective against neonatal, postnatal and child mortality and, as a single intervention, conferred greater protection across all age groups compared to no IFA supplementation and less than two ANC TT vaccination. In Bangladesh, considerable gains could be achieved in improving child survival and extend the longevity of life through ensuring universal access to appropriate ANC, promotion of TT vaccination during pregnancy and IFA supplementation in pregnant women.

Acknowledgments

The authors are grateful to Measure DHS/ICF International for providing the data for the analysis.

Author Contributions

Conceptualization: Tanvir Abir, Kingsley Emwinyore Agho.

Data curation: Tanvir Abir, Kingsley Emwinyore Agho.

Formal analysis: Tanvir Abir, Kingsley Emwinyore Agho.

Methodology: Felix Akpojene Ogbo, Kingsley Emwinyore Agho.

Resources: Felix Akpojene Ogbo, Garry John Stevens, Andrew Nicolas Page, Abul Hasnat Milton, Kingsley Emwinyore Agho.

Software: Tanvir Abir, Kingsley Emwinyore Agho.

Supervision: Andrew Nicolas Page, Abul Hasnat Milton, Kingsley Emwinyore Agho.

Writing – original draft: Tanvir Abir, Felix Akpojene Ogbo, Kingsley Emwinyore Agho.

Writing – review & editing: Felix Akpojene Ogbo, Garry John Stevens, Andrew Nicolas Page, Abul Hasnat Milton, Kingsley Emwinyore Agho.

References

1. Wang H, Bhutta ZA, Coates MM, Coggeshall M, Dandona L, Diallo K, et al. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016; 388(10053):1725–74.
2. Khan AA, Zahidie A, Rabbani F. Interventions to reduce neonatal mortality from neonatal tetanus in low and middle income countries-a systematic review. BMC Public Health. 2013; 13(1):322.
3. Jokhio AH, Winter HR, Cheng KK. An intervention involving traditional birth attendants and perinatal and maternal mortality in Pakistan. New England Journal of Medicine. 2005; 352(20):2091–9. https://doi.org/10.1056/NEJMsa042830 PMID: 15901862
4. Blencowe H, Lawn J, Vandelaer J, Roper M, Cousens S. Tetanus toxoid immunization to reduce mortality from neonatal tetanus. International journal of epidemiology. 2010; 39(suppl 1):i102–i9.
5. Lamberti LM, Walker C, Fischer L, Noiman A, Victora C, Black RE. Breastfeeding and the risk for diarrhea morbidity and mortality. BMC public health. 2011; 11(Suppl 3):S15.
6. West KP, Shamim AA, Mehra S, Labrique AB, Ali H, Shaikh S, et al. Effect of Maternal Multiple Micronutrient vs Iron–Folic Acid Supplementation on Infant Mortality and Adverse Birth Outcomes in Rural Bangladesh: The JiVitA-3 Randomized Trial. JAMA. 2014; 312(24):2649–58. https://doi.org/10.1001/jama.2014.16819 PMID: 25536256

7. Pervin J, Moran A, Rahman M, Razzaque A, Sibley L, Streatfield PK, et al. Association of antenatal care with facility delivery and perinatal survival–a population-based study in Bangladesh. BMC pregnancy and childbirth. 2012; 12(1):111.
8. Rahman A, Nisha MK, Begum T, Ahmed S, Alam N, Anwar I. Trends, determinants and inequities of 4+ ANC utilisation in Bangladesh. Journal of Health, Population and Nutrition. 2017; 36(1):2. https://doi.org/10.1186/s41043-016-0078-5 PMID: 28086970
9. Singh A, Pallikadavath S, Ogollah R, Stones W. Maternal tetanus toxoid vaccination and neonatal mortality in rural north India. PLoS one. 2012; 7(11):e48891. https://doi.org/10.1371/journal.pone.0048891 PMID: 23152814
10. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, De Bernis L, et al. Evidence-based, cost-effective interventions: how many newborn babies can we save? The Lancet. 2005; 365(9463):977–88.
11. Black RE, Huber D, Curlin GT. Reduction of neonatal tetanus by mass immunization of non-pregnant women: duration of protection provided by one or two doses of aluminium-adsorbed tetanus toxoid. Bulletin of the World Health Organization. 1980; 58(6):927. PMID: 6971190
12. National Institute of Population Research and Training (NIPORT) MaA, and ORC Macro,. Bangladesh Demographic and Health Survey 2004. Dhaka, Bangladesh and Calverton, Maryland [USA]: National Institute of Population Research and Training, Mitra and Associates, and ORC Macro, 2005.
13. National Institute of Population Research and Training (NIPORT), Mitra and Associates, Macro International. Bangladesh Demographic and Health Survey 2007. Dhaka, Bangladesh and Calverton, Maryland, USA: National Institute of Population Research and Training, Mitra and Associates, and Macro International, 2009.
14. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.
15. Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. Population and development review. 1984:25–45.
16. Alam N. Teenage motherhood and infant mortality in Bangladesh: maternal age-dependent effect of parity one. Journal of biosocial science. 2000; 32(2):229–36. PMID: 10765612
17. World Health Organisation. The World health report: Make every mother and child count. Geneva: WHO, 2005.
18. United Nations. The Millennium Development Goals Report 2015. New York: United Nations, 2015.
19. Ronsmans C, Chowdhury ME, Alam N, Koblinsky M, Arifeen SE. Trends in stillbirths, early and late neonatal mortality in rural Bangladesh: the role of public health interventions. Paediatric and perinatal epidemiology. 2008; 22(3):269–79. https://doi.org/10.1111/j.1365-3016.2008.00939.x PMID: 18426522
20. Rahman AS, Islam MR, Koehlmoos TP, Raihan MJ, Hasan MM, Ahmed T, et al. Impact of NGO Training and Support Intervention on Diarrhoea Management Practices in a Rural Community of Bangladesh: An Uncontrolled, Single-Arm Trial. PloS one. 2014; 9(11):e112308. https://doi.org/10.1371/journal.pone.0112308 PMID: 25398082
21. Hyder AA, Alonge O, He S, Wadhwaniya S, Rahman F, Rahman A, et al. A framework for addressing implementation gap in global drowning prevention interventions: experiences from Bangladesh. Journal of health, population, and nutrition. 2014; 32(4):564. PMID: 25895188
22. Zeng L, Cheng Y, Dang S, Yan H, Dibley MJ, Chang S, et al. Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. Bmj. 2008; 337.
23. Titaley CR, Dibley MJ, Roberts CL, Hall J, Agho K. Iron and folic acid supplements and reduced early neonatal deaths in Indonesia. Bulletin of the World Health Organization. 2010; 88(7):500–8. https://doi.org/10.2471/BLT.09.065813 PMID: 20616969
24. World Health Organization. Iron deficiency anaemia: assessment, prevention and control: a guide for programme managers. Geneva: WHO, 2001.
25. Nutrition International. Women's and Newborn Survival and Health in Bangladesh Online: Nutrition International 2017 [cited 2017 16 May]. http://www.nutritionintl.org/in-the-world/asia/bangladesh/.
26. Tall F, Prazuck T, Roisin A, Sanou J, Nacro B, Traore A, et al. [Risk factors for neonatal tetanus in western Burkina Faso. Case-control study]. Bulletin de la Societe de pathologie exotique (1990). 1990; 84(5 Pt 5):558–61.
27. Gitta SN, Wabwire-Mangen F, Kitimbo D, Pariyo G. Risk factors for neonatal tetanus—Busoga region, Uganda, 2002–2003. MMWR Morb Mortal Wkly Rep. 2006; 55(Suppl 1):25–30.
28. Chai F, Prevots DR, Wang X, Birmingham M, Zhang R. Neonatal tetanus incidence in China, 1996–2001, and risk factors for neonatal tetanus, Guangxi Province, China. International journal of epidemiology. 2004; 33(3):551–7. https://doi.org/10.1093/ije/dyh073 PMID: 15155708

29. Ministry of Health and Family Welfare, World Health Organisation, World Bank, Alliance for Health Policy and Systems Research. Success Factors for Women's and Children's Health. Bangladesh: Ministry of Health and Family Welfare, 2015.
30. United Nations. Sustainable Development—knowledge platform: United Nations; 2017 [cited 2017 16 May]. https://sustainabledevelopment.un.org/sdg3.
31. Basinga P, Gertler PJ, Binagwaho A, Soucat AL, Sturdy J, Vermeersch CM. Effect on maternal and child health services in Rwanda of payment to primary health-care providers for performance: an impact evaluation. The Lancet. 2011; 377(9775):1421–8.
32. Tate JE, Burton AH, Boschi-Pinto C, Steele AD, Duque J, Parashar UD. 2008 estimate of worldwide rotavirus-associated mortality in children younger than 5 years before the introduction of universal rotavirus vaccination programmes: a systematic review and meta-analysis. The Lancet infectious diseases. 2012; 12(2):136–41. https://doi.org/10.1016/S1473-3099(11)70253-5 PMID: 22030330
33. Victora CG, Bahl R, Barros AJ, França GV, Horton S, Krasevec J, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. The Lancet. 2016; 387(10017):475–90.
34. Ogbo FA, Page A, Idoko J, Claudio F, Agho KE. Diarrhoea and suboptimal feeding practices in Nigeria: evidence from the national household surveys. Paediatric and Perinatal Epidemiology. 2016; 30:346–55. https://doi.org/10.1111/ppe.12293 PMID: 27009844
35. Ezeh OK, Agho KE, Dibley MJ, Hall JJ, Page AN. Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. BMJ open. 2015; 5(3):e006779. https://doi.org/10.1136/bmjopen-2014-006779 PMID: 25818271
36. Abir T, Agho KE, Page AN, Milton AH, Dibley MJ. Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011. BMJ open. 2015; 5(8):e006722. https://doi.org/10.1136/bmjopen-2014-006722 PMID: 26297357
37. Martin LR, Williams SL, Haskard KB, DiMatteo MR. The challenge of patient adherence. Therapeutics and clinical risk management. 2005; 1(3):189. PMID: 18360559
38. Stewart MA. Effective physician-patient communication and health outcomes: a review. CMAJ: Canadian Medical Association Journal. 1995; 152(9):1423. PMID: 7728691
39. Jin J, Sklar GE, Oh VMS, Li SC. Factors affecting therapeutic compliance: A review from the patient's perspective. Therapeutics and clinical risk management. 2008; 4(1):269. PMID: 18728716
40. Hill K, Choi Y. Neonatal mortality in the developing world. Demographic research. 2006; 14(18):429–52.
41. Mahy M. Childhood mortality in the developing world: a review of evidence from the Demographic and Health Surveys: MEASURE DHS+, ORC Macro; 2003.
42. Curtis SL. Assessment of the quality of data used for direct estimation of infant and child mortality in DHS-II surveys. 1995.
43. Wang H, Naghavi M, Allen C, Barber RM, Bhutta ZA, Carter A, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016; 388 (10053):1459–544.

Appendix C

Predictors of stillbirths in Bangladesh: evidence from the 2004-2014 nation-wide household surveys.

Tanvir Abir, Kingsley Emwinyore Agho Felix Akpojene Ogbo, Garry John Stevens,Andrew Nicolas Page, Abul Hasnat Milton, Micheal John Dibley, Camille Raynes-Greenow

Global Health Action. 2017;10(1), PMID:29261451, 10 pages

GLOBAL HEALTH ACTION, 2017
VOL. 10, 1410048
https://doi.org/10.1080/16549716.2017.1410048

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Predictors of stillbirths in Bangladesh: evidence from the 2004–2014 nation-wide household surveys

Tanvir Abir[a], Kingsley E. Agho[a], Felix A. Ogbo[a], Garry J. Stevens [b], Andrew Page[a], Milton A. Hasnat[c], Michael J. Dibley[d] and Camille Raynes-Greenow [d]

[a]Translational Health Research Institute, School of Medicine, Western Sydney University, Penrith, Australia; [b]Humanitarian and Development Research Initiative (HADRI), School of Social Science and Psychology, Western Sydney University, Penrith, Australia; [c]School of Medicine and Public Health, Faculty of Health and Medicine, The University of Newcastle , Callaghan, Australia; [d]Sydney School of Public Health, Edward Ford Building (A27), University of Sydney, Sydney, Australia

ABSTRACT

Background: Globally, stillbirth remains a significant public health issue, particularly in developing countries such as Bangladesh.

Objective: This study aimed to investigate the potential predictors of stillbirths in Bangladesh over a ten-year period.

Methods: The Bangladesh Demographic and Health Surveys data for the years 2004, 2007, 2011 and 2014 (n = 29,094) were used for the study to investigate the predictors of stillbirths. Stillbirth was examined against a set of community, socio-economic and child characteristics, using a multivariable logistic regression model that adjusted for cluster and sampling variability.

Results: The pooled rate of stillbirth in Bangladesh was 28 in 1000 births (95% CI: 22, 34). Stillbirth rates were higher in rural compared to urban areas in Bangladesh. Mothers who had a secondary or higher level of education (OR = 0.59, 95%CI: 0.43–0.82, P = 0.002) and those with primary education (OR = 0.66, 95%CI: 0.55–0.80, P < 0.001) were less likely to experience stillbirths compared to mothers with no education. Mothers with more than two children were significantly less likely to have stillbirths compared to mothers with one child. Those from poor households reported increased odds of stillbirth compared to those from rich households.

Conclusion: Our analysis indicated that no maternal education, primiparity and poor household were predictors of stillbirths in Bangladesh. A collaborative effort is needed to reduce stillbirth rates among these high-risk groups in Bangladesh, with the socio-economic and health-related Sustainable Development Goals providing a critical vehicle for the co-ordination of this work.

ARTICLE HISTORY
Received 20 June 2017
Accepted 11 November 2017

RESPONSIBLE EDITOR
Stig Wall, Umeå University, Sweden

KEYWORDS
Bangladesh; infants; mortality; predictors; stillbirths; under-five

Background

The Global Burden of Disease, Injuries and Risk Factors Study 2015 (GBD 2015) reported that the rate of stillbirth has fallen worldwide by 47% since 1990, and more quickly from the year 2000 [1]. Despite this decline, recent studies have reported that global estimates of stillbirth ranged from 2.1 million [1] to 2.6 million [2] in 2015, and approximately 98% of those fetal deaths occurred in developing countries [1,2]. Variation in global estimates of the stillbirth rate may be due to access to data sources and modelling strategy, as both studies used the standard definition for stillbirth (fetal death after 28 weeks' gestation).

The United Nations reported that Bangladesh made a significant improvement in reducing under-5 mortality rate during the Millennium Development Goals (MDG) era (between 1990 and 2015) [3]. Despite this achievement, Bangladesh remains a major contributor to stillbirth rates in South Asia [2] with a reported stillbirth rate of 20 per 1000 live births in 2015 [1]. Stillbirths have an enormous impact on mothers, families, health care professionals and the community [4]. Previous studies have quantified the direct [5,6] and indirect [4] financial costs for parents after an experience of stillbirth, however, the psychological and social costs associated with stillbirth have been described as unquantifiable [7].

Based on the health burden associated with stillbirth, there is a renewed focus at the global level on ending preventable stillbirths by 2030 (Sustainable Development Goal, SDG-3.2) [8,9]. Similarly, the Lancet Series on ending preventable stillbirths highlighted the need for policy formulation and ongoing research, particularly improved data collection to support the implementation of evidence-based initiatives [8]. In the context of this global goal, country-specific evidence would be helpful in informing

CONTACT Kingsley E. Agho K.Agho@westernsydney.edu.au Translational Health Research Institute, School of Medicine, Western Sydney University, Locked Bag 1797, Penrith, NSW 2571, Australia

targeted interventions and policy decision-making to reduce stillbirth in Bangladesh.

In Bangladesh, information on risk factors for stillbirths is limited at the national level. Previous studies conducted in rural areas [10,11] and the inner city of Dhaka [12] found that a lack of maternal education, older maternal age (≥35 years), history of alcohol intake and drug abuse were associated with higher rates of stillbirth. The generalisability of these findings to the broader Bangladesh population may be limited, given differences in socio-economic status and geographical regions. The burden of stillbirths can vary within a country, with economically disadvantaged communities having higher rates compared to their economically well-off counterparts [13].

Using a reliable and population-based maternal and child health data source (Bangladesh Demographic and Health Survey, BDHS), we provide nationally representative information on the rate and predictors of stillbirth. Our study aimed to investigate the predictors of stillbirth in Bangladesh, using the BDHS datasets for the period (2004–2014).

Methods

Data sources

Datasets for the years 2004, 2007, 2011 and 2014 from the BDHS were pooled and used for the study. We pooled data across time to increase sample size and statistical power, consistent with previous studies [14–16]. The BDHS data were collected by the National Institute of Population Research and Training (NIPORT), with technical support from Measure DHS through the Inner City Fund (ICF) International. A weighted total sample of 29,094 pregnancies over 28 weeks' gestation for women aged 15–49 years were included in the final analysis (2004: n = 6,395; 2007: n = 5,409; 2011: n = 9,021; and 2014: n = 8,269). The data were weighted to ensure the representativeness of the survey results at the national level.

In the 2011 and 2014 BDHS, a new administrative region called 'Rangpur' was created, and when Rangpur was removed from the overall data sets, a total weighted sample of 27,540 pregnancies over 28 weeks' gestation for women aged 15–49 years was obtained (2004: n = 6,395; 2007: n = 5,409; 2011: n = 8,315; and 2014: n = 7,421). Data with Rangpur (general Bangladesh population) and without Rangpur were reported in this present study to ensure robustness of the analyses. The average response rate for the four surveys was 98%. A detailed description of the survey methodology, sampling procedure and questionnaires used for data collection is provided elsewhere [17].

Outcome variable

The study outcome was stillbirth, defined as death of a fetus of more than or equal to 28 weeks' gestation, consistent with previous studies [1,2,12]. The outcome was recorded as a binary variable in the datasets, coded as '1' for stillbirth and '0' for no stillbirth.

Study factors

The study factors included community, socio-demographic and child factors. These were selected based on previously published studies and availability of data [10–12]. The community factors were place of residence (urban or rural) and geographical region, covering divisions in Bangladesh, namely: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Sylhet and Rangpur. Socio-demographic factors included number of children ever born, age of mother at the time of the interview, mother's working status, mother's marital status, mother's body mass index (BMI), parents' level of education, mother's age at index childbirth, desire for pregnancy, mother's access to the media (television, radio or newspaper). Child factors comprised gender of the child, previous multiple births, previous death of a sibling and combined birth rank and interval. Based on previous studies [18,19], we combined birth order and interval in the analysis because of the impact of birth order that may be mediated by the birth interval. Household wealth index was constructed by NIPORT and ICF International [17], using the principal components analysis by assigning weights to three household characteristics; namely: type of floor and wall; access to electricity; and six household assets; namely, possession of a radio, television, bicycle, motorcycle, car and fridge. The household wealth index was ranked across the four surveys, where household wealth index was divided into three categories. The bottom 40% of households were arbitrarily classified as poor households, the next 40% as the middle households and the top 20% as rich households [20]. Type of cooking fuels available to household members at the time of survey will be referred to as 'household air pollution from solid fuel'. Household air pollution from solid fuel were categorised as solid fuels (coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop, animal dung) and non-solid fuels (electricity, liquefied petroleum gas (LPG), natural gas, biogas, kerosene).

Statistical analysis

Frequency tabulations were first conducted to describe the distributions of data by years of the

survey, followed by calculation of the rate of stillbirths, unadjusted odds ratios (OR) and their 95% confidence interval (CI) of all potential predictors.

A three-stage model was performed for the multivariable logistic regression analyses by following a conceptual model that was employed by Chowdhury et al. [21]. In the first modelling stage, community and socio-economic determinants were examined, and only significant variables associated with the study outcome at 5% significance level were retained in model 1. In the second stage, the significant variables in *model 1* were added to child demographic factors. In the final stage, media factors and environmental factor were added to significant variables in model 2 to determine factors associated with stillbirth. All analyses were performed in Stata statistical software version 14 (Stata Corp., College Station, TX, USA) that adjusted for sampling weights, intra-cluster variability and sampling design to provide population-based estimates.

Ethics

The study used existing survey datasets that are available online by application, with all identifier information removed. The surveys were approved by the Ethics Committee of the ICF International, USA and the National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Bangladesh. We obtained approval from Measure DHS to download and use the data for the study.

Results

Characteristics of the study population

The majority of mothers were from the Dhaka administrative region (32.2%), with the smallest group from the Barisal region (5.8%). Half of the mothers belonged to the youngest age group (15–24 years, 50.1%), with 8.8% aged 35–49 years. Mothers with no schooling and those with only primary education were almost equally represented (43.7% and 45.5%, respectively). Approximately 18 out of every 100 households were categorised as wealthy, and 42 out of every 100 households were categorised as poor households. Female and male children were almost equally distributed (Table 1).

Rates and predictors of stillbirths

As shown in Figure 1(a) (with Rangpur), the rate of stillbirth was 37 [95% confidence interval (CI): 32, 42] per 1000 births in 2004; 30 (95% CI: 25, 35) per 1000 births in 2007, 26 (95% CI: 23, 29) per 1000 births in 2011 and 21 (95% CI: 18, 25) per 1000 births in 2014. From 2004 to 2014, the overall rate of stillbirth was 28 (95% CI: 22, 34) per 1000 births. These results indicated that stillbirth decreased significantly in 2011 and 2014 compared to 2004, but in 2007 compared to 2011 and 2014, there was no significant decrease in stillbirth rate. In comparison to the population with Rangpur (Figure 1(a)), there was no significant differences in the rate of stillbirth in the population without Rangpur (Figure 1(b)).

The analysis showed that the rate of stillbirth was higher among rural mothers, older women, mothers with no schooling and mothers from poor households in Bangladesh (with Rangpur) [Table 2]. The stillbirth rate was significantly higher among households who reported non-solid fuel use and mothers who reported fourth birth order of child with more than 2 years' birth interval.

Multivariable analyses were performed with and without Rangpur division and showed that there was no substantial statistical difference between inclusion or removal of Rangpur division from the data sets. In this study, we provide interpretation of findings for all regions of Bangladesh (analyses with Rangpur division). In the multivariable analyses, the odds of stillbirth were significantly lower in educated mothers compared to those who had no schooling (Table 3). The risk of stillbirth was significantly higher among mothers from poorer households compared to those from rich households. Mothers with four or more children were significantly less likely to have a stillbirth compared to those who had one child. Mothers who did not read newspapers every week were significantly more likely to experience a stillbirth compared to those who read newspapers every week.

Discussion

The study found that the rates of stillbirth were lower in 2014 compared to 2004. Stillbirth rates were higher in rural areas compared to urban areas in Bangladesh, and low maternal education, poor household, and having one child (primiparity) were significant predictors of stillbirth in Bangladesh. A further stratified analysis (with or without Rangpur division) showed no substantial statistical differences in the results.

The finding that stillbirth declined during the decade 2004–2014 is consistent with previous studies which reported lower rates of stillbirth in Bangladesh between 2009 and 2015 [11,12] and from 1990 to 2015 [1]. The reduction in the rates of stillbirth in Bangladesh has been attributed to a range of maternal and newborn interventions and socio-economic policies. These include overall economic growth; improved education and social empowerment of women; increased health sector financing and investment; the scale-up of family planning services; and increased access to skilled birth attendants

Table 1. Characteristics of the study population in Bangladesh, 2004–2014 (n = 29,094).

	With Rangpur (a) (n = 29,094)			Without Rangpur (n = 27,540)		
VARIABLE	n	n*	%*	n	n*	%*
COMMUNITY LEVEL FACTORS						
Year of survey						
2004	6287	6395	22.0	6287	6395	23.2
2007	5473	5409	18.6	5473	5409	19.6
2011	8986	9021	31.0	7527	8316	30.2
2014	8069	8269	28.4	6714	7420	26.9
Cluster type						
Urban	8965	6423	22.1	8242	6212	22.6
Rural	19,850	22,670	77.9	17,759	21,328	77.4
Region						
Barisal	3313	1685	5.8	3313	1685	6.1
Chittagong	5876	6472	22.2	5876	6472	23.5
Dhaka	5406	9354	32.2	5406	9354	34.0
Khulna	3296	2605	9.0	3296	2605	9.5
Rajshahi	4124	4609	15.8	4124	4608	16.7
Sylhet	3986	2815	9.7	3986	2815	10.2
Rangpur	2814	1554	5.3			
SOCIOECONOMIC DETERMINANTS						
Mother's Age (years) (n = 29,087)						
15–24	14,271	14,576	50.1	13,102	13,920	50.6
25–34	11,890	11,953	41.1	10,571	11,239	40.8
35–49	2634	2558	8.8	2308	2375	8.6
Mother working status (n = 29,090)						
Not working	23,132	23,095	79.4	20,648	21,719	78.9
Working	5679	5995	20.6	5351	5818	21.1
Mother BMI (kg/m^2) (n = 28,939)						
≤18	6329	6360	21.9	5597	5967	21.7
19–25	18,595	19,064	65.5	16,905	18,090	65.7
25+	3724	3515	12.1	3350	3337	12.1
Maternal marital status						
Currently married	28,282	28,572	98.2	25,519	27,041	98.2
Formerly married	533	522	1.8	482	499	1.8
Maternal highest level of education (n = 29,079)						
No schooling	12,235	12,712	43.7	10,930	11,969	43.5
Primary	12,775	12,939	44.5	11,524	12,246	44.5
Secondary or more	3785	3428	11.8	3527	3309	12.0
Paternal highest level of education (n = 29,077)						
No schooling	13,898	14,440	49.6	12,413	13,588	49.3
Primary	9608	9697	33.3	8690	9178	33.3
Secondary or more	5291	4940	17.0	4880	4756	17.3
Household Wealth Index						
Rich	5763	5118	17.6	5123	4860	17.7
Middle	11,526	11,684	40.2	10,568	11,178	40.6
Poor	11,526	12,291	42.3	10,310	11,502	41.8
CHILD DETERMINANTS						
Sex (n = 28,685)						
Female	13,861	14,019	48.2	12,547	13,285	48.2
Male	14,538	14,666	50.4	13,137	13,899	50.5
Birth rank and birth interval						
2nd/3rd birth rank, more than 2 years interval	10,675	10,935	37.6	9776	10,455	38.0
1st birth rank	9948	9996	34.4	9164	9556	34.7
2nd/3rd birth rank, less than or equal to 2 years interval	1924	1907	6.6	1677	1777	6.5
4th birth rank, more than 2 years interval	5178	5200	17.9	4453	4787	17.4
4th birth rank, less than or equal to 2 years interval	1090	1056	3.6	931	965	3.5
Previous Death of Sibling						
No	28,067	28,352	97.5	25,318	26,832	97.4
Yes	748	742	2.6	683	708	2.6
Number of children born (n = 29,011)						
1	7990	7999	27.5	7401	7675	27.9
2	8732	8868	30.5	8012	8485	30.8
3	5278	5412	18.6	4727	5110	18.6
4+	6733	6732	23.1	5795	6196	22.5
Number of children under-five years						
1–2	17,873	18,113	62.3	16,467	17,365	63.1
3 or more	10,942	10,981	37.7	9534	10,175	37.0
MEDIA FACTORS						
Watches television every week (n = 29,011)						
Yes	16,123	16,080	55.3	14,775	15,421	56.0
No	12,688	13,011	44.7	11,224	12,116	44.0
Listens to radio every week (n = 29,088)						
Yes	5158	5385	18.5	5019	5305	19.3
No	23,650	23,703	81.5	20,975	22,229	80.7
Reads newspaper (n = 29,075)						
Yes	4501	4115	14.1	4054	3902	14.2
No	24,291	24,960	85.8	21,930	23,621	85.8

(*Continued*)

Table 1. (Continued).

VARIABLE	With Rangpur (a) (n = 29,094) n	n*	%*	Without Rangpur (n = 27,540) n	n*	%*
ENVIRONMENTAL FACTOR						
Type of cooking fuel (n = 26,325)						
Solid fuel	2995	2943	10.1	2644	2846	10.3
Non-solid fuel	23,140	23,382	80.4	20,871	22,018	80.0

[&]Weighted for the sampling probability; n[&] weighted 'n'
*percentage did not add up to 100% because of missing values.
(a) Overall Bangladesh population

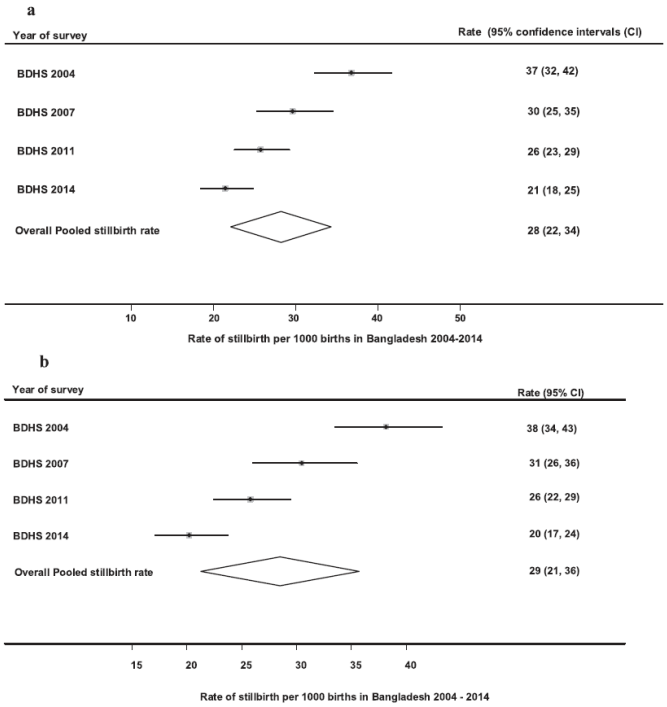


Figure 1. (a) Rate of stillbirth per 1000 births in Bangladesh (with Rangpur), 2004–2014. (b)Rate of stillbirth per 1000 births in Bangladesh (without Rangpur) 2004–2014.

and expansion of the private health sector [22]. The marked improvement in child survival may also be due to the broader influence of programmatic commitments to the MDG's between 1990 and 2015. Notably, the United Nations reported that Bangladesh was among the few countries worldwide to meet MDG-4 and MDG-5 (reduction of under-5 and maternal mortalities) [3]. While under-5 and maternal mortality rates are not direct measures of stillbirth rate, improvement in appropriate antenatal care, skilled births assistance and newborn care have been described as the core solutions to ending preventable stillbirth [22,23].

Although our study observed no association between maternal age and stillbirth, previous studies from developing countries such as Sudan [24] and Nigeria [25] and developed countries such as Australia [26] and the USA [27] have reported a higher risk of stillbirths in women aged over 35 years. The higher rate of stillbirths among older women may be due to increased risk of congenital anomalies associated with advanced maternal age. In contrast, hospital-based studies conducted in India [28] and Nigeria [29] reported an increased risk of stillbirths in mothers aged less than 20 years. This finding may reflect a lack of education, limited autonomy to make household decisions and poor health-seeking behaviours among teenage women, as reported in Nigeria [30] and India [31]. Nevertheless, a population-based study from Taiwan reported an increased risk of stillbirths in both older (>40 years) and younger mothers (<20 years) [32].

Consistent with previous studies conducted in developing countries, from rural Bangladesh to Uganda [10,11,33,34], this study showed that stillbirth rates were higher among mothers with no formal education compared to educated mothers. A study conducted in Norway indicated that stillbirth rates were higher in Norwegian women with fewer years of education, but not among Pakistani

Table 2. Rate and univariate analysis of stillbirth by study factors in Bangladesh, 2004–2014.

	With Rangpur (a)				Without Rangpur			
		Unadjusted odds ratio				Unadjusted odds ratio		
VARIABLE	Rate 95%[CI]	OR	(95% CI)		Rate 95%[CI]	OR	(95% CI)	
COMMUNITY LEVEL FACTORS								
Cluster type								
Urban	23 [19, 48]	1.00			22 [18, 26]	1.00		
Rural	30 [28, 43]	1.36	1.13	1.65	30 [27, 32]	1.39	1.14	1.69
Region								
Barisal	28 [19, 36]	1.00			28 [19, 36]	1.00		
Chittagong	26 [22, 30]	0.93	0.65	1.34	26 [22, 30]	0.93	0.65	1.35
Dhaka	27 [24, 30]	1.01	0.71	1.44	27 [24, 30]	1.02	0.71	1.45
Khulna	24 [18, 30]	0.87	0.57	1.32	24 [18, 30]	0.87	0.57	1.33
Rajshahi	33 [28, 39]	1.26	0.87	1.82	33 [28, 39]	1.26	0.87	1.83
Sylhet	33 [26, 39]	1.26	0.85	1.88	33 [26, 39]	1.27	0.85	1.90
Rangpur	36 [26, 46]	1.37	0.88	2.14				
SOCIOECONOMIC DETERMINANTS								
Mother's Age (years)*								
15–24	28 [26, 31]	1.00			28 [25, 31]	1.00		
25–34	28 [25, 31]	0.99	0.85	1.15	28 [25, 31]	0.99	0.85	1.16
35–49	31 [24, 38]	1.09	0.85	1.40	31 [24, 38]	1.11	0.86	1.44
Mother working status								
Not working	35 [31, 39]	1.00			28 [26, 30]	1.00		
Working	33 [26, 40]	0.97	0.76	1.25	29 [25, 34]	1.05	0.88	1.25
Mother BMI (kg/m^2)*								
≤18	30 [25, 34]	1.00			30 [25, 34]	1.00		
19–25	29 [26, 31]	0.97	0.82	1.15	28 [26, 31]	0.95	0.80	1.14
25+	24 [19, 29]	0.81	0.62	1.06	23 [18, 28]	0.78	0.59	1.03
Maternal marital status								
Currently married	28 [26, 30]	1.00			27 [25, 29]	1.00		
Formerly married	63 [41, 85]	2.28	1.56	3.32	59 [37, 81]	2.18	1.46	3.23
Maternal highest level of education*								
No schooling	34 [31, 38]	1.00			34 [30, 37]	1.00		
Primary	25 [22, 28]	0.72	0.62	0.84	25 [22, 28]	0.73	0.62	0.85
Secondary or more	20 [15, 25]	0.57	0.44	0.75	20 [15, 25]	0.59	0.45	0.77
Paternal highest level of education*								
No schooling	33 [30, 36]	1.00			32 [29, 35]	1.00		
Primary	28 [24, 31]	0.84	0.72	0.99	27 [24, 31]	0.85	0.72	0.99
Secondary or more	17 [13, 21]	0.51	0.40	0.65	17 [13, 20]	0.51	0.40	0.65
Household Wealth Index								
Rich	18 [14, 21]	1.00			17[14, 21]	1.00		
Middle	30 [26, 33]	1.71	1.35	2.17	29 [26, 33]	1.74	1.35	2.23
Poor	32 [29, 35]	1.85	1.46	2.35	31 [28, 35]	1.87	1.46	2.40
CHILD DEMOGRAPHICS								
Gender*								
Female	14 [12, 16]	1.00			15 [13, 17]	1.00		
Male	13 [12, 16]	0.97	0.79	1.19	14 [12, 17]	0.97	0.80	1.19
Birth rank and birth interval								
2nd/3rd birth rank, more than 2 years interval	11 [9,13]	1.00			11 [9,13]	1.00		
1st birth rank	16 [14, 19]	1.47	1.16	1.87	16 [14, 19]	1.48	1.16	1.88
2nd/3rd birth rank, less than or equal to 2 years interval	16 [10, 22]	1.49	0.99	2.23	17 [11, 23]	1.53	1.02	2.29
4th birth rank, more than 2 years interval	102 [93, 111]	9.91	8.05	12.20	98 [89, 107]	9.12	7.38	11.25
4th birth rank, less than or equal to 2 years interval	19 [10, 27]	1.79	1.09	2.92	20 [11, 29]	1.87	1.15	3.06
Previous Death of Sibling								
No	28 [26, 30]	1.00			28 [26, 30]	1.00		
Yes	37 [23, 51]	1.31	0.88	1.96	38 [23, 52]	1.36	0.90	2.04
Number of children born*								
1	35 [31, 39]	1.00			34 [34, 38]	1.00		
2	21 [18, 24]	0.57	0.47	0.69	21 [17, 24]	0.58	0.48	0.71
3	20 [17, 24]	0.58	0.46	0.73	20 [16, 24]	0.58	0.46	0.74
4+	25 [21, 29]	0.70	0.57	0.85	25 [21, 29]	0.73	0.59	0.89
Number of children under-five years								
1–2	33 [31, 36]	1.00			32 [30, 35]	1.00		
3+	20 [18, 23]	0.61	0.52	0.71	21 [18, 23]	0.63	0.53	0.74
MEDIA FACTORS								
Watches TV every week*								
Yes	25 [22, 27]	1.00			24 [22, 27]	1.00		
No	33 [30, 36]	1.36	1.18	1.58	33 [30, 36]	1.38	1.19	1.60
Listens to radio every week*								
Yes	31 [26, 36]	1.00			31 [26, 36]	1.00		
No	28 [26, 30]	0.90	0.76	1.08	27 [25, 30]	0.88	0.74	1.06
Read newspaper*								
Yes	19 [14, 23]	1.00			18 [14, 22]	1.00		
No	30 [28, 32]	1.61	1.27	2.05	30 [27, 32]	1.63	1.27	2.10
ENVIRONMENTAL FACTOR								
Type of cooking fuel*								
Solid fuel	18 [13, 23]	1.00			28 [16, 39]	1.00		
Non-solid fuel	31 [28, 33]	1.56	1.18	2.04	37 [33, 41]	1.34	0.82	2.18

*Rates did not add up because of missing values.
Note: 95% confidence intervals (CI) that include 1.00 indicate a non-significant result.
(a) Overall Bangladesh population

Table 3. Predictors of stillbirth: adjusted odds ratio (AOR) in Bangladesh, 2004–2014.

	With Rangpur (a)				Without Rangpur			
Characteristic	AOR	(95%CI)		P value	AOR	(95%CI)		P value
Year of survey								
2004	1.00				1.00			
2007	0.81	0.66	1.00	0.045	0.75	0.61	0.93	0.010
2011	0.54	0.44	0.66	<0.001	0.52	0.42	0.65	<0.001
2014	0.47	0.38	0.59	<0.001	0.41	0.32	0.52	<0.001
Maternal highest level of education								
No schooling	1.00				1.00			
Primary	0.66	0.55	0.80	<0.001	0.67	0.55	0.81	<0.001
Secondary or more	0.59	0.43	0.82	0.002	0.63	0.44	0.89	0.008
Household Wealth Index								
Rich	1.00				1.00			
Middle	1.30	1.01	1.66	0.040	1.51	1.14	2.01	0.004
Poor	1.47	1.13	1.90	0.004	1.62	1.21	2.16	0.001
Number of children born								
1	1.00				1.00			
2	0.56	0.46	0.69	<0.001	0.57	0.46	0.70	<0.001
3	0.49	0.39	0.63	<0.001	0.49	0.38	0.63	<0.001
4+	0.53	0.43	0.66	<0.001	0.51	0.40	0.65	<0.001
Number of children under-five years								
1–2	1.00				1.00			
3 or more	0.74	0.63	0.88	0.001	0.76	0.63	0.91	0.003
Read newspaper								
Yes	1.00				1.00			
No	1.34	1.02	1.76	0.037	1.38	1.03	1.86	0.033

Independent variables adjusted for community and socio-economic, child, media and environmental factor.
(a) Overall Bangladesh population

immigrant women in Norway [24]. In addition, our study found that mothers from poor households were more likely to experience stillbirths compared to those from rich households. A link between poverty and higher rates of stillbirth has been documented in developing countries [35,36], and a combination of no formal education associated with low-income family income may act as a major obstacle to timely and appropriate decision to seek early medical care in pregnant women. Our study provides supportive evidence that a lack of maternal education is associated with an increased risk of stillbirth in Bangladesh. This finding will assist public health campaigners advocating for targeted socio-educational initiatives to increase female education in Bangladesh.

In Bangladesh, the proportion of women who give birth at home with assistance from a traditional birth attendant (TBA) remains high [17], highlighting the poor uptake of appropriate perinatal health services such as antenatal care (ANC) and birth assistance from skilled health professionals. Antenatal care is an essential public health intervention and is recommended for all pregnant women worldwide by the WHO, based on evidence underpinning its importance in improving maternal and child health outcomes. However, in rural Bangladesh in particular, a range of factors have been linked with the persistent use of home birthing with TBA's [37] including; traditional beliefs, poverty, religious fallacy, poor road networks, limited knowledge on the importance of healthcare services and a shortage of skilled health workers. Bangladesh would likely see further substantial improvements in child survival by implementing interventions that increase access to, and use of perinatal services, particularly among mothers in rural settings and other high-risk groups.

This study revealed that the risk of stillbirth was lower in mothers who had more than two children compared to those with one child, consistent with findings from previous studies, which indicated that stillbirth rates were higher among primiparous women [26,38]. In this setting this could be partly attributed to the young age of first-time mothers which is also a known risk for stillbirth, and lower use of health services and knowledge of the importance of timely and routine ANC.

The study findings have policy implications for public health experts, policy decision-makers, health administrators and developmental partners in Bangladesh. The Lancet Series [2,4,8] suggest a roadmap for ending preventable stillbirths. These include stronger independent accountability within countries, the establishment of stillbirth prevention strategic plans, empowerment of women and families, ensuring skilled birth attendance in health facilities, reduction in stigma associated with stillbirths and improvement in bereavement care. Achievement of SDG-3.2 (end preventable deaths of newborns and children under-five years of age by 2030) appears feasible in Bangladesh given the country's MDGs achievement, however, targeted financial investment and strong political commitment are required. Furthermore, achievement of SDG-3.2 in Bangladesh would require collaborative efforts

among various government and non-government agencies at both national and sub-national levels, as well as drawing experiences and capacities from the implementation of the MDGs agenda.

Strengths and limitations

The following limitations should be considered when interpreting the study findings. First, the study used cross-sectional data, and a temporal association between exposure variables and the outcome cannot be determined. Second, the diagnosis of stillbirth was based on self-report, and this is a likely source of recall bias as respondents may incorrectly recall the gestational age they experienced a stillbirth. Third, data on other potential predictors of stillbirths (such as antepartum and intrapartum events, congenital anomalies or maternal drug use) as reported elsewhere [39] were not available. This latter information would have provided an additional contextual understanding of determinants of stillbirths in Bangladesh. Fourth, the study used pooled cross-sectional data, where population characteristics may differ over time. However, we adjusted for period and intracluster variability [40]. Additional information on the broader limitations of the DHS data utilisation has been described elsewhere [41].

Despite these limitations, the study has several specific strengths. First, selection bias is unlikely to affect the study findings, given the nationally representative sample and the high response rates that averaged 98%. Second, the BDHS used standardised questionnaires for data collection that provides population-based information on maternal and child health over time, allowing comparability across populations and time. Third, the data were collected by high-quality interviewers, which reduces the potential effect of interviewer bias. Fourth, this study provides country-wide evidence on predictors of stillbirths to health experts who can advocate for interventions to improve child survival and health at the national level in Bangladesh.

Conclusion

Our analysis showed that rates of stillbirth were lower in 2014 compared to 2004 in Bangladesh, and risk factors for stillbirth were low maternal education, primiparity and poor household. These findings highlight the need for collaborative efforts to end poverty, ensure healthy lives for all, promote inclusive and equitable education, and empower women to improve child survival in Bangladesh. Drawing lessons from the implementation of MDGs would help accelerate progress towards achievement of ending preventable stillbirths in Bangladesh by 2030.

Acknowledgments

The authors are grateful to Measure DHS for providing the datasets for the analysis.

Author contributions

TA and KEA were involved in the conception and designed for this study; TA performed the analysis and contributed to the manuscript draft. FAO interpreted results, drafted the original manuscript and critically revised the final manuscript. KEA, GJS, ANP, MAH, HM, MJD and CRG provided data analysis and interpretation advice, and revised drafts of the manuscript. All authors read and approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics and consent

The study used existing survey datasets that are available online by application, with all identifier information removed. The surveys were approved by the Ethics Committee of the ICF International, USA and the National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Bangladesh. We obtained approval from Measure DHS to download and use the data for the study.

Funding information

None.

Paper context

Globally, stillbirth is a significant public health issue, particularly in developing countries such as Bangladesh. We examined nationally representative data to identify potential predictors of stillbirths in Bangladesh over a ten-year period. Our study found that stillbirth rates were higher in rural areas, and no maternal education, poor household and primiparity were predictors of stillbirths in Bangladesh. There is need for more collaborative action to end preventable deaths and improve child survival in Bangladesh.

ORCID

Garry J. Stevens http://orcid.org/0000-0002-3556-4098
Camille Raynes-Greenow http://orcid.org/0000-0002-8802-6226

References

[1] Wang H, Bhutta ZA, Coates MM, et al. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the global burden of disease study 2015. Lancet. 2016;388:1725–1774.

[2] Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. Lancet. 2016;387:587–603.
[3] United Nations. The millennium development goals report 2015. New York: United Nations; 2015.
[4] Heazell AE, Siassakos D, Blencowe H, et al. Stillbirths: economic and psychosocial consequences. Lancet. 2016;387:604–616.
[5] Mistry H, Heazell AE, Vincent O, et al. A structured review and exploration of the healthcare costs associated with stillbirth and a subsequent pregnancy in England and Wales. BMC Pregnancy Childbirth. 2013;13:236.
[6] Gold KJ, Sen A, Xu X. Hospital costs associated with stillbirth delivery. Matern Child Health J. 2013;17:1835–1841.
[7] Tarricone R. Cost-of-illness analysis: what room in health economics? Health Policy (New York). 2006;77:51–63.
[8] Frøen JF, Friberg IK, Lawn JE, et al. Stillbirths: progress and unfinished business. Lancet. 2016;387:574–586.
[9] United Nations. Sustainable development - knowledge platform: united nations; 2017 [cited 2017 May 16]. Available from: https://sustainabledevelopment.un.org/sdg3.
[10] Cherry N, Shaikh K, McDonald C, et al. Stillbirth in rural Bangladesh: arsenic exposure and other etiological factors: a report from Gonoshasthaya Kendra. Bull World Health Organ. 2008;86:172–177.
[11] Owais A, Faruque ASG, Das SK, et al. Maternal and antenatal risk factors for stillbirths and neonatal mortality in rural Bangladesh: a case-control study. PLoS One. 2013;8:e80164.
[12] Nahar S, Rahman A, Nasreen HE. Factors influencing stillbirth in Bangladesh: a case–control study. Paediatr Perinat Epidemiol. 2013;27:158–164.
[13] Say L, Donner A, Gülmezoglu AM, et al. The prevalence of stillbirths: a systematic review. Reprod Health. 2006;3:1.
[14] Ogbo FA, Page A, Idoko J, et al. Diarrhoea and suboptimal feeding practices in Nigeria: evidence from the national household surveys. Paediatr Perinat Epidemiol. 2016;30:346–355.
[15] Ok E, Ke A, Mj D, et al. Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. BMJ Open. 2015;5:e006779.
[16] Ogbo FA, Agho K, Ogeleka P, et al. Infant feeding practices and diarrhoea in sub-Saharan African countries with high diarrhoea mortality. PLoS One. 2017;12:e0171792.
[17] National Institute of Population and Training Mitra and Associates D [Bangladesh], ICF International. Bangladesh demographic and health survey 2013. In: National Institute of Population and Training, editor. Maryland, USA: National Institute of Population and Training and ICF International; 2014.
[18] Titaley CR, Dibley MJ, Agho K, et al. Determinants of neonatal mortality in Indonesia. BMC Public Health. 2008;8:232.
[19] Kembo J, Van Ginneken JK. Determinants of infant and child mortality in Zimbabwe: results of multivariate hazard analysis. Demogr Res. 2009;21:367–384.
[20] Abir T, Agho KE, Page AN, et al. Risk factors for under-5 mortality: evidence from Bangladesh demographic and health survey, 2004–2011. BMJ Open. 2015;5:e006722.
[21] Chowdhury AH, Islam SS, Abdul Karim D. Covariates of neonatal and post-neonatal mortality in Bangladesh. Global J Human-Social Sci Res. 2013;13:7–14.
[22] Ministry of Health and Family Welfare, World Health Organisation, World Bank, Alliance for Health Policy and Systems Research. Success factors for women's and children's health. Bangladesh: Ministry of Health and Family Welfare; 2015.
[23] Horton R, Samarasekera U. Stillbirths: ending an epidemic of grief. Lancet. 2016;387:515–516.
[24] Ali AAA, Adam I. Anaemia and stillbirth in Kassala hospital, eastern Sudan. J Trop Pediatr. 2011;57:62–64.
[25] Ukaegbe U, Nwogu-Ikojo E, Ezegwui H, et al. Stillbirths at a tertiary medical centre in Enugu, Nigeria. Trop J Med Res. 2011;15:1–4.
[26] Gordon A, Raynes-Greenow C, McGeechan K, et al. Risk factors for antepartum stillbirth and the influence of maternal age in New South Wales Australia: a population based study. BMC Pregnancy Childbirth. 2013;13:12.
[27] Reddy UM, Ko C-W, Willinger M. Maternal age and the risk of stillbirth throughout pregnancy in the USA. Am J Obstet Gynecol. 2006;195:764–770.
[28] Mukhopadhyay P, Chaudhuri R, Paul B. Hospital-based perinatal outcomes and complications in teenage pregnancy in India. J Health, Popul Nutr. 2010;28:494–500.
[29] Olusanya BO, Solanke OA. Predictors of term stillbirths in an inner-city maternity hospital in Lagos, Nigeria. Acta Obstet Gynecol Scand. 2009;88:1243–1251.
[30] Onadeko M, Avokey F, Lawoyin T. Observations of stillbirths, birthweight and maternal haemoglobin in teenage pregnancy in Ibadan, Nigeria. Afr J Med Med Sci. 1996;25:81–86.
[31] Mukhopadhyay P, Chaudhuri R, Paul B. Hospital-based perinatal outcomes and complications in teenage pregnancy in India. J Health Popul Nutr. 2010;28:494.
[32] Hu I-J, Chen P-C, Jeng S-F, et al. A nationwide survey of risk factors for stillbirth in Taiwan, 2001–2004. Pediatrics Neonatal. 2012;53:105–111.
[33] Nankabirwa V, Tumwine JK, Tylleskär T, et al. Perinatal mortality in eastern Uganda: a community based prospective cohort study. PLoS One. 2011;6:e19674.
[34] Assaf S, Khawaja M, DeJong J, et al. Consanguinity and reproductive wastage in the Palestinian Territories. Paediatr Perinat Epidemiol. 2009;23:107–115.
[35] Lee AC, Mullany LC, Tielsch JM, et al. Community-based stillbirth rates and risk factors in rural Sarlahi, Nepal. Int J Gynecol Obstetrics. 2011;113:199–204.
[36] Cripe SM, Phung TTT, Nguyen TPL, et al. Risk factors associated with stillbirth in Thai Nguyen Province, Vietnam. J Trop Pediatr. 2007;53:366–367.
[37] Sarker BK, Rahman M, Rahman T, et al. Reasons for preference of home delivery with traditional birth attendants (TBAs) in Rural Bangladesh: a qualitative exploration. PLoS One. 2016;11:e0146161.
[38] Flenady V, Koopmans L, Middleton P, et al. Major risk factors for stillbirth in high-income countries: a

systematic review and meta-analysis. Lancet. 2011;377:1331–1340.
[39] McClure EM, Pasha O, Goudar SS, et al. Epidemiology of stillbirth in low-middle income countries: a global network study. Acta Obstet Gynecol Scand. 2011;90:1379–1385.
[40] Park I, Lee H. Design effects for the weighted mean and total estimators under complex survey sampling. Qual Contr App Stat. 2006;51:381.
[41] Corsi DJ, Neuman M, Finlay JE, et al. Demographic and health surveys: a profile. Int J Epidemiol. 2012;41:1602–1613.