Application of Cox Proportional Hazard Model for Scrutinizing Child Survival in Bangladesh

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Abstract— The child survival strategies and interventions are considered to be the fourth obligation of Millennium Development Goal which focused on reducing under five child mortality in near future. Thus many countries are now devoted to the child survival interventions as a way of reducing the child mortality. This study aims to evaluate the predictors of child survival (age under 5 years) in Bangladesh by utilizing data extracted from 2011 Bangladesh Demographic and Health Survey (BDHS, 2011). For study purpose contingency analysis and Cox's proportional hazard model technique have been applied to different demographic, socio-economic and health care service related variables. Entirely division, socio economic status, mother's age, education, and her working status, birth order, antenatal care during pregnancy, breastfeeding status, child's medical check-up and proper immunization have been found as major factors by using both cross-tabulation and Cox's proportional hazard techniques that raise child survival and decrease child mortality in Bangladesh. Finally, these findings suggest that an increase in mother's education, breastfeeding to child, encourage child bearing age of mothers at 21-40 years, improve health care services for both mother and child could in turn raise child survival and reduce the rate of under-five child mortality in Bangladesh.

Keywords— Child survival, contingency analysis, proportional hazard model, antenatal care, vaccination.

1 INTRODUCTION

The chance to survive is a right owed to every child. In the present era, child survival is considered as a key objective for every country especially for the developing countries of the world. Survival is a massive challenge for children younger than one year of age and especially for neonates who are younger than one month. According to UNICEF (2005), under-five child mortality is certainly one of the most sensitive indices of improvement of a country [1]. According to BDHS 2007, in Bangladesh, 120,000 babies under one month of age die every year and 14 babies every hour. But now-a-days Bangladesh has made substantial advancement in improving the health of its children. It is one of the few countries in the developing world that is on the way to attain success by reducing under-five child mortality. Consequently, Bangladesh has reduced by half or more their child mortality rate since 1990 (from 151/1000 in 1990 to 65 in 2007). The infant mortality rate has also considerably deteriorated to reach 52 deaths per 1000 live births in 2007 from 117 deaths/1000 in 1990 [2].The general medical definition distinguishes mortality of a child with respect to the child age: death within the first week of life is included with prenatal mortality (which also includes late fatal mortality) and death within the first month is referred to as neonatal mortality, and death within one year is referred to as infant mortality. The death under five is referred to as child mortality (WHO, 2005) [3]. From various literatures, it has been found that the mortality after first month is mostly related to socio-economic and health conditions of the household and it is possible to analyse the determinants of child mortality at various levels of causality [4]. The main causes of these deaths are infection, birth choking and low birth weight or pre-term deliveries. In spite of recent deterioration in Bangladesh, infant and child mortality is still one of the highest among the developing countries with strong urban-rural discrepancies. Nearly one in ten children in Bangladesh dies before reaching age five. According to the 1999-2000 Bangladesh Demographic and Health Survey, infant and under-five mortality in Bangladesh are 66 and 94 per 1000 live births respectively [5]. The biomedical along with epidemiological literature typically focuses on the immediate determinants of child mortality especially as the impact of various diseases and weakened resistance. On the other hand, socio-economic, environment & sanitation, medical and health care, demographic, exposure to mass media, etc., are usually focused on underlying determinants of child mortality that make children

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more vulnerable to the outbreak of various diseases [4].Successfully, in the last two decades, Bangladesh attains notable achievement to decline under-five mortality; especially in the case of infant mortality. Essential new-born care including the assurance of proper immunization of mothers, ensuring clean delivery practices in a hygienic birthing atmosphere, drying and wrapping the baby immediately after birth, providing necessary warmth, and promoting immediate and continued breastfeeding, proper and timely immunization could save the lives of 3 million new-borns annually. Mothers' adequate antenatal care, practice of frequent breast feeding, upgraded sanitation system and access to fresh drinking water also considered as significant determinant of under-five child survival [6].The study of Vos et al. (2005) exhibited that the coverage of immunization has significant impact on lower prevalence of infant mortality [7]. M. Rahman (2008) focused mainly on the impact of utilization of heath care services on child mortality by using BDHS, 2004 data. Using relative hazards, he found that child mortality is higher among mothers who do not take sufficient ANC and also not receive assistance from medically trained personnel. The research suggests that mothers and father's education, extensive breastfeeding, the household infrastructure as well as assets index are associated to reduce the child mortality risks in our country [3]. Similarly, Mutunga (2007) explored the relationship between household's environmental and socio-economic characteristics on child mortality. Using Weibull hazard rate framework, he explores that infant and child mortality is related to the household's environmental and socio-economic characteristics, such as mother's education, source of drinking water, sanitation facility, type of cooking fuels and access to electricity. [8].On the other hand, Rutstein (2008) used multivariate analyses and examined that household's environmental and socio-economic characteristic were found to have a significant impact on under-five child mortality. He suggested that strategies aimed at reaching the goal of reduced child mortality should be done by improving the household's environmental and socio-economic condition [9].There, young children are sensitive not only to their environment but they can be affected by the health and well-being of their mothers and also the quality of health services and support offered to them. Besides, improved sanitation and access to clean drinking water can also reduce childhood infections and diarrhoea [1].With this in view an attempt was made to investigate the effect of selected socio-economic, demographic and environmental factors on child survival in Bangladesh. The above studies indicated that the urban-rural discrepancies might have been medicated through the other variables included in the analysis. The review of stated literature of child survival shows that a number of variables are affecting child survival. However, the predictors of child survival are changing through time since the facilities and awareness are changing day by day. Hence, it is necessary to identify the segment of population where programs need strengthen in order to achieve the goal for increasing child survival.

In this study, an attempt has been made:

- To examine the predictors of under-five child survival in Bangladesh.
- To identify the factors which are influencing under five child survival and
- To suggest possible plans to increase child survival in Bangladesh.

2 ORGANIZATION OF THE STUDY:

This paper is organized in the following manner. Section 3 illustrates the data source and provides a brief description about data and variables used in this study. This section also elaborates the method employed in the construction of Cox proportional hazard model techniques. Section 4 contains empirical results and discussions. The concluding remarks have been provided in section 5.

3 METHODOLOGY

3.1 Data and variables

Data used in this study have been extracted from the 2011 Bangladesh Demographic and Health Survey (BDHS) which had conducted under the authority of the National Institute for Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare of the Government of Bangladesh. Women data of BDHS 2011 have been used for study purpose. This survey provides complete information on demographic and socio-economic characteristics of the household. The survey has commenced a two-stage stratified sampling method where stratification of the sample

was achieved by separating the sample into seven divisions and within divisions these were sub-divided into both urban and rural areas. At the initial stage of sampling, 600 enumeration areas were selected with 207 clusters located in urban zones and remaining 393 in rural parts. From the total of 17,964 selected households, 17,511 were found to be occupied. Interviews were successfully completed in 17,141 households, or 98 percent of all the occupied households. A total of 18,222 ever married women age 12-49 were identified in these households, and 17,842 were interviewed (yielding a response rate of 98 percent). According to this survey result, among all the children, information of 8753 children within these age limits has been recorded. These response rates don't vary notably by urban-rural residences.

In this study, we have used contingency analysis along with Cox proportional hazard model technique in order to scrutinize the key determinants of under-five child survival in Bangladesh. Since contingency analysis is important in first step for studying the relationship between dependent and independent variables. After that, Cox proportional model is used to properly detect the most significant variables related to the dependent variables. SPSS (version 16) was used for overall data analysis.

In this study we consider the important variables which are education of mother; education of father; economic status; currently working status of mother; occupation of father; type of place of residence; region, Religion; type of toilet facility; sources of drinking water; access to mass media; breastfeeding status; birth order; birth spacing with previous child; age of mother; age at first marriage; sex of child; place of delivery and antenatal visit during pregnancy.

3.2 Cox proportional hazard model

Cox' proportional hazards model is the standard for survival analysis in the field of bio-statistical research. Actually, survival analysis typically examines the relationship of the survival distribution to covariates. Most commonly, this examination entails the specification of a linear-like model for the log hazard. Cox proportional hazards models are a class of survival models in statistics. Survival models relate to the time that passes before some event occurs to one or more covariates that may be associated with that quantity (Cox, 1972) [10].

Logistic regression models are usually used to identify the covariates for categorical variables by ignoring continuous events. In a proportional hazards model, the unique effect of a unit increase in a covariate is multiplicative with respect to the hazard rate. Hence, Cox proportional hazard model has also been adopted in order to estimate independent effects of each variable while controlled for others. This analysis has carried out for the child according to the age at survived. The survival status of children who were surviving at the time of survey is considered as censored events. In this regards, Cox proportional hazard model is most appropriate technique for analysis of such data. This analysis has considered all the covariates that have found significant in cross-tabulation analysis up to 10% level of significance.

For example, a parametric model based on the exponential distribution may be written as

$$\log h_i(t) = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik}$$

or, equivalently,

$$h_i(t) = \exp(\alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik})$$

that is, as a linear model for the log-hazard or as a multiplicative model for the hazard. Here, 'i' is a subscript for observation, and the x's are the covariates. The constant α in this model represents a kind of log-baseline hazard, since $\log h_i(t) = \alpha\ [or\ h_i(t) = e^{\alpha}]$when all of the x's are zero.

The Cox model, in contrast, leaves the baseline hazard function $\alpha(t) = log\ h_0(t)$unspecified:

$$\log h_i(t) = \alpha(t) + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik}$$

$$\log h_i(t) = log\ h_0(t) + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik}$$

or, again equivalently,

$$h_i(t) = h_0(t) \exp(\beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik})$$

This model is semi-parametric because while the baseline hazard can take any form, the covariates enter the model linearly.

4 Results And Discussion

This section provides overall structure of under-five child survival along with contingency analysis and the analysis of Cox proportional hazard model. Initially Table 1 depicts the status of under-five child survival according to the survey data. Contingency table (Table 2) is constructed to study the pattern of the relationship among dependent and independent variables. Chi-square test of association has been performed to identify whether the primarily selected socio-economic, bio-demographic and health care predictors(such as

division, area of residence, sources of drinking water, type of toilet facilities, religion, mass-media, wealth index, births in past year, father's education and occupation, mother's age, education, her currently working status and occupation, birth order, sex of child, antenatal care received by mother, place of delivery, baby's postnatal check-up, having vaccination and breastfeeding status)have association with the response variable (child survival) or not.

Table 1

Status of under-five child survival in Bangladesh according to BDHS 2011

Under five child survival	Frequency with percentage
Alive	8343(95.3%)
Dead	410(4.7)

Among all children under five years old, almost ninety-five percent are found to be alive within these age range. Mere about five percent children are dead.

Table 2

Contingency analysis of child survival with explanatory variables

Explanatory variables	$\chi 2$ values	df	p values
Mother's age*	13.227	2	<.10
Divisions**	16.637	6	<.05
Mother's education**	13.899	2	<.05
Sources of drinking water*	4.970	2	<.10
Wealth index**	8.793	2	<.05
Births in past year***	29.324	2	<.01
Father's education***	16.844	2	<.01
Father's occupation**	10.010	3	<.05
Mother's working status**	4.439	1	<.05
Mother's occupation**	10.010	3	<.05
Sex of child**	5.960	1	<.05
Antenatal care***	140.1	1	<.01
Baby's postnatal check-up***	48.616	1	<.01
Vaccination***	231	1	<.01
Breast feeding status***	1769	3	<.01

* = p value < .10, ** = p value < .05, *** = p value < .01

After examining the contingency table, the results indicate that there is substantial association between under five child survival status and different socio-economic, bio-demographic and health care predictors. Among different socio economic variables division, sources of drinking water, wealth index, parent's education, occupation and their working status have significant impact on the current issue. Various bio-demographic factors like mother's age, sex of child, previous births must have more or less influence on child survival. Therefore, maternal health care, infants' postnatal check-up and time to time vaccination have been found as the most important and significant determinants of child survival. Moreover, in current analysis it is clear that breast feeding status of children has significant effect on under-five child survival in our country.

Table 3

Estimates of the Cox proportional hazard model for child survivals

Factors	Coefficient	Standard error of coefficient	Odds ratio	95%CIfor odds ratio	
				Lower CI	Upper CI
Mother's age***					
≤ 20(RC)					
21-40***	.475	.091	1.607	1.345	1.921
>40**	.204	.085	1.226	1.038	1.448
Divisions**					
Dhaka(RC)					
Barisal**	-.086	.040	.918	.849	.992
Chittagong	-.064	.044	.938	.860	1.023
Khulna***	-.037	.037	.963	.895	1.037
Rajshahi**	-.157	.044	.855	.784	.931
Rangpur	-.096	.043	.908	.835	.987
Sylhet	-.048	.043	.954	.876	1.038
Mother's education					
No(RC)					
Primary*	.022	.029	1.023	.967	1.081
Secondary and higher	.062	.037	1.064	.990	1.144
Sources of drinking water***					
Piped water(RC)	-.238	.052	.791	.712	.872
Well water***	-.153	.036	.892	.799	.921
Other***					
Wealth index**					
Poor(RC)					
Middle**	.078	.031	1.081	.990	1.144
Rich	.011	.033	1.012	.967	1.081

Births in past year***					
No birth(RC)	-1.530	.157	.217	.159	.295
One birth***	-.198	.154	.821	.606	1.110
More than one birth					
Mother's working status					
No(RC)	.197	.096	.041	1.008	1.470
Yes**					
Sex of child					
Male(RC)					
Female*	-.038	.022	.083	.922	1.005
Antenatal care					
No(RC)					
At least once**	.068	.028	1.935	1.884	1.988
Baby's postnatal check-up***					
No(RC)	.083	.026	1.920	1.874	1.968
Yes***					
Vaccination***					
No(RC)					
Yes***	.202	.024	1.224	1.167	1.284
Breast feeding***					
Never(RC)					
≤ 11 months***	.927	.047	1.396	1.361	1.434
12-23 months***	1.370	.040	1.078	1.038	1.257
≥ 24 months and more***	.847	.031	1.236	1.196	1.480

RC = Reference Category, * = p value <.10, ** = p value <.05, *** = p value <.01

For the study purpose, Cox proportional hazard model is basically applied to properly extract the important factors. Using this hazard model, Table 3 emphasizes the odds ratio and confidence interval of odds ratio for child survival. The significant variables found in the contingency analysis have been considered as the covariates of Cox proportional hazard model which indicates that the covariates such as mothers' age, education, working status, division, sources of drinking water in households, wealth index, births in previous years, mothers' antenatal care, baby's postnatal check-up, proper vaccination and their breast feeding status have potential significant effect on the child survival in Bangladesh. Since a considerable number of children are still surviving at the time of interview and after the interview period, thus they are considered as the censored cases; because their exact duration of surviving cannot be observed. In the stated table for all cases, odds ratio of reference categories is one. When the odds ratio is greater than one then the probability of that event is more likely to occur and vice versa for less than one. Accordingly, the results indicate that the likelihood of child survival is greater for the higher aged mother. The odds ratios are found 1.607 and 1.226 for the ages 21-40 and more than 40 years of mothers respectively. This infers that the child survival is 1.607 and 1.226 times significantly higher for the children whose mothers age are 21-40 and greater than 40 years respectively as compared to the mother's age less than 21 years(RC≤ 20 years). Administrative divisions found to have partial significant importance on child survival. This study reveals that all the divisions are found to be less likely to compare with child survival of the reference category, Dhaka. Among them Rajshahi has showed the lowest scenario of child survival (For Rajshahi OR = 0.855). Among socio economic variables mother's education has a positive strong relationship with child survival.The child survival is significantly 1.023 times and 1.064 times higher for the children whose mother's having primary, secondary and higher education as compared to the mothers who have no education. This result clearly indicates that the child survival is growing with the advancement of mother's education. This result may be due to the fact that child survival is mainly affected by environmental factors and educated mothers may be more conscious to the environments and surroundings where child grow up. Though father's education has been found significant in contingency analysis but in hazard model this factor does not have any significant impact. Sources of drinking water of households are closely related with this matter. The child survival is found to have .791 times and .892 times lower for the children who uses well and other sources for drinking water respectively as compared to child who use piped water.Similarly, asset index, births orders, mother's working status and sex of child have been detected to significantly explain the child survival in our country. Stated factors have both direct and indirect influences on this issue.The maternal health care services variables have strong influence in increasing child survival, because the mothers who sought antenatal care during pregnancy are well aware about utilization of existing health care facilities and they can properly apply such facilities for their children in times of their need. The result reveals that the child survival is 1.935 times higher for the children whose mothers receive antenatal check-up at least once as compared to mothers who have not taken any antenatal check-up during pregnancy. Equally,

postnatal check-up and proper immunization of infant must reduce the chance of child mortality. Above table depicts that the child survival is 1.920 and 1.224 times significantly higher for those who have taken proper check-up as well as vaccination respectively as compared to the children who don't have proper immunization. Among the bio-demographic variables, breastfeeding status has been found to have significant effect on child survival. Now-a-days breastfeeding is universal and in current analysis, it is clear that for all cases the tendency of child survival is higher for those children who are habituated with breast-feeding. The analysis infers the child survival is 1.396, 1.078 and 1.236 times significantly higher for those children whose mothers breastfeed their children less than or equal to 11 months, within 12 to 23 months and 24months and above respectively as compared to their counterparts (children whose mother never breastfeed after their birth). These outcomes visibly specify that the child survival is growing with enhancing the duration of breast-feeding of infant.

5 Conclusion And Recommendation

Bangladesh is one of the developing countries of the world where many health and nutrition related indicators have been upgraded over the past few decades. Bangladesh successfully declined the total number of childhood mortalities and nutrition related mortalities and complexities. This study scrutinizes the predictors of under-five child survival in Bangladesh by applying the national representative data from the Bangladesh Demographic and Health Survey (BDHS) - 2011. Both cross-tabulation and Cox regression analysis techniques have been applied to ascertain the important explanatory variables of child survival under the age of 5 years. From the analyses several interesting decisions can be made because interpretations of the findings appear to be difficult in many cases. Sometimes, it is observed that logical or theoretical hypothesis are supported by the results of crude analysis (Like cross-tabulation) but are rejected as invalid when checked by those based on refined techniques (such as Cox's proportional hazard model). Such a situation may be due to interrelationship between covariates. The findings suggest that parents' education has been identified to be the most important socio-economic predictors of child survival that means child survival increase with increase in both mother's and father's education level. The study indicates that currently working status of mother has no significant impact on child survival but in both analyses father's occupation has played significant role in increasing child survival. Socio-economic status has found to have significant association with child survival by cross-tabulation analysis but it has found insignificant by Cox's proportional hazard analysis. Some characteristics have no major effect on child survival; these are religion, type of place of resident, region, mother's access to mass media, and type of toilet facility. Several bio-demographic variables have a substantial effect on child survival. Among these variables breastfeeding status, birth order, birth spacing with previous child, age of mother and age of first marriage have been found by both cross-tabulation and Cox's proportional hazard analysis. The antenatal visit during pregnancy has a principal effect on child survival in Bangladesh. Therefore, attention should be given especially to parents' education, type of toilet facility, mothers' access to mass media, currently breastfeeding, age at first marriage, age of mother and maternal health care factors in order to increase the child survival in Bangladesh. To make it possible, many government and non-government organizations should run some effective and sustainable programs to overcome the situation completely in Bangladesh. Urban development also should be practiced frequently along with providing proper education and instruction about health facilities to mass people, which will work as the enormous interventions to progress the entire health status in Bangladesh. In such way we can hope that, each and every child of our country will remain healthy and safe after their birth and so far.

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