Original Article

Factors affecting under-five child mortality in Bangladesh: Cox proportional hazard model and cox frailty model

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ABSTRACT

Introduction: Bangladesh is a developing country with a large population. It experienced a significant reduction in under-five child mortality over the past few decades. Nevertheless, the rate of under-five child mortality is still high in Bangladesh. This study aimed to determine the risk factors of under-five child mortality.

Methods: In this study, the dataset from the Bangladesh Demographic Health Survey- 2014 was assessed. We utilized the information on 7760 children that were born in the five years preceding the survey; 314 did not survive, and 7346 were still alive at the time of the survey. The Cox proportional hazard model and the Cox frailty model for testing unobserved heterogeneity among children were used to determining the factors affecting under-five child mortality.

Results: Our results revealed that multiplicity of birth, preceding birth interval, number of antenatal care visits, place of delivery, child-size at birth, total children ever born, and number of living children were the main factors for under-five child mortality. These results also showed that the variance of frailty term was 0.000361.

Conclusion: Our findings highlight the potential risk factors associated with under-five child mortality in Bangladesh. According to our results, it is evident that special attention should be given to these significant predictors, which may increase the under-five child survival.

Introduction

Child mortality is a widely accepted indicator of the health status of a specific community as well as the level of development. It also reflects the social, economic, and environmental circumstances in which children live, including the health care system provided. Under-five child mortality is defined as the death of a child before reaching the age of five on a specific period of his/her lifetime. Children have been in the spotlight of recent global efforts to improve their well-being conditions in developing countries. Since 1990, the year when Millennium Development Goal 4 (MDG4) began to be monitored, which called for a two-thirds reduction in the under-five mortality rate by 2015, developing countries have made many efforts towards reducing child mortality. Over the last 20 years, child mortality rates have fallen considerably, from 87 deaths per 1,000 live births to 51 deaths per 1,000. In other terms, it means a reduction from 12 to 6.9 million in the number of children dying every year (UNICEF, 2012). Bangladesh is a densely populated small country of 147,570 km^2 in South Asia, which its estimated population is 163 million (World Bank, 2016). According to

UNICEF-2018, South Asian countries, including Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Srilanka, and Afganistan) brought down under-five child mortality in the year 1990 to 2017. In Bangladesh, the rate of under-five child mortality was estimated at 32.4 per 1000 live births in 2017 (UNICEF-2018) (Table 1) (1).

The early childhood mortality rates obtained for the five years preceding the DHS surveys conducted in Bangladesh since 1993-1994 confirm a declining trend in mortality. A Bangladeshi child was around three times more likely to die before reaching his/her fifth birthday in the early 1990s than in 2014 (Figure 1) (2). To prevent child deaths and ensure child survival, reducing under-five mortality to at least as low as 25 per 1,000 live births by 2030 is referred to as the third Sustainable Development Goals (SDGs). Bangladesh has to reduce the child's death further to obtain the SDGs. Bangladesh, as a member of the World Health Organization (WHO) and a signatory of the Alma-Ata declaration in 1978, is executed to achieve the goal of health care as the key approach.

Table 1. Under-five child mortality rate (per 1,000 live births) in South Asian countries (1990-2017), UNICEF-2018

	Bangladesh	India	Pakistan	Bhutan	Nepal	Srilanka	Maldives	Afghanistan
1990	143.8	125.9	138.8	127.6	140.9	21	93.9	177.3
1991	137.8	122.4	136.2	121.9	133.9	21	89.2	171.1
1992	131.7	119	133.6	116.4	127	21.1	84.6	165.2
1993	125.7	115.7	131.1	111.2	120.5	21.1	79.9	159.6
1994	119.7	112.5	128.6	106	114.2	20.8	75	154.5
1995	113.9	109.1	126	101	108.2	20.3	70	149.6
1996	108.3	105.7	123.4	96	102.5	19.6	64.8	145.1
1997	102.7	102.3	120.7	91.1	97	18.8	59.6	141
1998	97.3	98.7	118	86.4	91.7	17.9	54.2	137
1999	92.2	95.1	115.4	81.8	86.6	17.1	48.8	133.4
2000	87.4	91.5	112.8	77.4	81.7	16.4	43.5	129.7
2001	82.8	87.9	110.3	73.2	77.1	15.9	38.4	126
2002	78.4	84.4	108	69.2	72.8	15.5	33.7	122.2
2003	74.3	81	105.7	65.3	68.7	15.3	29.4	118.3
2004	70.3	77.7	103.6	61.5	65	29.3	28.6	114.4
2005	66.5	74.4	101.6	57.9	61.5	14.3	22.6	110.3
2006	62.8	71.2	99.6	54.5	58.2	13.6	20	106.3
2007	59.3	68	97.7	51.3	55.2	12.9	17.8	102.2
2008	55.8	64.9	95.8	48.2	52.3	12.2	16	98.2
2009	52.6	61.9	93.9	45.4	49.6	11.7	14.5	94.1
2010	49.4	58.8	92.1	42.7	47	11.2	13.2	90.2
2011	46.5	55.9	90.1	40.4	44.6	10.9	12	88.4
2012	43.7	53	88	38.4	42.3	10.5	11	82.8
2013	41.1	50.3	85.7	36.7	40.1	10.2	10.2	79.3
2014	38.6	47.7	83.3	35.1	38	9.9	9.5	76.1
2015	36.3	45.2	81	33.6	36.1	9.6	9	73.2
2016	34.2	43	78.8	32.4	34.5	9.4	8.5	70.4
2017	32.4	39.4	74.9	30.8	33.7	8.8	7.9	67.9

Source- UNICEF 2018
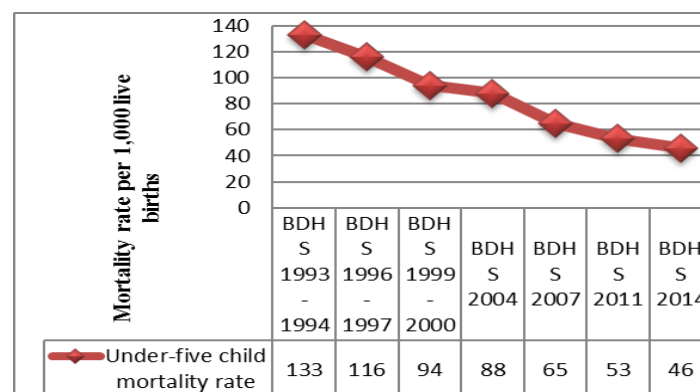
Figure 1. Trends in under-five child mortality rate per 1000 live births, BDHS (1993-1994)-BDHS 2014

In recent years, Bangladesh's health and family planning program has successfully implemented a wide range of fertility and mortality reduction interventions. In 1993, GOB (Government of Bangladesh) started a phase implementation of the Acute Respiratory Infection (ARI) control program. However, despite all its efforts, health care facilities in Bangladesh remain limited and inadequate. Besides, the existing health personnel, medicines, and other facilities are not uniformly available.

Children in Bangladesh continue to lack basic services and life opportunities; One-third of these children are born with low birth weight. A large proportion of the child population is suffering from malnutrition in which 17.4% is due to wasting (weight for height) 43.2% is due to stunting (height for age), and 41% are caused by to underweight (weight for age). 11% of all the children are severely malnourished. One newborn dies every seven minutes in this country. Also, one in every seven children born dies before their fifth birthday. The high fertility rate is boosted up by high child mortality because of the fear of child death at an early age. There are many factors that are closely related to the mortality rate among children, such as paternal-maternal education, household income status. Generally, underprivileged mothers have more child deaths. Demographic variables are also associated with under-five child

mortality such as maternal age at marriage, and at the birth of the first child, birth spacing pattern, parity, maternal height and weight, size of child at birth, place of delivery, mode of delivery, Antenatal Care (ANC) visits, duration of breastfeeding, vaccination, etc. environmental, hygienic, and household variables are also associated with childhood mortality which includes region, type of place of residence, exposure to mass media, type of toilet facility, and source of drinking water.

Methods

This study provides an extension of the Cox model to frailty model that analyzes the factors affecting under-five child mortality in Bangladesh by taking into consideration any extra heterogeneity present in the data.

Inclusion and exclusion criteria

Data for determining risk factors of under-five child mortality extracted from 2014 Bangladesh Demographic and Health Survey (BDHS), which is the seventh DHS undertaken in Bangladesh, following those implemented in 1993-94, 1996-97, 1999-2000, 2004, 2007, and 2011. Also, the expected number of

interviews was 17863, with ever-married women aged between 15 to 49 years. Among 43842 total live births (weighted), 7760 under-five aged children were selected as samples. In the data, variables that may be considered as the risk factors of early childhood mortality studied in previous works referred to in the References section were included. Variables that were interacted by other variables were excluded, e.g., mode of delivery, currently breastfeeding, baby postnatal checkup, etc.

Ethical consideration

This study was based on an analysis of Demographic Health Survey data with all identifiers information has been removed. The present study was approved by the Ethics Committee in Bangladesh and the Ethics Committee of the Demographic and Health Surveys (DHS) Programs.

Study population

The main objective of the 2014 BDHS was to provide up-to-date information on fertility and childhood mortality levels, fertility preferences, awareness approval and use of family planning methods, maternal and child health, knowledge and attitudes toward HIV/AIDS and other sexually transmitted infections (STI), and community-level data on accessibility and availability of health and family planning services. The BDHS-2014 utilized a two-stage cluster sample design, including a household survey of ever-married women age between 15-49 years. In the first stage, 600 enumeration areas (207 in urban and 393 in rural areas) were selected with probability proportional to the size. The second stage involved the selection of 30 households per clusters with an equal likelihood of systematic selection from the newly created household listing. A critical objective of the BDHS-2014 was to measure levels and trends of mortality among children. The data for early childhood mortality and associated factors were obtained from the woman's questionnaire, which was collected by conducting face-to-face interviews on 18,000 residential households.

Variables in the study

The dependent variable used for this analysis is the "survival status of a child", which was defined as the probability of dying before the age of five (< 60 months) in a specific time. The independent variables or risk factors for under-five child mortality were classified as; Socioeconomic factors (Region, Type of place of residence, Mother's educational level, Mother's working status, Father's educational level, Father's occupation, Wealth status of the family, Religion, Sex of household head); Demographic factors (Mother's age at first birth, Place of delivery, Currently breastfeeding, Number of living children, Preceding birth interval, Sex of child, Birth order number, Child is twin/ Multiplicity of birth, Child size at birth, Number of ANC visits, Exposure to Mass media, and Hygienic and household factors such as Source of drinking water and Type of toilet facility).

Statistical analysis

The Kaplan-Meier procedure is an empirical or non-parametric method of estimating S(t) from right-censored data. The Kaplan-Meier estimate of the survivor function is given by [Kalbfleisch, J.D and Prentice, R.L. (1980)], $\widehat{S(t)} = \prod_{j=1}^{k}\left(\frac{n_j - d_j}{n_j}\right)$; j= 1, 2, 3, ..., k; Where, t(0), t(1), t(2),… ,t(k) are ordered times of death with t(0) is time zero (failure could not occur at or before starting); depending on how times are collected, more than one subject die at a given time t (i). n_j denote the number of individuals alive (at risk) just before time t (j) and d_j denote the number of failures (deaths) at time t(j). The hazard function h(t) (also known as the hazard rate, conditional failure rate or force of mortality) is defined as the event rate at time t conditional or surviving up to or beyond time t. As h(t) is a rate, not a probability, which has 1/t units.

The log-rank test is one of the most popular tests for evaluating the equality of hazard functions. This test does not make any assumptions regarding the distribution of the data set. The null hypothesis was defined as H_0 = All survival curves are the same. The Cox-Mantel log-rank test statistic was formulated as $\chi^2_{CM} = \sum_{j=1}^{k}\frac{(O_j - E_j)^2}{E_j}$. The test statistic follows a chi-square distribution with (G-1) d.f., where G represents the number of groups, $O_j = d_{oj} =$ Number of deaths observed for group 1 at the j-th death time, $E_j = \frac{d_j n_{oj}}{n_j}$ = Number of death expected for group 1 at the j-th death time and, j= 1, 2, 3,….,k.

The Bonferroni correction is a multiple-comparison correction used when several dependent or independent statistical tests are performed simultaneously. To avoid false positives, the alpha value needs to be lowered to account for the number of performed comparisons. For Bonferroni adjustment, the critical p-value (α) was divided by the number of comparisons.

For testing the proportional hazard assumption, we checked whether the independent variables meet the proportional assumption by using log-minus-log (LML) plot. The LML plot is a graph constructed by applying the log-log transformation to the survival function, in other words, it is a graph of the logarithm of time against the logarithm of the negative logarithm of the estimated survival function; i.e., $\log\left[-\log(S(t))\right]$ versus the survival time (t). If the curves of the independent variable are not crossing, which means they are parallel and well defined, then the proportional hazard (PH) assumption is satisfied.

Cox proportional hazard model (1972) is a popular model used in survival analysis that can be used to assess the importance of various covariates in the survival time of individuals or objects through the hazard function that could make us capable of estimating the relationship between the hazard rate and explanatory variables without having to make assumptions on the shape of the baseline hazard function. The Cox proportional hazard model is given in the form of, $h(t, X) = h_0(t)\exp(\beta^T X)$.

Where $h(t, X)$ is the hazard rate depends on time. $h_0(t)$, which is the baseline hazard function depends on time but not the covariates. $\exp(\beta^T X)$, is the term that depends on the covariates but not time. β^T is the regression coefficient. Xs are covariates.

Cox frailty model enters the Cox proportional hazard model as random effects, and the estimated variance of the frailty effects is used to test if the frailty term is significant or not. A large variance indicates a considerable heterogeneity or difference among individuals. In the presence of unobserved components, represented by a vector denoted as U, then the modified Cox proportional hazard model can be written as $h(t; X, U) = h_0(t)\exp(\beta^T X + U) = h_0(t)\exp(U)\exp(\beta^T X) = Zh_0(t)\exp(\beta^T X)$. Where Z= $\exp(U)$ is representing frailty term and Z is a random positive quantity and Z is distributed as Gamma distribution with a mean of one and variance $\frac{1}{\alpha} = \theta$; and probability density function is, $f(z) = \frac{z^{\frac{1}{\theta}-1}e^{-\frac{z}{\theta}}}{\Gamma(\frac{1}{\theta})\theta^{\frac{1}{\theta}}}$.
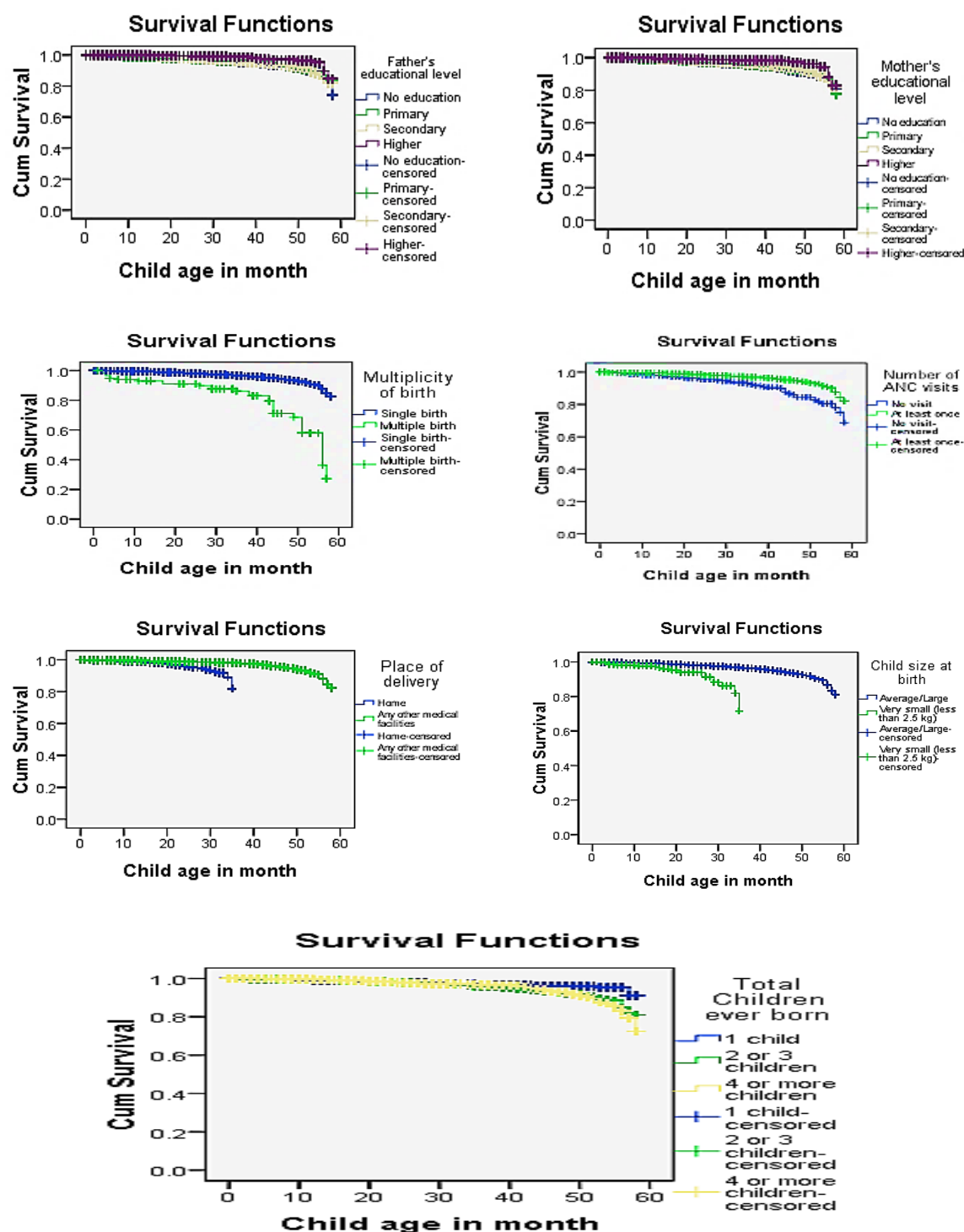
Results

The descriptive statistics of the variables selected for the study among children is reported in Table 2. Our results show that in the Sylhet division, 5.54% of children died before reaching age five, which is the highest percentage of death compared to other categories of the region. We have found that the majority of children were born in rural areas. The death percentage in these regions was 4.26%, higher than the urban areas.

Table 2. Percantage distribution of children according to selected variables and Log-rank test (Mantel-Cox) for under-five child mortality, BDHS-2014

Background Characteristics	Categories	Total N (%)	No. of deaths within 5 years of survey (%)	Log-rank test (Cox-Mantel) χ^2	d.f	p-value
Region	1= Dhaka	1353 (17.4)	43 (3.17)			
	2=Chittagong	1493 (19.2)	63 (4.21)			
	3= Barisal	896 (11.5)	24 (2.67)			
	4=Khulna	849 (10.9)	40 (4.71)	13.839	6	0.031**
	5=Rajshahi	943 (12.2)	36 (3.82)			
	6=Rangpur	946 (12.2)	37 (3.91)			
	7=Sylhet	1280 (16.5)	71 (5.54)			
Type of place of residence	1=Urban	2454 (31.6)	88 (3.58)	1.843	1	0.175
	2=Rural	5306 (68.4)	226 (4.26)			
Religion	1=Islam	7128 (91.9)	291 (4.08)			
	2=Non-islam	632 (8.1)	23 (3.64)	0.485	1	0.486
Mother's educational level	0=No education	1214 (15.6)	64 (5.27)			
	1=Primary	2158 (27.8)	96 (4.45)			
	2=Secondary	3575 (46.1)	139 (3.89)	8.034	3	0.045**
	3=Higher	813 (10.5)	15 (1.85)			
Mother's working status	0=No	5816 (74.9)	220 (3.78)			
	1=Yes	1944 (25.1)	94 (4.84)	0.192	1	0.661
Father's educational level	0=No education	1971 (25.4)	104 (5.28)			
	1=Primary	2339 (30.1)	101 (4.32)			
	2=Secondary	2322 (29.9)	87 (3.75)	13.813	3	0.003***
	3=Higher	1128 (14.5)	22 (1.95)			
Father's occupation	1= Agricultural worker	1696 (21.9)	82 (4.83)	2.463	2	0.292
	2=Non-agricultural worker	636 (8.2)	25 (3.93)			
	3= Others	5428 (69.9)	207 (3.81)			
Wealth status of family	1=Poor	3187 (41.1)	159 (5.00)			
	2=Middle	1491 (19.2)	55 (3.69)	9.918	2	0.010**
	3=Rich	3082 (39.7)	100 (3.30)			
Mother's age at first birth	1= Age 12-17 years	3513 (45.3)	150 (4.27)			
	2= Age 18-29 years	4181 (53.9)	163 (3.90)	1.325	2	0.515
	3= Age 30+ years	66 (0.9)	1 (1.52)			
Number of ANC visits	0=No visit	1255 (16.2)	74 (5.90)			
	1= At least once	6505 (83.8)	240 (3.69)	47.612	1	0.000***
Place of delivery	1=Home	2867 (36.9)	107 (3.73)	131.970	1	0.000***
	2=Any other medical facilities	4893 (63.1)	207 (4.23)			
Number of living children	1= 1 or 2 children	5429 (70.0)	256 (4.72)			
	2= 3 or more	2331 (30.0)	58 (2.49)	38.152	1	0.000***
Total children ever born	1= 1 child	2548 (32.8)	55 (2.16)			
	2= 2 or 3 children	3884 (50.1)	183 (4.71)	9.778	1	0.008***
	3= 4 or more	1328 (17.1)	76 (5.72)			
Preceding birth interval	1= 1st child	3016 (39.4)	138 (4.58)			
	2=Interval < 48 months	2077 (26.8)	79 (3.80)	7.054	2	0.029**
	3= Interval >= 48 months	2622 (33.8)	97 (3.70)			
Currently breastfeeding	0=No	3217 (41.5)	207 (6.43)			
	1=Yes	4543 (58.5)	107 (2.36)	0.345	1	0.557
Birth order number	1=1st birth order/rank	3039 (39.2)	132 (4.43)			
	2=2nd birth order /rank	2314 (29.8)	75 (3.24)	5.728	2	0.057*
	3= 3rd order or more	2407 (31.0)	107 (4.45)			
Multiplicity of birth	1=Single birth	7642 (98.5)	283 (3.70)			
	2=Multiple birth	118 (1.5)	31 (26.27)	115.617	1	0.000***
Child size at birth	1=Average/Large	7455 (96.1)	295 (3.96)			
	2=Very small (<= 2.5 kg)	305 (3.9)	19 (6.23)	51.833	1	0.000***
Sex of child	1= Male	3998 (51.5)	165 (4.13)	0.141	1	0.707
	2= Female	3762 (48.5)	149 (3.96)			
Exposure to mass media	0=No	3934 (50.7)	180 (4.58)			
	1=Yes	3826 (49.3)	134 (3.50)	5.288	1	0.021**
Sex of household head	1=Male	7042 (90.7)	295 (4.19)			
	2=Female	718 (9.3)	19 (2.65)	4.666	1	0.031**
Source of drinking water	1= Tube-well water	6270 (80.8)	257 (4.10)			
	2= Piped water	583 (7.5)	27 (4.63)	0.525	2	0.769
	3= Others	907 (11.7)	30 (3.31)			
Type of toilet facility	1= Pit-toilet latrine	3674 (47.3)	138 (3.76)			
	2= Flush toilet	1282 (16.5)	45 (3.51)			
	3=No facility	191 (2.5)	9 (4.71)	6.903	3	0.075*
	4=Others	2613 (33.7)	122 (4.67)			

[Note: ANC: Antenatal care; * p<0.10, **p<0.05 and ***p<0.01]

**Figure 2.** Survival plots for the covariates

We found that 5.27% of the children died had illiterate mothers, 4.84% had working mothers, 5.28% had illiterate fathers, and 5.90% had mothers with any ANC visits during pregnancy. The birth history data of BDHS-2014 showed that 5.72% of deaths were reported for the children who were born to mothers with four or more previous deliveries, 26.27% for children born multiple births, 6.23% for children born with very low birthweights (<=2.5 kg). The Kaplan-Meier estimate was used for bivariate analysis to estimate the survival probabilities for under-five child mortality. The Log-rank test

was also employed to evaluate whether the survival probabilities in different categories of a variable are equal or not. Figure 2 shows the graphical representation of survival curves for the selected covariates obtained by Log-rank test p-values (Figure 2).

Table 2 shows that, for bivariate analysis, 15 variables had significant results (Table 2). After conducting Bonferroni correction for multiple comparisons, we did not find any significant change for the region, mother's educational level, birth order number, and type of toilet facility. Then we tested

the PH (proportional hazard) assumption by the LML plot (Figure 3). Ten variables were considered as the covariates for the multivariate analysis. Table 3 shows that the cox proportional hazard model is significant at a 1% level of significance (chi-square = 443.357). There also were seven covariates that showed association with under-five child mortality. Our model showed that children born multiple births were 4.213 times more likely to die than single birth children. We also observed that children who were born in intervals less than 48 months and 48 months or more had 50.3%, 47.2% respectively, had a lower risk of death than the children who were born as a single birth. Our results showed that a significant difference was present in the categories of ANC visits (Table 3). We observed that the children whose mothers were visited for ANC by a qualified doctor/hospital/clinic at least once during their pregnancy had a 33.1% lower risk of dying than those with mothers who did not get any ANC visits. Our results also demonstrated that the children who born with access to medical facilities had an

81% lower risk of death than the children born at home. Children born with low birth weight were 2.562 times more risk of death than the large/average weights. This table also shows that the number of children born to a mother has a significant effect on child survival for the categories "2 or 3" and "4 or more". They are 2.908 times and 20.932 times more likely to die than the category "1", respectively. Furthermore, the number of living children in the household is effective on the death risk. Children in the categories "3 or more" had 91% lower risk of death than the children live in a family with 1 or 2 children. The data in Table 3 also reveal the estimated hazard ratios obtained by applying the frailty of the Cox-proportional hazard model with gamma distribution. The Cox frailty model is significant at 1% level of significance (chi-square = 368.9 and variance=0.000361). The heterogeneity analysis showed that the same factors were found to be significant with a slight change in their parameter estimates, standard error, hazard ratio; 95% CI of HR (Hazard ratio) (Table 3).
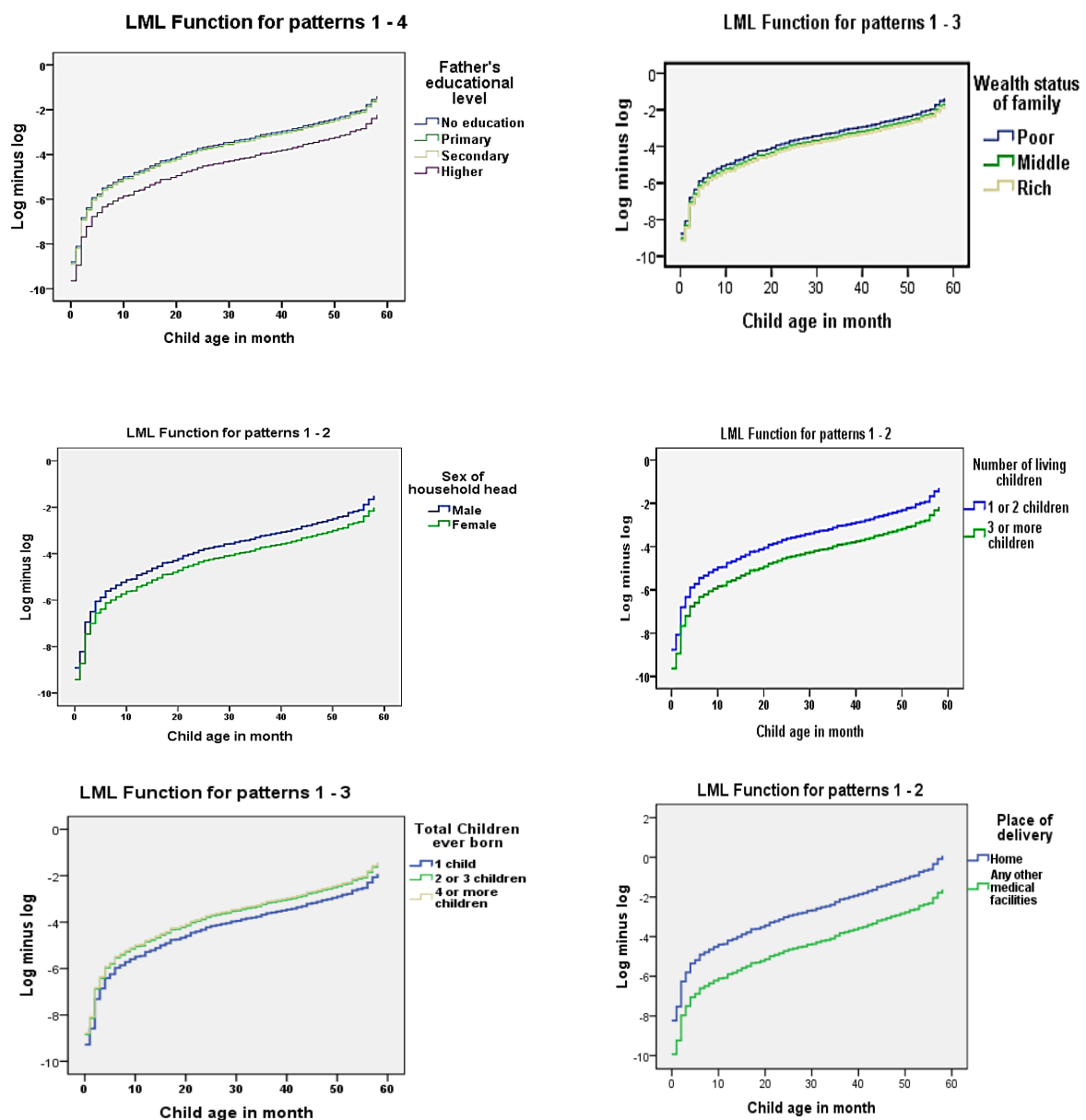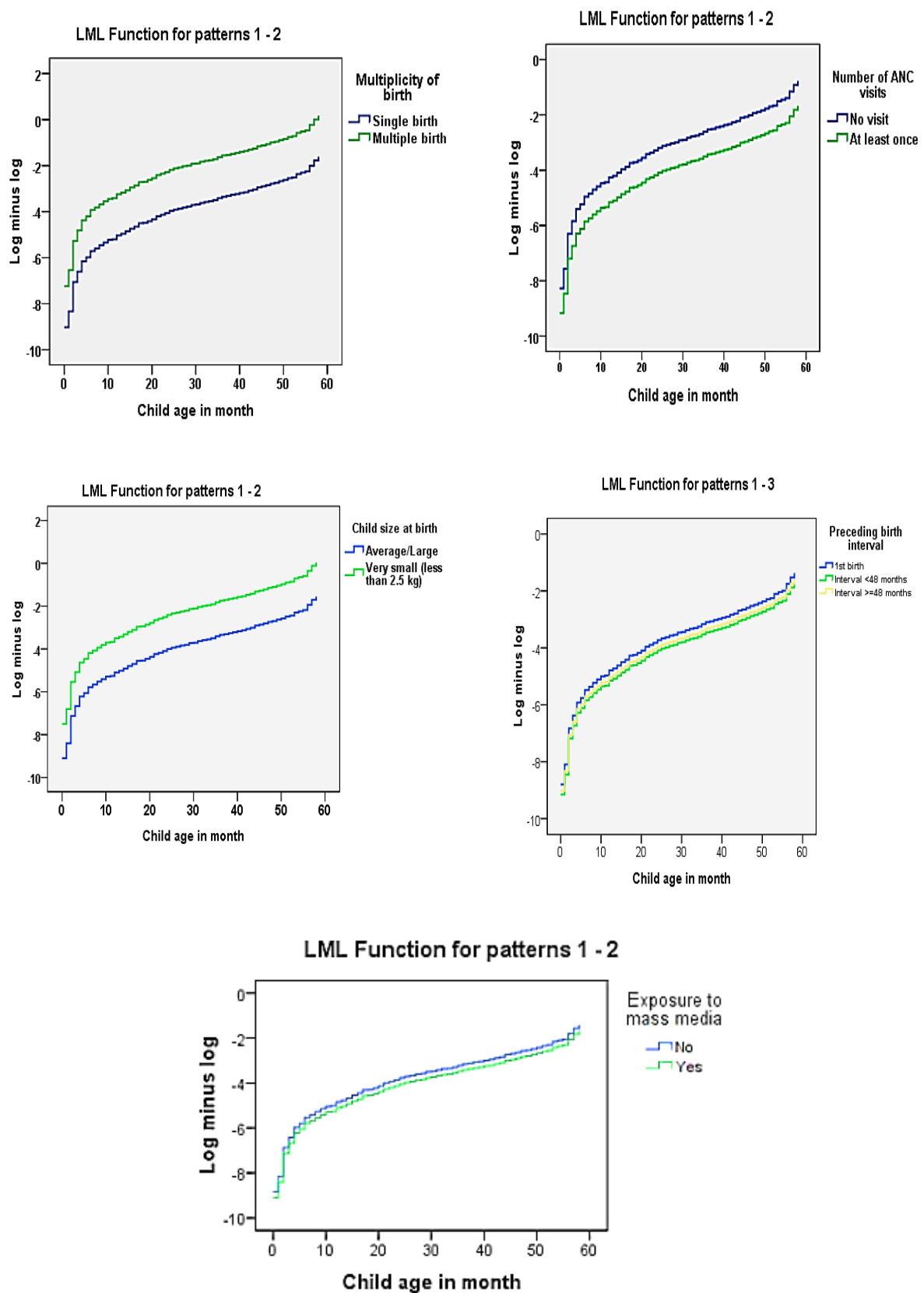
Figure 3. LML plot for the covariates of under-five child mortality

Table 3. Estimated hazard ratios obtained from both Cox proportional hazard model and Cox frailty model of under-five child mortality, BDHS-2014

Covariates	Cox proportional hazard model				Cox frailty model			
	B coefficients [SE(B)]	Hazard ratio, HR	95% CI of HR	p-value	B [SE(B)]	Hazard ratio, HR	95% CI of HR	p-value
Multiplicity of birth Single birth (rc)		1.000				1.000		
Multiple birth	1.442 [0.206]	4.213	(2.828, 6.332)	0.000***	1.468 [0.205]	4.343	(2.905, 6.494)	0.000***
Preceding birth interval 1st birth (rc)		1.000				1.000		
Interval <48 months	-0.698 [0.178]	0.497	(0.351, 0.705)	0.000***	-0.696 [0.178]	0.498	(0.351, 0.706)	0.000***
Interval>=48 months	-0.638 [0.171]	0.528	(0.378, 0.739)	0.000***	0.633 [0.171]	0.530	(0.379, 0.742)	0.000***
Number of ANC visits No visit (rc)		1.000				1.000		
At least once	-0.402 [0.150]	0.669	(0.498, 0.898)	0.000***	-0.402 [0.150]	0.668	(0.497, 0.898)	0.007***
Place of delivery Home (rc)		1.000				1.000		
Any other medical facilities	-1.625 [0.173]	0.197	(0.140, 0.276)	0.000***	-1.631 [0.173]	0.195	(0.139, 0.274)	0.000***
Child size at birth Average/Large (rc)		1.000				1.000		
Very Small (less than 2.5 kg)	0.941 [0.251]	2.562	(1.567, 4.190)	0.000***	0.944 [0.251]	2.570	(1.571, 4.203)	0.000***
Total children ever born 1 child (rc)		1.000				1.000		
2 or 3 children	1.068 [0.184]	2.908	(2.030, 4.168)	0.000***	1.066 [0.183]	2.904	(2.026, 4.163)	0.000***
4 or more	3.041 [0.300]	20.932	(11.626, 37.687)	0.000***	3.067 [0.300]	21.492	(11.936, 38.698)	0.000***
Number of living children 1 or 2 children (rc)		1.000				1.000		
3 or more	-2.395 [0.225]	0.091	(0.059, 0.142)	0.000***	-2.425 [0.225]	0.088	(0.056, 0.137)	0.000***
Sex of household head Male (rc)		1.000				1.000		
Female	-0.391 [0.239]	0.677	(0.424, 1.080)	0.102	-0.390 [0.238]	0.676	(0.423, 1.079)	0.101
Wealth status of family Poor (rc)		1.000				1.000		
Middle	-0.046 [0.166]	0.916	(0.690, 1.324)	0.784	-0.045 [0.169]	0.955	(0.689, 1.324)	0.785
Rich	-0.020 [0.163]	0.910	(0.712, 1.349)	0.903	-0.020 [0.144]	0.979	(0.711, 1.347)	0.898
Exposure to mass media No (rc)		1.000				1.000		
Yes	-0.038 [0.145]	0.962	(0.725, 1.278)	0.791	-0.042 [0.144]	0.958	(0.722, 1.272)	0.770
n= 7760 Number of events =314	Value of chi-square= 443.357 Degrees of freedom= 13 Level of significance= 0.01 p-value=0.000				Value of chi-square= 368.9 Degrees of freedom= 13 Variance of frailty term= 0.000361 Level of significance= 0.01 p-value=0.000			

[Note: ANC= Antenatal care. CI= Confidence interval rc = Reference category. * p<0.10, ** p<0.05 and *** p<0.01]

Discussion

This study utilized the risk factors of under-five child mortality in Bangladesh using the Cox proportional hazard model and the Cox frailty model. The multiplicity of birth, preceding birth interval, number of antenatal care visits, place of delivery, child-size at birth, total children ever born, number of living children showed a significant effect on under-five child mortality.

Our study showed that twins or triplets or other multiples had more than four times death risk than single birth children in their first five years of life. Multiple birth children were more likely to be born with lower birth weight, prematurity, and congenital anomalies than single birth ones. These factors lead to lower survival among children born in multiple births. There are pieces of evidence that point quite unambiguously to higher mortality

where there are short preceding intervals between births (3). Our findings also suggest that first birth children were at higher risk of death. We found that ACN visits allowed better management during pregnancy and the promotion of better maternal care and child health (4). In the rural areas of Bangladesh, many women did not get enough support from qualified doctors or hospitals during pregnancy. The death risk among these children was high than the children whose mothers were visited for ACN at least once during the pregnancy period. Our study also revealed that total children ever born to mothers had a significant impact on the under-five mortality rate. Parents who achieved their preferred sex children did not give birth to more children than those who give birth to either all boys or girls. A previous study about determinants of child death in Bangladesh, which was conducted in 2011, revealed that children whose mothers had three or more and seven or more those children had five times and 21 times more likely to die (5). The size of the children was correlated with early childhood mortality (5). Children born with small-sized (less than 2.5 kg) had malnourishment problems, even if they faced critical diseases, which may the cause of their death. We have found that child delivery at home was less safe than birth at medical/clinic/hospital/NGO related satellite clinics. Each year, nearly 4 million newborns in developing countries (including Bangladesh) die globally. In Bangladesh, most of the child's death occurred during their perinatal period (first seven days of life) and the neonatal period (first 28 days of life) (6). The number of living children also has a significant effect on early childhood mortality. Having more than four living children was highly substantial. There was about 99% less likelihood of premature childhood mortality in those children compared to a single living child with desired confidence intervals (7).

Our results were in line with which similar previous studies. The study of the Cox proportional hazard model, according to BDHS-2007 conducted by AH Chowdhury, showed that Father's educational level, place of residence, the region of residence, preceding birth interval, currently breastfeeding were significant factors on under-five child mortality (8). Child mortality was higher among mothers who did not undergo sufficient ANCs and did not receive assistance from medical personnel. A study conducted by Rahman showed that delivery in a hospital was associated with less child mortality (9). Research by Md. Sazedur Rahman et al. Evaluating the determinants of under-five child mortality in Bangladesh, according to BDHS-2014, implies that the multiple birth children were around 12 times more likely to die before reaching age five compared to the single birth child (10). Md. Moniruzzaman et al. conducted a study that employed multiple logistic regression on BDHS-2011 and BDHS-2014 for child mortality. They showed that region, father's educational level, mother's educational level, birth order number, succeeding birth interval, mother's age at birth were imperative factors in 2011 study and Father's educational level, father's occupation, mother's age at birth were associated factors in 2014 study (11).

Child's size at birth appeared as a potential determinant of under-five mortality; small-sized children had 1.431 times more risk of death than average/large sized children at birth, according to BDHS-2011 and BDHS-2014 (12). Jahidur Rahman Khan and Nabil Awan n another study searched for the determinants of under-five child mortality according to BDHS-2007, 2011, 2014. They combined effect of birth order and preceding birth interval length, sex of the child, maternal age at birth, mother's working status, paternal education affects mortality using Cox proportional hazard model and Frailty models (13). The data extracted from BDHS-2014 showed that higher educated mother's children had a 52% lower risk of death than illiterate mothers (14). Using Cox proportional hazard model analysis to determine the risk factors for under-five child mortality, BDHS-2007 showed that place of residence, parent's

education, father's working status, sources of drinking water, type of toilet facility, wealth status, television watching, mother's age, months of breastfeeding and birth interval had a significant effect (15). A research conducted by Chukwu Angela and Okonkwo Oju to find the determinants of under-five child mortality from Nigerian Demographic Health Survey 2008 using Cox proportional hazard model and Cox frailty model shoed that which incorporates the term frailty measures the unobserved heterogeneity among children were significantly associated with mother's age and mother's educational level (16). Total children ever born, the number of living children, the current status of breastfeeding, size of child at birth were strongly associated with under-five child mortality in a study done by Uttar Pradesh in India. Rakesh Kumar Sharoj also employed the Kaplan-Meier non-parametric method for an estimation of the survival function and the Cox proportional hazard model for an estimation of the co-efficient (17). A previous study showed that for correlated/hierarchical data, the estimates of the Cox proportional hazard model could be misleading so that proper steps should be taken into consideration of frailty while determining early childhood mortality in any clustered population (18).

Conclusion

The results of this study demonstrated that under-five child mortality has a significant relationship with various factors. Frailty is defined as a situation where some children may be exposed to death before five years old age. In other words, it is the possibility of death due to unobserved or unmeasured causes before five. Frailty captures the cumulative effects of all factors that influence the child's risk of death that is not included in the Cox proportional hazard model. In this study, we found that the Cox frailty model is a better model for under-five child mortality estimation than the Cox proportional hazard model. The causes of under-five child mortality in resource-poor settings are complex, and merit concerted efforts are in process to clarify the implications to improve child survival. Based on the outcomes of this research, we urge the policymakers to focus on demographic factors and policy aiming at maternal and child health care to increase the rate of under-five child survival.

Ethical disclosure

This study was based on an analysis of Demographic Health Survey data with all identifiers information has been removed. The present study was approved by the Ethics Committee in Bangladesh and the Ethics Committee of the Demographic and Health Surveys (DHS) Programs.

Author contributions

All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

Conflict of interest

The authors declare no conflict of interest.

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