Bivariate Generalized Linear Models for Analyzing Survival of Live Births at Neonatal, Infant and under Five Stages

M.S. THESIS

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RECOMMENDATION

This is to certify that the thesis paper entitled **"Bivariate Generalized Linear Models for Analyzing Survival of Live births at Neonatal, Infant and under Five Stages"** is an original research work, of B. M. Rajib Ahmed, Registration No. 2013-1-82-002, Department of Applied Statistics, East West University, Dhaka, conducted under my supervision.

The undersigned certify that the contents presented in this thesis paper are the results of an individual academic effort by the author/examinee, and that as to the forms and styles, this thesis paper is suitable for submission.

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Declaration

I, hereby, certify that this thesis report entitled "**Bivariate Generalized Linear Models for Analyzing Survival of Live births at Neonatal, Infant and under Five Stages.**" submitted as a partial requirement for the degree of M.Sc in Applied Statistics is the result of my own research, expect where otherwise acknowledged and that this study in whole or in part has not been submitted for an award including higher degree to any other University or Institution.

B. M. Rajib Ahmed

Signature: ____________________

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TO MY PARENTS AND TEACHERS, WHO GIVE ME

OPPORTUNITY TO DO

AND TO MY FRIENDS, WHO ARE ALWAYS WITH ME.

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Abstract

Dependence in binary responses may pose challenge in analyzing longitudinal data. For the child survival longitudinal data, determinants of child survival for the child death by the relationship between risk factors and survival status. In the previous studies, mainly marginal survival analysis was performed for specific birth orders or combined analysis of all birth orders. However, the dependence in the outcome of survival status of the consecutive birth order was not taken into account. To overcome this problem, conditional model, GEE or joint model can be applied for the child survival analysis. In this study we have used a joint model proposed by Islam et al (2013) which provides conditional estimates as well as marginal estimates of child survival analysis. We also test the dependency of successive births by using a test statistic proposed by Islam et al (2013) by using the conditional estimates. In our study, we consider a mother who has consecutive three births and to examine the survival status of the first three children at neonatal, infant and under-5 stages. Using this model in our study, we observe that when a mother given birth to her second and third children in the age less than 20 years than the risk of child death continue not only at neonatal stage but also it continues up to under-5 stage. In additional to age of mother at child birth, birth interval appears to be a high risk factor causing increased risk of child mortality at neonatal, infant and under-5 stages. This study also shows that there is no sex preference of the survival status for the first three children at neonatal, infant and under-5 stages. It is also found that there is statistically significant dependence of the survival status of the consecutive births.

Keywords: *Child Survival, Longitudinal Data, Neonatal, Infant, Under-5 Years Child, Consecutive Births.*

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Chapter: One

Introduction

1.1 Introduction

Bangladesh, a developing country that is going through a transition in demographic and economic perspectives requires improvement in health indicators for both demographic and economic dividends. The country has been well on the track to achieve the Millennium Development Goal by 2015 and has made remarkable progress in reducing child deaths in the neonatal, infant and under five age groups. The under-5 year mortality has reduced from 133 deaths per 1000 live births in 1989-1993 to 53 deaths per 1000 live births in 2007-2011, the infant mortality rate reduced from 87 deaths per 1000 live births in 1989-1993 to 43 deaths per 1000 lives in 2007-2011 and the neonatal mortality rate reduced from 52 deaths per 1000 live births in 1989-1993 to 32 deaths per 1000 live births in 2007-2011. (BDHS, 2011)

The child mortality rates were obtained for five years through successive Demographic Health System surveys conducted in Bangladesh since 1993-1994. During 1989 to 1993 and 2007 to2011, the infant mortality rate had declined by half, from 87 deaths per 1,000 live births to 43 deaths per 1,000 live births. More impressive decline of 71 percent in the post neonatal mortality and 60 percent in under-5 mortality were observed over the same periods. The corresponding decline in the neonatal mortality was 38 percent. With this rapid decline, Bangladesh is well on track to achieve the Millennium Development Goal of an under-5 mortality rate of 48 deaths per 1,000 live births by 2015. An examination of the neonatal, infant, and under-5 mortality rates in Bangladesh over the last 18 years therefore revealed that the neonatal mortality declined at a slower pace than the infant and the under five child mortality.

According to the BDHS 2011 report, the percentage of death among the first child born was higher (11.4 percent) than the second (9.3 percent) and third (9.4 percent) birth. Several factors including age of mother, birth interval, malnutrition, education of mother and other socioeconomic and demographic variables have been implicated to lead to a higher risk of death among the first birth than other birth order. On the other hand, second and subsequent child survival was also influenced by previous birth interval.

At this backdrop, the present study is designed to explore the important determinants of the child survival status of the consecutive births at the neonatal, infant and under five phases among the mothers who started their marriage life during the period from 1983 to 1993 in the Matlab Demographic Surveillance System area being conducted by the icddr,b. Given the observed, dependence in the survival status of the consecutive births we have employed a generalized linear model for bivariate Bernoulli outcomes to take account of the correlation between the survival status of the consecutive births. To our knowledge, this is the first research conducted using follow up data to analyze the determinants of survival status of consecutive births taking into account the underlying dependence in the outcome responses.

1.2 Child Survival: An Important Child Health Indicator

The BDHS 2011 obtained key information on children health and childhood mortality that reflected the health status of the country.

1.3 Childhood Mortality

The childhood mortality indicators in BDHS-2011 are:

1. Neonatal Mortality
2. Post Neonatal Mortality
3. Infant Mortality
4. Child Mortality
5. Under-5 years Mortality

1.3.1 Neonatal Mortality

From the United Nations Children Emergency Fund (UNICEF) we found that the probability of dying within first 28 days of life was known as the neonatal mortality. Early neonatal mortality in the life table refers to dying within the first 7 days of life. And late neonatal mortality refers to dying within the next 7 to 28 days after birth.

1.3.2 Post Neonatal Mortality

The post neonatal mortality is the difference between infant and neonatal mortality. It refers to the probability of dying between 2nd to 12th months of birth.

1.3.3 Infant Mortality

The infant mortality is the death of a child less than one year of age. It is most widely accepted as one of the most sensitive indicators of health status of a country/region due to several reasons. The IMR always reflect the overall health scenario of a region/country. The rate is low in developed countries and high to very high in developing to underdeveloped countries. If health infrastructure (preventive and curative infrastructures) of a region of a country is very good, the IMR is always good.

1.3.4 Child Mortality

The child mortality is also known as the under-5 mortality. The child mortality is the probability of dying between the first and fifth birthday. The child mortality rate is the highest in low-income countries such as the most countries in the SubSaharan Africa. A child's death is emotionally and physically damaging for the mourning parents. Many deaths in the third world go unnoticed since many poor families cannot afford to register their babies in the government registry.

1.4 Objective:

The main objectives of this study are:

1. To discuss the application of the Generalized Bivariate Bernoulli Model (GBBM) for the analysis of survival of successive births.

2. To identify the determinants related to the survival of the 1st, 2nd and 3rd births separately by using the Marginal Generalized Linear Model for the neonatal, infant and under five phases.

3. To find out the conditional estimates of child survival analysis by using the Generalized Bivariate Bernoulli Model (GBBM) for the neonatal, infant and under five phases.

4. To test dependence of survival of successive births by using Generalized Bivariate Bernoulli Model (GBBM) for the neonatal, infant and under five phases for the neonatal, infant and under five phases.

5. To compare the results for the survival status of the consecutive births for the neonatal, infant and under five phases.

1.5 Organization of the Chapter

We have organized the full study paper in seven chapters.

Chapter 1 consists of short introductory information on child survival in rural Bangladesh briefly. Discussed about the type of child mortality indicators and objectives of our study.

Chapter 2 consists of literature review, a short review of literature for both methodology and applications with objectives of the study. In the methodological literature review we mainly focused on the establishing background of Generalized Bivariate Bernoulli Model.

In ***Chapter 3***, we have discussed the data, variable and background characteristics of the study. Here we have discussed the source and limitation of the data regarding our study.

Chapter 4 includes the bivariate analysis of the survival status of child for the first, second and third birth order separately. Besides that, for each birth order we repeated the analysis for three stages which were neonatal, infant and under 5 year's period.

Chapter 5 includes Although our focus on the application of Bivariate Generalized Bernoulli Model provided conditional estimates we have applied this to the data for the analysis of survival status of the first, second and third birth order separately. This chapter will give us insight about the differential effect of different determinant on the survival of the first, second and third birth of woman.

In the ***Chapter 6***, we have discussed the Generalized Bivariate Bernoulli Model and applied this model for the conditional survival analysis of the second and third birth given the previous birth. Afterword, we have tested the dependency of survival of successive birth. Besides that, we have estimated the conditional and joint transitional probability of child survival from the first to second birth and from the second to third birth.

At the end, ***Chapter 7***, we have discussed the discussion and conclusion regarding the study.

Chapter: Two

Literature Review

2.1 Introduction:

In this chapter, we discuss literature related to child survival analysis and methodology of analyzing child survival data. We divide the literature review into two subsections. In the first section, the literature review on child survival analysis is summarized and in the second section the literature on proposed methodology for analyzing child survival data is addressed. Here, it is important to note that the conditional child survival analysis was not conduct before but marginal model were used usually for analyzing the child survival data.

2.2 Literature Review of Child Survival Analysis:

Child survival analysis is a very important and interesting issue for researchers. A large number of works have been conducted on child survival analysis worldwide. Here we review some of the works conducted in South Asian counties especially Bangladesh.

Haque and Sayem [2009] examined in their study that socioeconomic and cultural determinants of age at the first birth and they considered a sample of married women aged 15 to 29 years in rural areas. They found that 72.8 percent women gave first birth at under 20 years of age and the mean age at the first birth was 18.74. The simple linear regression model explained 30.9 percent of the varition in age at first live birth and found that family pressure explained the most of the variation.

Jocelyn et al [2011] found that women who had their first birth between the age were at the risk of poor child health while the risk was the lowest among those who exported birth between the age of 27 to 29. On the other hand they also found that both biological and socio mechanisms explained why children of young mothers have poorer outcomes.

Neal and Matthews [2013] found that poor women of the rural areas and those who had no education gave the birth in institutions have very poor outcome than those who gave the birth at home. On the other hand, neonatal mortality low risk while women who gave their birth in institution than those gave birth at home.

Miller [1994] studied that the effects of birth order and inter pregnancy interval on birth weight, gestational age, weight-for-gestational age, infant length, and weight-for-length in a sample of 2063 births from a longitudinal study in the Philippines. First births are the most disadvantaged of any birth order spacing group. The risks associated with short intervals (< 6 months) and high birth order (fifth or higher) are confined to infants who have both attributes; there is no excess risk associated with short previous intervals among lower-order infants, nor for high birth order infants conceived after longer intervals. This pattern is observed for all five birth outcomes and neonatal mortality, and persists in models that control for mother's age, education, smoking, family health history and nutritional status. Since fewer than 2 percent of births are both short interval and high birth order, the potential reduction in the incidence of low birth weight or neonatal mortality from avoiding this category of high-risk births is quite small (1-2) percent.

Yego et al [2013] found that between 2004 and 2011in Kenya, the overall maternal mortality ratio was 426 per 100,000 live births and the early neonatal mortality rate (<7 days) was 68 per 1000 live births. The Hospital record audit showed that half (51 percent) of the neonatal death were for young mothers (15-24 years) and 64 percent of maternal deaths were in women between 25 and 45 years. This paper provides important information about maternal and early neonatal mortality in Kenya's second largest tertiary hospital. A range of socio demographic, clinical and health system factors are identified as possible contributors to Kenya's poor progress towards reducing maternal and early neonatal mortality.

Adams et al [2013] found that child health in Bangladesh over the past several decades, significant improvements in gender and socioeconomic inequities have been revealed. With the use of social determinants of health approach, key features of the country's development experience can be identified that help explain its unexpected health trajectory. The systematic equity orientations of health and socioeconomic development in Bangladesh, and the implementation attributes of scale, speed, and selectivity, have been important drivers of health improvement. Despite this impressive pro-equity trajectory, there remain significant residual inequities in survival of girls and lower wealth quintiles as well as a host of new health and development challenges such as urbanization, chronic disease, and climate change.

Razzaque et al [2013] found that children who are born shortly before their mother's death, the cumulative proportion of survival up to 60 months of age was significantly lower than those born just before the last child of the same mother. Such a difference is mainly due to high mortality in the first six months of age. Over the period between 1974 and 2005, for the children, the cumulative proportion of survival up to 60 months of age was significantly higher if adopted by other households by the age of 15 days compared to those who stayed in their own households.

Choe et al [1995] found gender, birth order, and other correlates of childhood mortality in China. Controlling for family-level factors, childhood mortality is found to be associated with the child's gender and birth order. Among firstborn children the difference between male and female childhood mortality is not statistically significant, but among others, female children between ages 1 and 5 experience higher mortality than male children. Childhood mortality is slightly higher for children who have older brothers only than for those who have older sisters only, and it is highest for those who have both older brothers and sisters. Other factors affecting childhood mortality in China include mortality of older siblings, birth interval, urban/rural residence, mother's level of education, and mother’s occupation. All interactive effects between gender and family-level characteristics are found to be statistically insignificant.

Hussain [2002] examined the risk factors for neonatal mortality (0-28 days of life) for full-term singleton live births in low-income areas of Karachi, Pakistan during 1995. Results showed that 4.8 percent of all births ended in death in the neonatal period, and 76 percent of these neonatal deaths occurred in the first week of life. While neonatal mortality rates had declined appreciably over time, a large proportion of neonatal deaths were clustered in a small group of women. The bivariate analysis showed that a statistically significant association between a number of maternal-level parameters (e.g., mother's age at birth, level of formal education, employment status, religious affiliation, and consanguinity) and child-level parameters (e.g., birth order, birth interval, survival status of the preceding child, sex of the neonate, year of death).

Alam [1995] showed that a preceding birth interval of <15 months was associated with a greater mortality risk in the post-neonatal period for children with an older sibling who survived infancy. However, a short preceding birth interval did not adversely affect post-neonatal mortality if the older sibling died in infancy. Neonatal and post-neonatal deaths were higher if older siblings had died in respective age intervals. A pregnancy interval of <12 months after childbirth raised the risk of death at ages 1–2 years considerably if the child was born after a short birth interval (<15 months).

Bhuiya et al [2002] observed that risk of death during infancy was highest among children of mothers aged less than 20 years at birth, followed by children of mothers aged 30 years or more, 25–29 years, and 25–29 years of age. Children born to mothers with no education and with 1–5 years of schooling had a similar risk of death during infancy, which was 29 percent higher than children of mothers with more than 6 years of schooling. The risk of infant death during 1993–97 was 62 percent of the risk observed during 1988–92 in rural Bangladesh.

Hong et al [2007] found that the children born in five years preceding the BDHS by prenatal care status and other selected characteristics. More than one third (38 percent) of births, the mothers received prenatal care from professional providers during pregnancy. About 51 percent of all births were males and 49 percent were females. Only 13 percent of births received professional assistance at delivery. Twenty-nine percent of children were first order births, and 28 percent were fourth order birth or higher. Sixteen percent of births were to mothers aged 13–17, 47 percent were to mothers aged 18–24, 31 percent were to mothers aged 25–34, and the remaining 6 percent were to mothers aged 35–48.

2.3 Literature Review of Methodology

Statistical method for analyzing is a very important issue for longitudinal data with dependent repeated binary outcomes. Analysis of data in longitudinal study with dependent outcome variables creates many difficulties and tests for dependence in models for repeated measures remain a challenge where covariates are associated with previous outcomes and both covariates and previous outcomes are included simultaneously in a model. In the past, most of the longitudinal models developed are based on marginal approaches and relatively few are based on conditional models. If we want to analyze the dependence of the survival of subsequent births with covariates associated with each birth then we have to deal with dependent binary outcome variables which will be either child is alive or death for subsequent births.

The joint models are examined mainly to focus on the characterization problems but not much has been employed to focus the covariate dependent models with dependence in the outcomes. And the model is based on the integration of conditional and marginal models.

Markov chains are an obvious model. There are however many distinct ways of introducing them. Ware, Lipsitz and Speizer (1988) proposed that a first broad distinction is between transitional and marginal models, depending on whether the covariates determine the conditional distribution given the past or the marginal distribution of any nominated observation. Within transitional models, the effect of the covariates may be on the transition probabilities of the Markov chain or on its mean value.

Azzalini [1994] shows that how to construct the model so that the covariates relate only to the mean value of the process, independently of the association parameter. Azzalini [1994] proposed that a stochastic model for the study of the influence of time-dependent covariates on the marginal distribution of the binary response in serially correlated binary data. Markov chains are expressed in terms of transitional rather than marginal probabilities.

Cessie and Houwelingen [1994] have proposed that different association measures for the dependence between correlated binary outcomes for the marginal response probabilities are logistic regression.

Glonek [1996] proposed that a class of link functions that lie between the two extremes of the multivariate logistic transform of McCullagh and Nelder (1989) and the log-linear decomposition of contingency table analysis.The models derived from these link functions are shown to inherit various desirable properties of both the multivariate logistic regression models and the log-linear regression models. A computational scheme for implementing these models is derived and they are demonstrated to be computationally more tractable than the multivariate logistic regression model.

Bonney [1987] show that this paper is largely expository and is intended to motivate the development and usage of the regressive logistic models. The likelihood of a set of binary dependent outcomes, with or without explanatory variables, is expressed as a product of conditional probabilities each of which is assumed to be logistic are called regressive logistic models They provide a simple but relatively unknown parameterization of the multivariate distribution. They have the theoretical and practical advantage that they can be analyzed and fitted as in logistic regression for independent outcomes.

Carey and Zeger [1993] proposed that an alternative approach of logistic regression for the simultaneously response on explanatory variables as well as response to pair wise odds ratios. This algorithm iterates between a logistic regression using the first order generalized estimating equations to estimate regression coefficients and a logistic regression of each response on others from the same cluster using the odds ratio parameters. When Liang and Zeger [1986] shows that a first order generalized estimating equation method is easy to implement and gives efficient estimates of regression coefficient, although estimates of the association among the binary outcomes can be inefficient.

Lin and Clayton [2005] described the application of quasi-likelihood estimating equations for correlated binary data. They used a logistic function to model the marginal probabilities of binary responses in term of parameters of interest.

Lovison [2006] proposed that a matrix-valued Bernoulli distribution based on the log-linear representation introduced by Cox [1972] models for the analysis of multivariate binary data. They also discussed the relation of standard second order techniques.

Liang and Zeger [1986] proposed that an extension of generalized linear models to the analysis of longitudinal data. They introduced a class of estimating equations that give consistent estimates of the regression parameters and of their variance about the time dependence. Efficiency of the proposed estimator in two simple situations is considered.

Liang, Zeger and Qaqish [1992] proposed the marginal models are constructed with log-linear models and a class of models for the marginal expectations of each response is pair wise associated. Two generalized estimating equations approaches are compared for parameter estimations. The first focuses on the regression parameters and the second estimates regression and association parameters.

Glonek and McCullagh [1995] gives us that a general definition of generalized multivariate logistic models and their properties. The bivariate logistic transform was defined by McCullagh and Nelder [1989] to define regression models of its applications and related joint distribution of the responses to predictors. They introduced a computational scheme for performing maximum likelihood estimation for moderate data size described and a system of model formulated. In additional, they proposed model employs the conditional and marginal models for the outcome variables of interest and thus the measure of association can be linked with the link function as a function of conditional models which provides a natural measure from the odds ratio.

Muenz and Rubinstein [1985] proposed Markov models for covariates dependence of binary sequence. But Islam and Chowdhury [2006] have extended this model that they proposed higher order Markov model with covariate dependence for binary outcomes. In 2008, Islam and Chowdhury further extended their proposed model [2006] for multistate processes. After that Islam et al [2013] proposed a new model based on both marginal and conditional probabilities of the correlated binary events. In their proposed model, both the marginal and conditional probabilities are expressed as a function of explanatory variables and a test for dependence in outcomes is proposed. By using their model we can obtain conditional and marginal estimate simultaneously and using these estimates we can obtain conditional, marginal and joint transition probability. This model also uses link functions to test for dependence in outcome variables. The estimation and test procedures are illustrated with an application to the mobility index data from the Health and Retirement Survey and also simulations are performed for correlated binary data generated from the bivariate Bernoulli distributions.

Chapter: Three

Data, Variable and Methodology

3.1 Introduction

In the chapter, the data and methods for analyzing the child survival are presented. It is noteworthy that the analysis is performed for survival at i) Neonatal stage, ii) Infant stage and iii) under five stage.

3.2 Data

In this section, we discuss the source of data and limitation of data of our study. We focus the background of our study data in the source of data section and some limitations of data discussed in limitation of data section.

3.2.1. Source of Data

The data are from the Demographic Surveillance System of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B). Since 1963 the ICDDR, B has conducted a longitudinal surveillance system in Matlab thana, Comilla District, a rural area of Bangladesh, providing vital registration data of high quality (Demographic Surveillance System 1993). All vital events are recorded by Demographic Surveillance System and are linked to periodic censuses conducted in 1983 to 1993 (Depending on Village location). The data collection of a village based Maternal Child Health and Family Planning Program (MCH-FP) programme, in 70 Demographic Surveillance System area villages.

For our Study, we have used every mother information .Here we collect mother reproductive age information from their birth history. Then we have obtained the birth order from their birth information data by using the variables surviving son, surviving daughter, death son and death daughter. For our study, we need survival status of the first to second and third births. So we select mother’s first, second and third from the birth order.

Our main focus of the study is to investigate the dependence in the survival status of successive births, so we select successive births from the data. For our study we conduct survival of first birth to second birth as well as second birth to third birth. For our analysis we consider the woman marriage cohort 1983 to 1993. We select all the mothers who gave staring from birth who gave first to second, to second to third birth since the marriage during the period from 1983 to 1993.

3.2.2 Limitation of Data

Since 1963, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) starts the Demographic Surveillance System at Matlab, Chadpur. Here, continue collecting the data in regional basis but many people migrated in every year. So that many information of the study may arise the question. So, we take a cohort 1983 to 1993 where women marriage in this interval.

3.3 Description of the Variables

Here only the factors that determine the child survival in Bangladesh. Demographic factor characterize them in the following way.

The Demographic variables are sex of first child, sex of second child, sex of third child, preceding birth interval first to second child, preceding birth interval second to third child, mother’s age at first birth, mother’s age at second birth and mother’s age at third birth.

3.3.1 Demographic Variables

Sex of Child

We want to see the sex of child according to birth order then we found the 1^{st}, 2^{nd} and 3^{rd} child. In the original data set we found two categories. Sex is coded as 1 for male and 2 for female. Sex is a dummy variable so we coded it 1 for male and 0 for female.

Birth Interval

A birth interval is the length of time of time between two successive live births and birth spacing patterns which have impact on fertility and child mortality levels. Mahmood and Zainab (2010) found those children born in short interval after previous birth are increased high risk at the early age.

Mother's Age at Birth

Mother's age at birth affected on first child outcomes explored in several studies in many countries. In every development and develop countries try to explored mother's age at birth. We try to find out the effect of mother age at birth for second and third birth. For the first to second birth and second to third birth we made dummy variable such as less or equal than 20 years and more than 20 years.

3.4 Background Characteristic

In this thesis we will mainly focus on the conditional analysis of survival of child at neonatal, infant and under-5 year stage. For the conditional survival analysis of second birth given first birth, we consider the woman who have first and second child.

On the other hand, for the conditional survival analysis of third birth given second birth, we consider the women who have second and third child.

Here question may arise regarding taking women marriage duration 1983 to 1993 for the analysis. The answer is number of woman who have their first, second and third birth after women marriage duration 1983 to 1993 really small and our analysis require relatively large sample size since we are finding the estimate under condition. For instant, if first child is dead then second child will dead then the estimate regarding covariates.

For the analysis of survival of second child given first we have 9614 women who have their first and second child. Besides for third given second birth we have 9614 women who have their second and third child. So, we have to discuss the Background characteristics in two sections, one for the second birth given first birth survival and another for third given second birth survival.

3.4.1 Background Characteristic of the Mothers Having First and Second Births

The background characteristics of the women who have their first and second child after marriage during 1983 to 1993 are discussed in this section. For the conditional survival analysis, second child at neonatal, Infant and under-5 year period as well as for the marginal survival analysis of the first and second birth order we have found a sample of 9614 women who have their first and second births.

Following table presents the percent distribution of the different variables used in the study for the first two consecutive births.

Table 3.1: Percentage Distribution of Mother Having the First and Second Births by Different Variables

Characteristics	Covariates	Frequency	Percentage
First to Second Birth Interval (Month)	Less than 18	846	8.8
	18 to 36(Ref)	3780	39.3
	More than 36	4988	51.9
Sex of First Child	Male	4795	49.9
	Female(Ref)	4819	50.1
Sex of Second Child	Male	4776	49.7
	Female(Ref)	4838	50.3
Mother's Age at First Birth (Year)	Less than 20	4570	47.5
	Greater or Equal 20(Ref)	5044	52.5
Mother's Age at Second Birth (Year)	Less than 20	744	8.1
	Greater or Equal 20(Ref)	8840	91.9
*Ref= Reference Category			

First to Second Birth Interval (Month)

In our sample, women who take their second child between 18 months of their first child are about 8.8 percent. In addition, for the interval 18 to 36 month it is 39.3 percent. It appears that 51.9 percent women take a break of more than 36 months to take their second child.

Sex of First child

We observe a slightly lower proportion of males (49.9%) among the first births as compared to females.

Sex of Second child

It is noteworthy that the proportion of males is lower (49.7%) for the second births recorded in the data.

Mother's Age at First Birth (Year)

From the table, it is evident that 47.5 percent mothers take the first child at age less than 20 years.

Mother's Age at Second Birth (Year)

From table says that 8.1 percent women take their second child before 20 years age and 91.9 percent women take child greater or equal 20 years of age.

3.4.2 Background Characteristic of the Mothers Having Second and Third Consecutive Births

The characteristics of the mothers having second and third consecutive births are displayed in this section. For the application of the conditional survival analysis of the third birth given the second birth at the neonatal, infant and under-5 year stages and the marginal analysis of the second birth we have found the sample size 9614.

Following table present the percent distribution of the different variables used in the study for the Second cohort.

Table 3.2: Percentage Distribution of Mother having the Second and Third Birth by Different variables

Characteristics	**Covariates**	**Frequency**	**Percentage**
Second to Third Birth Interval (Month)	Less than 18	427	4.4
	18 to 36(Ref)	2809	29.2
	More than 36	6378	66.3
Sex of Second Child	Male	4776	49.7
	Female(Ref)	4838	50.3
Sex of Third Child	Male	4851	50.5
	Female(Ref)	4763	49.5
Mother's Age at	Less than 20	744	8.1

Second Birth (Year)	Greater or Equal 20(Ref)	8840	91.9
Mother's Age at Third Birth (Year)	Less than 20	52	0.5
	Greater or Equal 20(Ref)	9562	99.5
*Ref= Reference Category			

Second to Third Birth Interval (Month)

From the table, it is observed that 4.4 percent women who take their third child in less than 18 months from their second birth, while 29.2 percent women take their third child between 18 to 36 months from the second child and 66.3 percent gave birth to their third child at an interval of more than 36 months after the birth of their second child. .

Sex of Second Child

Our data shows that slightly less than 50 percent of the second births are males as compared to the females.

Sex of Third Child

It is displayed in the table that there is a visible increase in the percentage of males at the third birth (50.5%) as compared to that of females.

Mother's Age at Second Birth (Year)

We observe that 8.1 percent of the women take their second child at the age less than 20 years and on the other hand 91.9 percent women take their second child greater or equal 20 years of age.

Mother's Age at Third Birth (Year):

In the data, 0.5 percent women who take their third child at the age of less than 20 years and 99.5 percent women who take their third child at the age greater or equal 20 years.

Summary

In our study mainly focus survival analysis of the second birth under the condition of the first birth survival and other analysis third birth under the condition of the second birth survival. We follow that, the demographic variable such as birth interval, sex of child and mother's age. From the first cohort we observed that 47.5 percent of women take their first child before 20 years of age and 8.1 percent of them take second child before 20 years of age. On the other hand 8.1 percent take their second child before 20 years of age and 0.5 percent of them take third child before 20 years of age.

3.5 Methodology

In this section, we have discussed the methodology of the study. Firstly, we assume the variable of the model ling factor discuses and then we briefly discussed the conditional model, marginal model and joint model of conditional and marginal.

3.5.1 Definition of the variables in the models

First Birth to Second Birth

$Y_1 = Survival\ Status\ of\ first\ birth$

$Y_2 =\ Survival\ Status\ of\ second\ birth$

$X_1 = sex\ of\ male\ first\ birth$

$X_2 = sex\ of\ male\ second\ birth$

$X_3 = mother's\ age\ of\ second\ child$

$X_4 = Birth\ interval\ less\ than\ 18\ months\ of first\ child\ to\ second\ child$

$X_5 = Birth\ interval\ 18\ months\ to\ 36\ months\ of first\ child\ to\ second\ child$

Second Birth to Third Birth

$Y_1 = Survival\ Status\ of\ Second\ birth$

$Y_2 =\ Survival\ Status\ of\ third\ birth$

$X_1 = sex\ of\ male\ second\ birth$

$X_2 = sex\ of\ male\ third\ birth$

$X_3 = mother's\ age\ of\ third\ child$

$X_4 = Birth\ interval\ less\ than\ 18\ months\ of second\ child\ to\ third\ child$

$X_5 = Birth\ interval\ 18\ months\ to\ 36\ months\ of second\ child\ to\ third\ child$

3.5.2 Generalized Linear Models

A generalized linear model consists of three components:

1. A random component, specifying the condition distribution of the response variable Y_i (for the ith of n independently sampled observation), given the values of the explanatory variables in the model. In Nelder and Wedderburn's orginal formulation, the distribution of Y_i is a member of an exponential family, such as the Gaussian (normal), binomial, Poisson, gamma or inverse-Gaussian families of distribution. Subsequent work, however has extended GLMs to multivariate exponential families (such as the multi nominal distribution) to certain non-exponential families (such as the two- parameter negative-binomial distribution) and to some situations in which the distribution of Y_i is not specified completely.

2. A linear predictor—that is a linear function of regressor's

$$\eta_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik}$$

As in the linear model, and in the logit and probit models, the regressors X_{ij} are pre-specified functions of the explanatory variables and therefore may include quantitative explanatory variables, transformations of quantitative explanatory variables, polynomial regressors, dummy regressors, interactions, and so on. Indeed, one of the advantages of GLMs is that the structure of the linear predictor is the familiar structure of a linear model.

3. A smooth and invertible linearizing link function g (·), which transforms the expectation of the response variable, $\mu_i = E(Y_i)$, to the linear predictor:

$$E(\mu_i) = \eta_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik}$$

The linear models of classical regression analysis involve the assumption of independence of the observations. This assumption is carried over the wider class of generalized linear models.

So, an important characteristic of a generalized linear model is that it assumes independent or at least uncorrelated observations. For example, data showing the auto-regression of time series are excluded.

Logit Models for Proportions

In most applications in health studies, the response variable may be dichotomous or polytomous and one or more independent variables are qualitative or measured in ordinal scale. Then the assumption of normality analysis as well as the condition of continuous independent or dependent variables for linear discriminate analysis or linear regression is violated. A standard approach of predicting and analyzing the risk factors in this situation is the logistic regression model that does not require any distributional assumption of the independent variables and treats the response variable as dichotomous. This procedure can be applied to identify the risk factors as well as to predict the probability of success e.g. probability of developing a disease as a function of the particular risk factors. This probability can serve as an index of risk for a given disease or not for responding to a certain treatment. The logistic regression proposed by cox (1920) has become the standard method for finding the relationship between the qualitative outcome variable and asset of explanatory variables. Initially this model has developed for dichotomous response variables but later its extension has been made for polytomous data.

Suppose that there are N individuals in our study. Let Y be a dichotomous dependent (disease) variable such that,

$$Y_i = \begin{Bmatrix} 1, if\ child\ died\ at\ the\ study\ period \\ 0, if\ child\ alive \end{Bmatrix}$$

We suppose that, for each of the N individuals, k independent variables $X_1, X_2, \ldots \ldots, X_k$ are measured. These variables can either be qualitative such as sex, mother's age and birth interval etc. For *i th* individuals we have the outcome

Y_i and the vector of the covariates $X_i = (X_{i1}, X_{i2}, \ldots\ldots, X_{ik})$ .Thus the data for individual consist of the observation(Y_i, X_i).

The linear function of regression can be written as $Z_i = X_i\beta$, *i=1,...N*

Here $\beta = (\beta_1, \beta_2, \ldots\ldots, \beta_k)'$ is a $(K \times 1)$ column vector of regression parameters. If we include the intercept term β_0 , then we have $\beta = (\beta_0, \beta_1, \beta_2, \ldots\ldots, \beta_k)'$

$$\text{And } Z_i = X_i\beta = (1, X_{i1}, X_{i2}, \ldots, X_{ik}) \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_{k-1} \\ \beta_k \end{pmatrix}$$

$$= \beta_0 + X_{i1}\beta_1 + \cdots + X_{ik}\beta_k$$

$$= \sum_{j=0}^{k} X_{ij}\beta_j \qquad \text{Where, } X_{i0} = 1 \; for \; all \; i = 1,2, \ldots N$$

Now the probability of developing the specific survival event during the study period is

$$P_i = \Pr\,(Y_i = 1|X_i) = \frac{exp(X_i\beta)}{1 + exp(X_i\beta)};$$

The probability of not developing the event during the study period is,

$$1 - P_i = 1 - \Pr(Y_i = 1|X_i) = \frac{1}{1+exp(X_i\beta)}$$

Then the logit transformation is defined to be

$$Z_i = logit(P_i) = log\left(\frac{P_i}{1 - P_i}\right) = X_i\beta$$

This equation is known as the logit model that relates the independent variables to the transformation of P_i .Taking these probabilities (p and 1-p) as the basis of analysis, some functions are considered that transforms the (0,1) scale for the probabilities on to the real line. These functions are known as link functions or response functions. According to McCullagh and Nelder (1989), Logit, Probit, and complementary Log-Log link functions are used to transform the interval (0, 1) on the real line. We use the Logit model as the link function of our study.

3.5.3 Generalized Bivariate Bernoulli model: Conditional Approach

The bivatiate Bernoulli distribution for outcomes Y_1 and Y_2 can be expressed as

$$\boldsymbol{P}\,(Y_1{=}y_1, Y_2{=}y_2) = P_{00}^{(1-y_1)(\ (1-y_2)} \quad P_{01}^{(1-y_1)y_2} \quad P_{10}^{y_1(\ (1-y_2)} \quad P_{11}^{y_1 y_2} \quad (3.1)$$

We have demonstrated the probabilities without function of covariates in the previous expression. Now, let us consider $\boldsymbol{X} = (1, X_1, X_2, \ldots\ldots X_p)$ and $\boldsymbol{X} = (1, x_1, x_2, \ldots\ldots.., x_p)$ Where $\boldsymbol{X}^* = (1, X_1, X_2, \ldots\ldots X_p)$ and $\boldsymbol{x}^* = (1, x_1, x_2, \ldots\ldots.., x_p)$ are the vector of covariates and their corresponding covariates values respectively.

The transition probabilities can be defined in terms of function of the covariates as follows:

$$\pi_{sl}\big(Y_j = l \big| Y_{j-1} = s, X\big) = \pi_{sl}(X) = \frac{e^{\beta_s' X}}{1+e^{\beta_s' X}} \ldots\ldots\ldots.(2) \qquad (3.2)$$

Where s= 0, 1.

The likelihood function can be defined as

$$L = \prod_{i=1}^{n} \prod_{j=1}^{ni} \prod_{s=0}^{1} \prod_{m=0}^{1} \big[\{\pi_{sm}(X_i)\}^{\delta_{smij}}\big] \ldots\ldots\ldots\ldots (3) \qquad (3.3)$$

Where $n_i = total\ number\ of\ followup\ observations\ since\ the\ entry\ into\ the\ study$

$$for\ the\ ith\ individual;$$

$$\delta_{smij} = 1\ if\ a\ transition\ type\ s - m\ is\ observed\ during\ jth\ followup$$

$$for\ the\ ith\ individual;$$

The log likelihood function, after substituting (3.2) and (3.3), can be expressed as

$$lnL = lnL_0 + \ln L_1$$

Where $L_0\ and\ L_1$ correspond to s=0 and s=1, respectively, from (3.2)

Hence

$$lnL_0 = \sum_{i=1}^{n}\sum_{j=1}^{ni}[\delta_{01ij}\{\beta_{01}'X_i\} - (\delta_{00ij} + \delta_{01ij})\ln\{1 + e^{\beta_{01}'X_i}\}]$$

$$\ln L_1 = \sum_{i=1}^{n}\sum_{j=1}^{ni}[\delta_{11ij}\{\beta_{11}'X_i\} - (\delta_{10ij} + \delta_{11ij})\ln\{1 + e^{\beta_{01}'X_i}\}]$$

The joint probability can be shown in a 2 X 2 table as follows:

y_2

y_1	0	1	Total
0	P_{00}	P_{01}	P_{00}
1	P_{10}	P_{11}	P_{00}
	P_{+0}	P_{+1}	1

The joint probability mass function in Equation (3.3) can be demonstrated in terms of the exponential family for the general linear models as

$\boldsymbol{P}(Y_1{=}y_1, Y_2{=}y_2) = \exp\{y_1 \log\frac{P_{10}}{P_{00}} + y_2 \log\frac{P_{01}}{P_{00}} + y_1y_2 \log\frac{P_{00}P_{11}}{P_{01}P_{10}} + \log P_{00}\}$

$(y_1, y_2) = (0, 0), (0, 1), (1, 0), (1, 1), \sum_{i,j} P_{ij} = 1.$

Let us consider a sample of size n then the log likelihood function in this case is given by

$$l = \sum_{i=1}^{n} l_i = \sum_{i=1}^{n}\left\{y_{1i}\log\frac{P_{10i}}{P_{00i}} + y_{2i}\log\frac{P_{01i}}{P_{00i}} + y_{1i}y_{2i}\log\frac{P_{00i}P_{11i}}{P_{01i}P_{10i}} + \log P_{00i}\right\}.$$

Then the components of the link function can be denoted as follows:

$\eta_0 = (\log P_{00})$, $\eta_1 = \left(\log\frac{P_{01}}{P_{00}}\right)$, $\eta_2 = \left(\log\frac{P_{10}}{P_{00}}\right)$, and $\eta_3 = \left(\log\frac{P_{00}P_{11}}{P_{01}P_{10}}\right)$,

Where η_0 is the baseline link function, η_2 is the link function for Y_1, η_1 is the link function for Y_2 and η_3 is the link function for dependence between Y_1 and Y_2.

We have demonstrated the probabilities without function of covariates in the previous expression. Now, let us consider $\boldsymbol{X} = (1, X_1, X_2, \ldots\ldots X_p)$ and $\boldsymbol{X} = (1, x_1, x_2, \ldots \ldots \ldots, x_p)$ Where $\boldsymbol{X}^* = (1, X_1, X_2, \ldots\ldots X_p)$ and $\boldsymbol{X}^* = (1, x_1, x_2, \ldots \ldots \ldots, x_p)$ are the vector of covariates and their corresponding covariates values respectively. Then we can express the conditional probabilities in terms of the logit link function as follows:

$$P(Y_2 = 1|Y_1 = 0, x) = \frac{e^{X\beta_{01}}}{1+e^{X\beta_{01}}} = \pi_{01}(\boldsymbol{X}) \quad (3.4)$$

$$P(Y_2 = 1|Y_1 = 1, x) = \frac{e^{X\beta_{11}}}{1+e^{X\beta_{11}}} = \pi_{11}(\boldsymbol{X}) \quad (3.5)$$

And

$$P(Y_2 = 1|Y_1 = 0, x) = \frac{1}{1+e^{X\beta_{01}}} = \pi_{00}(\boldsymbol{X}) \quad (3.6)$$

$$P(Y_2 = 1|Y_1 = 1, x) = \frac{1}{1+e^{X\beta_{01}}} = \pi_{01}(\boldsymbol{X}) \quad (3.7)$$

Where

$\beta_{01} = (\beta_{010}, \beta_{011}, \beta_{012}, \ldots \ldots, \beta_{01p})'$, and $\beta_{11} = (\beta_{110}, \beta_{111}, \beta_{112}, \ldots \ldots, \beta_{11p})'$.

The marginal probabilities are as follows:

$$P(Y_1 = 1|X = x) = \pi_1(x), \quad \text{and } P(Y_1 = 0|X = x) = 1 - \pi_1(x) \quad (3.8)$$

Now, we may assume that

$$P(Y_1 = 1|x) = \frac{e^{X\beta_1}}{1+e^{X\beta_1}} = \pi_1(\boldsymbol{X}) \text{ and } P(Y_1 = 0|x) = \frac{1}{1+e^{X\beta_1}} = 1 - \pi_1(\boldsymbol{X}) \quad (3.9)$$

Where

$\beta_{11} = (\beta_{10}, \beta_{11}, \beta_{12}, \ldots \ldots, \beta_{1p})'$.

Also, we can write

$$P_{01}(\mathbf{X}) = P(Y_2 = 1|Y_1 = 0, X = x).P(Y_1 = 0|X = x) = \frac{e^{x\beta_{01}}}{1+e^{x\beta_{01}}} \cdot \frac{1}{1+e^{x\beta_1}},$$

$$P_{00}(\mathbf{X}) = P(Y_2 = 0|Y_1 = 0, X = x).P(Y_1 = 0|X = x) = \frac{1}{1+e^{x\beta_{01}}} \cdot \frac{1}{1+e^{x\beta_1}}, \quad (3.10)$$

$P_{11}(\mathbf{X})= P(Y_2 = 1|Y_1 = 1, X = x). P(Y_1 = 1|X = x) = \frac{e^{x\beta_{11}}}{1+e^{x\beta_{11}}} . \frac{e^{x\beta_1}}{1+e^{x\beta_1}},$

$P_{10}(\mathbf{X})= P(Y_2 = 0|Y_1 = 1, x). P(Y_1 = 1|x) = \frac{1}{1+e^{x\beta_{11}}} . \frac{e^{x\beta_1}}{1+e^{x\beta_1}}$

Now, we can show that

$$\eta_0 = \ln (P_{00}(x))= -\ln(1+x\beta_{01}) - \ln(1+x\beta_1)$$

$$\eta_1 = \ln (\frac{P_{01}(x)}{P_{00}(x)}) = x\beta_{01}$$

$$\eta_2 = \ln (\frac{P_{10}(x)}{P_{00}(x)}) = x\beta_1 + \ln (1+x\beta_{01}) - \ln (1+x\beta_{11}), \qquad (3.11)$$

$$\eta_3 = \ln(\frac{P_{00}(x)P_{11}(x)}{P_{01}(x)\, P_{10}(x)}) = x(\beta_{11} - \beta_{01})$$

Which is indicates that if there is no association between Y_1 *and* Y_2 then $\eta_3 = 0$ and this is true for $\beta_{01} = \beta_{11}$.

Parameter Estimation

The estimating equation for j=0, 1, 2,… p are as follows:

$$\frac{\delta l}{\delta\beta_{01j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_s}\frac{\delta\eta_s}{\delta\beta_{01j}} \qquad (3.12)$$

$$\frac{\delta l}{\delta\beta_{11j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_s}\frac{\delta\eta_s}{\delta\beta_{11j}} \qquad (3.13)$$

And

$$\frac{\delta l}{\delta\beta_{1j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_s}\frac{\delta\eta_s}{\delta\beta_{01j}} \qquad (3.14)$$

The elements of derivatives with respect to the link function are:

$$\left[\frac{\delta l_i}{\delta l_{1j}}\right] = \begin{bmatrix} \frac{\delta l_i}{\delta \eta_{0i}} \\ \frac{\delta l}{\delta \eta_{1i}} \\ \frac{\delta l}{\delta \eta_{2i}} \\ \frac{\delta l}{\delta \eta_{3i}} \end{bmatrix} = \begin{bmatrix} 1 \\ y_{2i} \\ y_{1i} \\ y_{1i}y_{2i} \end{bmatrix}$$

The estimating equations are:

$$\left[\frac{\delta l}{\delta \beta_j}\right] = \begin{bmatrix} \frac{\delta l}{\delta \beta_{01j}} \\ \frac{\delta l}{\delta \beta_{11j}} \\ \frac{\delta l}{\delta \beta_{1j}} \end{bmatrix} = \begin{bmatrix} -\sum_{i=1}^{n} x_{ij}(1-y_{1i})[\pi_{01}(x_i) - y_{2i}] \\ -\sum_{i=1}^{n} x_{ij}y_{ij}[\pi_{11}(x_i) - y_{2i}] \\ -\sum_{i=1}^{n} x_{ij}[\pi_{1}(x_i) - y_{1i} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ . \\ 0 \end{bmatrix} \qquad (3.15)$$

Where j=0, 1, 2, 3… *p.*

The second derivatives are shown below:

$$\left[\frac{\delta^2 l}{\delta \beta_j \delta \beta_{j'}}\right] = \begin{bmatrix} \frac{\delta^2 l}{\delta \beta_{01j}\delta \beta_{01j'}} \\ \frac{\delta^2 l}{\delta \beta_{11j}\delta \beta_{11j'}} \\ \frac{\delta^2 l}{\delta \beta_{1j}\delta \beta_{1j'}} \end{bmatrix} =$$

$$\begin{bmatrix} -\sum_{i=0}^{n} x_{ij}x_{ij'}(1-y_{1i})\pi_{01}(x_i)(1-\pi_{01}(x_i)) & 0 & 0 \\ 0 & -\sum_{i=1}^{n} x_{ij}x_{ij'}y_{1i}\pi_{11}(x_i)\big(1-\pi_{11}(x_i)\big) & 0 \\ 0 & 0 & \sum_{i=0}^{n} x_{ij}x_{ij'}\pi_{1}(x_i)(1-\pi_{1}(x_i)) \end{bmatrix}$$

……………… (3.16)

Where j, j'= 0, 1… p

Now the estimates are obtained at the *mth* iteration by the following iterative process in general;

$$\hat{\beta}_j^{(m+1)} = \hat{\beta}_j^{(m)} + \{I[\hat{\beta}_j^{(m)}]\}^{-1} U(\hat{\beta}_j^{(m)})$$

We need to choose a set of suitable initial guess for the parameters and iterative process continues until convergence is obtained.

The variance – covariance matrix for the parameters sets are obtained as in general;

$$COV(\hat{\beta}_j) = \left\{I[\hat{\beta}_j^{(m)}]\right\}^{-1} \qquad j = 0,1,2, \dots . p$$

Test for Significance of Parameters

We can test for the overall significance of a model using the likelihood ratio test. To test the significance of individual parameters we can use the Wald test.

Wald test

For testing the significance of a modeling of *jth* parameter, the null hypothesis is;

$$H_0: \beta_j = 0$$

And the corresponding test statistics for Wald test is;

$$W = \frac{\hat{\beta}_j}{\widehat{se}(\hat{\beta}_j)}$$

This follows normal distribution with 1 degree of freedom.

Test for Dependence

We see that if there is no association between $Y_1 and\ Y_2$ then $\eta_3 = 0$ and this is true for $\beta_{01} = \beta_{11}$.

So, to test the dependence of $Y_1 and\ Y_2$ the null hypothesis can be written as:

$$H_0: \eta_3 = 0$$

Or

$$H_0: \beta_{01} = \beta_{11}$$

We can test the equality of two test sets of regression parameters β_{01} and β_{11} using the following test statistic:

$$\chi^2 = \left(\hat{\beta}_{01} - \hat{\beta}_{11}\right)^{'} [\mathrm{Va\hat{r}}(\hat{\beta}_{01} - \hat{\beta}_{11})^{-1}\left(\hat{\beta}_{01} - \hat{\beta}_{11}\right) \qquad (3.17)$$

Which is the distributed asymptotically as chi-square with (p+1) degree of freedom.

Where, $\widehat{Var}\left(\hat{\beta}_{01} - \hat{\beta}_{11}\right) = \widehat{Var}\left(\hat{\beta}_{01}\right) + \widehat{Var}\left(\hat{\beta}_{11}\right)$

Comparison with an alternative test

We have compared the proposed test for development in the bivarite Bernoulli outcome variables, Y_1 and Y_2, with a test proposed by employing the regressive model. We can express the joint mass function for Y_1 and Y_2 as shown below:

$$P(y_1, y_2|x)= P(y_1|x)\ P(y_1|y_2, x),$$

Where $X = x$ is the vector of covariate value. Then the regressive model includes the previous outcomes, Y_1 as a covariate, in additional to the explanatory variables $x_1, x_2, x_3 \ldots \ldots . x_p$ as follows:

$$P(y_2|y_1, x) = \frac{e^{(\beta_0+\beta_1 x_1+\cdots+\beta_p x_p+\gamma y_1)y_2}}{1+e^{\beta_0+\beta_1 x_1+\cdots+\beta_p x_p+\gamma y_1}} \qquad (3.18)$$

Where $\beta_0, \beta_1, \ldots., \beta_p$ and γ are the regressive model parameters. It is noteworthy that γ is the parameter associated with the outcome variable Y_1 such that, $H_0{:}\ \gamma = 0$ indicates a lack of dependence between Y_1 and Y_2.

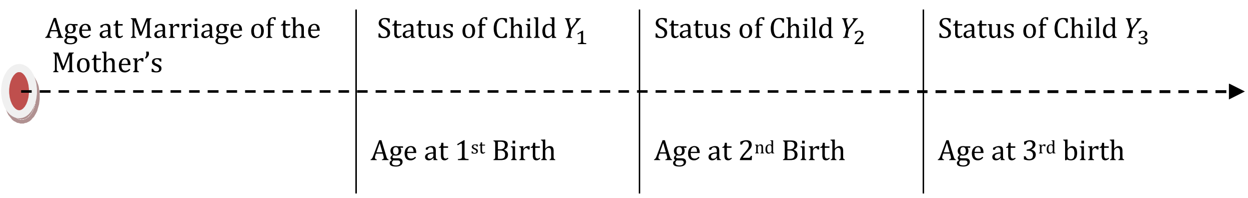
Chapter: Four

Bivariate Analysis of subsequent birth

4.1 Introduction

In the previous chapters, we have discussed the background characteristics of the study, data, variables and methodology. In this chapter, we discuss the analysis of survival status of the successive births. We examine the potential risk factors for neonatal, infant and under-5 year death for first to third birth orders by bivariate analysis. We will also show some cross tables to study the percentage distribution of child death by underlying independent variables. This chapter is a very important because by the bivariate analysis we can explore the underlying association between dependent and explanatory variables.

- **Mother's life time table having subsequent child**



4.2 Bivariate Analysis of the First Birth

Here we discuss the bivariate analysis of first birth of the subsequence child birth of a mother's.

Table 4.1: Percentage Distribution of Survival Status of the First Child by Independent Variables

	Neonatal Survival			Infant Survival			Under-5 Year Survival		
Variables	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**
Sex of First Child									
Male	96.1	3.9		93.5	6.5		91.9	8.1	
Female	95.9	4.1	0.641	93.8	6.2	0.558	92.1	7.9	0.735
Mother's Age at First Birth (Year)									

Less than 20	95.9	4.1	0.641	93.7	6.3	0.867	92.0	8.0	0.970
Greater or Equal 20	96.1	3.9		93.6	6.4		92.0	8.0	
*=significant at 10%				**= significant at 5%			***= significant at 1%		

Table 4.1 shows that sex of first child and mother's age at first birth are not associated with first birth at neonatal, infant and under-5 year stages. It indicates that there is no sex preference in case of death of the first child at the neonatal, infant or under 5 stages. On the other hand, mother's age at first birth does not depend on case of death of the first child at the neonatal, infant or under 5 stages.

4.3 Bivariate Analysis of the Second Birth

Here we discuss the bivariate analysis of second birth of the subsequence child of a mother's.

Table 4.2: Percentage Distribution of Survival Status of the Second Child by Independent Variables

	Neonatal Survival			**Infant Survival**			**Under-5 Year Survival**		
Variables	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**
Sex of First Child									
Male	95.5	4.5	0.187	93.4	6.6	0.165	91.4	8.6	0.338
Female	96.1	3.9		94.1	5.9		91.9	8.1	
Sex of Second Child									
Male	95.9	4.1	0.612	94.1	5.9	0.113	91.9	8.1	0.338
Female	95.7	4.3		93.4	6.6		91.4	8.6	
Mother's Age at Second Birth (Year)									
Less than 20	90.3	9.7	0.00***	87.6	12.4	0.00***	85.1	14.9	0.00***

Greater or Equal 20	96.3	3.7		94.3	5.7		92.2	7.8	
First to Second Birth Interval (Month)									
Less than 18	83.2	16.8	0.00***	77.2	22.8	0.00***	74.8	25.2	0.00***
18 to 36	95.9	4.1		93.4	6.6		91.0	9.0	
More than 36	97.8	2.2		96.8	3.2		95.0	5.0	
*=significant at 10%				**= significant at 5%			***= significant at 1%		

Table 4.2 shows the bivariate relationships between survival status of the second birth during neonatal, infant and under 5 stages by selected variables. It is observed that sex of the first and second children are not associated with survival status of second birth at the neonatal, infant and under-5 year stages (p-value>0.05). It indicates that there is no sex preference in case of death of the first and second children at the neonatal, infant or under 5 stages. As we observe for the survival status of the second child is born at an age less than 20 years of a mother then the risk of death continues to increase at each stage, starting from neonatal to under-5 (p-value<0.01). It means that giving birth to the second baby at an age less than 20 years does not only increase the risk of dying of a child soon after delivery but the child has a significantly higher risk of dying until age 5. This is a very important finding with major policy implications. If the birth interval between the first and second birth is less than 18 months then the risk of death for the second birth increases sharply from 16.8 percent at the neonatal to 22.8 percent at the infant and 25.2 percent at the under 5 as compared to 2.2 percent at the neonatal to 3.2 percent at the infant and 5.0 percent at the under 5 stages for mothers with birth interval more than 36 months.

4.4 Bivariate Analysis of the Third Birth

Here we discuss the bivariate analysis of third birth of the subsequence birth of a mother’s.

Table 4.3: Percentage Distribution of Survival Status of the Third Child by Independent Variable

	Neonatal Survival			Infant Survival			Under-5 Year Survival		
Variables	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**	**Alive**	**Dead**	**p-value**
Sex of Second Child									
Male	96.3	3.7	0.585	93.6	6.4	0.187	91.6	8.4	0.143
Female	96.5	3.5		94.2	5.8		92.4	7.6	
Sex of Third Child									
Male	96.6	3.4	0.210	94.2	5.8	0.187	92.1	7.9	
Female	96.1	3.9		93.6	6.4		91.8	8.2	0.548
Mother's Age at Third Birth (Year)									
Less than 20	82.7	17.3	0.00***	69.2	30.8	0.00***	69.2	30.8	0.00***
Greater or Equal 20	96.5	3.5		94.0	6.0		92.1	7.9	
Second to Third Birth Interval (Month)									
Less than 18	85.0	15.0	0.00***	75.9	24.1	0.00***	74.7	25.3	0.00***
18 to 36	95.6	4.4		92.0	8.0		89.3	10.7	
More than 36	97.5	2.5		95.6	4.1		94.4	5.6	
*=significant at 10%				**= significant at 5%			***= significant at 1%		

Table 4.3 shows the bivariate relationships between survival status of the third birth during the neonatal, infant and under 5 stages by selected variables. It is observed, similar to Tables 4.2, that sex of the second and third children are not associated with survival status of second birth at the neonatal, infant and under-5 year stages (p-value>0.05). It indicates that there is no sex preference in case of death of the first and second children at the neonatal, infant or under-5 stages. Similar to the findings from

the survival status of the second child, we observe for the survival status of the third child too that if the third birth takes place at an age less than 20 years of a mother then the risk of death continues to increase at each stage, starting from neonatal to under 5 (p-value<0.01). It means that giving birth to the third baby at an age less than 20 years does not only increase the risk of death for a child soon after delivery but the child has a significantly higher risk of dying until age 5. This is a very important finding with major policy implications. If the birth interval between the second and third birth is less than 18 months then the risk of death for the third birth increases sharply from 15.0 percent at the neonatal to 24.1 percent at the infant and 25.3 percent at the under 5 as compared to 2.5 percent at the neonatal to 4.1 percent at the infant and 5.6 percent at the under 5 stages for mothers with birth interval more than 36 months.

Chapter: Five

Marginal Generalized Linear Model for Subsequent Birth

5.1 Introduction

We have discussed the bivariate analysis of child survival of the subsequence birth of mother's data set. In this chapter we discuss the marginal generalized linear model and will apply to the child survival data to investigate the factor influencing the survival of the subsequence child of a mother at the neonatal, infant and under-5 year period. We will review the marginal generalized linear model and the application of the model to the icddr,b data will be summarized. Survival Analysis of the subsequence birth of a mother by using marginal generalized linear model. Each of these again divided for the analysis at the neonatal, infant, under-5 year period and for the comparison among these periods.

5.2 Marginal Generalized Linear Model

In statistics, the generalized linear model (GLM) is a flexible generalization of ordinary linear regression that allows for response variables that have error distribution models other than a normal distribution. The GLM generalizes linear regression by allowing the linear model to be related to the response variable via a link function and by allowing the magnitude of the variance of each measurement to be a function of its predicted value.

Generalized linear models were formulated by Nelder and Wedderburn as a way of unifying various other statistical models, including linear regression, logistic regression and Poisson regression. They proposed an iteratively reweighted least squares method for maximum likelihood estimation of the model parameters. Maximum-likelihood estimation remains popular and is the default method on many statistical computing packages. Other approaches, including Bayesian approaches and least squares fits to variance stabilized responses, have been developed.

Generalized linear models cover all these situations by allowing for response variables that have arbitrary distributions (rather than simply normal distributions), and for an arbitrary function of the response variable (the link function) to vary linearly with the predicted values (rather than assuming that the response itself must vary linearly). For example, the case above of predicted number of beach attendees would typically be modeled with a Poisson distribution and a log link, while the case of predicted probability of beach attendance would typically be modeled with a Bernoulli distribution (or binomial distribution, depending on exactly how the problem is phrased) and a log-odds (or logit) link function.

An important aspect of the generalization is the presence of a linear predictor in all the models based on a linear combination of explanatory variables (continuous or categorical or both). Generalized linear models have a common algorithm for the estimation of parameters by maximum likelihood. The weighted least square method is applied here with an adjusted dependent variable and no preliminary guesses are required to be made of the parameter values. Since we are working with binary dependent variable survival of children, in this chapter we will review the generalized linear model with Logit link function for binomial responses.

5.2.1 Survival Analysis of the First Birth

Here we fit the marginal Generalized Linear Model for the neonatal survival of the first child followed by the infant and under-5 year period survival of the first child. After that, we compare the child survival at the three stages of the first birth order.

Neonatal Survival of the First Birth

According to WHO report the neonatal period of the survival child born to first 27 days. It is the most high risk period of the new born baby. And First birth child has highest risk of dying than any other birth order.

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the first birth at the neonatal period.

Table 5.1: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the First Child at the Neonatal Stage

Variables	Estimate	Odds Ratio	S.E	P- value
Constant	-3.168	0.042	0.089	0.00***
Sex of index Child				
Male	-0.048	0.953	0.104	0.64

Female (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	0.049	1.050	0.104	0.63
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

We find from the table that there is no significant association between the survival status of the first child at the neonatal stage and sex of the child (p>0.10). Also mother's age at birth shows no significant (p>0.10) association, first child cause of death does not depend on sex of the child and mother's age at neonatal stage.

Infant Survival of the First Birth

According to the definition, the infant period is the survival child first one year of life. It remains as a high risk period for the new born baby. The following table displays the estimates by the marginal generalized linear model for the survival of the first birth at the infant period.

Table 5.2: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the First Child at the Infant Stage

Variables	**Estimate**	**Odds Ratio**	**S.E**	**P- value**
Constant	-2.711	0.066	0.072	0.00***
Sex of index Child				
Male	0.051	1.052	0.084	0.545
Female (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	-0.017	0.983	0.084	0.840

Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

As expected, there is no significant association between the survival status of the first child at the Infant stage and sex of the child (p>0.10). Other side, mother's age at birth shows no significant (p>0.10) association, first child cause of death does not depend on sex of the child and mother's age at Infant stage.

Under-5 year Survival of the First Birth

According to the definition, the under-5 year period is the survival child first 5 years of life. The risk is lower than that of the neonatal and infant periods but still remains higher than the subsequent stages. The following table displays estimates by the marginal generalized linear model for the survival of the first birth at the under-5 year period.

Table 5.3: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the First Child at the Under-5 year Stage

Variables	**Estimate**	**Odds Ratio**	**S.E**	**P- value**
Constant	-2.453	0.086	0.064	0.00***
Sex of index Child				
Male	0.028	1.028	0.075	0.710
Female (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	-0.005	0.995	0.075	0.942
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

Similar to neonatal and infant stages, we find from the above table that there is no significant association between the survival status of the first child at the under-5 stage and sex of the child (p>0.10). However, mother's age at birth shows does not significantly associated (p>0.10) that means first child cause of death does not depend on sex of the child and mother's age at under-5 stage.

Comparison of the Neonatal Infant and Under 5 Years Survival for the First Birth

The following table summarizes the findings for the survival status of the first birth during the neonatal, infant and under-5 stages.

Table 5.4: Comparison of Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the First Child at the Neonatal, Infant and Under-5 year's Stage

Variables	**Neonatal Death**		**Infant Death**		**Under-5 year Death**	
	Odds Ratio	**p-value**	**Odds Ratio**	**p-value**	**Odds Ratio**	**p-value**
Constant	0.042	0.00***	0.066	0.00***	0.086	0.00***
Sex of index Child						
Male	0.953	0.64	1.052	0.545	1.028	0.71
Female (Ref)	1.00		1.00		1.00	
Mother's age at index birth (Year)						
Less than 20	1.050	0.63	0.983	0.840	0.995	0.942
Greater or Equal 20 (Ref)	1.00		1.00		1.00	
	*=significant at 10%		**=significant at 5%		***=significant at 1%	

A comparison of the odds ratios for mother's age, sex of first and second child are not associated of survival of first child at neonatal, infant and under 5 stage.

5.2.2 Survival Analysis of the Second Birth

Here we fit the marginal Generalized Linear Model for the neonatal survival of the second child followed by the infant and under-5 year period survival of the child. After that, we compare the child survival at the three stages of the second birth order.

Neonatal Survival of the Second Birth

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the second birth at the neonatal period.

Table 5.5: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Second Child at the Neonatal Stage

Variables	Estimate	Odds Ratio	S.E	P-value
Constant	-3.821	0.022	0.121	0.00***
Sex of Previous Child				
Male	0.074	1.077	0.104	0.475
Female (Ref)		1.00		
Sex of index Child				
Male	-0.070	0.932	0.104	0.500
Female (Ref)		1.00		
First to Second Birth interval (Months)				
Less than 18	2.117	8.308	0.141	0.00***
18 to 36	0.626	1.871	0.129	0.00***
More than 36 (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	0.306	1.358	0.145	0.03**
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

Our findings indicate that sex of the first and second children does not show significant association with the survival status of the second child at the neonatal stage. However, mother's age at birth shows significant ($p<0.05$) association, odds being much higher for the mothers giving birth at age less than 20 years (1.36) as compared to that of mothers giving birth at an age greater than 20 years. On the other side, first to second birth interval at birth shows significant ($p<0.01$) association, odds being much higher for the mothers giving birth at birth interval less than 18 months (8.3) and birth interval 18 to 36 months (1.8) as compared to that of mothers giving birth at birth interval more than 36 months at the neonatal stage.

Infant Survival of the Second Birth

According to the definition, the infant period is the survival child second one year of life. It remains as a high risk period for the second child. The following table displays the estimates by the marginal generalized linear model for the survival of the second birth at the infant period.

Table 5.6: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Second Child at the Infant Stage

Variables	**Estimate**	**Odds Ratio**	**S.E**	**P-value**
Constant	-3.369	0.034	0.099	0.00***
Sex of Previous Child				
Male	0.070	1.072	0.086	0.418
Female (Ref)		1.00		
Sex of index Child				
Male	-0.133	0.875	0.086	0.123
Female (Ref)		1.00		
Previous Birth interval (Months)				
Less than 18	2.136	8.468	0.120	0.00***

18 to 36	0.731	2.077	0.104	0.00***
More than 36 (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	0.134	1.143	0.128	0.298
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

We found from the above table that sex of the first and second children are not significantly associated with the survival status of the second child at the infant stage. We observed that mother's age at birth does not show significant (p>0.10) association but odds being much higher for the mothers giving birth at age less than 20 years (1.14) as compared to that of mothers giving birth at an age greater than 20 years. However, first to second birth interval at birth shows significant (p<0.01) association, odds being much higher for the mothers giving birth at birth interval less than 18 months (8.4) and birth interval 18 to 36 months (2.0) as compared to that of mothers giving birth at birth interval more than 36 months at the infant stage.

Under-5 year Survival of the Second Birth

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the second birth at the neonatal period.

Table 5.7: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Second Child at the Under-5 year Stage

Variables	**Estimate**	**Odds Ratio**	**S.E**	**P-value**
Constant	-2.923	0.054	0.083	0.00***
Sex of Previous Child				
Male	0.032	1.032	0.075	0.672

Female (Ref)		1.00		
Sex of index Child				
Male	-0.087	0.917	0.075	0.248
Female (Ref)		1.00		
Previous Birth interval (Months)				
Less than 18	1.822	6.184	0.108	0.00***
18 to 36	0.627	1.872	0.087	0.00***
More than 36 (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	0.124	1.132	0.117	0.292
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

As expected that similar to the Table 5.6, sex of the first and second children are no significant association with the survival status of the second child at the under-5 stage. It is observe that mother's age at birth does not show also significant ($p>0.10$) association but odds being higher for the mothers giving birth at age less than 20 years (1.13) as compared to that of mothers giving birth at an age greater than 20 years. However, first to second birth interval at birth shows significant ($p<0.01$) association, odds being much higher for the mothers giving birth at birth interval less than 18 months (6.1) and birth interval 18 to 36 months (1.8) as compared to that of mothers giving birth at birth interval more than 36 months at the infant stage.

Comparison of the Neonatal Infant and Under 5 Years Survival for the Second Birth

Table 5.8: Comparison of Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Second Child at the Neonatal, Infant and Under-5 year's Stage:

Variables	**Neonatal Death**		**Infant Death**		**Under-5 year Death**	
	Odds Ratio	**p-value**	**Odds Ratio**	**p-value**	**Odds Ratio**	**p-value**
Constant	0.022	0.00***	0.034	0.00***	0.054	0.00***
Sex of Previous Child						
Male	1.077	0.475	1.072	0.41	1.032	0.672
Female (Ref)	1.00		1.00		1.00	
Sex of index Child						
Male	0.932	0.50	0.875	0.093	0.917	0.248
Female (Ref)	1.00		1.00		1.00	
Preceding Birth interval (Months)						
Less than 18	8.308	0.00***	8.468	0.00***	6.182	0.00***
18 to 36	1.871	0.00***	2.077	0.00***	1.872	0.00***
More than 36 (Ref)	1.00		1.00		1.00	
Mother's age at index birth (Year)						
Less than 20	1.358	0.00***	1.143	0.298	1.132	0.292
Greater or Equal 20 (Ref)	1.00		1.00		1.00	
*=significant at 10%			**=significant at 5%		***=significant at 1%	

A comparison of the odds ratios for mother's birth interval less than 18 months as compared to the mother's birth interval 18 to 36 month and more than 36 months that the odds remain more than 8 for the second birth of not surviving at the neonatal and infant stages which reduces slightly less than 6 at the under 5 stage. In other words, if the birth takes place to mother's birth interval at less than 18 months then there is eight times risk of dying starting from neonatal and infant stages and remain very high at under 5 stages too.

5.2.3 Survival Analysis of the Third Birth

Here we fit the marginal Generalized Linear Model for the neonatal survival of the Third child followed by the infant and under-5 year period survival of the child. After that, we compare the child survival at the three stages of the third birth order.

Neonatal Survival of the Third Birth

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the third birth at the neonatal period.

Table 5.9: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Third Child at the Neonatal Stage

Variables	Estimate	Odds Ratio	S.E	P-value
Constant	-3.595	0.027	0.111	0.00***
Sex of Previous Child				
Male	0.038	1.038	0.111	0.734
Female (Ref)		1.00		
Sex of index Child				
Male	-0.162	0.850	0.111	0.143
Female (Ref)		1.00		
Preceding Birth interval (Months)				
Less than 18	1.862	6.436	0.162	0.00***
18 to 36	0.564	1.757	0.122	0.00***
More than 36 (Ref)		1.00		
Mother's age at index birth (Year)				

Less than 20	0.746	2.109	0.392	0.05**
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

We found from the above table that sex of the first and second children are not significantly associated with the survival status of the second child at the under-5 stage. However, mother's age at birth shows significant (p<0.05) association, odds being much higher for the mothers giving birth at age less than 20 years (2.1) as compared to that of mothers giving birth at an age greater than 20 years. On the other hand, first to second birth interval at birth shows significant (p<0.01) association, odds being much higher for the mothers giving birth at birth interval less than 18 months (6.4) and birth interval 18 to 36 months (1.7) as compared to that of mothers giving birth at birth interval more than 36 months at the under-5 stage.

Infant Survival of the Third Birth

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the second birth at the neonatal period.

Table 5.10: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Third Child at the Infant Stage

Variables	Estimate	Odds Ratio	S.E	P- value
Constant	-3.141	0.043	0.088	0.00***
Sex of Previous Child				
Male	0.098	1.103	0.087	0.257
Female (Ref)		1.00		
Sex of index Child				
Male	-0.141	0.869	0.087	0.105
Female (Ref)		1.00		
Preceding Birth interval (Months)				

Less than 18 (Ref)	1.939	6.954	0.133	0.00***
18 to 36	0.709	2.032	0.094	0.00***
More than 36		1.00		
Mother's age at index birth (Year)				
Less than 20	0.959	2.609	0.323	0.03**
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

From the above table, it is similar to Table 5.9 that sex of the first and second children are not significantly (p>0.10) associated with the survival status of the second child at the infant stage. However, mother's age at birth shows significant (p<0.05) association, odds being much higher for the mothers giving birth at age less than 20 years (2.6) as compared to that of mothers giving birth at an age greater than 20 years. On the other hand, first to second birth interval at birth shows significant (p<0.01) association, odds being much higher for the mothers giving birth for birth interval less than 18 months (6.9) and birth interval 18 to 36 months (2.0) as compared to that of mothers giving birth at birth interval more than 36 months at the infant stage.

Under-5 year Survival of the Third Birth

The following table obtained estimate by Marginal Generalized Linear Model for the survival of the second birth at the neonatal period.

Table 5.11: Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Third Child at the Under-5 year Stage

Variables	**Estimate**	**Odds Ratio**	**S.E**	**P- value**
Constant	-2.850	0.058	0.077	0.00***
Sex of Previous Child				
Male	0.104	1.110	0.076	0.172
Female (Ref)		1.00		

Sex of index Child				
Male	-0.065	0.937	0.076	0.397
Female (Ref)		1.00		
Preceding Birth interval (Months)				
Less than 18	1.686	5.397	0.076	0.00***
18 to 36	0.725	2.064	0.082	0.00***
More than 36 (Ref)		1.00		
Mother's age at index birth (Year)				
Less than 20	0.770	2.159	0.317	0.01***
Greater or Equal 20 (Ref)		1.00		
*=significant at 10%	**= significant at 5%		***= significant at 1%	

It is observed, similar to Table 5.9 and 5.10, that sex of the first and second children are not significantly ($p>0.10$) associated with the survival status of the second child at the under-5 stage. However, mother's age at birth shows significant ($p<0.05$) association, odds being much higher for the mothers giving birth at age less than 20 years (2.1) as compared to that of mothers giving birth at an age greater than 20 years. It is also observed that first to second birth interval at birth shows significant association ($p<0.01$) odds being much higher for the mothers giving birth at birth interval less than 18 months (5.3) and birth interval 18 to 36 months (2.0) as compared to that of mothers giving birth at birth interval more than 36 months at the under-5 stage.

Comparison of the Neonatal Infant and Under 5 Years Survival for the First Birth:

Table 5.12: Comparison of Estimates of Parameter from Marginal Generalized Linear Model for the Survival of the Third Child at the Neonatal, Infant and Under-5 year's Stage:

Variables	**Neonatal Death**		**Infant Death**		**Under-5 year Death**	
	Odds Ratio	**p-value**	**Odds Ratio**	**p-value**	**Odds Ratio**	**p-value**
Constant	0.027	0.00***	0.043	0.00***	0.058	0.00***
Sex of Previous Child						
Male	1.038	0.734	1.103	0.257	1.110	0.172
Female (Ref)	1.00		1.00		1.00	
Sex of index Child						
Male	0.850	0.143	0.869	0.105	0.937	0.397
Female (Ref)	1.00		1.00		1.00	
Preceding Birth interval (Months)						
Less than 18	6.436	0.00***	6.954	0.00***	5.397	0.00***
18 to 36	1.757	0.00***	2.032	0.00***	2.064	0.00***
More than 36 (Ref)	1.00		1.00		1.00	
Mother's age at index birth (Year)						
Less than 20	2.109	0.05**	2.609	0.03**	2.159	0.01***
Greater or Equal 20 (Ref)	1.00		1.00		1.00	
*=significant at 10%			**=significant at 5%		***=significant at 1%	

A comparison of the odds ratios for mother's age less than 20 years as compared to the mother's age greater than or equal to 20 years that the odds remain more than 2 for the third birth of not surviving at the neonatal, infant and under 5 stages. In other words, if the birth takes place to mothers at an age less than 20 years then there is two times risk of dying starting from birth to neonatal stages. Also comparison of the odds ratios from birth interval less than 18 months to birth interval 18 to 36 and more than 36 months. The birth interval less than 18 months odds remain more than 6 for the third birth of not surviving at the neonatal and infant stage which reduces slightly less than 6 at the under 5 stage. And the birth interval 18 to 36 months odds remain more than 2 for the third birth of not surviving at the infant and under 5 stage which reduces slightly less than 2 at the neonatal stage. In other words, if the birth interval takes place to mothers at less than 18 months then there is six times risk of dying starting from birth to under 5 stages and birth interval takes place to mothers at 18 to36 months then there is two times risk of dying starting from birth to neonatal stages.

Chapter: Six

GBBM & MGLM Analysis for Subsequent Birth

6.1 Introduction:

Previous chapter, we have analyzed the survival of first, second and third child by using marginal generalized linear model. If there is correlation between the survivals of successive child than the findings obtained from marginal model may not portray the situation correctly. In that case, we apply conditional model where we will analyze the survival of current child under the condition of survival of previous child. To deals with this type of correlation problem, Islam et al (2013) proposed a Generalized Bivariate Bernoulli Model from which we can obtain the conditional estimate. They also proposed a test to test the dependence of event in two successive time point by using these conditional estimates.

6.2 Conditional and Marginal Estimates of Parameters for Second birth at Neonatal Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation second child at neonatal stage.

Table 6.1: Conditional and Marginal Estimates of Parameters for the Survival of the Second Birth at the Neonatal Stage obtained from GBBM and MGLM

Conditional Model							**Marginal Model**		
Variables	**Model $\hat{\beta}_{01j}$**			**Model $\hat{\beta}_{11j}$**			**Model $\hat{\beta}_{.1j}$**		
	$\hat{\beta}_{01j}$	**S.E**	**p-value**	$\hat{\beta}_{11j}$	**S.E**	**p-value**	$\hat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-3.889	0.1265	0.00***	-2.4004	0.4348	0.00***	-3.821	0.121	0.00***
Sex of Previous Child									
Male	0.0754	0.1088	0.488	0.077	0.3578	0.828	0.074	0.104	0.511
Female (Ref)									
Sex of Index Child									
Male	-0.0444	0.1085	0.682	-0.345	0.3600	0.336	-0.070	0.104	0.500
Female (Ref)									
Preceding Birth interval (Months)									

Less than 18	2.230	0.1488	0.00***	0.4671	0.4753	0.325	2.117	0.141	0.00***
18 to 36	0.6546	0.1333	0.00***	-0.1457	0.4897	0.765	0.626	0.129	0.00***
More than 36 (Ref)									
Mother's age at index birth (Year)									
Less than 20	0.2792	0.1544	0.07*	0.4252	0.4324	0.325	0.306	0.145	0.03**
Greater or Equal 20 (Ref)									
Chi-square test	**18.44003**								
*=significant at 10%			**= significant at 5%				***= significant at 1%		

6.3 Conditional Survival Analysis of the second child at the Neonatal period

The table 6.1, shows that the estimates obtained by the application of Generalized Bivariate Bernoulli Model (GBBM) for the conditional survival of the second child at the neonatal period under the condition of first child survival at the neonatal period.

Table 6.1, observed that marginal estimation obtained from Marginal Generalized Linear Model (MGLM) for the survival of the second child at the neonatal period.

Here,

$\hat{\beta}_{01j}$ = Estimate for the log of odds of occurring neonatal death of the second child under the condition that the first child was alive at the neonatal period with respect to the covariate j.

$\hat{\beta}_{11j}$ = Estimate for the log of odds of occurring neonatal death of the second child under the condition that the first child was died at the neonatal period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring neonatal death of the second child with respect to the covariate j.

6.3.1 Interpretation of the Estimates

From Table 6.1 shows that conditional and marginal estimation of parameters for the survival of the second birth at the neonatal stage. It is observed that sex of the first and second children are not significantly associated ($p>0.10$) with conditional and marginal models of the second children at the neonatal stage. This result indicates that there is no sex preference in case of death of second child at neonatal stage. As we observed mothers age of second children is significant association ($p<0.10$) with both marginal and conditional models of survival status at the neonatal stage. It is observed that preceding birth interval shows significantly associated ($p<0.01$) with both conditional and marginal models of the second child at neonatal stage. These results indicate that mother's age less than 20 years and mother's birth interval less than 18 months or 18 to 36 months for the survival status of the second child are significantly associated in both conditional and marginal models of survival status at neonatal stage.

6.3.2 Test for the Dependence of the Neonatal Survival of First and Second Birth

In this section we will show the hypothesis, result and interpretation of the test for dependence of the neonatal survival of the second child on the neonatal survival of the first birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of neonatal births for the first and second births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive first two births at neonatal stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the neonatal survival of the first and second birth the test statistic is

$$\chi^2=(\hat{\beta}_{01}-\hat{\beta}_{11})'[Var(\hat{\beta}_{01}-\hat{\beta}_{11})']^{-1}(\hat{\beta}_{01}-\hat{\beta}_{11})$$

=18.44003

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0. 00<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, neonatal survival of the second child depends on the neonatal survival of the first child.

6.4 Conditional and Marginal Estimates of Parameters for Second birth at Infant Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation second child at Infant stage.

Table 6.2: Conditional and Marginal Estimates of Parameters for the Survival of the Second Birth at the Infant Stage obtained from GBBM and MGLM

	Conditional Model						Marginal Model		
Variables	**Model $\hat{\beta}_{01j}$**			**Model $\hat{\beta}_{11j}$**			**Model $\hat{\beta}_{.1j}$**		
	$\hat{\beta}_{01j}$	**S.E**	**p-value**	$\hat{\beta}_{11j}$	**S.E**	**p-value**	$\hat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-3.419	0.103	0.00***	-2.4193	0.3549	0.00***	-3.369	0.099	0.00***
Sex of Previous Child									
Male	0.078	0.091	0.390	0.0521	0.2795	0.852	0.070	0.086	0.418
Female (Ref)									
Sex of Index Child									
Male	-0.14	0.091	0.01**	-0.0207	0.2777	0.940	-0.133	0.086	0.123

Female (Ref)									
Preceding Birth interval (Months)									
Less than 18	2.358	0.128	0.00***	0.3967	0.3747	0.02**	2.136	0.120	0.00***
18 to 36	0.778	0.108	0.00***	-0.1693	0.3769	0.653	0.731	0.104	0.00***
More than 36 (Ref)									
Mother's age at index birth (Year)									
Less than 20	0.077	0.138	0.577	0.4017	0.3509	0.252	0.134	0.128	0.298
Greater or Equal 20 (Ref)									
Chi-square test	**25.9370**								
*=significant at 10%		**= significant at 5%				***= significant at 1%			

6.5 Conditional Survival Analysis of the Second Child at the Infant period

Table 6.2 Shows that the estimates obtained by the application of the Generalized Bivariate Bernoulli Model (GBBM) for the Second Child at the infant period under the condition of first child at the infant period. This table also shows that the marginal estimates obtained from the Marginal Generalized Linear Model (MGLM) for the survival of the second child at the infant period.

Here,

$\hat{\beta}_{01j}$ = Estimate for the log of odds of occurring infant death of the second child under the condition that the first child was alive at the infant period with respect to the covariate j.

$\hat{\beta}_{11j}$ = Estimate for the log of odds of occurring infant death of the second child under the condition that the first child was died at the infant period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring infant death of the second child with respect to the covariate j.

6.5.1 Interpretation of the Estimation

From Table 6.2 shows that conditional and marginal estimation of parameters for the survival of the second birth at the infant stage. It is observed that sex of the first and second children does not significantly associated ($p>0.10$) with conditional and marginal models of the second children at the infant stage. That means there has no sex preference in risk of death of second child at infant stage. As we observed mother's age of second children does not significant association ($p>0.10$) with both marginal and conditional models of survival status at the infant stage. So, these results indicate that mothers birth age less than 20 years of second child of risk of death are not associated with both conditional and marginal models of survival status at infant stage. However, preceding birth interval shows significantly associated ($p<0.01$) with both conditional and marginal models of the second child at infant stage. This result indicate that mothers birth interval less than 18 months or 18 to 36 months for the survival status of second child of risk of death are associated with both conditional and marginal models of survival status at infant stage.

6.5.2 Test for the Dependence of the Infant Survival of First and Second Birth

Here we will obtain the hypothesis, result and interpretation of the test for dependence of infant survival of the second child on the neonatal survival of the first birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of infant births for the first and second births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive first two births at infant stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the Infant survival of the first and second birth the test statistic is

$$\chi^2 = (\hat{\beta}_{01} - \hat{\beta}_{11})' [Var(\hat{\beta}_{01} - \hat{\beta}_{11})']^{-1} (\hat{\beta}_{01} - \hat{\beta}_{11})$$

=25.9370

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0. 00<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, infant survival of the second child depends on the infant survival of the first child.

6.6 Conditional and Marginal Estimates of Parameters for Second birth at Under-5 years Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation second child at under-5 year's stage.

Table 6.3: Conditional and Marginal Estimates of Parameters for the Survival of the Second Birth at the Under-5 year Stage obtained from GBBM and MGLM

	Conditional Model						**Marginal Model**		
Variables	**Model $\hat{\beta}_{01j}$**			**Model $\hat{\beta}_{11j}$**			**Model $\hat{\beta}_{.1j}$**		
	$\hat{\beta}_{01j}$	**S.E**	**p-value**	$\hat{\beta}_{11j}$	**S.E**	**p-value**	$\hat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-2.9546	0.0866	0.00***	-2.4230	0.2988	0.00***	-2.923	0.083	0.00***
Sex of Previous Child									
Male	0.0527	0.0798	0.50	-0.0969	0.2346	0.67	0.032	0.075	0.672
Female (Ref)									
Sex of Index Child									

Male	-0.0976	0.0797	0.22	-0.0222	0.2337	0.92	-0.087	0.075	0.248
Female (Ref)									
Preceding Birth interval (Months)									
Less than 18	2.0293	0.1165	0.00***	0.6678	0.3306	0.04**	1.822	0.108	0.00***
18 to 36	0.6460	0.0909	0.00***	0.2498	0.3125	0.42	0.627	0.087	0.00***
More than 36 (Ref)									
Mother's age at index birth (Year)									
Less than 20	0.080	0.1280	0.53	0.2946	0.3043	0.33	0.124	0.117	0.292
Greater or Equal 20 (Ref)									
Chi-square test	**19.5585**								
*=significant at 10%			**= significant at 5%			***= significant at 1%			

6.7 Conditional survival Analysis of the Second Child at Under-5 year period:

The table shows that the estimate obtained by the application of Generalized Bivariate Bernoulli Model (GBBM) for the conditional survival of the second child at the under- 5 year period under the condition of the first child survival at the Under-5 year period. Table also shows that the marginal estimates obtained from Marginal Generalized Linear Model (MGLM) for the survival of the second child at the under-5 period.

Here,

$\hat{\beta}_{01j}$ = Estimate for the log of odds of occurring under-5 year death of the second child under the condition that the first child was alive at the under-5 year period with respect to the covariate j.

$\hat{\beta}_{11j}$ = Estimate for the log of odds of occurring under-5 year death of the second child under the condition that the first child was died at the under-5 year period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring under-5 year death of the second child with respect to the covariate j.

6.7.1 Interpretation of the Estimation

Table 6.3 shows that sex of the first and second children does not significantly associated ($p>0.10$) with conditional and marginal models of the second children at the under-5 stage. That means there is no sex preference in case of death of second child at under-5 stage. As we observed mothers age of second children does not significant association ($p>0.10$) with both marginal and conditional models of survival status at the under-5 stage. So, these results indicate that mother's birth age less than 20 years of second child of risk of death are not associated with both conditional and marginal models of survival status at under-5 stage. However, preceding birth interval shows significantly associated ($p<0.01$) with both conditional and marginal models of the second child at under 5 stage. This result indicate that mothers birth interval less than 18 months or 18 to 36 months of second child of risk of death are associated with both conditional and marginal models of survival status at under 5 stage.

6.7.2 Test for the Dependence of the Under-5 year Survival of First and Second Birth

Here we will obtain the hypothesis, result and interpretation of the test for dependence of under-5 year survival of the second child on the neonatal survival of the first birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of under-5 year births for the first and second births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive first two births at under-5 stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the under-5 year survival of the first and second birth the test statistic is

$$\chi^2 = (\hat{\beta}_{01} - \hat{\beta}_{11})' [Var(\hat{\beta}_{01} - \hat{\beta}_{11})']^{-1} (\hat{\beta}_{01} - \hat{\beta}_{11})$$

$$=19.5585$$

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0. 000<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, under-5 year survival of the second child depends on the under-5 year survival of the first child.

6.8 Conditional and Marginal Estimates of Parameters for Third birth at Neonatal Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation third child at neonatal stage.

Table 6.4: Conditional and Marginal Estimates of Parameters for the Survival of the Third Birth at the Neonatal Stage obtained from GBBM and MGLM

	Conditional Model						Marginal Model		
Variables	**Model $\hat{\beta}_{01j}$**			**Model $\hat{\beta}_{11j}$**			**Model $\hat{\beta}_{.1j}$**		
	$\hat{\beta}_{01j}$	**S.E**	**p-value**	$\hat{\beta}_{11j}$	**S.E**	**p-value**	$\hat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-3.6778	0.1167	0.00***	-2.3815	0.3528	0.00***	-3.595	0.111	0.00***
Sex of Previous Child									
Male	0.069	0.116	0.55	-0.1762	0.359	0.62	0.038	0.111	0.734

Female (Ref)									
Sex of Index Child									
Male	-0.147	0.1165	0.20	-0.3138	0.358	0.38	-0.162	0.111	0.143
Female (Ref)									
Preceding Birth interval (Months)									
Less than 18 (Ref)	1.839	0.178	0.00***	1.234	0.425	0.00***	1.862	0.162	0.00***
18 to 36	0.594	0.127	0.00***	-0.0056	0.4442	0.98	0.564	0.122	0.00***
More than 36									
Mother's age at index birth (Year)									
Less than 20	0.9867	0.422	0.01***	-0.4427	1.1001	0.68	0.746	0.392	0.05**
Greater or Equal 20 (Ref)									
Chi-square test	**20.056**								
*=significant at 10%			**= significant at 5%			***= significant at 1%			

6.9 Conditional survival Analysis of the Third Child at Neonatal period

The table shows that the estimate obtained by the using of application of Generalized Bivariate Bernoulli Model (GBBM) for the conditional survival of the third child at the neonatal period under the condition of the second child survival at the neonatal period. Table also shows that the marginal estimates obtained from Marginal Generalized Linear Model (MGLM) for the survival of the third child at the neonatal period.

Here,

$\hat{\beta}_{01j}$ = Estimate for the log of odds of occurring neonatal death of the second child under the condition that the second child was alive at the neonatal period with respect to the covariate j.

$\hat{\beta}_{11j}$ = Estimate for the log of odds of occurring neonatal death of the second child under the condition that the second child was died at the neonatal period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring neonatal death of the second child with respect to the covariate j.

6.9.1 Interpretation of the Estimates

From Table 6.4 shows that conditional and marginal estimation of parameters for the survival of the third birth at the neonatal stage. It is observed that sex of the second and third children does not significantly associated (p>0.10) with conditional and marginal models of the second children at the infant stage. That means there is no sex preference in case of death of second child at infant stage. As we observed that mothers age of third children significant (p<0.05) with both marginal and conditional models of survival status at the neonatal stage. So, these results indicate that mothers birth age less than 20 years of third child of risk of death are associated with both conditional and marginal models of survival status at neonatal stage. However, preceding birth interval shows significant association (p<0.01) with both conditional and marginal models of the third child at neonatal stage. This result indicate that mothers birth interval less than 18 months or 18 to 36 months for the survival status of the third child of risk of death are associated with both conditional and marginal models of survival status at neonatal stage.

6.9.2 Test for the Dependence of the Neonatal year Survival of Second and Third Birth

Here we will obtain the hypothesis, result and interpretation of the test for dependence of neonatal survival of the third child on the neonatal survival of the second birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of neonatal births for the second and third births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive second two births at neonatal stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the Neonatal survival of the first and second birth the test statistic is

$$\chi^2 = (\hat{\beta}_{01} - \hat{\beta}_{11})' [Var(\hat{\beta}_{01} - \hat{\beta}_{11})']^{-1} (\hat{\beta}_{01} - \hat{\beta}_{11})$$

$$=20.05694$$

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0.00<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, neonatal survival of the third child depends on the neonatal survival of the second child.

6.10 Conditional and Marginal Estimates of Parameters for Third birth at Infant Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation third child at infant stage.

Table 6.5: Conditional and Marginal Estimates of Parameters for the Survival of the Third Birth at the Infant Stage obtained from GBBM and MGLM

	Conditional Model						Marginal Model		
Variables	**Model $\widehat{\beta}_{01j}$**			**Model $\widehat{\beta}_{11j}$**			**Model $\widehat{\beta}_{.1j}$**		
	$\widehat{\beta}_{01j}$	**S.E**	**p-value**	$\widehat{\beta}_{11j}$	**S.E**	**p-value**	$\widehat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-3.194	0.0926	0.00***	-2.5002	0.2951	0.00***	-3.141	0.088	0.00***
Sex of Previous Child									
Male	0.0913	0.0914	0.31	0.2836	0.2835	0.31	0.098	0.087	0.257
Female (Ref)									
Sex of Index Child									
Male	-0.0955	0.0913	0.29	-0.5315	0.2891	0.06*	-0.141	0.087	0.105
Female (Ref)									
Preceding Birth interval (Months)									
Less than 18	2.0388	0.1469	0.00***	1.1849	0.3502	0.00***	1.939	0.133	0.00***
18 to 36	0.709	0.094	0.00***	0.2570	0.3354	0.33	0.7449	0.094	0.00***
More than 36 (Ref)									
Mother's age at index birth (Year)									
Less than 20	1.3473	0.3569	0.00***	-0.7967	1.074	0.45	0.959	0.323	0.003***
Greater or Equal 20 (Ref)									
Chi-square test	**14.89213**								
*=significant at 10%	**= significant at 5%			***= significant at 1%					

6.11 Conditional survival Analysis of the Third Child at Infant period

The table shows that the estimate obtained by the using of application of Generalized Bivariate Bernoulli Model (GBBM) for the conditional survival of the third child at the infant period under the condition of the second child survival at the infant period. Table also shows that the marginal estimates obtained from Marginal Generalized Linear Model (MGLM) for the survival of the third child at the infant period.

Here,

$\hat{\beta}_{01j}$ =Estimate for the log of odds of occurring infant death of the second child under the condition that the second child was alive at the infant period with respect to the covariate j.

$\hat{\beta}_{11j}$ =Estimate for the log of odds of occurring infant death of the second child under the condition that the second child was died at the infant period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring infant death of the second child with respect to the covariate j.

6.11.1 Interpretation of the Estimation

From Table 6.5 shows that sex of the second and third children are not associated ($p>0.10$) with conditional and marginal models of the third children at the infant stage. These results indicate that there is no sex preference in case of death of third child at infant stage. As we observed mothers age of third children significantly associated ($p<0.01$) with both marginal and conditional models of survival status at the infant stage. So, this result indicate that mothers birth age less than 20 years of third child of risk of death are associated with both conditional and marginal models of survival status at infant stage. Observed that preceding birth interval shows significantly associated ($p<0.01$) with both conditional and marginal models of the third child at infant stage. These results indicate that mother's birth interval less than 18 months or 18 to 36 months of third child for the survival status of risk of death are associated with both conditional and marginal models of survival status at infant stage.

6.11.2 Test for the Dependence of the Infant Survival of Second and Third Birth

Here we will obtain the hypothesis, result and interpretation of the test for dependence of infant survival of the third child on the infant survival of the second birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of infant births for the second and third births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive second two births at infant stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the Infant survival of the first and second birth the test statistic is

$$\chi^2 = (\hat{\beta}_{01} - \hat{\beta}_{11})' [Var(\hat{\beta}_{01} - \hat{\beta}_{11})']^{-1} (\hat{\beta}_{01} - \hat{\beta}_{11})$$

$$=14.89213$$

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0.00<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, infant survival of the third child depends on the infant survival of the second child.

6.12 Conditional and Marginal Estimates of Parameters for Third birth at Under-5 years Stage

We are using GBBM and MGLM for the conditional and marginal parameter estimation third child at under-5 year's stage.

Table 6.6: Conditional and Marginal Estimates of Parameters for the Survival of the Third Birth at the Under-5 year Stage obtained from GBBM and MGLM

Conditional Model							**Marginal Model**		
Variables	**Model $\widehat{\beta}_{01j}$**			**Model $\widehat{\beta}_{11j}$**			**Model $\widehat{\beta}_{.1j}$**		
	$\widehat{\beta}_{01j}$	**S.E**	**p-value**	$\widehat{\beta}_{11j}$	**S.E**	**p-value**	$\widehat{\beta}_{.1j}$	**S.E**	**p-value**
Constant	-2.9060	0.0819	0.00***	-2.3707	0.2436	0.00***	-2.850	0.077	0.00***
Sex of Previous Child									
Male	0.1041	0.0809	0.198	0.1543	0.2344	0.510	0.104	0.076	0.172
Female (Ref)									
Sex of Index Child									
Male	0.0050	0.0808	0.950	-0.6315	0.2429	0.00***	-0.065	0.076	0.397
Female (Ref)									
Preceding Birth interval (Months)									
Less than 18	1.772	0.1413	0.00***	1.2536	0.3206	0.00***	1.686	0.127	0.00***
18 to 36	0.7358	0.0860	0.00***	0.5258	0.2660	0.04**	0.725	0.082	0.00***
More than 36 (Ref)									
Mother's age at index birth (Year)									
Less than 20	1.1328	0.0348	0.01***	-0.8782	1.0698	0.411	0.770	0.317	0.01***
Greater or Equal 20 (Ref)									
Chi-square test	**14.19953**								
*=significant at 10%			**= significant at 5%			***= significant at 1%			

6.13 Conditional survival Analysis of the Third Child at Under-5 year period

The table shows that the estimate obtained by the using of application of Generalized Bivariate Bernoulli Model (GBBM) for the conditional survival of the third child at the under-5 year period under the condition of the third child survival at the under-5 year period. Table also shows that the marginal estimates obtained from Marginal Generalized Linear Model (MGLM) for the survival of the third child at the under-5 year period.

Here,

$\hat{\beta}_{01j}$ = Estimate for the log of odds of occurring under-5 year death of the second child under the condition that the second child was alive at the under-5 year period with respect to the covariate j.

$\hat{\beta}_{11j}$ = Estimate for the log of odds of occurring under-5 year death of the second child under the condition that the second child was died at the under-5 year period with respect to the covariate j.

$\hat{\beta}_{.1j}$ = Estimate for the log of odds of occurring under-5 year death of the second child with respect to the covariate j.

6.13.1 Interpretation of the Estimation

From Table 6.6, observed that sex of the second and third children does not significantly associated ($p>0.10$) with conditional and marginal models of the second children at the under 5 stage. So that, these results remained that there has no sex preference in risk of death of second child at infant stage. As we observed mothers age of third children significantly associated ($p<0.05$) with both marginal and conditional models of survival status at the under 5 stage. So, these results indicate that mothers birth age less than 20 years of third child of risk of death are associated with both conditional and marginal models of survival status at under 5 stage. However, preceding birth interval shows significant association ($p<0.01$) with both conditional and marginal models of the second child at under 5 stage. That means mothers birth interval less than 18 months or 18 to 36 months for the survival status of third child of risk of death are associated with both conditional and marginal models of survival status at under 5 stage.

6.13.2 Test for the Dependence of the Under-5 year Survival of Second and Third Birth

Here we will obtain the hypothesis, result and interpretation of the test for dependence of under-5 year survival of the third child on the under 5 survival of the third birth.

Hypothesis:

To test of these hypotheses of independence of the survival status of under-5 year births for the second and third births we have used the chi-square test statistic proposed by Islam et al (2013) which is given in chapter 3.

The null hypothesis for the independence of the survival status of the consecutive second two births at under-5 stage,

$$H_0: \beta_{01} = \beta_{11}$$

And the alternative is,

$$H_1: \beta_{01} \neq \beta_{11}$$

Test statistic:

To test the dependency of the Under-5 year survival of the second and third birth the test statistic is

$$\chi^2 = \left(\hat{\beta}_{01} - \hat{\beta}_{11}\right)' [Var\left(\hat{\beta}_{01} - \hat{\beta}_{11}\right)']^{-1} \left(\hat{\beta}_{01} - \hat{\beta}_{11}\right)$$

=14.1995

Which is distributed asymptotically as chi-square distributed with (p+1) =6 degrees of freedom. This shows that there is statistically significant between the survival status of the consecutive birth at neonatal stage (P-value=0.00)

Decision:

For the p-value=0.00<0.05, so that null hypothesis is not accepted at 5% level of significance. So we make the decision above the result that, under-5 year survival of the second child depends on the under-5 year survival of the first child.

Chapter: Seven

Conclusion

7.1 Introduction

The objective of the study is to identify the determinants of child survival at neonatal, infant and under-5 stages taking into account the dependence in study of child survival of consecutive births. In our study, we consider a mother who has consecutive first three births and apply the marginal, conditional and joint models.

7.2 Findings and Discussion

From the Demographic Surveillance System, Matlab, we have examined the survival status of the first three children at neonatal, infant and under-5 stages. Determinants of survival for the first three children considered were sex of child, mother's age at birth and birth interval. To analyze the survival status of the first three children we have used statistical models including the marginal, conditional and joint models. In marginal model, survival analysis of specific birth orders or combined analysis of all birth orders may provide misleading results. To overcome this problem, conditional or joint models can be applied for the child survival analysis. In this study we have used a joint model proposed by Islam et al (2013) which provides conditional estimates as well as marginal estimates of child survival analysis. The dependence between survivals of the consecutive births for first to second birth and second to third births are analyzed in this study. For all the models we have observed that there is no sex differential in the survival status of the children impact of the sex. On the other hand, mother's age is not found significant for the first child but appears to be significant for the second and third children. For all the models, the birth interval less than 18 months appears to have substantial impact on the survival status of the child. The tests for dependence of the survival status of the consecutive births indicate that the survival status of second birth depends on first birth and third birth depends on the second birth. It appears that age of mother at the time of giving birth and birth interval are significantly associated with survival status of the second and third children. The risk remains substantially high not only at neonatal stage but also at infant and under-5 stages.

7.3 Recommendations

We may suggest from our findings that if mother wanted an alive and healthy child then mothers needed to start their child bearing after the teenage to reduce the risk of death of children. In addition, they need to have children at large intervals particularly for the second and third births.

7.4 Conclusion

Here we have analyzed the survival of the successive first three births of a mother. We have taken into account dependence in the outcome variable and used Generalized Bivariate Bernoulli Model which provides conditional inference of the survival of the current child under the condition of survival of the previous child. This allows us to analyze the survival of successive births more precisely. We hope that the findings of this study obtained by using the joint methods will help the policy makers to understand the child survival mechanism more preciously.

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