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

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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.

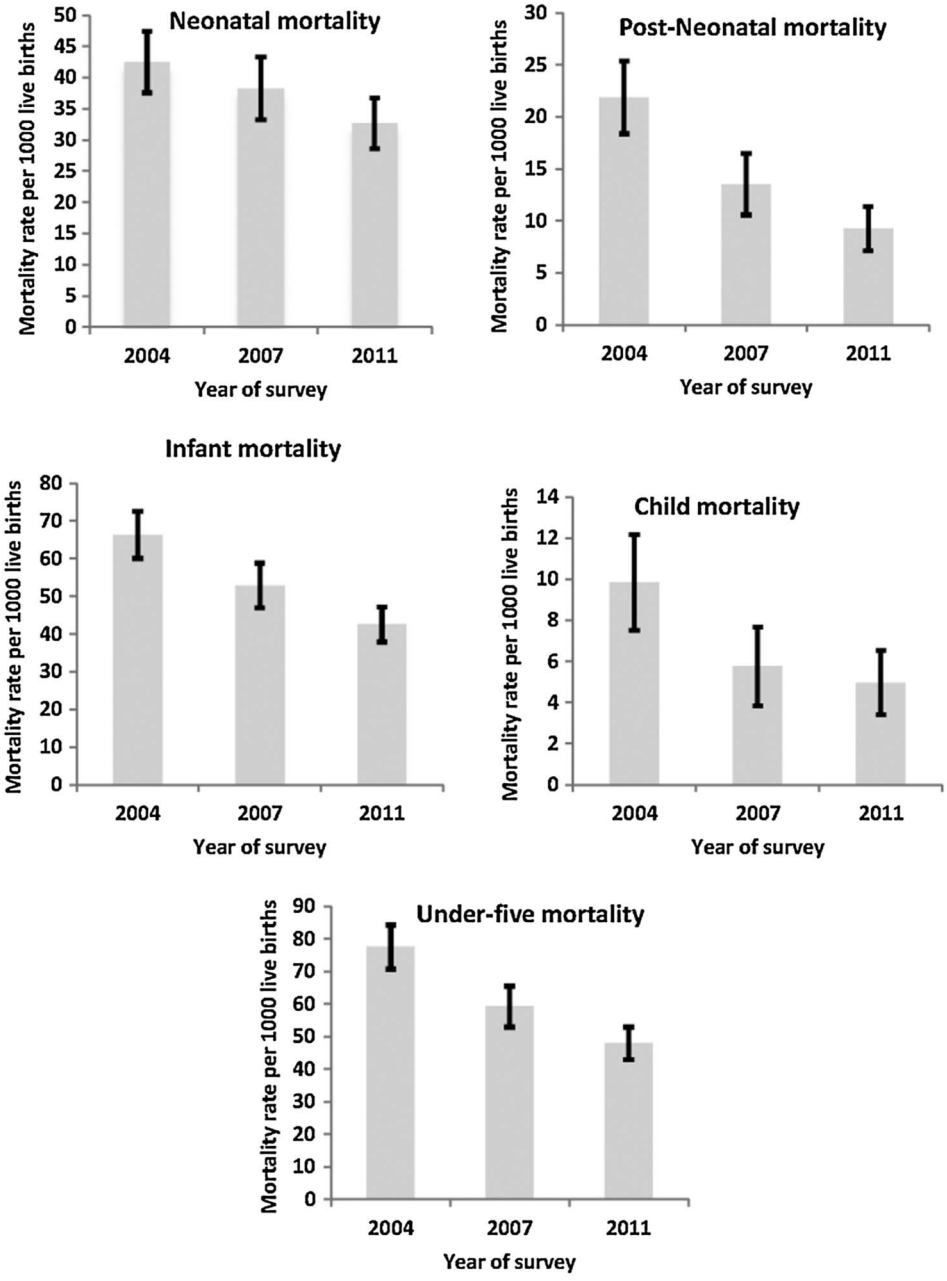

Figure 1 Neonatal, postneonatal, infant, child and under-5 mortality rates per 1000 live births in Bangladesh.

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

Characteristic	Neonatal mortality (0–30 days) Adjusted OR	(95% CI)		p Value	Postneonatal mortality (1–11 months) Adjusted OR	(95% CI)		p Value	Infant mortality (0–11 months) Adjusted 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

	Child mortality (12–59 months)				Under-5 mortality (0–59 months)			
	Adjusted				Adjusted			
Characteristic	**OR**	**(95% CI)**		**p Value**	**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.

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