Bivariate Generalized Bernoulli Model for Analyzing Dependence between Antenatal Care and Cesarean Section Births

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RECOMMENDATION

This is to certify that the thesis paper entitled **"Bivariate Generalized Bernoulli Model for Analyzing Dependence between Antenatal Care and Cesarean Section Births"** is an original research work, of Shafayatul Islam Shiblee, ID: 2016-1-82-003, Department of Applied Statistics, East West University, Dhaka, conducted under my supervision.

The undersigned certify that this thesis paper is suitable for submission.

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Declaration

I, hereby, certify that this thesis report entitled **“Bivariate Generalized Bernoulli Model for Analyzing Dependence between Antenatal Care and Cesarean Section Births”** submitted as a partial requirement for the degree of MSc 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.

Shafayatul Islam Shiblee

Signature: ______________________________

Date: __________________

To my parents and teachers, who guided me what to do
and to my friends, who are always with me to do so.

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Abstract

Cesarean section delivery can prevent maternal and child mortality effectively. However, if there is no medical necessity then it has no benefit. During the past two decades, cesarean delivery has been increasing alarmingly both in developed and developing countries. Along with clinical factors, Number of antenatal visits, Antenatal provider and Place of antenatal care has influence on the increase of cesarean section delivery. In this study, the dependence between antenatal care (i.e. number of antenatal visits, from whom received the antenatal and place of antenatal care) and cesarean section delivery is assessed along with some selected demographic-socioeconomic covariates by implying Generalized Bivariate Bernoulli Model. Bangladesh Demographic and Health Survey, 2014 is used in this study to illustrate the model. In this present study prevalence of cesarean delivery in Bangladesh is 24%, though this rate varies from 12.1% to 34.4% in different divisions. Women with advance age were more likely to have cesarean section (OR = 1.83, p-value = 0.01 and OR = 2.84, p-value = 0.03 respectively for age groups “20-34” and “35-49”). Though the risk was higher only if 4 or more than 4 antenatal visits were made and in case the care was received from qualified doctor then women aged 20-34 years likely to have higher risk of CS (OR = 1.79, p-value = 0.05). Higher risk of CS for this group was also found if antenatal care was received from public or private sector (OR = 1.83, p-value = 0.03) and if the care was received from home or NGO sector then women aged 35-49 years were more likely to have CS compared to those aged <20 years. Overweight and obese women risk of having CS delivery was higher compared to those with BMI level below normal and this higher risk was found if the care was received from qualified doctor and from Public or Private sector. If number of antenatal visits were 4 or more than 4, qualified doctor provided antenatal care and received from public or private sector then women living in Chittagong division were less likely to have cesarean section than those living in Barisal division. Women living in Khulna division were more likely to have CS if number of antenatal visit was no or less than 4 and the care was received from public or private sector. Women living in rural areas and with previous female child were less likely to have CS if antenatal care was received from qualified doctor and private or public sector. Women belonging to the higher economical class exposed with higher risk of CS. In case, if number of antenatal

visits was no or less than 4 and antenatal care was received from qualified doctor only then women with middle economical class were more likely to have CS otherwise not. Dependence was found between antenatal care and cesarean section, which implies how many antenatal visits were made, motive and influence of doctors and antenatal care providers and the place from where the care was received can instigate which type of delivery will be conducted. Interventionist should take proper steps to evaluate management from where women receive antenatal care, even the quality of antenatal care needs to be reviewed.

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Chapter 1

Introduction

1.1 Introduction

Cesarean section (CS), the surgical procedure of delivering baby through an incision in mother's abdominal and uterine, which is chosen as an alternate of vaginal delivery. CS is introduced as a lifesaving procedure for both mother and neonates, when they are at risk. But increased use of CS is continuing the concern about its risk with maternal and perinatal mortality and morbidity, especially when there is absence of medical reasons [1].

Cesarean section is supposed to be performed for medical indications, which includes labor and delivery abnormality, placental and cord abnormalities and repeat of CS delivery. But recently older ages of first time of mother, high birthweight prematurity and breech presentation [2], maternal request for CS in absence of medical reason have been added as common CS indications for performing CS [3]. Currently, to schedule a planned CS, to avoid the pain associated with labor, to diminish the risk of damaging the perineum are found to be reasons of maternal request for CS [4]. Although, fear of vaginal birth and desire of keeping sexual performance intact also indicates as the reasons of maternal request for CS instead of vaginal delivery [4].

The non-medical indications for CS have increased the risks in subsequent pregnancies (unexplained stillbirth, placenta accreta and percreta, placental abruption, decreased fertility, ectopic pregnancy and spontaneous abortion) and might also have increased infant morbidity (neonatal respiratory problems) and possible associations with childhood asthma, food allergies and childhood-onset type 1 diabetes. Even after high stand and practice complications of CS may be avoided successfully; the slower recovery, more time away from family and increased pain, put a psychological implication on mother [5].

In last few decades CS has increased both in developed and developing countries. Currently CS is the most performed surgery among women [6]. In 2012 about 23 million CS were done globally [7]. The global caesarean section (CS) rate is estimated as 15%, with CS rates over 20% in many developed countries, Latin America and the Caribbean [8]. In the United States, the rate has risen from 22.8% in 1993 to 31.8 % in 2007 [6, 9]. The rate in England increased from 21.5% in 2000 to 23.5% in 2006 [8]. In Brazil, it increased from 38% in 2000 to 52.3% in 2010 [6, 10] and across Latin American countries overall CS rates are 33% [8]. In China the rate nearly doubled in 1981 to 2008 (20.5%-39%) [9, 2]. In South Korea CS rate approached to 40% in 2000 [11]. These excessive rates are beyond the WHO recommended level of 15%, which costs approximately US $2.32 billion unnecessarily [12].

CS rate in Southern Asia is also rising rapidly. In India the CS rate has increased from 2.40% in 1992 to 8.37% in 2006 and in Pakistan the rate is 7.15%. But in these countries the rate of CS is comparatively higher in ‘urban richer’ people (21.75% and 14.97% respectively) [13]. Meanwhile, in Bangladesh the CS rate rose from 4% in 2004 to 23% in 2014 [14].

Although clinical determinant factors for cesarean delivery do not vary among the various countries of the world, the factors associated with increased cesarean rates are influenced by demographic and socioeconomic variables [6]. In Bangladesh, the rate of CS is high as 73% in private facilities [15] and 51.4% among richest wealth quantile women. High rate of CS is also observed among urban and higher educated women (56.8% and 51.2% respectively) [14]. Such high rates cannot be attributed as actions of a fraction of the obstetricians with private practice or prevalence in the population as usual medical indicators for CS [16]. This suggests that economic gain and pressures of private practice may motivate doctors to perform CS delivery in absence of medical indications [2]. However, sometimes doctors prefer CS for manageable and short timing as a defensive medical practice for fear of malpractice accusation [2]. Even such evidence that doctor’s preference put forward rather than directly from women themselves [16].

As knowledge and information about childbirth is obtained during pregnancy, antenatal Care (ANC) providers’ attitudes towards CS, from which type of place antenatal care is received and the number of antenatal visits are likely to be an important influence on women’s views in the process of choosing the type of delivery [2]. In this study the dependence between antenatal care (i.e. number of antenatal visits, from whom received the ANC and place ANC) and CS delivery along with some selected demographic-socioeconomic covariates are evaluated by implying Generalized Bivariate Bernoulli Model [17]. To assess the relationship we will be using data from BDHS 2014.

1.2 Objective

The main objectives of this study are:

1. To identify the risk factors associated with Cesarean Section, Number of Antenatal Visits, Place of Antenatal Care and Antenatal Care Provider: Qualified Doctor using marginal models.

3. To find out the conditional estimates of Cesarean Section by using the Conditional Logistic Regression Model for Number of Antenatal Visits.

4. To find out the conditional estimates of Cesarean Section by using the Conditional Logistic Regression Model for Place of Antenatal Care.

5. To find out the conditional estimates of Cesarean Section by using the Conditional Logistic Regression Model for Antenatal Care Provider: Qualified Doctor.

6. To test dependence between number of antenatal visits and caesarean-section (CS) by using Generalized Bivariate Bernoulli Model (GBBM).

7. To test dependence between Antenatal Care Provider: Qualified Doctor and caesarean-section (CS) by using Generalized Bivariate Bernoulli Model (GBBM).

8. To test dependence between Place of Antenatal Care and caesarean-section (CS) by using Generalized Bivariate Bernoulli Model (GBBM).

1.3 Organization of the Chapter

This study has been organized into seven chapters including different sections and sub-sections.

- **Chapter 1** consists of introductory discussion including literature review and objectives of the present study.
- **Chapter 2** consists the description of data and variables considered in the study, 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.
- **Chapter 3** consists of the background characteristics of the study. Here we have discussed the bivariate analysis of the variables.
- **Chapter 4** consists of the marginal models for identifying the risk factors associated with Cesarean Section, Number of Antenatal Visits, Place of Antenatal Care and Antenatal Care Provider: Qualified Doctor.
- **Chapter 5** consists of the conditional models of Cesarean Section under different condition of antenatal factors (i.e. number of antenatal visits, from whom received the ANC and place of ANC).
- **Chapter 6** consists of the test of dependence of between Antenatal Care and Cesarean Section births.
- **Chapter 7** consists of an overall discussion, summery of important findings and conclusion.

Chapter 2

Data and Methods

2.1 Introduction

In this chapter, the source of data and methods for analyzing dependence between antenatal care and cesarean section births, antenatal care includes number of antenatal visits are made, antenatal care provider qualified doctor or not and the place from where the care is received, along with some selected demographic-socioeconomic covariates is described.

2.2 Source of Data

All of the data that we used – retrospectively – came from Bangladesh Demographic and Health Survey (BDHS) 2014, which is nationally representative cross sectional household survey in which detailed birth histories for women of reproductive age are collected. This dataset that is used was downloaded from the MEASURE DHS website.

The 2014 Bangladesh Demographic and Health Survey (BDHS) is the seventh DHS undertaken in Bangladesh which was conducted under the authority of the National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare. The survey was implemented by Mitra and Associates, a Bangladeshi research firm located in Dhaka. ICF International of Rockville, Maryland, USA, provided technical assistance to the project as part of its international Demographic and Health Surveys (DHS) Program. The U.S. Agency for International Development (USAID) provided financial support.

2.3 Study Population

Among a total of 17,989 selected households, 17,565 were found to be eligible for the survey. Interviews were successfully completed of 17,300 households. A total of 18,245 ever-married women age 15-49 were identified in these households and 17,863 were interviewed. The principal reason for nonresponse among women was their absence from home despite repeated visits to the household.

In this present study information of the last birth (n=4626) in the three years preceding the survey were used.

2.4 Sample Design

The sample for the 2014 BDHS is nationally representative and covers the entire population residing in non-institutional dwelling units in the country. In 2014 Bangladesh is divided into seven administrative divisions: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet. Each division is divided into zilas, and each zila into upazilas. Each urban area in an upazila is divided into wards, which are further subdivided into mohallas. A rural area in an upazila is divided into union parishads (UPs) and, within UPs, into mouzas. These divisions allow the country as a whole to be separated into rural and urban areas.

The survey is based on a two-stage stratified sample of households. In the first stage, 600 EAs were selected with probability proportional to the EA size, with 207 EAs in urban areas and 393 in rural areas. A complete household listing operation was then carried out in all of the selected EAs to provide a sampling frame for the second-stage selection of households. In the second stage of sampling, a systematic sample of 30 households on average was selected per EA to provide statistically reliable estimates of key demographic and health variables for the country as a whole, for urban and rural areas separately, and for each of the seven divisions. With this design, the survey selected 18,000 residential households, which were expected to result in completed interviews with about 18,000 ever-married women.

2.5 Data Collection and Processing

Data processing were performed by Mitra and Associates. To perform this task Census and Survey Processing System (CSPro) was used.

2.6 Data Analysis

2.6.1 Variables and their Characteristics

This study is focused on whether women receiving four or more antenatal visits, receiving antenatal care from Public or Private sectors and receiving antenatal care from qualified doctor have influence on women for delivering child by caesarean section; while the exposure (predictor) variables used in the analysis are some sociodemographic and reproductive factors.

2.6.2 Dependent Variables

- Number of Antenatal Visits
- Place of Antenatal Care
- Antenatal Care Provider: Qualified Doctor
- Cesarean Section

Antenatal Care

Antenatal care (also known as prenatal care) provides information and educate a pregnant woman and her family on a variety of issues related to pregnancy, birth and parenthood. This includes both health care and childbirth education and counseling. The aim of good prenatal care is to detect any potential problems early, to prevent them if possible, and to direct the women to appropriate specialists or hospitals if necessary. Additionally, prenatal care can grant reassurance of wellbeing to a pregnant woman and her family while providing education and information. Community support and engagement for pregnant women is also important to improving outcomes. Early and regular prenatal care can increase the chances of having a healthy baby. The plan of antenatal care should take into consideration the medical, nutritional, psychosocial, and educational needs of the woman and her family [18].

Number of Antenatal Care Visits

The recommended number of Antenatal Care Visits depends on when Antenatal Care Visits was begun in the pregnancy. Several indices have been used to aid in identifying adequacy of Antenatal Care, with one of the most widely used ones being the Kotelchuck Adequacy of Prenatal Care Utilization (APNCU) Index. The APNCU compares the number of attended visits to the number of expected visits, as determined by ACOG recommendations (AAP 2012). The ACOG recommended standard schedule includes a visit before 14 weeks followed by visits every four weeks for the first 28 weeks, every two to three weeks until 36 weeks, and every week until delivery. More frequent visits are recommended if the patient is complicated by medical or obstetric issues such as gestational diabetes, hypertension or multiple gestation. Less frequent visits are acceptable for women at low risk for complications (AAP 2012). There has been a global trend toward de-medicalizing prenatal care which emphasizes less frequent visits for low-risk pregnant women. The WHO recommends only **four routine** antepartum visits over the course of pregnancy, with a plan for more frequent visits if that patient has hypertension, severe anemia, HIV or malaria [18].

In the questionnaire, for the last live birth in the three years preceding the BDHS 2014 survey, mothers were asked “How many times did you receive antenatal care during this pregnancy?”

For analysis, variable “M14$1” labeled as “Number of antenatal visits during pregnancy” in the dataset, recoded into two groups as if women receiving ANC visits four or more times then coded as “1” and if number of ANC visits zero or less than four then coded as “0”.

Antenatal Care Provider: Qualified Doctor

Antenatal care (ANC) from a medically trained provider is important to monitor the status of pregnancy, to identify the complications associated with the pregnancy and to prevent adverse pregnancy outcomes. To prevent adverse pregnancy outcomes or sometimes for economic gain and other purpose a doctor can suggest or influence a mother to have cesarean delivery instead of normal delivery.

In the questionnaire women were asked about, “Who provided the care?” among the answers first choice was whether the provider was “health professional/worker qualified doctor” or not.

In the BDHS 2014 dataset variable “M2A$1” labeled as “Prenatal: qualified doctor” which is recoded as “Antenatal Care Provider: Qualified Doctor” if yes than denoted as “1” and if not than denoted as “0”.

Place of Antenatal Care

The place where a woman receives antenatal care influences the frequency and quality of care received. As the knowledge and information about childbirth is obtained during pregnancy, place of antenatal care plays an important influence on women’s view.

As women may visited more than one type of facility for ANC during the same pregnancy in BDHS 2014 dataset, the categories are not mutually exclusive and do not sum to 100 percent.

In BDHS 2014 dataset variable “M57A$1”, “M57E$1” to “M57X$1” labeled as “Antenatal care:” which is recoded into “1” if Place of ANC is “Public or Private Sector” and “0” if Place of ANC is “respondent's home or NGO or Other”. The data is coded into such a way that if a woman has visited both place of ANC during pregnancy then she will be coded as “1”.

Cesarean Section

Cesarean section (CS), the surgical procedure by which a baby is delivered through an incision in mother’s abdominal and uterine.

In BDHS 2014 questionnaire women were asked, “Was (NAME) delivered by caesarean section, that is, did they cut your belly open to take the baby out?”. Which is the variable “V401” labeled as “Last birth a caesarean section” in the dataset and coded as binary variables if it was a cesarean case then coded as “1” and if not then coded as “0”.

2.6.3 Independent Variables

Clinical, demographic, socioeconomic and health service reasons for the rising rates have been extensively studied in recent literatures. There is a growing consensus that clinical factors alone cannot explain the increase of occurrence of CS. In recent studies following risk factors have been shown to be associated with CS delivery: Among socioeconomic factors—high income level, higher level of maternal education, private insurance, urban residence and rural residence; Among demographic and reproductive factors—older maternal age, maternal BMI, prim parity, previous miscarriages, previous stillbirth, low birthweight, high birthweight and among health service factors—delivery in private hospitals, delivery in non-teaching hospitals, high number of prenatal visits or early initiation of prenatal care, recently graduated physician, delivery assisted by a male physician, individual physician, board certified obstetrician, solo practice setting, antenatal care under an obstetrician working in the same hospital, request for CS by women and offer of CS by the obstetrician, delivery in daylight hours, delivery in the late afternoon and evening, at the end of office hours and delivery on Fridays [10].

In this study among the demographic, socioeconomic variables the selected Independent Variables are:

- Mother's age at birth
- BMI
- Division
- Highest educational level
- Type of residence
- Sex of previous Child
- Wealth Index

Mother's age at birth

In recent studies mother’s age has been found to be an important factor among the associate factors for CS [6, 9, 19 - 30].

In the dataset responses age was given at the time of interview. By using this code "gen agebt_deliv = int((b3 - v011)/12)" mother's age at last child birth have been generated. Then age was recorded into three categories as "<20", "20 – 34", "35-49" .

BMI

The body mass index (BMI) or Quetelet index is a value derived from the mass (weight) and height of an individual. The BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2, resulting from mass in kilograms and height in meters.

Table 2.1 Classification of maternal BMI and cutoffs for definition of maternal obesity

	BMI in kg/m^2
Underweight	<18·5
Normal	18·5–24·9
Overweight	25–29·9
Obese class I	30–34·9
Obese class II	35–39·9
Obese class III	≥40

In previous studies it has been found that maternal obesity increases the risk of cesarean delivery. [ref-26,27(44),44] In the current study BMI has been recoded into "Below Normal("1")", "Normal("2")" and "Above Normal("3")".

Division

The geographical factor has great impact on the outcome variables. In some areas CS rate may be less for the negative view and perception. Even in some areas there is low level of access to CS, which associated with extremely poor access to emergency surgical care in general. In BDHS 2014 survey Bangladesh is divided into seven administrative divisions: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet.

Highest educational level

Mother's highest educational level is an important factor. In the current study the education of the mother is recoded into "No education and Primary("0")" and "Secondary or Higher("1")".

Type of residence

Type of residence where the household resides as either urban or rural. Type of residence is coded as binary variable. Women living in Urban areas coded as “0” and if living in Rural areas then coded as “1”.

Sex of previous Child

Sex of previous child is binary coded. If sex of previous child is Male then coded as “0” and if female then coded as “1”.

Wealth Index

The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household’s ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. Generated with a statistical procedure known as principal components analysis, the wealth index places individual households on a continuous scale of relative wealth. DHS separates all interviewed households into five wealth quintiles to compare the influence of wealth on various population, health and nutrition indicators. The wealth index is presented in the DHS Final Reports and survey datasets as a background characteristic.

In this study this Wealth Index “V190” variable is recoded as, by merging “poorest” and “poorer” we have “poor” which is coded as “1”, “Middle” as “2” and merging “richer” and “richest” we have “rich” which is coded as “3”.

2.7 Statistical Analysis

This study is focused on whether there is dependence between antenatal care (i.e. number of antenatal visits, from whom received the ANC and place ANC) and CS delivery along with some selected demographic-socioeconomic covariates.

In this study we used four types of analysis. Firstly, **Chi-square (χ2)-statistics** was used to determine the bivariate relationship between the dependent and the explanatory variables.

Where the analysis took account of sampling weights. Secondly, we constructed marginal models to find out the association between the outcome variables and explanatory variables. The association was assessed with **logistic regression model**. Thirdly, we developed conditional models to assess the effect of the explanatory variables on CS under the condition of Number of Antenatal Care Visits whether "less than four" or "more than or equal to four" and whether "Antenatal Care Provider: Qualified Doctor" or not. For constructing the models we used **conditional logistic regression** through stratification of the dataset into subsets based on each of the three outcome variables (Number of Antenatal Care Visits, Antenatal Care Provider: Qualified Doctor). With each variable, we constructed two disjoint data strata whose union is identical to the original data set. We then fitted each data stratum with a **logistic regression model** and each time our outcome variable is Cesarean Section. Finally, dependence in outcome variables was tested by **Generalized Bivariate Bernoulli model** [17]. All of the data analyses were performed using R package version x64 3.3.2 and Statistical Package for the Social Sciences (SPSS) for Windows version 23.0 (Chicago, IL, USA).

2.8 Statistical Models

In this section, we discuss the methodology of this study. The conditional models, marginal models and joint models of conditional and marginal will be briefly discussed in this section.

2.8.1 Definition of the variables in the models

Number of Antenatal Visits to Cesarean Section

Y_1 = Number of antenatal visits

Y_2 = Cesarean Section

X_1 = Mother's age at birth

X_2 = BMI

X_3 = Division

X_4 = Highest education level

X_5 = Type of place of residence

X_6 = Sex of previous Child

X_7 = Wealth index

Antenatal Care Provider: Qualified Doctor to Cesarean Section

Y_1 = Antenatal Care Provider: Qualified Doctor

Y_2 = Cesarean Section

X_1 = Mother's age at birth

X_2 = BMI

X_3 = Division

X_4 = Highest education level

X_5 = Type of place of residence

X_6 = Sex of previous Child

X_7 = Wealth index

Place of Antenatal Care to Cesarean Section

Y_1 = Place of Antenatal Care

Y_2 = Cesarean Section

X_1 = Mother's age at birth

X_2 = BMI

X_3 = Division

X_4 = Highest education level

X_5 = Type of place of residence

X_6 = Sex of previous Child

X_7 = Wealth index

2.8.2 Generalized Linear Model

Generalized linear model (GLM) extend ordinary regression models to encompass non-normal response distributions and modeling functions of the mean [31]. It was originally introduced by Nelder and Wedderburn in 1972 to extend linear regression analysis with normal response variable to an exponential family of distribution including normal, binomial, Poisson, gamma, or inverse-Gaussian families of distributions.

Components of Generalized Linear Models

Consider a vector of observations $y = [y_1, y_2, \dots y_n]^T$ to be a realization of a random variable $Y = [Y_1, Y_2, \dots Y_n]^T$ where each Y_i is a one ‐ dimensional response to independent covariates $x_i = [x_{i1}, \dots x_{ip}]^T$. A generalized linear model (GLM) consists of three components [32].

1. Random component, Y_i, $1 \leq i \leq N$, assumed to be independent with probability density or mass function of the form [36]

$$f(y_i; \theta_i, \varphi) = e^{\frac{y_i\theta_i - b(\theta_i)}{a(\varphi)} + c(y_i, \varphi)} \tag{2.1}$$

For known a b and c if φ, called the dispersion parameter, is known then it becomes an exponential distributions with canonical parameter θ.

2. Systematic component, η_i, a linear function of covariates x_i given by

$$\begin{aligned} \eta_i &= x_i\beta \\ &= \sum_j x_{ij}\,\beta_j \end{aligned} \tag{2.2}$$

where $\beta = [\beta_0, \dots, \beta_p]^T$ are regression parameters.

3. Link function, g a monotonic function that links it to the linear predictor η_i with the mean μ_i.

$$\begin{aligned} g(\mu_i) &= \eta_i \\ &= \sum_j x_{ij}\,\beta_j \end{aligned} \tag{2.3}$$

It is called canonical link function if $\theta = \eta$.

Since the link function invertible, we may write

$$\mu_i = g^{-1}(\eta_i)$$

$$= g^{-1}(\sum_j x_{ij}\,\beta_j) \tag{2.4}$$

Thus, the GLM may be thought as a linear model for transformation of the expected response or as a nonlinear regression model for the response. The inverse link g^{-1} is also called the mean function.

The mean and variance of the random component Y_i can be easily found to be as under.

$$\mu_i = E(Y_i) = b'(\theta_i) \tag{2.5}$$

$$Var(Y_i) = b''(\theta_i)a(\varphi) \tag{2.6}$$

The variance of Y_i is the product of two factors. One is $b''(\theta)$ that depends on the canonical parameter, therefore on the mean and called the variance function, V The other, $a(\varphi)$ depending only on φ, commonly of the form $a(\varphi) = \varphi/w$, where w is a known prior weight that varies from observation to observation [32].

2.8.3 Logistic Regression Models

Logistic regression is a mathematical modeling approach that uses logit transformation to describe the relationship of several explanatory variables to a categorical dependent variable. If the categorical variable is dichotomous then the model is called Binary Logistic Regression.

Multiple Logistic Regression Model

Suppose we have a sample of n independent observations of the pair (X_i, Y_i), i=1,2,…,n. Where Y_i denotes the value of a dichotomous outcome variable, Cesarean section such that,

Y_i = 1, if type of delivery is Cesarean Section,

= 0, otherwise.

and

we suppose that, for each of the N individuals, k independent variables $X_1, X_2, \dots X_k$ are measured. These variables can either be qualitative such as sex, mothers age and birth interval etc. For i^{th} individuals we have the outcome Y_i and the vector of the covariates

$X_i = \begin{bmatrix} 1 & X_{11} & X_{12} & \cdots & X_{1p} \\ 1 & X_{21} & X_{22} & \cdots & X_{2p} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ 1 & X_{k1} & X_{k2} & \cdots & X_{kp} \end{bmatrix}$ Here, X_i is a $(K \times P)$ vector of K independent variables.

Thus the data for individual consist of the observation (Y_i, X_i).

The linear function of regression can be written as $Z_i = X_i\beta$, Here $i = l, \dots N$

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

$$\text{And } Z_i = X_i\beta = \begin{bmatrix} 1 & X_{11} & X_{12} & \cdots & X_{1p} \\ 1 & X_{21} & X_{22} & \cdots & X_{2p} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ 1 & X_{k1} & X_{k2} & \cdots & X_{kp} \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ . \\ . \\ \beta_p \end{bmatrix}$$

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

$$= \beta_0 + \sum \beta_i X_i$$

Now the probability of delivery method CS is

$$P(X) = P(Y = 1|X_1, X_2, \dots \dots X_k) = \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}$$

And the probability of delivery method not CS is,

$$1 - P(X) = P(Y = 0|X_1, X_2, \dots \dots X_k) = 1 - \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}} = \frac{1}{1 + e^{\beta_0 + \sum \beta_i X_i}}$$

The transformation of P(X) is the logit transformation. This transformation is defined, in terms of P(X), as follows:

logit P(X) = $\ln[\frac{P(X)}{1-P(X)}]$ = $\ln[\frac{e^{\beta_0 + \sum \beta_i X_i}/(1+e^{\beta_0 + \sum \beta_i X_i})}{1/(1+e^{\beta_0 + \sum \beta_i X_i})}]$ = $\ln[e^{\beta_0 + \sum \beta_i X_i}]$ = $\beta_0 + \sum \beta_i X_i$

Thus, the logit of P(X) simplifies to the linear sum of β_0 plus sum of $\beta_i X_i$ The importance of this transformation is that logit P(X) has many of the desirable properties of a linear regression model. The logit P(X) is linear in its parameters, may be continuous, and may range from $-\infty$ to ∞ , depending on the range of X.

Maximum Likelihood Estimation (MLE) of Parameters

The contribution to the likelihood function for the pair (X_i, Y_i), is through the term

$$L_i(X_i) = [P(X_i)]^{Y_i}[1 - P(X_i)]^{1-Y_i}$$

Since the observations are assumed to be independent, the likelihood function is obtained as the product of the terms given above:

$$L(\beta) = \prod_{i=1}^{n} L_i\,(X_i)$$

$$= \prod_{i=1}^{n} [\,P(X_i)]^{Y_i}[1 - P(X_i)]^{1-Y_i}$$

$$= \prod_{i=1}^{n} [\frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}]^{Y_i}[\frac{1}{1 + e^{\beta_0 + \sum \beta_i X_i}}]^{1-Y_i}$$

The log likelihood function is

$$\ln L(\beta) = \sum_{i=1}^{n} [\,y_i \ln \{\frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}\} + (1 - Y_i) \ln \{\frac{1}{1 + e^{\beta_0 + \sum \beta_i X_i}}\}]$$

$$= \sum_{i=1}^{n} [\,Y_i\{(\beta_0 + \sum \beta_i X_i) - \ln (1 + e^{\beta_0 + \sum \beta_i X_i})\} - (1 - Y_i) \ln (1 + e^{\beta_0 + \sum \beta_i X_i})]$$

$$= \sum_{i=1}^{n} [\,Y_i\{(e^{\beta_0 + \sum \beta_i X_i}) - \ln (1 + e^{\beta_0 + \sum \beta_i X_i})\}].$$

Differentiating with respect to β_0 and setting equal to zero, we obtain

$$\frac{\partial \ln L(\beta)}{\partial \beta_0} = \sum_{i=1}^{n} [\, Y_i - \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}] = 0$$

$$or, \sum_{i=1}^{n} [\, Y_i - P(X_i)] = 0$$

Similarly differentiating with respect to β_J where j=1,2…p and setting the equation equal to zero

$$\frac{\partial \ln L(\beta)}{\partial \beta_j} = \sum_{i=1}^{n} X_{ij} \, [Y_i - \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}] = 0$$

$$\sum_{i=1}^{n} X_{ij} \, [Y_i - P(X_i)] = 0 \ \text{ where j} = 1,2,..\text{p}$$

Solving the above equations, we obtain the estimates for β_0 and β_j .

Variances and covariances

The variances and covariances of the estimated coefficients can be obtained from:

$$I_{ju}^{*} = -\sum_{i=1}^{n} X_{ij} \, X_{iu} P_i (1 - P_i)$$

for j, $u = 0,1, \ldots, p$ where $P_j = P(X_j)$. Let $I_{ju} = (-1). I_{ju}^{*}$. Then the information matrix is defined by

$$I(\beta)$$

Where ju[th] element of $I(\beta)$ is I_{ju}.

The variances and covariances of the estimated coefficients are obtained from the inverse of the information matrix, i.e.

$$\Sigma(\beta) = I^{-1}(\beta)$$

where $\hat{\sigma}(\hat{\beta})$ is the j^th diagonal element of $\hat{\Sigma}(\beta)$ and $\hat{\sigma}(\hat{\beta},\hat{\beta})$ is the ju^th element of $\hat{\Sigma}(\beta)$. $\hat{\sigma}(\hat{\beta})$ is the variance of $\hat{\beta}$ and $\hat{\sigma}(\hat{\beta},\hat{\beta})$ is the estimated covariance of $\hat{\beta}$ and $\hat{\beta}$, and

$se\ (\hat{\beta}) = [\hat{\sigma}(\hat{\beta})]^{1/2}$

The information matrix can be expressed as

$$\hat{I}(\hat{\beta}) = X'VX$$

where X is an n x (p+l) matrix containing the data for each subject

$$X = \begin{bmatrix} 1 & X_{11} & \cdots & X_{1p} \\ 1 & X_{21} & \cdots & X_{2p} \\ \cdots & \iddots & \cdots & \vdots \\ \cdots & \iddots & \cdots & \vdots \\ 1 & X_{n1} & \cdots & X_{np} \end{bmatrix}$$

and

$$V = \begin{bmatrix} \hat{P}_1(1-\hat{P}_1) & 0 & \cdots & 0 \\ 0 & \hat{P}_2(1-\hat{P}_2) & \cdots & 0 \\ \cdots & \iddots & \cdots & \vdots \\ \cdots & \iddots & \cdots & \vdots \\ 0 & 0 & \cdots & \hat{P}_n(1-\hat{P}_n) \end{bmatrix}$$

Testing for the Significance of the Model

An approximate $100(1-\alpha)$ percent confidence interval for β_j can be obtained as

$$\hat{\beta} \pm z_{\alpha/2}\sqrt{I_{jj}^{-1}}$$

where $z_{\alpha/2}$ is the $100(1-\alpha/2)$ percentile of the standard normal distribution.

To test the hypothesis that some of the β_j' s are zero, a likelihood ratio test can be used.

For testing the null hypothesis

$$H_0: \beta_1 = \beta_2 = \ \beta_p = 0$$

we can use the test statistic

$$\chi^2 = -2[\ \ln L(\hat{\beta}) - \ \ln L(\hat{\beta}, \hat{\beta}, \dots \dots, \hat{\beta})].$$

An alternative test for the significance of the coefficients is the Wald test which uses the following test statistic:

$$W = \frac{\widehat{\beta_J}}{se(\widehat{\beta_J})}$$

which follows the standard normal distribution under the null hypothesis $H_0 : \beta_j = 0$.

Interpreting Coefficients As Odds Ratios

Then odds of occurrence of the method of delivery Cesarean Section for given X is

$$\frac{\hat{P}(X)}{1-\hat{P}(X)} = \frac{e^{\widehat{\beta}_0+\Sigma\widehat{\beta}_i X_i}/1+e^{\widehat{\beta}_0+\Sigma\widehat{\beta}_i X_i}}{1/1+e^{\widehat{\beta}_0+\Sigma\widehat{\beta}_i X_i}} \text{ Here, i= 1,2…k}$$

$$= e^{\widehat{\beta}_0+\Sigma\widehat{\beta}_i X_i}$$

The relative odds of occurrence of Cesarean delivery comparing those for whom X_1 is present ($X_1 = 1$) with those for whom X_1 is absent ($X_1 = 0$) is

Odds Ratio $= \frac{e^{\widehat{\beta}+\widehat{\beta}.\cdot 1+\widehat{\beta}X_2+\cdots+\widehat{\beta}X_k}}{e^{\widehat{\beta}+\widehat{\beta}0+\widehat{\beta}X_2+\cdots+\widehat{\beta}X_k}} = e^{\widehat{\beta}}$

And ln $OR = \hat{\beta}$.

The levels of X_2, X_3 ... X_k are same for both $X_1 = 0$ and $X_1 = 1$.

2.8.4 Generalized Bivariate Bernoulli Model: marginal-conditional approach

For the analysis of the longitudinal data the models were proposed on the basis of marginal and conditional approaches. Some joint models were considered as well but the models could not be made useful for limitations in estimating or interpreting the parameters of such models to real life data. **Islam et al. 2013** propose the model based on the marginal-conditional approach to obtain joint models [17].

Bivariate Bernoulli Distribution

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

$$P(Y_1 = y_1, Y_2 = y_2) = P_{00}^{(1-y_1)((1-y_2)} \, P_{01}^{(1-y_1)y_2} \, P_{10}^{y_1((1-y_2)} \, P_{11}^{y_1 y_2}. \tag{2.7}$$

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_{0+}
1	P_{10}	P_{11}	P_{1+}
	P_{+0}	P_{+1}	1

The joint probability can be obtained from the conditional and marginal probability as

$$P(Y_1 = y_1, Y_2 = y_2) = P(Y_2 = y_2 | Y_1 = y_1) P(Y_1 = y_1) \tag{2.8}$$

The bivariate probabilities as a function of covariates X are as follows:

$$P(Y_1 = y_1, Y_2 = y_2 | x) = P(Y_2 = y_2 | Y_1 = y_1; x) P(Y_1 = y_1 | x) \tag{2.9}$$

Generalized Bivariate Bernoulli Model

The joint probability mass function in Equation (2.7) can be demonstrated in terms of the exponential family for the general linear models as

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

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

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:

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

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.

Joint Model to obtain the test of dependence by Generalized Bivariate Bernoulli Model

Suppose we have a sample of n independent observations with dichotomous outcome variables $Y_1$and Y_2

Let, Y_1 = 1, if Number of Antenatal Care Visits,

= 0, otherwise.

Y_2 = 1, if type of delivery is Cesarean Section,

= 0, otherwise.

And, $X = (1, X_1, X_2, \dots \dots .. X_p)$ and $x = (1, x_1, x_2, .., x_p)$ Where $X^* = (1, X_1, X_2, \dots \dots .. X_p)$ and $x^* = (1, x_1, x_2, .., x_p)$ 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:

$$P(Y_2 = 1 | Y_1 = 0, x) = \frac{e^{X\beta_{01}}}{1+e^{X\beta_{01}}} = \pi_{01}(X) \tag{2.10}$$

$$P(Y_2 = 1 | Y_1 = 1, x) = \frac{e^{X\beta_{11}}}{1+e^{X\beta_{11}}} = \pi_{11}(X) \tag{2.11}$$

And

$$P(Y_2 = 1 | Y_1 = 0, x) = \frac{1}{1+e^{X\beta_{01}}} = \pi_{00}(X) \tag{2.12}$$

$$P(Y_2 = 1 | Y_1 = 1, x) = \frac{1}{1+e^{X\beta_{01}}} = \pi_{01}(X) \tag{2.13}$$

Where

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

The marginal probabilities are as follows:

$P(Y_1 = 1|X = x) = \pi_1(x)$, and $P(Y_1 = 0|X = x) = 1 - \pi_1(x)$ (2.14)

Now, we may assume that

$P(Y_1 = 1|x) = \frac{e^{X\beta_1}}{1+e^{X\beta_1}} = \pi_1(X)$ and $P(Y_1 = 0|x) = \frac{1}{1+e^{X\beta_1}} = 1 - \pi_1(X)$ (2.15)

Where

$\beta_1 = (\beta_{10}, \beta_{11}, \beta_{12}, \ldots \beta_{1p})'$

Also, we can write

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

$P_{00}(X) = P(Y_2 = 0|Y_1 = 0, X = x).P(Y_1 = 0|X = x) = \frac{1}{1+e^{x\beta_{01}}}\frac{1}{1+e^{x\beta_1}},$ (2.16)

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

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

The log-likelihood function can be rewrite as

$l_i = y_{1i}\,\eta_{2i} + y_{2i}\,\eta_{1i} + y_{1i}y_{2i}\eta_{3i} +\ \eta_{0i}$ (2.17)

Where,

$\eta_{0i} = ln(P_{00}(x)) = -ln\left(1 + e^{x_i\beta_{01i}}\right) - (1 + e^{e^{x_i\beta_{1i}}})$

$\eta_{1i} =\ ln(\frac{P_{01}(x)}{P_{00}(x)}) = e^{x_i\beta_{01i}}$

$\eta_{2i} =\ ln(\frac{P_{10}(x)}{P_{00}(x)}) = e^{x_i\beta_{1i}} +\ ln\ (1 + e^{x_i\beta_{01i}}) - In\ (1 + e^{x_i\beta_{11i}})$

$$\eta_{3i} = \ln\left(\frac{P_{00}(x)P_{11}(x)}{P_{01}(x)P_{10}(x)}\right) = x(\beta_{11} - \beta_{01})$$

Which indicates that if there is no association between Y_1 *and* Y_2 then $\eta_3 = 0$ and this is true for $\beta_{01} = \beta_{11}$. The conditional and marginal models provide the necessary background to obtain the test for dependence in the repeated outcome variables based on the above link function.

Estimation of Parameters

Newton-Raphson iterative technique can be used to estimate the parameters. The estimating equation for j $= 0,1,2\ldots$p are as follows:

$$\frac{\delta l}{\delta\beta_{01j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_S}\frac{\delta\eta_S}{\delta\beta_{01j}} \tag{2.19}$$

$$\frac{\delta l}{\delta\beta_{11j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_S}\frac{\delta\eta_S}{\delta\beta_{11j}} \tag{2.20}$$

And

$$\frac{\delta l}{\delta\beta_{1j}} = \sum_{i=1}^{n}\sum_{s=0}^{3}\frac{\delta l_i}{\delta\eta_S}\frac{\delta\eta_S}{\delta\beta_{1j}} \tag{2.21}$$

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

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

The score equations are:

$$U\left[\beta_j\right] = \left[\frac{\delta l}{\delta \beta_j}\right] = \begin{bmatrix} -\sum_{i=1}^{n} x_{ij}\,(1-y_{1i})[\pi_{01}(x_i) - y_{2i}] \\ -\sum_{i=1}^{n} x_{ij}\,y_{ij}[\pi_{11}(x_i) - y_{2i}] \\ -\sum_{i=1}^{n} x_{ij}\,[\pi_{1}(x_i) - y_{1i} \end{bmatrix} \text{where}, j = 0,1,2, \dots p$$

The second derivatives are shown below:

$$\left[\frac{\delta^2 l}{\delta \beta_j \delta \beta_{j'}}\right] = \begin{bmatrix} \frac{\delta^2 l}{\delta \beta_{01j} \delta \beta_{01j'}} \\ \frac{\delta^2 l}{\delta \beta_{11j} \delta \beta_{11j'}} \\ \frac{\delta^2 l}{\delta \beta_{1j} \delta \beta_{1j'}} \end{bmatrix} = \begin{bmatrix} -J_{11} & 0 & 0 \\ 0 & -J_{22} & 0 \\ 0 & 0 & -J_{33} \end{bmatrix} \quad \text{where } j, j' = 0,1,2 \dots p$$

Where,

$$J_{11} = \sum_{i=1}^{n} x_{ij}\, x_{ij'}(1-y_{1i})\pi_{01}(x_i)(1-\pi_{01}(x_i))$$

$$J_{22} = \sum_{i=1}^{n} x_{ij}\, x_{ij'} y_{1i} \pi_{11}(x_i)(1-\pi_{11}(x_i))$$

$$J_{33} = \sum_{i=0}^{n} x_{ij}\, x_{ij'} \pi_{1}(x_i)\big(1-\pi_{1}(x_i)\big) \text{ where } j, j' = 0,1,2 \dots p$$

Fisher’s Information matrixes can be written as:

$$I\left[\beta_j\right] = \left[-\frac{\delta^2 l}{\delta \beta_j \delta \beta_{j'}}\right] = \begin{bmatrix} J_{11} & 0 & 0 \\ 0 & J_{22} & 0 \\ 0 & 0 & J_{33} \end{bmatrix} \qquad \text{where, } j, j' = 0,1,2 \dots p$$

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

$$\hat{\beta}_j{}^{(m+1)} = \hat{\beta}_j{}^{(m)} + I[\hat{\beta}_j{}^{(m)}]^{-1} U[\hat{\beta}_j] \tag{2.22}$$

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 by the following formula,

$COV(\hat{\beta}_j) = I[\hat{\beta}_j{}^{(m)}]^{-1}$ where $j = 0,1,2, \dots$ 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 j^{th} parameter, the null hypothesis is,

$$H_0: \beta_j = 0$$

And the corresponding test statistics for Wald test is,

$$W = \frac{\widehat{\beta_j}}{se(\widehat{\beta_j})}$$

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:

$$\chi^2 = (\hat{\beta}_{01} - \hat{\beta}_{11})'[Va\hat{r}(\hat{\beta}_{01} - \hat{\beta}_{11})^{-1}(\hat{\beta}_{01} - \hat{\beta}_{11}) \tag{2.23}$$

which is the distributed asymptotically as chi - square with (p+1) degree of freedom, where, $Va\hat{r}(\hat{\beta}_{01} - \hat{\beta}_{11}) = Va\hat{r}(\hat{\beta}_{01}) + Va\hat{r}(\hat{\beta}_{11})$

Chapter 3

Bivariate Analysis

3.1 Introduction

Bivariate analysis can explore the underlying association between dependent and explanatory variables. In this chapter the background characteristics of different independent variable, their descriptive statistics (frequency and percentage) and their association with dependent variables is examined. For examining the bivariate relationship chi-square test is used.

3.2 Women's background characteristics, Bangladesh Demographic and Health Survey 2014

Here we discuss the percent distribution of ever-married women who have given birth of live child in the three years preceding the survey by selected background characteristics, Bangladesh Demographic and Health Survey 2014.

Table 3.1 Background characteristics of respondents by selected background characteristics

Factors	Category	Weighted Frequency	Weighted Percentage
Last birth a caesarean section	No	3504	75.7%
	Yes	1122	24.3%
No. of Antenatal Visits	No or less than 4	3178	68.8%
	four or above	1442	31.2%
Antenatal care provider: Qualified Doctor	No	1950	42.1%
	Yes	2677	57.9%
Place of ANC	Home or NGO	638	17.6%
	Public or Private Sector	2993	82.4%
Mother's age at birth	<20	1491	32.2%
	20-34	2955	63.9%
	35-49	180	3.9%

BMI	Below Normal	1093	23.6%
	Normal	2714	58.7%
	Above Normal	820	17.7%
Division	Barisal	268	5.8%
	Chittagong	1011	21.8%
	Dhaka	1634	35.3%
	Khulna	371	8.0%
	Rajshahi	464	10.0%
	Rangpur	450	9.7%
	Sylhet	428	9.2%
Highest educational level	No education or Primary	1947	42.1%
	Secondary or Higher	2679	57.9%
Type of place of residence	Urban	1209	26.1%
	Rural	3417	73.9%
Sex of previous Child	Male	1416	50.9%
	Female	1364	49.1%
Wealth Index	Poor	1878	40.6%
	Middle	882	19.1%
	Rich	1867	40.3%

From table 3.1 we found that around 76% of the delivery was vaginal delivery and 24.3% of the delivery was cesarean section delivery. Among the respondents with live birth in three year preceding around 69% of women made no or less than 4 antenatal visits. 58% of women received antenatal care from qualified doctor and 82.4% of women received antenatal care from Public or Private sector. Most of the mother's age at last child birth was between 20-34 years (63.9%). About 59% of women was with BMI level normal and 17.7% women BMI was above normal. The respondents were not evenly distributed across geographic divisions. More than one-third (35%) of the respondents lived in Dhaka, 21% resided in Chittagong, 10% each in Rajshahi, Sylhet and Rangpur, 8% in Khulna and 6 % in Barisal division. The rate of Secondary or Higher educated women was higher than illiterate and primary educated women (57.9% and 42.1% respectively). Around seven in ten respondents (74% of women) resided in the rural areas. Women with previous child male or female were likely to be equal. In this study, the number of women from poor or rich wealth index were nearly same but only 19.1% of women were with middle wealth index.

3.3 Women’s background characteristics of Cesarean Section

Here we discuss the bivariate analysis of women’s background characteristics of Cesarean Section by various background characteristics.

Table 3.2 Women’s background characteristics of Cesarean Section by various background characteristics

Factors	Type of delivery				
	Vaginal (75.7%)		Cesarean (24.26%)		p-value
	n	%	n	%	
Mother's age at birth					
<20	1151	77.2%	340	22.8%	
20-34	2207	74.7%	748	25.3%	**0.04**
35-49	146	81.1%	34	18.9%	
BMI					
Below Normal	936	85.7%	156	14.3%	
Normal	2108	77.7%	606	22.3%	**0.00**
Above Normal	460	56.1%	360	43.9%	
Division					
Barisal	219	81.7%	49	18.3%	
Chittagong	814	80.5%	197	19.5%	
Dhaka	1127	69.0%	507	31.0%	
Khulna	244	65.6%	128	34.4%	**0.00**
Rajshahi	356	76.6%	109	23.4%	
Rangpur	369	82.0%	81	18.0%	
Sylhet	376	87.9%	52	12.1%	
Highest educational level					
No education and Primary	1737	89.2%	211	10.8%	**0.00**
Secondary or Higher	1767	66.0%	912	34.0%	
Type of place of residence					
Urban	726	60.0%	483	40.0%	**0.00**
Rural	2778	81.3%	639	18.7%	
Sex of previous Child					
Male	1114	78.7%	302	21.3%	**0.00**
Female	1131	82.9%	233	17.1%	
Wealth Index					
Poor	1709	91.0%	169	9.0%	
Middle	708	80.3%	174	19.7%	**0.00**
Rich	1088	58.3%	779	41.7%	

Table 3.1 shows the association between prevalence of cesarean section and socioeconomic and demographic independent variables. In this present study information of the last birth

in the three years preceding the survey were used. During this period 4626 live births were delivered and of these live births 1122 were delivered by Cesarean Section. Overall CS rate was 24%. The results show that CS is more common among wealthy and urban women. The CS rate was high as around 41% in this category. In this respect, rates decreased with decreasing social status reveals a social gradient in CS. The CS rate was 34.4% in Khulna division and 31% in Dhaka division. In Sylhet division, the CS rate was low as 12%. Secondary or higher educated women had cesarean section much more than illiterate or primary educated women. Among the secondary or higher educated women the rate was 34.0%. Women who have previous male child then among them the rate was 21.3% and who have previous female child the rate was 17.1%. Here we can see that all of the variables were significantly associated with cesarean section.

3.4 Women's background characteristics of Number of Antenatal Visits

Here we discuss the bivariate analysis of women's background characteristics of Number of Antenatal Visits by various background characteristics.

Table 3.3 Women's background characteristics of Number of Antenatal Visits by various background characteristics

Factors	Number of Antenatal Visits				p-value
	<4 (68.8%)		≥4 (31.2%)		
	n	%	n	%	
Mother's age at birth					
<20	1015	68.1%	475	31.9%	
20-34	2020	68.4%	932	31.6%	**0.00**
35-49	144	80.0%	36	20.0%	
BMI					
Below Normal	845	77.4%	247	22.6%	
Normal	1895	69.9%	815	30.1%	**0.00**
Above Normal	439	53.6%	380	46.4%	
Division					
Barisal	202	75.4%	66	24.6%	
Chittagong	752	74.5%	257	25.5%	
Dhaka	1052	64.4%	581	35.6%	
Khulna	226	61.1%	144	38.9%	**0.00**
Rajshahi	340	73.4%	123	26.6%	

Rangpur	263	58.6%	186	41.4%	
Sylhet	343	80.1%	85	19.9%	
Highest education level					
No education and Primary	1587	81.6%	359	18.4%	**0.00**
Secondary or Higher	1591	59.5%	1083	40.5%	
Type of place of residence					
Urban	656	54.4%	550	45.6%	**0.00**
Rural	2522	73.9%	892	26.1%	
Sex of previous child					
Male	1016	71.8%	399	28.2%	0.43
Female	996	73.1%	366	26.9%	
Wealth Index					
Poor	1545	82.4%	330	17.6%	
Middle	641	72.8%	240	27.2%	**0.00**
Rich	991	53.2%	873	46.8%	

Table 3.2 shows that 31% of women made 4 or more antenatal visits, though the WHO recommends that **four routine** antenatal visits over the course of pregnancy, with a plan for more frequent visits if that patient has hypertension, severe anemia, HIV or malaria [18]. The rate of having 4 or more antenatal visits were pretty similar among mothers aged <20 years and 20-34 years. In these age groups the rate of women making 4 or more antenatal visits was around 32%. Only 20% of women aged 35-49 years made 4 or more antenatal visits. The percentage of women with 4 or more antenatal visits was 46.8% among rich wealth quantile women but only 17.6% among poor wealth quantile women made 4 or more antenatal visits. The rate of making 4 or more antenatal visits was high among overweight and obese women. 4 or more antenatal visits were made by 41.4% of women living in Rangpur division. There was no significant association between “Sex of previous child” and “Number of antenatal visits”. Making 4 or more antenatal visits rate was high among secondary or higher educated women. The rate was high as 40.5% among secondary or higher educated women in the other hand only 18.4% of illiterate and primary educated women made 4 or more antenatal visits. There was a huge variation of percentage of women making 4 or more antenatal visits between urban and rural women. Where only 26.1% of rural women made 4 or more antenatal visits, in the other hand 45.6% of urban women made 4 or more antenatal visits.

3.5 Women's background characteristics of ANC provider: Qualified Doctor

In this section we discuss the bivariate analysis of women's background characteristics of ANC provider: Qualified Doctor by various background characteristics.

Table 3.4 Women's background characteristics of ANC provider: Qualified Doctor by various background characteristics

Factors	ANC provider: Qualified Doctor				
	No (42.13%)		Yes (57.87%)		p-value
	n	%	n	%	
Mother's age at birth					
<20	628	42.1%	863	57.9%	
20-34	1237	41.9%	1718	58.1%	0.40
35-49	85	47.0%	96	53.0%	
BMI					
Below Normal	569	52.1%	523	47.9%	
Normal	1199	44.2%	1515	55.8%	0.00
Above Normal	181	22.1%	639	77.9%	
Division					
Barisal	132	49.3%	136	50.7%	
Chittagong	403	39.9%	608	60.1%	
Dhaka	638	39.0%	996	61.0%	
Khulna	122	32.9%	249	67.1%	0.00
Rajshahi	209	45.0%	255	55.0%	
Rangpur	216	48.0%	234	52.0%	
Sylhet	228	53.4%	199	46.6%	
Highest education level					
No education and Primary	1150	59.0%	798	41.0%	
Secondary or Higher	800	29.9%	1879	70.1%	0.00
Type of place of residence					
Urban	314	26.0%	895	74.0%	0.00
Rural	1635	47.8%	1782	52.2%	
Sex of previous Child					
Male	671	47.4%	745	52.6%	0.55
Female	631	46.3%	733	53.7%	
Wealth Index					
Poor	1165	62.0%	713	38.0%	
Middle	370	42.0%	512	58.0%	0.00
Rich	414	22.2%	1452	77.8%	

Table 3.4 shows the association between Antenatal care provider and socioeconomic and demographic independent variables. In this study, 58% of mothers received antenatal care

from qualified doctors. The rate of receiving ANC from qualified doctor was higher among affluent and educated women. Among the secondary or higher educated women the rate of receiving antenatal care from qualified doctor was 70.1%, in the other hand 41% of illiterate and educated women received antenatal care from qualified doctor. There was variation in rate of receiving antenatal care from qualified doctor among the different wealth index women. The rate varied from 38% to 77.8%. The rate of receiving antenatal care from a qualified doctor was high among overweight and obese women. In this group around 78% of women received from qualified doctor. There was difference in rates of receiving care from qualified doctor in different divisions. Among the divisions the rate was high in Khulna division. In this division around 67.1% of women received antenatal care from qualified doctor. In urban areas 74.0% of women received antenatal care from qualified doctor where in rural areas the rate was 52.2%. Mother's age at birth and Sex of previous child were not significantly associated with antenatal care provider.

3.6 Women's background characteristics of Place of Antenatal Care

In this section, we discuss the bivariate analysis of women's background characteristics of Place of Antenatal Care by various background characteristics.

Table 3.5 Women's background characteristics of Place of Antenatal Care by various background characteristics

Factors	Place of Antenatal Care				
	Home, NGO and Other (17.01%)		Public or Private Sector (82.99%)		p-value
	n	%	n	%	
Mother's age at birth					
<20	189	19.2%	952	80.8%	
20-34	388	16.9%	1871	83.1%	0.85
35-49	23	15.1%	104	84.9%	
BMI					
Below Normal	155	21.7%	607	78.3%	
Normal	355	18.8%	1686	81.2%	0.00
Above Normal	90	9.8%	634	90.2%	
Division					
Barisal	219	15.8%	49	84.2%	
Chittagong	814	13.3%	197	86.7%	

Dhaka	1127	19.9%	507	80.1%	
Khulna	244	17.7%	128	82.3%	0.02
Rajshahi	356	13.1%	109	86.9%	
Rangpur	369	20.8%	81	79.2%	
Sylhet	376	20.2%	52	79.8%	
Highest Education Level					
No education and Primary	297	25.4%	892	74.6%	
Secondary or Higher	303	13.3%	2035	86.7%	0.00
Type of place of residence					
Urban	246	16.7%	1032	83.3%	0.01
Rural	354	18.0%	1895	82.0%	
Sex of previous child					
Male	195	18.0%	788	82.0%	0.33
Female	181	18.3%	817	81.7%	
Wealth Index					
Poor	239	23.6%	902	76.4%	
Middle	108	19.2%	580	80.8%	0.00
Rich	253	12.7%	1445	87.3%	

Table 3.5 shows that, 17.01% of women received antenatal care from Home or NGO sector and around 83% of women received the care from Public or Private sector. Overweight and obese women's rate of receiving ANC from Public or Private Sector was more than women with any other level of BMI. In this category around 90% of women received antenatal care from public or private sector. There was not much variation among different divisions. In different divisions the rate of receiving antenatal care from public or private sector varied from 79.2% to 86.9%. Among the secondary or higher educated women around 87% of women received antenatal care from public or private sector and the rate was 74.6% among the illiterate and primary educated women. Between the different economical class of women the rate of receiving antenatal care from public or private sector varied from 76.4% to 87.3%. Although, from the above table we can see that all the factors except mother's age at child birth and sex of previous child were significantly associated with place of antenatal care.

Chapter 4

Marginal Models

4.1 Introduction

In previous chapter we have discussed the bivariate analysis of the outcome variables with socio-economic and demographic factors. In this chapter we apply marginal models to investigate the risk factors influencing the outcome variables. As our outcome variables are binary coded, so logit link function of the Generalized Linear Model is used. We apply the Logistic Regression Model to the outcome variables to assess with risk factors and estimate the odds ratio. Four marginal model are fitted in this chapter for the outcome variables, number of antenatal visits, antenatal care provider: qualified doctor, place of antenatal care and cesarean section.

4.2 Marginal estimates of Cesarean Section Delivery

In this section the marginal model analysis of Cesarean Section by various background characteristics is discussed.

Table 4.1 Estimates of Parameters from Marginal model of Cesarean Section Delivery by various risk factors

Variables	Estimate	S.E.	Odds Ratio	p-value
Constant	-3.51	0.35	0.03	**0.00**
Mother's age at birth				
<20 (Ref)				
20-34	0.61	0.25	1.83	**0.01**
35-49	0.71	0.34	2.04	**0.03**
BMI				
Below Normal (Ref)				
Normal	0.13	0.17	1.14	0.45
Above Normal	1.04	0.19	2.84	**0.00**
Division				
Barisal (Ref)				
Chittagong	-0.52	0.22	0.59	**0.02**

Dhaka	0.33	0.21	1.38	0.12
Khulna	0.75	0.22	2.11	**0.00**
Rajshahi	0.17	0.23	1.18	0.48
Rangpur	0.19	0.24	1.21	0.43
Sylhet	-0.46	0.24	0.63	0.06
Highest educational level				
No education and Primary (Ref)				
Secondary+	0.98	0.13	2.66	**0.00**
Type of residence				
Urban				
Rural	-0.33	0.12	0.72	**0.01**
Sex of previous Child				
Male (Ref)				
Female	-0.31	0.11	0.73	**0.01**
Wealth Index				
Poor (Ref)				
Middle	0.67	0.18	1.96	**0.00**
Rich	1.43	0.16	4.16	**0.00**

From Table 4.1, we found that odds of CS prevalence for women aged 20-34 years was 1.83 times higher compared to those aged less than 20 years (OR = 1.81, p-value = 0.01) and compared to the reference age group odds of CS delivery was 2.04 times higher for women aged 35-49 years (OR = 2.04, p-value = 0.03).

No significant difference was found in odds of CS prevalence between women BMI level below normal and normal, though the odds was 2.84 times higher for overweight and obese women compared to women with BMI level below normal.

There was no significant difference in odds of CS delivery between women’s living in Barisal and other divisions except for those living Chittagong and Khulna divisions. Though in these divisions odds were of opposite nature. Women living in Chittagong division had 0.59 times lower odds of cesarean section than those living in Barisal division and women living in Khulna division had 2.11 times higher odds of CS delivery (OR = 0.59, p-value = 0.02 and OR = 2.11, p-value = 0.00).

From the above table we found that secondary or higher educated women’s odds of CS prevalence was 2.66 times higher compared to those were illiterate or primary educated.

From the logistic regression model of CS delivery type of residence was found to be a protective predicting factor of cesarean section. Women living in rural areas had 0.72 times lower odds of cesarean section than those living in urban areas.

From the above table we found that, women with previous female child had 0.72 times lower odds of CS compared to those with previous male child (OR = 0.72, p-value = 0.01).

Odds of CS prevalence was 1.96 times higher for middle wealth index women compared to poor wealth index women (OR = 1.96, p-value = 0.00) and for women with rich wealth index the odds of CS was 4.16 times higher (OR = 4.16, p-value = 0.00).

4.3 Marginal estimates of Number of antenatal visits

In this section we discuss the Marginal model analysis of Number of ANC visits by various background characteristics.

Table 4.2 Estimates of Parameters from Marginal model of Number of ANC visits by various risk factors

Variables	Estimate	S.E.	Odds Ratio	p-value
Constant	-1.93	0.26	0.15	**0.00**
Mother's age at birth				
<20 (Ref)				
20-34	-0.10	0.17	0.90	0.55
35-49	-0.20	0.26	0.82	0.45
BMI				
Below Normal (Ref)				
Normal	0.13	0.13	1.14	0.33
Above Normal	0.63	0.15	1.89	**0.00**
Division				
Barisal (Ref)				
Chittagong	0.04	0.19	1.04	0.82
Dhaka	0.40	0.19	1.49	**0.03**
Khulna	0.79	0.20	2.20	**0.00**
Rajshahi	0.24	0.20	1.27	0.23
Rangpur	1.18	0.20	3.26	**0.00**
Sylhet	-0.19	0.20	0.83	0.35
Highest educational level				
No education and Primary(Ref)				
Secondary+	0.65	0.10	1.92	**0.00**

Type of residence				
Urban				
Rural	-0.39	0.11	0.68	**0.00**
Sex of previous Child				
Male (Ref)				
Female	-0.03	0.09	0.97	0.74
Wealth Index				
Poor (Ref)				
Middle	0.16	0.14	1.17	0.27
Rich	0.94	0.13	2.56	**0.00**

Table 4.2 shows that overweight and obese pregnant women's odds of making 4 or more antenatal visits was 1.88 times higher than underweight pregnant women (OR = 1.89, p-value = 0.00) and there was no significant difference of odds for making 4 or more antenatal visits between women with BMI level below normal and BMI level normal.

From the above table we found that women living in Dhaka division had 1.49 times higher odds of making 4 or more antenatal visits compared to those living in Barisal division (OR = 1.49, p-value = 0.00). Women living in Khulna and Rangpur divisions also had higher odds of making 4 or more antenatal visits than those living in Barisal division (OR = 2.20, p-value = 0.00 and OR = 3.26, p-value = 0.00).

Odds of making 4 or more antenatal visits was 1.92 times higher for women with secondary or higher education compared to those with illiterate or primary education (OR = 1.92, p-value = 0.00).

Type of residence was found to be a protective predicting of number of antenatal visits. Women living in rural areas had 0.72 times lower odds of making 4 or more antenatal visits compared to those living in urban areas. (OR = 0.72, p-value = 0.00)

Rich women's odds of making 4 or more antenatal visits was 2.56 times higher than poor women and there was no significant difference of odds between women with poor and middle wealth index.

Mother's age at child birth and sex of previous child were not found to be significant risk factor for predicting the number of antenatal visits.

4.4 Marginal estimates of ANC provider: Qualified Doctor

Here we discuss the Marginal Model analysis of ANC provider: Qualified Doctor by various background characteristics.

Table 4.3 Estimates of Parameters from Marginal model of ANC provider: Qualified Doctor by various risk factors

Variables	Estimate	S.E.	Odds Ratio	p-value
Constant	-1.17	0.23	0.31	**0.00**
Mother's age at birth				
<20 (Ref)				
20-34	0.23	0.16	1.26	0.15
35-49	0.27	0.23	1.31	0.23
BMI				
Below Normal (Ref)				
Normal	0.12	0.11	1.13	0.27
Above Normal	0.70	0.14	2.02	**0.00**
Division				
Barisal (Ref)				
Chittagong	-0.15	0.16	0.86	0.36
Dhaka	0.22	0.16	1.24	0.19
Khulna	0.46	0.18	1.58	**0.01**
Rajshahi	-0.13	0.17	0.88	0.45
Rangpur	0.10	0.18	1.11	0.55
Sylhet	-0.20	0.16	0.82	0.21
Highest educational level				
No education and Primary (Ref)				
Secondary+	0.83	0.09	2.30	**0.00**
Type of residence				
Urban (Ref)				
Rural	-0.11	0.11	0.89	0.29
Sex of previous Child				
Male (Ref)				
Female	0.05	0.09	1.05	0.58
Wealth Index				
Poor (Ref)				
Middle	0.53	0.12	1.69	**0.00**
Rich	1.19	0.12	3.29	**0.00**

From Table 4.2, we found that odds of receiving antenatal care from qualified doctor was 2.02 times higher for overweight and obese pregnant women than those with below normal

BMI (OR = 2.02, p-value = 0.00) and there was no significant difference of odds between women with BMI level below normal and normal (p-value = 0.27).

Women living in Khulna division had 1.58 times higher odds of receiving antenatal care from qualified doctor than those living in Barisal division (OR = 1.58, p-value = 0.01). There was no significant difference of odds of receiving antenatal care from qualified doctor between women living in other divisions and Barisal division.

Secondary or higher educated women's odds of receiving antenatal care from qualified doctor was 2.30 times higher compared to illiterate or primary educated women (OR = 2.30, p-value = 0.00).

Odds of receiving antenatal care from qualified doctor was 1.69 times higher for Middle wealth index women compared to poor wealth index women (OR = 1.69, p-value = 0.00). The odds of CS prevalence was 3.29 times higher for rich wealth index women (OR = 3.29, p-value = 0.00).

Mother's age at child birth, type of residence and sex of previous child were not found as a significant risk factor for influencing women for receiving the ANC from qualified doctor.

4.5 Marginal estimates of Place of Antenatal Care

Here we discuss the Marginal model analysis of Place of Antenatal Care by various background characteristics.

Table 4.4 Estimates of Parameters from Marginal model of Place of Antenatal Care by various risk factors

Variables	Estimate	S.E.	Odds Ratio	p-value
Constant	0.73	0.33	2.07	**0.03**
Mother's age at birth				
<20 (Ref)				
20-34	0.02	0.22	1.02	0.92
35-49	0.19	0.32	1.21	0.55
BMI				
Below Normal (Ref)				

Normal	0.22	0.15	1.25	0.15
Above Normal	0.64	0.20	1.90	**0.00**
Division				
Barisal (Ref)				
Chittagong	-0.08	0.24	0.92	0.74
Dhaka	-0.23	0.23	0.79	0.32
Khulna	-0.47	0.24	0.63	**0.05**
Rajshahi	-0.13	0.26	0.88	0.62
Rangpur	-0.59	0.24	0.55	**0.01**
Sylhet	-0.26	0.24	0.77	0.29
Highest educational level				
No education and Primary (Ref)				
Secondary+	0.74	0.13	2.09	**0.00**
Type of residence				
Urban				
Rural	0.30	0.14	1.35	**0.03**
Sex of previous Child				
Male (Ref)				
Female	0.13	0.12	1.14	0.26
Wealth Index				
Poor (Ref)				
Middle	0.16	0.17	1.18	0.35
Rich	0.01	0.16	1.01	0.95

In Table 4.4, the odds of receiving ANC from Private or Public Sector for overweight and obese pregnant women was 1.90 times higher than women with BMI level below normal (OR = 1.90, p-value = 0.00). There was no significant difference of odds between normal BMI level and below normal BMI.

There was no significant difference of odds of receiving antenatal care from public or private sector between women living in Barisal division and other divisions except for those living in Khulna and Rangpur divisions. Women living in Khulna and Rangpur division had lower odds of receiving ANC from Public or Private Sector than those Barisal division (OR = 0.63 , p-value = 0.05 and OR = 0.55, p-value = 0.01 respectively).

Odds of receiving antenatal care from public or private sector was found 2.09 times higher for secondary or higher educated women compared to illiterate or primary educated women (OR = 1.92, p-value = 0.00).

Women residing in rural areas had 1.35 times higher odds of receiving antenatal care from public or private sector compared to women residing in urban areas (OR = 1.35, p-value = 0.03).

Though wealth index was found significant in bivariate analysis but was no longer significant in marginal model after adjusting other independent variables.

Mother's age and sex of previous child were not significant risk factor for influencing the place from where women received antenatal care. These variables were not also found significant in bivariate analysis.

4.6 Comparison of Marginal models

From the marginal models we found that Mother's age at child birth was a significant risk factor for predicting the odds of CS delivery but for the other models it was not significant risk factor.

In all the marginal models there was a significant difference between women with BMI level above and below normal. Overweight and obese women had higher odds ratio compared to below normal level BMI women. But there was no significant difference of odds ratio between women with BMI level below normal and normal in all the marginal models.

From all the marginal models we found that, for predicting the outcome variables secondary or higher educated women had higher odds compared to illiterate or primary educated women.

For predicting the odds of Cesarean delivery and number of antenatal visits, type of residence was found to be a protective risk factor, though for predicting the odds of place of antenatal care, this variable was found to be a progressive risk factor. This variable was not found as a significant risk factor for predicting the odds of Antenatal care provider: qualified doctor.

Sex of previous child was a significant risk factor for predicting the odds of Cesarean delivery. However, for the other models this variable was not a significant risk factor.

From the marginal models we found that middle wealth index women had higher odds of undergoing for Cesarean delivery and receiving antenatal care from qualified doctor compared to poor wealth index women. These odds was more higher for rich wealth index women in both models. For rich women the odds of making 4 or more antenatal visits was 2.56 times higher than poor women and there was no significant difference of odds between poor and middle wealth index women. This variable was not found to be significant risk factor in the marginal model of Place of antenatal care.

Chapter 5

Conditional Models

5.1 Introduction

In previous chapter we have discussed the risk factors associated with the outcome variables using marginal models and in this chapter we apply conditional models to analyze the risk factors influence on the occurrence of cesarean section under different conditions of Antenatal Care factors. We have conducted three antenatal care variables as conditions for analyzing CS which are Number of antenatal visits, Antenatal Care provider: Qualified doctor and Place of antenatal care.

5.2 Conditional Estimates of Cesarean Section Delivery under condition of Number of Antenatal Care Visits

In this section we discuss the Conditional Model analysis of Cesarean Section under the conditions of Number of Antenatal Care Visits by the selected socio-economic and demographic independent variables.

To apply the conditional models here our Y_1= Number of antenatal care and Y_2=Last birth a cesarean section.

Let us consider P($Y_2 = 1|Y_1 = 0, x$) represents the conditional probability of last birth a cesarean section under the condition that number of antenatal visits is no or less than 4 and P($Y_2 = 1|Y_1 = 1, x$) represents the conditional probability of last birth a CS under the condition that number of antenatal visits is 4 or more than 4. Model 1 and Model 2 represents two conditional models P($Y_2 = 1|Y_1 = 0, x$) and P($Y_2 = 1|Y_1 = 1, x$) respectively.

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that number of antenatal visits is no or less than 4.

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that number of antenatal visits is 4 or more than 4.

Table 5.1 Conditional Estimates of Parameters for Cesarean Section under condition of Number of Antenatal Care Visits

Variables	Model 1				Model 2			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$
Constant	-3.44	0.43	**0.00**	0.03	-3.26	0.63	**0.00**	0.04
Mother's age at birth								
<20 (Ref)								
20-34	0.25	0.31	0.41	1.29	1.22	0.42	**0.00**	3.39
35-49	0.17	0.43	0.70	1.19	1.46	0.56	**0.01**	4.29
BMI								
Below Normal (Ref)								
Normal	0.18	0.22	0.39	1.20	-0.07	0.31	0.82	0.93
Above Normal	0.82	0.24	**0.00**	2.26	1.09	0.32	**0.00**	2.99
Division								
Barisal (Ref)								
Chittagong	-0.43	0.28	0.12	0.65	-0.77	0.38	**0.04**	0.46
Dhaka	0.36	0.27	0.19	1.43	0.18	0.37	0.63	1.19
Khulna	1.11	0.28	**0.00**	3.02	0.06	0.38	0.87	1.06
Rajshahi	0.29	0.29	0.32	1.34	-0.14	0.41	0.73	0.87
Rangpur	0.25	0.33	0.44	1.28	-0.23	0.39	0.55	0.79
Sylhet	-0.64	0.32	**0.04**	0.53	0.03	0.43	0.94	1.03
Highest educational level								
No education and Primary (Ref)								
Secondary+	0.74	0.16	**0.00**	2.09	1.23	0.24	**0.00**	3.43
Type of residence								
Urban (Ref)								
Rural	-0.18	0.17	0.27	0.83	-0.34	0.19	0.08	0.71
Sex of previous Child								
Male (Ref)								
Female	-0.30	0.15	**0.04**	0.74	-0.38	0.18	**0.04**	0.69
Wealth Index								
Poor (Ref)								
Middle	0.91	0.21	**0.00**	2.48	0.13	0.34	0.71	1.13
Rich	1.47	0.21	**0.00**	4.37	1.05	0.28	**0.00**	2.85

In table 5.1 we found that if 4 or more than 4 antenatal visits were made then women aged 20-34 years had 3.39 times higher odds of CS prevalence compared to those aged less than 20 years (OR = 3.39, p-value = 0.00) and the odds was 4.29 times higher for the women aged 35-49 years (OR = 4.29, p-value = 0.01). But if no or less than 4 antenatal visits were made then there was no significant difference in odds of CS between different age groups.

From the above table we found that, under both conditions there was no significant difference in odds of CS between women with BMI level normal and below normal, though the odds was higher for those with BMI level above normal. If no or less than 4 antenatal visits were made then women with BMI level above normal had 2.26 times higher odds (OR = 2.26, p-value = 0.00) and 2.99 times higher if 4 or more than 4 antenatal visits were made (OR = 2.99, p-value = 0.00).

In the above table we found that, if no or less than 4 antenatal visits were made then women living in Khulna division had around 3 times higher odds of CS delivery compared to those living in Barisal division and for those living in Sylhet division odds was 0.53 times lower. However, if 4 or more than 4 antenatal visits were made then there was not found any significant difference of odds among women living in these divisions except for those living in Chittagong division. In this division under this condition women had 0.46 times lower odds than those living in Barisal division.

We found that in both conditional models “secondary or higher education” was significant risk factor. Women who made 4 or more than 4 antenatal visits among them those with secondary or higher education had 3.43 times higher odds of CS prevalence than those with no or primary education (OR = 3.43, p-value = 0.00).

In both conditional models the type of place where women reside was not found to be a significant risk factor for predicting the mode of child delivery.

In both conditional models sex of previous child was found to be a significant protective predicting factor. We found that, if 4 or more than 4 antenatal visits were made then women with previous female child had 0.69 times lower odds of cesarean section than those with previous male child and this odds was 0.74 times lower if no or less than 4 antenatal visits were made.

For women with middle economical class had 2.48 times higher odds of CS delivery compared to women with poor economical class if no or less 4 antenatal visits were made. But if 4 or more antenatal visits were made then there was no significant difference in odds of CS between these economical classes. Though, under this condition the odds of CS delivery was 2.85 times higher for women with rich economical class compared to those with poor economical class (OR = 2.85, p-value = 0.00) and the odds was 4.37 times higher if no or less than 4 antenatal visits were made (OR = 4.37, p-value = 0.00).

5.3 Comparison of marginal model of Cesarean Section delivery and conditional model of Cesarean Section Delivery under condition of Number of Antenatal Care Visits

From the marginal of Cesarean delivery we found that odds of CS prevalence was 1.83 times higher for women aged 20-34 years compared to those aged less than 20 years (OR = 1.83, p-value = 0.01) and the odds was 2.04 times higher for women aged between 35-49 years (OR = 2.04, p-value = 0.03). But from the conditional models, this increased risk of CS were associated with the increase in maternal age only if 4 or more than 4 antenatal visits were made. Otherwise, maternal age was not found to be a significant risk factor.

In the marginal model we found that, the odds of CS delivery was 2.84 times higher for overweight and obese women compared to women with BMI level below normal. This higher risk of CS was true for the both conditions of number of antenatal visits.

In the marginal model of CS we found that Odds of CS was 0.59 times lower for women living in Chittagong division than those living in Barisal. From the conditional models, lower odds of CS for women living in Chittagong division was found only if 4 or more than 4 antenatal visits were made, otherwise there was no significant difference. However, Women who made no or less than 4 antenatal visits, among them those lived in Khulna division had 2.11 times higher odds and those lived in Sylhet division had 0.53 times lower odds of CS.

In marginal model, Women with secondary or higher education had 2.66 times higher odds of CS prevalence compared to those were illiterate or primary educated. And as in marginal model, in the both conditional models this variable was found to be a significant progressive predictive factor.

The marginal model showed that type of residence was a significant protective predicting factor of cesarean section. However, in the conditional models this variable was no longer found to be a significant risk factor.

In marginal model of CS we found that women with previous female child had 0.59 times lower odds of cesarean section compared to those with previous male child. And in both conditional models this variable was also found as protective predicting factor of cesarean section.

From the marginal model we found that odds of CS was 1.96 times higher for women with Middle wealth index compared to those with poor wealth index (OR = 1.96, p-value = 0.00) and for rich wealth index women odds of CS was 4.16 times higher (OR = 4.16, p-value = 0.00). In the conditional models, the increased of risk of CS was associated with the increase of BMI level only if no or less than 4 antenatal visits were made. However, if 4 or more antenatal visits were made then those with rich wealth index had 2.85 times higher of odds of CS and those with middle wealth index was not significantly different in prevalence of CS compared to women with poor wealth index.

5.4 Conditional Estimates of Cesarean Section Delivery under condition of ANC Provider: qualified doctor

Here we discuss the Conditional Model analysis of Cesarean Section under conditions of ANC Provider: qualified doctor by various risk factors.

To apply the conditional model here our Y_1= ANC Provider: qualified doctor and Y_2= Last birth a cesarean section.

Let us consider P($Y_2 = 1|Y_1 = 0, x$) represents the conditional probability of last birth a CS under the condition that ANC Provider is not qualified doctor and P($Y_2 = 1|Y_1 = 1, x$) represents the conditional probability of last birth a CS under the condition that ANC

Provider is qualified doctor. Model 1 and Model 2 represents two conditional models $P(Y_2 = 1|Y_1 = 0, x)$ and $P(Y_2 = 1|Y_1 = 1, x)$ respectively.

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that ANC Provider is not a qualified doctor

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that ANC Provider is qualified doctor

Table 5.2 Conditional Estimates of Parameters for Cesarean Section under condition of ANC Provider: qualified doctor

Variables	Model 1				Model 2			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$
Constant	-4.70	0.76	**0.00**	0.01	-2.51	0.42	**0.00**	0.08
Mother's age at birth								
<20 (Ref)								
20-34	0.45	0.49	0.36	1.57	0.58	0.29	**0.05**	1.79
35-49	0.38	0.73	0.60	1.46	0.71	0.39	0.07	2.03
BMI								
Below Normal (Ref)								
Normal	0.21	0.35	0.55	1.24	**0.03**	0.21	0.88	1.03
Above Normal	0.67	0.43	0.12	1.96	0.94	0.22	**0.00**	2.55
Division								
Barisal (Ref)								
Chittagong	0.05	0.57	0.93	1.05	-0.67	0.25	**0.01**	0.51
Dhaka	0.64	0.55	0.25	1.90	0.21	0.24	0.39	1.23
Khulna	1.32	0.55	**0.02**	3.76	0.52	0.25	**0.04**	1.68
Rajshahi	0.85	0.55	0.12	2.35	0.06	0.27	0.81	1.07
Rangpur	0.98	0.56	0.08	2.67	-0.03	0.28	0.92	0.97
Sylhet	-0.50	0.66	0.44	0.60	-0.37	0.28	0.18	0.69
Highest educational level								
No education and Primary (Ref)								
Secondary+	0.72	0.27	**0.01**	2.06	0.80	0.16	**0.00**	2.23
Type of residence								
Urban (Ref)								
Rural	0.00	0.30	0.99	1.00	-0.41	0.14	**0.00**	0.66
Sex of previous Child								
Male (Ref)								
Female	-0.29	0.26	0.26	0.75	-0.34	0.13	**0.01**	0.71

Wealth Index								
Poor (Ref)								
Middle	0.40	0.38	0.30	1.49	0.57	0.21	**0.01**	1.76
Rich	1.55	0.32	**0.00**	4.70	1.06	0.20	**0.00**	2.89

In table 5.2 we found that, if antenatal care was received from qualified doctor then women aged 20-34 years had 1.79 times higher odds of CS than those aged less than 20 years (OR = 1.79, p = 0.05), otherwise there was no difference of odds. However, maternal age was not found to be a significant risk factor if antenatal care was not received from qualified doctor.

In conditional models, overweight and obese women had 2.55 times higher odds of CS delivery than those with BMI level below normal if antenatal care was provided by qualified doctor (OR = 2.55, p = 0.00). But when the care was not provided by qualified doctor then there was no significant difference of cesarean section prevalence among women with different BMI levels.

In the conditional models, if the ANC was provided by a qualified doctor then women living in Chittagong division had 0.51 times lower odds of cesarean section. Otherwise, there was no significant difference of CS prevalence. However, antenatal care was provided by qualified doctor or not, women living in Khulna division had higher odds of cesarean section. The odds was 3.76 times higher than those living in Barisal division if the care was not provided by qualified doctor and in the other hand the odds was 1.68 times higher if the care was provided by qualified doctor. In other divisions women's odds of CS was not significantly differ from those living in Barisal division.

Odds ratio of CS delivery was 2.23 times higher for secondary or higher educated women under the condition that antenatal care was provided by qualified doctor. (OR = 2.23, p-value = 0.00). But odds ratio was 2.06 if the provider was not qualified doctor. (OR = 2.06, p-value = 0.01)

If the care was provided by qualified doctor then type of residence was found to be a protective predicting factor of cesarean section and women living in rural areas had 0.66 times lower odds of CS delivery compared to those living in urban areas (OR = 0.66, p-value = 0.00). Though this variable was not found to be significant risk factor if the care was not provided by qualified doctor.

If the antenatal care was provided by qualified doctor then the odds of CS prevalence was 0.71 times lower for women with previous female child compared to those with previous male child (OR = 0.71, p-value = 0.01). But if the care was not provided by qualified doctor then “sex of previous child” was not found to be a significant risk factor of cesarean section.

From the conditional models we found that, when antenatal care was provided by qualified doctor then the higher economical class was associated with increased risk of cesarean section. However, if antenatal care was not received from qualified doctor then risk of CS was higher for only for women with rich wealth index than those with poor wealth index (OR = 4.70, p-value = 0.00).

5.5 Comparison of marginal model of Cesarean Section delivery and conditional model of Cesarean Section Delivery under condition of ANC Provider: qualified doctor

In marginal model of CS, maternal age was found to be associated with increased risk of cesarean section. However, from the conditional models we found that women aged 20-34 years had 1.79 higher odds than those aged less than 20 years only if ANC was provided by qualified doctor and under this condition there was no significant difference in odds of cesarean section between women age 35-49 years and less than 20 years. For the other condition i.e. if the care was not provided by qualified doctor then maternal age was not found to be statistically significant risk factor for predicting cesarean section.

In marginal model, women with BMI level above normal had 2.84 times higher odds of CS delivery compared to those with BMI level below normal. From the conditional models we found that this variable was significant only if the care was received from qualified doctor and the odds of CS was 2.84 times higher compared to women with BMI level below normal. However, if the care was not received from qualified doctor then women’s BMI was not found to be a significant risk factor for predicting the odds of CS prevalence.

In marginal model of cesarean section odds of CS was lower for women living in Chittagong division than women living in Barisal division. And this lower odds was only if the care was received from qualified doctor. For the other condition, there was no significant difference between odds of CS between women living in these divisions. In marginal model odds of CS was higher for women living in Khulna division and this higher odds was also found true under both conditions.

In both marginal and conditional models we found that secondary or higher educated women had higher odds of CS prevalence compared to illiterate or primary educated women and in the conditional models odds ratio of undergoing for CS was more higher for this category of women under the condition that ANC was received from qualified doctor.

Type of residence was a significant protective predicting risk factor in marginal model of CS. But in the conditional models we found that if antenatal care was provided by qualified doctor then rural women had 0.66 times lower odds of CS compared to urban women and if the care was not provided by qualified doctor then type of residence was not found to be a significant risk factor for predicting the odds of CS.

We found that, odds of CS was 0.73 times lower for women with previous female child than those with previous male child and odds of CS was 0.71 times lower if women received antenatal care from qualified doctor. However, when the care was not received from qualified doctor then this variable was not significant risk factor for predicting the odds of CS.

In marginal model of CS wealth index was found to be statistically significant predictive factor for cesarean section. And from the conditional models we found that in both models rich women had higher odds of CS delivery compared to poor women, though the odds of CS prevalence was more higher if the antenatal care was not provided by qualified doctor. For middle wealth index women the odds of CS was higher if the care was provided by qualified doctor and if the care was not provided by qualified doctor then there was no significant difference of CS prevalence between poor and middle wealth index women.

5.6 Conditional Estimates of Cesarean Section Delivery under condition of Place of Antenatal care

Here we discuss the Conditional Model analysis of Cesarean Section under the conditions of Place of Antenatal care by various risk factors.

To apply the conditional model here our Y_1= Place of Antenatal care and Y_2=Last birth a cesarean section.

Let us consider P($Y_2 = 1|Y_1 = 0, x$) represents the conditional probability of last birth a CS under the condition that Place of Antenatal care is Home or NGO or Other Place and P($Y_2 = 1|Y_1 = 1, x$) represents the conditional probability of last birth a c-section under the condition that Place of Antenatal care is Public or Private Sector. Model 1 and Model 2 represents two conditional models P($Y_2 = 1|Y_1 = 0, x$) and P($Y_2 = 1|Y_1 = 1, x$) respectively.

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that Place of Antenatal care is Home or NGO or Other Place.

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that Place of Antenatal care is Public or Private Sector

Table 5.3 Conditional Estimates of Parameters for Cesarean Section under condition of Place of Antenatal Care

Variables	Model 1				Model 2			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$
Constant	-3.58	1.27	**0.00**	0.03	-2.85	0.40	**0.00**	0.06
Mother's age at birth								
<20 (Ref)								
20-34	1.31	1.07	0.22	3.70	0.60	0.28	**0.03**	1.83
35-49	2.35	1.21	**0.05**	10.46	0.53	0.38	0.16	1.69
BMI								
Below Normal (Ref)								
Normal	-0.14	0.50	0.77	0.87	0.00	0.20	0.99	1.00
Above Normal	0.97	0.55	0.07	2.65	0.85	0.21	**0.00**	2.34

Division								
Barisal (Ref)								
Chittagong	-1.30	0.74	0.08	0.27	-0.48	0.24	**0.05**	0.62
Dhaka	-0.61	0.64	0.34	0.54	0.39	0.24	0.10	1.47
Khulna	0.11	0.60	0.86	1.11	0.77	0.25	**0.00**	2.16
Rajshahi	-0.58	0.71	0.41	0.56	0.29	0.26	0.27	1.33
Rangpur	-0.71	0.71	0.32	0.49	0.29	0.27	0.28	1.34
Sylhet	-1.36	0.79	0.09	0.26	-0.20	0.27	0.46	0.82
Highest educational level								
No education and Primary (Ref)								
Secondary+	0.89	0.40	0.03	2.42	0.79	0.15	**0.00**	2.21
Type of residence								
Urban (Ref)								
Rural	-0.30	0.41	0.47	0.74	-0.39	0.14	**0.00**	0.67
Sex of previous Child								
Male (Ref)								
Female	-0.16	0.35	0.65	0.85	-0.40	0.13	**0.00**	0.67
Wealth Index								
Poor (Ref)								
Middle	0.19	0.59	0.74	1.21	0.67	0.20	**0.00**	1.96
Rich	0.80	0.49	0.11	2.23	1.33	0.19	**0.00**	3.79

Table 5.2 shows that if antenatal care was received from Public or Private sector then odds of CS prevalence was 1.83 times higher for women aged at child birth 20-34 years compared to those aged less than 20 years (OR = 1.83, p-value = 0.03). But if the care was received from home or NGO sector then there was no significant difference between these age groups. For women who aged between 35-49 years had higher odds of CS prevalence than less than 20 years aged women if the care was received from home or NGO sector (OR = 10.46, p-value = 0.05) and if the care was received from Public or Private sector then there was no significant difference between these age groups of mothers.

If women received ANC from Public or Private sector then the odds of CS prevalence was 2.34 times higher for those with BMI level above normal compared to women with below normal BMI level (OR = 2.34, p-value = 0.00). Under both conditions there was no significant difference of CS prevalence between the women with BMI level normal and below normal.

There was no significant difference of odds of CS prevalence in different divisions if antenatal care was received from Home or NGO sector. But if the care was received from

Public or Private sector then the odds for women living in Chittagong division was 0.62 times lower (OR = 0.62, p-value = 0.05) and for those living in Khulna division was 2.16 times higher (OR = 2.16, p-value = 0.00) compared to Barisal division's women.

In both conditional models secondary or higher educated women's odds of undergoing for CS was higher than illiterate and primary educated women. Though the odds was more higher if the antenatal care was received from Home or NGO sector (OR = 2.42, p-value = 0.03).

Women residing in rural areas had 0.67 times lower odds of undergoing for CS compared to those residing in urban areas under condition that the antenatal care was received from Public and Private Sector (OR = 0.67, p-value = 0.00). But if the care was received from Home or NGO sector then type of residence was not found to be a significant risk factor for cesarean delivery (p-value = 0.47).

Sex of previous child was found to be significant only if antenatal care was received from Public or Private sector and the odds of CS prevalence was 0.67 times lower for women who had a previous female child compared to women with previous male child (OR = 0.67, p-value = 0.00). If the care was received from Home or NGO sector then "Sex of previous child" was not significant risk factor (p-value = 0.65).

From the above table we found that if antenatal care was received from Public or Private sector then the odds of CS prevalence was 1.96 times higher for middle economic class women compared to poor economical class women (OR = 1.96, p-value = 0.00) and the odds was 3.79 times higher for rich economical class (OR = 3.79, p-value = 0.00). Though, if the care was received from Home or NGO sector then there was no significant difference of odds for CS delivery between women with different wealth indexes.

5.7 Comparison of marginal model of Cesarean Section delivery and conditional model of Cesarean Section Delivery under conditions of Place of Antenatal care

In marginal model of CS we found that mother's age at child birth was a significant risk factor. And in conditional models, if ANC was received from Public or Private sector then odds for prevalence of CS was 1.83 times higher for women aged between 20-34 years compared to those aged less than 20 years. If the care was received from home or NGO sector then there was no significant difference between these age groups of women and for women aged 35-49 years had 10.46 times higher odds of CS prevalence (OR = 10.46, p-value = 0.05).

In marginal model, there was significant difference between women's BMI level below normal and above normal. From the conditional models we found that if antenatal care was received from Public or Private sector then odds of CS prevalence was 2.34 times higher for women with BMI level above normal compared to those with BMI level below normal. Under both conditions there was no significant difference of CS prevalence between women with BMI level normal and below normal.

In marginal model of cesarean delivery we found that women's odds of CS was lower for those living in Chittagong division and higher for those living in Khulna division. But there was no significant difference in odds of CS prevalence in different divisions if antenatal care was received from Home or NGO sector and if the care was received from Public or Private sector then odds difference was similar as the marginal model.

Both in the conditional and marginal models secondary or higher educated women's odds for undergoing for CS was higher compared to illiterate and primary educated women.

In marginal model of CS delivery we found that type of residence was protective predicting factor for cesarean delivery and women who resided in rural areas had 0.67 times lower odds of undergoing for CS only if antenatal care was received from Public and Private Sector. If the care was received from Home or NGO sector then there was no significant difference of odds of CS delivery between women with different types of residence.

We found that "Sex of previous child" was a significant risk factor in the marginal model of CS. And in the conditional models, it was significant only if ANC was received from Public or Private sector and odds of CS prevalence was 0.67 times lower for women with previous female child compared to those with previous male child under this condition.

In the marginal model of CS delivery "Wealth index" was found to be significant risk factor and in the conditional model it was significant only if antenatal care was received from

Public or Private sector. For the other condition there was no significant difference of odds in prevalence of CS.

Chapter 6

Test for association between Outcome Variables

6.1 Introduction

In previous chapter we have applied the conditional logistic regression model to identify the risk factors influencing the occurrence of cesarean section under condition of different factors of Antenatal Care. In this chapter we test the dependence of Antenatal Care and Cesarean Section births to investigate whether women making four or more antenatal visits, antenatal care provider was qualified doctor and place of antenatal care have influence on mode of child delivery. For testing the dependency of two outcome variables **Islam et al.** proposed **Generalized Bivariate Bernoulli model** [17]**.** To obtain this test of dependence a joint model is needed which takes account of both conditional and marginal model. We have already assessed the conditional and marginal estimates in previous chapters and now in this chapter we discuss the dependence of antenatal care and cesarean section births.

6.2 Test for the Dependence between Number of Antenatal Visits and Cesarean Section

In this section we discuss the joint model, hypothesis, test statistic, result and interpretation of the test for dependence between Number of Antenatal Visits and Cesarean Section.

6.2.1 Joint Model for last birth cesarean section given number of antenatal visits

For applying the joint model our Y_1= Number of antenatal visits and Y_2= Last birth a cesarean section.

Let us consider that P($Y_2 = 1|Y_1 = 0, x$) represents the conditional probability of last birth a CS under the condition that number of antenatal visit is no or less than 4, P($Y_2 = 1|Y_1 =$

$1, x$) represents the conditional probability of last birth a cesarean section under the condition that number of antenatal visits is 4 or more than 4 and P($Y_1 = 1|x$) represents the marginal probability of Number of antenatal visits. Model 1 and Model 2 represents two conditional models P($Y_2 = 1|Y_1 = 0, x$) and P($Y_2 = 1|Y_1 = 1, x$) respectively. And model 3 represents marginal model P($Y_1 = 1|x$).

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that number of antenatal visits is no or less than 4.

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that number of antenatal visits is 4 or more than 4.

β_{1j}=regression coefficient of the model for probability of Number of antenatal visits.

Table 6.1 Conditional and Marginal estimates of the parameters of last birth a cesarean section given number of antenatal visits from Generalized Bivariate Bernoulli Model (GBBM)

Factors	Conditional model								Marginal Model			
	Model 1				Model 2				Model 3			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$	β_{1j}	S.E.	p-value	$\widehat{OR}$
Constant	-3.44	0.43	**0.00**	0.03	-3.26	0.63	**0.00**	0.04	-1.93	0.26	**0.00**	0.15
Mother's age at birth												
<20 (Ref)												
20-34	0.25	0.31	0.41	1.29	1.22	0.42	**0.00**	3.39	-0.10	0.17	0.55	0.90
35-49	0.17	0.43	0.70	1.19	1.46	0.56	**0.01**	4.29	-0.20	0.26	0.45	0.82
BMI												
Below Normal (Ref)												
Normal	0.18	0.22	0.39	1.20	-0.07	0.31	0.82	0.93	0.13	0.13	0.33	1.14
Above Normal	0.82	0.24	**0.00**	2.26	1.09	0.32	**0.00**	2.99	0.63	0.15	**0.00**	1.89
Division												
Barisal (Ref)												
Chittagong	-0.43	0.28	0.12	0.65	-0.77	0.38	**0.04**	0.46	0.04	0.19	0.82	1.04
Dhaka	0.36	0.27	0.19	1.43	0.18	0.37	0.63	1.19	0.40	0.19	**0.03**	1.49
Khulna	1.11	0.28	**0.00**	3.02	0.06	0.38	0.87	1.06	0.79	0.20	**0.00**	2.20
Rajshahi	0.29	0.29	0.32	1.34	-0.14	0.41	0.73	0.87	0.24	0.20	0.23	1.27
Rangpur	0.25	0.33	0.44	1.28	-0.23	0.39	0.55	0.79	1.18	0.20	**0.00**	3.26
Sylhet	-0.64	0.32	**0.04**	0.53	0.03	0.43	0.94	1.03	-0.19	0.20	0.35	0.83

Highest educational level												
No education and Primary (Ref)												
Secondary+	0.74	0.16	**0.00**	2.09	1.23	0.24	**0.00**	3.43	0.65	0.10	**0.00**	1.92
Type of residence												
Urban (Ref)												
Rural	-0.18	0.17	0.27	0.83	-0.34	0.19	0.08	0.71	-0.39	0.11	**0.00**	0.68
Sex of previous Child												
Male												
Female	-0.30	0.15	**0.04**	0.74	-0.38	0.18	**0.04**	0.69	-0.03	0.09	0.74	0.97
Wealth Index												
Poor (Ref)												
Middle	0.91	0.21	**0.00**	2.48	0.13	0.34	0.71	1.13	0.16	0.14	0.27	1.17
Rich	1.47	0.21	**0.00**	4.37	1.05	0.28	**0.00**	2.85	0.94	0.13	**0.00**	2.56

6.2.2 Hypothesis:

$$\boldsymbol{\beta_{01} = \beta_{11}}$$

And the alternative is,

$$\boldsymbol{\beta_{01} \neq \beta_{11}}$$

6.2.3 Test statistic:

To test the dependency between Number of Antenatal Visits and Cesarean Section the test statistic is,

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

= **117.3104**

Which is distributed asymptotically as chi-square distributed with (p+1) =**16** degrees of freedom. This shows that there is statistically significant relationship between Number of Antenatal Visits and Cesarean Section (p-value = 0.00).

Since p-value = 0. 00 <0.05, so that null hypothesis is rejected at 5% level of significance. So we can say from the result that, there exists dependence between Number of Antenatal Visits and Cesarean Section.

6.3 Test for the Dependence between Cesarean Section and ANC Provider: qualified doctor

In this section we discuss the joint model, hypothesis, test statistic, result and interpretation of the test for dependence between ANC Provider: qualified doctor and Cesarean Section.

6.3.1 Joint Model for last birth cesarean section given ANC Provider: qualified doctor

To apply the joint model here our Y_1= ANC Provider: qualified doctor and Y_2= Last birth a cesarean section.

Let us consider that $P(Y_2 = 1|Y_1 = 0, x)$ represents the conditional probability of last birth a cesarean section under the condition that ANC Provider was not a qualified doctor, $P(Y_2 = 1|Y_1 = 1, x)$ represents the conditional probability of last birth a CS under the condition that ANC Provider was a qualified doctor and $P(Y_1 = 1|x)$ represents the marginal probability of ANC Provider: qualified doctor. Model 1 and Model 2 represents two conditional models $P(Y_2 = 1|Y_1 = 0, x)$ and $P(Y_2 = 1|Y_1 = 1, x)$ respectively. And model 3 represents marginal model $P(Y_1 = 1|x)$.

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that ANC Provider was not a qualified doctor.

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that ANC Provider was a qualified doctor.

β_{1j}=regression coefficient of the model for probability of ANC Provider: qualified doctor.

Table 6.2 Conditional and Marginal estimates of the parameters of last birth a cesarean section given ANC Provider: qualified doctor from Generalized Bivariate Bernoulli Model (GBBM)

Factors	Conditional model								Marginal Model			
	Model 1				Model 2				Model 3			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$	β_{1j}	S.E.	p-value	$\widehat{OR}$
Constant	-4.70	0.76	**0.00**	0.01	-2.51	0.42	**0.00**	0.08	-1.17	0.23	**0.00**	0.31
Mother's age at birth												
<20 (Ref)												
20-34	0.45	0.49	0.36	1.57	0.58	0.29	**0.05**	1.79	0.23	0.16	0.15	1.26
35-49	0.38	0.73	0.60	1.46	0.71	0.39	0.07	2.03	0.27	0.23	0.23	1.31
BMI												
Below Normal (Ref)												
Normal	0.21	0.35	0.55	1.24	0.03	0.21	0.88	1.03	0.12	0.11	0.27	1.13
Above Normal	0.67	0.43	0.12	1.96	0.94	0.22	**0.00**	2.55	0.70	0.14	**0.00**	2.02
Division												
Barisal(Ref)												
Chittagong	0.05	0.57	0.93	1.05	-0.67	0.25	**0.01**	0.51	-0.15	0.16	0.36	0.86
Dhaka	0.64	0.55	0.25	1.90	0.21	0.24	0.39	1.23	0.22	0.16	0.19	1.24
Khulna	1.32	0.55	0.02	3.76	0.52	0.25	**0.04**	1.68	0.46	0.18	**0.01**	1.58
Rajshahi	0.85	0.55	0.12	2.35	0.06	0.27	0.81	1.07	-0.13	0.17	0.45	0.88
Rangpur	0.98	0.56	0.08	2.67	-0.03	0.28	0.92	0.97	0.10	0.18	0.55	1.11
Sylhet	-0.50	0.66	0.44	0.60	-0.37	0.28	0.18	0.69	-0.20	0.16	0.21	0.82
Highest educational level												
No education and Primary (Ref)												
Secondary+	0.72	0.27	**0.01**	2.06	0.80	0.16	**0.00**	2.23	0.83	0.09	**0.00**	2.30
Type of residence												
Urban (Ref)												
Rural	0.00	0.30	0.99	1.00	-0.41	0.14	**0.00**	0.66	-0.11	0.11	0.29	0.89
Sex of previous Child												
Male (Ref)												
Female	-0.29	0.26	0.26	0.75	-0.34	0.13	0.01	0.71	0.05	0.09	0.58	1.05
Wealth Index												
Poor (Ref)												
Middle	0.40	0.38	0.30	1.49	0.57	0.21	**0.01**	1.76	0.53	0.12	**0.00**	1.69
Rich	1.55	0.32	**0.00**	4.70	1.06	0.20	**0.00**	2.89	1.19	0.12	**0.00**	3.29

6.3.2 Hypothesis:

$$\boldsymbol{\beta_{01} = \beta_{11}}$$

And the alternative is,

$$\boldsymbol{\beta_{01} \neq \beta_{11}}$$

6.3.3 Test statistic:

To test the dependence between ANC Provider: qualified doctor and Cesarean Section the test statistic is,

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

= **170.8966**

Which is distributed asymptotically as chi-square distributed with (p+1) =**16** degrees of freedom. This shows that there is statistically significant dependence between ANC Provider: qualified doctor and Cesarean Section (p-value = 0.00).

Since p-value = 0. 00 <0.05, so that alternative hypothesis is accepted at 5% level of significance. So we can say from the result that, there exists dependence between ANC Provider: qualified doctor and Cesarean Section.

6.4 Test for the Dependence between Place of Antenatal Care and Cesarean Section

In this section we discuss the joint model, hypothesis, test statistic, result and interpretation of the test for dependence between Place of antenatal care and Cesarean Section.

6.4.1 Joint Model for last birth cesarean section given Place of Antenatal Care

For applying the joint model here our Y_1= Place of Antenatal Care and Y_2=Last birth a cesarean section.

Let us consider P($Y_2 = 1|Y_1 = 0, x$) represents the conditional probability of last birth a CS under the condition that Place of Antenatal care is Home or NGO or Other Place, P($Y_2 = 1|Y_1 = 1, x$) represents the conditional probability of last birth a CS under the condition that Place of Antenatal care is Public or Private Sector and P($Y_1 = 1|x$) represents the marginal probability of Number of antenatal visit. Model 1 and Model 2 represents two conditional models $P(Y_2 = 1|Y_1 = 0, x)$ and $P(Y_2 = 1|Y_1 = 1, x)$ respectively. And model 3 represents marginal model $P(Y_1 = 1|x)$.

Here,

β_{01j}= regression coefficient of the model for probability of last birth a CS under the condition that Place of Antenatal care was Home or NGO or Other Place.

β_{11j}= regression coefficient of the model for probability of last birth a CS under the condition that Place of Antenatal care is Public or Private Sector.

β_{1j}=regression coefficient of the model for probability of Place of Antenatal Care.

Table 6.3 Conditional and Marginal estimates of the parameters of last birth a cesarean section given Place of Antenatal Care from Generalized Bivariate Bernoulli Model (GBBM)

Factors	Conditional model								Marginal Model			
	Model 1				Model 2				Model 3			
	β_{01j}	S.E.	p-value	$\widehat{OR}$	β_{11j}	S.E.	p-value	$\widehat{OR}$	β_{1j}	S.E.	p-value	$\widehat{OR}$
Constant	-3.58	1.27	**0.00**	0.03	-2.85	0.40	**0.00**	0.06	0.73	0.33	**0.03**	2.07
Mother's age at birth												
<20 (Ref)												
20-34	1.31	1.07	0.22	3.70	0.60	0.28	**0.03**	1.83	0.02	0.22	0.92	1.02
35-49	2.35	1.21	**0.05**	10.46	0.53	0.38	0.16	1.69	0.19	0.32	0.55	1.21
BMI												
Below Normal (Ref)												
Normal	-0.14	0.50	0.77	0.87	0.00	0.20	0.99	1.00	0.22	0.15	0.15	1.25
Above Normal	0.97	0.55	0.07	2.65	0.85	0.21	**0.00**	2.34	0.64	0.20	**0.00**	1.90
Division												
Barisal (Ref)												
Chittagong	-1.30	0.74	0.08	0.27	-0.48	0.24	**0.05**	0.62	-0.08	0.24	0.74	0.92
Dhaka	-0.61	0.64	0.34	0.54	0.39	0.24	0.10	1.47	-0.23	0.23	0.32	0.79
Khulna	0.11	0.60	0.86	1.11	0.77	0.25	**0.00**	2.16	-0.47	0.24	**0.05**	0.63
Rajshahi	-0.58	0.71	0.41	0.56	0.29	0.26	0.27	1.33	-0.13	0.26	0.62	0.88
Rangpur	-0.71	0.71	0.32	0.49	0.29	0.27	0.28	1.34	-0.59	0.24	**0.01**	0.55
Sylhet	-1.36	0.79	0.09	0.26	-0.20	0.27	0.46	0.82	-0.26	0.24	0.29	0.77
Highest educational level												
No education and Primary (Ref)												
Secondary+	0.89	0.40	**0.03**	2.42	0.79	0.15	**0.00**	2.21	0.74	0.13	**0.00**	2.09
Type of residence												

Urban (Ref)												
Rural	-0.30	0.41	0.47	0.74	-0.39	0.14	**0.00**	0.67	0.30	0.14	**0.03**	1.35
Sex of previous child												
Male (Ref)												
Female	-0.16	0.35	0.65	0.85	-0.40	0.13	**0.00**	0.67	0.13	0.12	0.26	1.14
Wealth Index												
Poor (Ref)												
Middle	0.19	0.59	0.74	1.21	0.67	0.20	**0.00**	1.96	0.16	0.17	0.35	1.18
Rich	0.80	0.49	0.11	2.23	1.33	0.19	**0.00**	3.79	0.01	0.16	0.95	1.01

6.4.1 Hypothesis:

$$\boldsymbol{\beta_{01} = \beta_{11}}$$

And the alternative is,

$$\boldsymbol{\beta_{01} \neq \beta_{11}}$$

6.2.2 Test statistic:

To test the dependency between Place of Antenatal Care and Cesarean Section the test statistic is,

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

= **129.9156**

Which is distributed asymptotically as chi-square distributed with (p+1) =**16** degrees of freedom. This shows that there is statistically significant between Place of Antenatal Care and Cesarean Section (p-value = 0.00)

Since p-value = 0. 00 <0.05, so that null hypothesis is not accepted at 5% level of significance. So we can say from the result that, there exists dependence between Place of Antenatal Care and Cesarean Section.

Chapter 7

Discussion and Conclusion

7.1 Introduction

Knowledge and information about childbirth obtained during antenatal care is likely to be an important influence on pregnant women and her family's view about child delivery. Even sometimes doctors or antenatal care providers motive also influence the method of delivery. For this reason, number of antenatal visits, place of antenatal care and form whom the care has been received are likely to be an important influence on method of delivery. This study is undertaken to identify the dependence between antenatal care and Cesarean section births.

7.2 Discussion

In this present study prevalence of cesarean delivery in Bangladesh is 24%, though this rate varies 34.4% to 12.1% in different divisions. However, all these rates are excessive which exceed the WHO recommendation rate. WHO pointed that it is not justified for any region having a rate higher than 10-15%. All these unnecessary cesarean sections provide no medical benefit for mother or newborn, even increase the risks of medically induced prematurity, respiratory disease, maternal and fetus morbidity and mortality [9].

7.2.1 Socio economic factors association with Prevalence of CS (findings from the marginal model of CS)

Before discussing about the conditional models and their dependence, first in this section we discuss the risk factors association for predicting the occurrence of CS which were assessed in marginal model.

In this study we found that increase of maternal age was associated with the increased risk of CS. After adjustment of confounding factors, risk of CS was found significantly higher for women aged 20-34 years compared to <20 years and the risk was more for women aged 35-49 years. This may be because as the mother's age increase many obstetric and maternal problems also increase. Previous research also highlights that women with advance maternal age at childbirth increase the risk for cesarean delivery [6, 9, 19 - 30].

From this study we found that the women above normal body mass index are likely to have higher risk of CS compared to women with BMI level below normal. This may be due to overweight and obesity resulting in high risk for fetal macrosomia, which leads to cephalopelvic disproportion which causes the need of CS delivery. This finding is similar to the results in earlier studies [25, 33, 34].

Maternal educational level was found to be statistically significant risk factor for predicting the prevalence of cesarean section in this study. Women with secondary or higher education level had increased risk of undergoing for CS compared to illiterate or primary educated women. Other authors also confirmed same evidence in their studies [6, 35, 36].

This study showed that women living in rural areas were more likely to have lower risk of CS compared to those living in urban areas. This may be because in rural areas there is poor access to emergency surgical care. This finding is similar to the other findings in previous [13, 36, 37].

In this study we found that women with previous female child had lower risk of undergoing for cesarean section compared to those with previous male child. This may be the reflection of the view of women and their family about a female child. As far as we know there is no such study which determined the association between sex of previous child and cesarean section.

Women’s wealth index is found to be an important risk factor for predicting the occurrence of CS. As belonging to the higher economical class also increase the risk of CS. This may be due to affordability of cost for cesarean delivery that increases with the higher economical class. Previous research also highlights similar finding [6, 35 - 39].

7.2.2 Dependence between number of antenatal visits and cesarean section births along with the socio-economic and demographic factors

In our study we found that increase of maternal age was associated with the increased risk of CS. This association was significant only if 4 or more than 4 antenatal visits were made and if women made no or less than 4 antenatal visits then for them increase of maternal age was not associated with increased risk of cesarean section.

In this study women with BMI level above normal were likely to have higher risk of cesarean section compared to those with below normal. However, whether the number of antenatal visits was for both conditions women with BMI level above normal have higher risk of CS.

In our study we found that risk of CS was lower for women living in Chittagong division than those living in Barisal division and this risk was lower only if 4 or more antenatal visits were made. In Khulna division for women risk of CS was higher and this risk was higher only for them who made no or less than 4 antenatal visits. We also found that, Sylhet division living women who made no or less than 4 antenatal visits had lower risk of cesarean section.

This study showed that women with secondary or higher education had higher risk of cesarean section compared to those were illiterate or primary educated. This high risk of CS was found for both category of women whether made 4 or more than 4 antenatal visits or not. However, this risk was more higher if 4 or more antenatal visits were made.

In this study, women living in rural areas were likely to have lower risk of CS compared to those living in urban areas. However, we also found that women who made 4 or more antenatal visits among them the risk of CS was lower for those living in rural areas. If no or less than 4 antenatal visits were made then there was no significant difference in risk of cesarean section births between women living in urban and rural areas.

This study showed that women having previous female child had lower risk of undergoing for cesarean delivery compared to women who had previous male child. This low risk of CS was for both category of women who made 4 or more than 4 antenatal visits or not.

In this study, women with middle wealth index level had higher risk of cesarean section and this risk was even more for those with rich wealth index compared to women with poor wealth index. Which implies that as women belonging to the higher economical class have higher risk of undergoing cesarean section. This increased risk of CS was associated with wealth index only if no or less than 4 antenatal visits were made. If 4 or more antenatal visits were made then there was higher risk of CS if women belonging to rich economical class otherwise no significant difference was found in risk of CS compared to women belonging to the poor economical class.

In dependence test of the outcome variables, number of antenatal visits and cesarean section we found significant dependence (p-value = 0.00). This implies that, when women made more number of antenatal visits then the negotiation and bonding with the doctor or the antenatal provider strengthen, which contributes towards a CS delivery. Other studies also corroborate this result, though in those studies association was assessed with marginal approach [6, 40].

7.2.3 Dependence between ANC provider: Qualified doctor and cesarean section births along with the socio-economic and demographic factors

In this study, we found that as the increased of maternal age also increase the risk of CS. But upon considering that whether antenatal care was received from qualified doctor or not maternal age was not found to be significantly associated with cesarean section anymore.

This study showed that, women with body mass index above normal were likely have higher risk of cesarean section compared to women with BMI level below normal and this higher risk was only if antenatal care was received from qualified doctor.

In this study, we found that women living in Khulna division had higher risk of CS compared to those who lived in Barisal division. This high risk was for both conditions i.e. antenatal care was received from qualified doctor or not and comparing the conditions this risk was found more higher if the care was not received from qualified doctor. The lower risk of Chittagong division was only found if the care was received from a qualified doctor otherwise there was no difference with women living Barisal division.

This study showed that secondary or higher educated women were more likely to undergo for cesarean section compared to those are illiterate or primary educated. This was true for both conditions, whether received the antenatal care from qualified doctor or not. However, secondary or higher educated women risk of CS was even more higher if antenatal care was received from qualified doctor.

In this study, the risk of CS was lower for women living in rural areas compared to those living in urban areas. This risk was lower only if the antenatal care was received from qualified doctor otherwise there was no difference in risk of cesarean section between women living in urban and rural areas.

In this study women with previous female child were likely to have lower risk of cesarean section than those with previous male child. Considering the antenatal care provider qualified doctor or not it depicts that, if the care was received from a qualified doctor only then women with female child had lower risk of cesarean section.

This study showed that as upper economical class women belong higher the risk of cesarean section. And if the care was received from qualified doctor for then belonging to the more upper class were likely to have higher risk of cesarean delivery. If the care was not received from qualified doctor then rich women had higher risk of cesarean section than poor women.

In this study from the dependence test we found significant dependence between the outcome variables, ANC provider: qualified doctor and cesarean section births (p-value = 0.00). Which suggests that, if the antenatal care was received from qualified doctor then it will contributes towards a cesarean section delivery. As far we know there is no such study which was undertaken to assess the association between ANC provider: qualified doctor and cesarean section births.

7.2.4 Dependence between Place of antenatal care and cesarean section births along with the socio-economic and demographic factors

In this study we found that the increased of maternal age also increase the risk of CS. Upon considering the place from where women received antenatal care we saw that women who received the care from public or private sector if aged 20-34 years then had higher risk of cesarean section compared to those aged <20 years. Though, who received the care from home or NGO sector if aged 35-49 years had higher risk of cesarean section than those aged <20 years.

We found that women with BMI level above normal had higher risk cesarean section delivery than those with BMI level below normal and this higher risk only for if antenatal care was received from public or private sector.

From this study we found that, women living in Chittagong division were likely to have lower risk and those living in Khulna division were likely to have higher risk of cesarean section compared to women living in Barisal division. These type of risks was exposed to only them who received antenatal care from public or private sector otherwise not.

We found that secondary or higher educated women were more likely to undergo cesarean section compared to women who are illiterate or primary educated. Whether antenatal care was received from public or private sector or not, women with secondary or higher education had higher risk of cesarean section.

In this study women living in rural areas had lower risk of cesarean delivery than those living in urban areas. Considering the place from where women received antenatal care we found that, this risk was lower only if the care was received from public or private sector otherwise there was no significant difference in risk of CS between women living urban and rural areas.

From this study we found that women with previous female child had lower risk than those with previous male child. This lower risk was only if antenatal care was received from public or private sector otherwise there was no significant difference in risk of CS.

In this study women belonging to the upper economical class increased the risk of cesarean section and this increased risk only if antenatal care was received from public or private sector.

From the dependence test between Place of antenatal care and CS delivery we found significant dependence. It suggests that, if women receive antenatal care from Public or Private sector then this will contribute towards a CS delivery. As far we know there is no such study which was undertaken to assess the association between place of antenatal care and cesarean section births.

7.3 Conclusion

Present study shows that there is dependence between Antenatal Care and prevalence of cesarean section delivery, antenatal care includes number of antenatal visits are made, motive and influence of doctors/antenatal care providers and the place from where the care is received. In other words, the practice of CS in Bangladesh is immensely influenced at antenatal care stage. Although, antenatal care is expected to be motivated by practices and attitudes to promote a healthy delivery which will preserve women's autonomy and will prevent unnecessary CS delivery. Interventionist should take proper steps to evaluate management from where women receive antenatal care, even the quality of antenatal care needs to be reviewed.

Appendix A

R Source Codes

```
mdt<-read.csv("D:/BDIR70FLv1.3.csv")
head(mdt)
ls(mdt)
names(mdt)[names(mdt) == 'ï..V401'] <- 'v401'
ls(mdt)
mdt1<-subset(mdt,mdt[,4]==0)
table(mdt1[,4])
mdt2<-subset(mdt,mdt[,4]==1)
table(mdt2[,4])
table(mdt2[,1])

#No. of antenatal visit to CS

#Conditional Model
mdt1<-subset(mdt,mdt[,2]==0)
mdt2<-subset(mdt,mdt[,2]==1)

#Y2=1|Y1=0
trt01=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt1)
summary(trt01)

#Y2=1|Y1=1
trt11=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt2)
summary(trt11)

#marginal Model
trt1=glm(formula = antvd ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt1)

trt2=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt2)

#dependence test between number of antenatal visit and CS
source("D:/Applied STAT/Thesis/literature review/Writng/Data
Set/dtestBIVBSTD.R")
dpt<- dtest(trt01,trt11,trt1,trt2)
dpt

#anc provider to CS

#Conditional Model
mdt1<-subset(mdt,mdt[,3]==0)
mdt2<-subset(mdt,mdt[,3]==1)

#Y2=1|Y1=0
```

```
trt01=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt1)
summary(trt01)

#Y2=1|Y1=1
trt11=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt2)
summary(trt11)

#Marginal Model
trt1=glm(formula = mtvpvdr ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt1)

trt2=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt2)

#dependence test between anc provider and CS
dpt1<- dtest(trt01,trt11,trt1,trt2)
dpt1

#place of anc to CS

#Conditional Model
mdt1<-subset(mdt,mdt[,4]==0)
mdt2<-subset(mdt,mdt[,4]==1)

#Y2=1|Y1=0
trt01=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt1)
summary(trt01)

#Y2=1|Y1=1
trt11=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt2)
summary(trt11)

#Marginal Model
trt1=glm(formula = PANC ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt1)

trt2=glm(formula = v401 ~
agebt_d2+agebt_d3+bmin_d2+bmin_d3+div_d2+div_d3+div_d4+div_d5+div_d6+div_d7+edu+
res+sexpc+wealthindx_d2+wealthindx_d3, family = binomial(), data = mdt)
summary(trt2)

#dependence test between place of anc and CS
dpt2<- dtest(trt01,trt11,trt1,trt2)
dpt2
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Bibliography

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