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Application of Binary Logistic Regression Model for Assessing the Caesarean Risk Factors in Bangladesh: A Case Study of Khulna and Gopalganj District

Biplab Biswas[a]*, Md. Murad Hossain[b], Mohammad Kamal Hossain[c]

[a,b,c]*Department of Statistics, Faculty of Science, Bangabandhu Sheikh Mujibur Rahman Science & Technology University, Gopalganj-8100, Bangladesh*

[a]*Email: bbiswas@isrt.ac.bd*

[b]*Email: sadid.shimul@yahoo.com*

[c]*Email: kamalbsmrstu@gmail.com*

Abstract

The main focus of this study is to investigate the caesarean risk factors in a particular area of Bangladesh. The caesarean delivery rate is increasing day by day in most developing countries like Bangladesh and number of caesarean births has almost doubled in the last eight years in Bangladesh largely due to maternal, socio-economic and demographic factors. Instead of many disadvantages, caesarean deliveries are most common among women but it is not clinically justified. For improving the maternal health status, it is essential to determine the risk factors of caesarean delivery. For this study some hospitals have selected from Khulna and Gopalganj district. Our population is the total number of pregnant women admitted for delivery in the hospitals and 600 respondents were taken as sample. After collecting data, information were arranged in tables and analyzed. For the analysis, chi-square test and fisher's exact test were performed to identify the significant association between delivery type (caesarean/non-caesarean) and maternal, socio-demographic and socio-economic factor's respectively. A stepwise binary logistic regression analysis was carried out to identify the most impact factors on caesarean delivery. We found that 14 risk factors were statistically associated with delivery type out of 21 risk factors. From this study, it is clear to us that above influential factors may affects the mother's health status in Bangladesh as well as Khulna and Gopalganj district.

Keywords: Caesarean delivery; Fisher's exact test; Chi-square test; Stepwise binary logistic regression.

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* Corresponding author.

1. Introduction

Caesarean delivery or caesarean birth, also known as caesarean section (C-section) occurs through a scratch in the abdominal wall and uterus rather than through the vagina [1, 2]. In spite of many risks this surgical procedure is most common among women. There has been a gradual increase in cesarean births over the past 30 years in many developed and developing countries [1-2, 3, 4]. Over the last few years, caesarean delivery rates in South-Asian country increase annually for Bangladesh (1.19%), India (1.09%), Nepal (1.15%) and Pakistan (1.08%) [6, 9].The average CS rate in Asia is 15.9%. China, Malaysia (15.7%) [8], Hong Kong and Lebanon present the highest CS rates in Asia, with estimates of 40.5%, 27.4% and 23.3%, respectively. Nepal and Cambodia's rates are lowest (1%), followed by Yemen (1.5%) [5, 6]. The caesarean delivery rate is increasing day by day in most developing countries like Bangladesh and number of caesarean births has almost doubled in the last eight years in Bangladesh largely due to maternal, socio-economic and demographic factors [1]. The figure rose to 690,000 or 23% of total deliveries last year from 355,000 or 9% of total deliveries in 2007, according to Bangladesh Demographic and Health Survey (BDHS) 2014 and this increase has not been clinically justified [3]. The World Health Organization recommends that a country should keep births through caesarean section below 15%, as it is a major operation that carries risks and takes a lot longer for a patient recover compared to a normal delivery [3, 6]. In Bangladesh, most of women during pregnancy are deprived from proper medical facility, balanced food and socio-economic facility as a whole [1]. Instead of some advantages of caesarean delivery, most of mothers and baby are sufferings from various health problems such as infection, hemorrhage, injury to organs, adhesions, reactions to medicine, maternal mortality rate, effects of future pregnancies, remove the uterus (hysterectomy) and premature birth, fetal injury, breathing problems respectively [1, 5]. So, increasing C-section rate is one of the main concern in most of the countries in the world and now, it is an identified as emerging "global epidemic" [10, 11]. The increase in caesarean deliveries has been attributed to multiple factors ranging from maternal, socio-demographic, socio-economic and institutional factors [3]. There are some common factors which are related to caesarean delivery such as maternal age at birth [12-14], order of birth [15], baby birth weight [16], socioeconomic status [17], high levels of maternal education [14, 18, 19], previous C-section [20-22], obstetric complications [23], high income level [14, 19, 24] etc. Age at marriage is also a significant cause of caesarean birth rates in the developing countries [25]. Many study were conducted about on this topic and many factors have been identified which are related to caesarean delivery but some factor were not included in the previous study. In the South-west region especially Khulna and Gopalganj district of Bangladesh, no early studies were carried out to examine the possible risk factors associated with the evaluated rates of caesarean birth. This study presents the most recent estimate of caesarean delivery in the south-west region of Bangladesh and identified some new factors which effect on the motivation of caesarean delivery by using data from sample survey.

2. Methodology

2.1. Conceptual Relationship

We have to understand from the literature review, caesarean deliveries or caesarean birth rates (CBR) are influenced by various factors such as maternal, socio-demographic socio-economic and other relevant factors

[3]. Maternal factors are directly effect on caesarean delivery, socio-demographic and socio-economic factors are indirectly related to caesarean delivery but most of the factors are interrelated to each other.

2.2. Study Area and Study Population

Both public and private hospitals have facility for caesarean and non-caesarean delivery in Bangladesh. For this reason study were conducted in the Khulna and Gopalganj district of Bangladesh for the public and private hospitals to represent the real scenario of caesarean section and to identify the risk factors which influence the caesarean delivery. Our study population is the pregnant women who were admitted for delivery in the selected public and private hospitals.

2.3. Data Collection

In this study, we consider the proportion $P = 0.5$ with an acceptable precision $E = 0.040$, significance level of $\alpha = 0.05$ and $Z = 1.96$. When the population size is unknown for Simple random sampling, the sample determinant formula is $n = P(1 - P)\left(\frac{Z}{E}\right)^2$ [26]. The study sample contained of 600 women who had delivery either through normal or caesarean delivery from three private and three public hospitals. Questions were close-ended and questionnaire was filled up by direct interview methods. Most important criteria was that the pregnant women who were admitted to maternity ward of private or public hospitals for their deliveries. The study followed a cross-sectional design and participants were selected by simple random sampling during the period of February to April 2016. Since, 60% of total deliveries occurred during the period of February to April 2016. It can be ensured that data were sufficient to represent the population. All the Interviews were conducted in 1-3 days post deliveries. Among the 600 delivery cases, 435 were caesarean and remaining 165 were non-caesarean delivery.

2.4. Data Description

Dependent variable: Delivery type was the dependent variable and it was taken to be dichotomous in nature (coded by the values 1 if the respondents undergo caesarean deliveries and 0 non-caesarean deliveries).

Independent variables: The maternal variables were baby birth weight (<2.5kg or more than equal 2.5 kg), previous C-section (Yes=1/No=0), death of previous children (Yes=1/No=0), previous delivery type (caesarean/normal), pregnancy induced swollen of leg (Yes=1/NO=0) (it is the condition of pregnant women that causes fluid retention and the inability of muscles to absorb liquid), pregnancy brought senseless (Yes/No), maternal high blood pressure (Yes/No), maternal asthma (Yes/No), malnutrition (Yes/No), lack of vitamin, calcium and iron (Yes/No) and breast feeding (Yes/No).

The socio-demographic variables included maternal age at birth, age at marriage, occupation, education level, family planning (Yes/No), pregnant before age 18 (Yes=1/No=0), order of birth (one/two/three/four), husband age at birth, ultrasonography (Yes/No), maternal body mass index, balanced diet during pregnancy (Yes/No). The maternal age at birth was categorized into four groups (Years): <20, 20-24, 25-29 and more than 30. Age at

marriage was classified into three categories: less than 18 years, 18-22 years, 23 years and above. Most of the maternal were housewife and some were businessman or related to other occupations. Maternal body mass index which are related to maternal height and weight and it was classified into four categories: Under weights, Normal, Over weights and Obese according to less than 18.5, 18.5-25, 25-30, 31 and above. Education status is the highest level of schooling attained, measured as primary and below, secondary and higher. The socio-economic variables were husband occupation, family income and some other variables were included in the study. Husbands occupation were service holder, businessman, farmer and their income can be categorized as below 15000, 15000-25000, 25000-35000, 35000 and above.

2.5. Statistical Equipment

After collecting data, information was organized in table and analyzed using some statistical tools. In the beginning some percentage distribution and graphical representation were presented to realize the scenario of caesarean delivery and its related factors. Bivariate analysis was implemented to detect the significant association between types of deliveries (caesarean/non-caesarean) and a series of independent variables. Categorical or nominal variables were analyzed by the Chi-square test or Fishers exact test according their suitability. Finally, binary logistic regression analysis was conducted to separate factors which are connected to caesarean delivery. Here, tolerable 5% level of significance was considered for each of the test.

2.5.1 Pearson's Chi-square Test

Chi-square test is a statistical test commonly used for testing independence and goodness of fit [27]. The independent test is applied when you have two categorical variables from a single population. Independence test is used to determine whether there is a significant association between the two variables and Goodness of fit test is used to determine whether observed frequency distribution matches the theoretical frequency distribution. In both the cases chi-square test statistic is,

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{\left(O_{i,j}-E_{i,j}\right)^2}{E_{i,j}} \sim \chi^2_{(r-1)(c-1),\alpha} \qquad (1)$$

χ^2 =Pearson's cumulative test statistic, which asymptotically approaches a χ^2 distribution

$O_{i,j}$ = Observed frequency of type (i,j), $E_{i,j}$ = Expected frequency of type (i,j), r = Number of row in contingency table, c = Number of column in contingency table, α = Level of significance.

To remove the overestimation of statistical significance Yate's correction is needed. When at least one cell of a contingency table contain frequency less than 5 then Yate's correction is appropriate to use. Yate's corrected version of Pearson's chi-square statistic:

$$\chi^2_{Yates} = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{\left(|O_{i,j}-E_{i,j}|-0.5\right)^2}{E_{i,j}} \sim \chi^2_{(r-1)(c-1),\alpha} \qquad (2)$$

2.5.2 Fisher's Exact Test

Fisher's exact test is a statistical significance test used in the analysis of contingency tables and it is employed when sample sizes are small, also valid for sample sizes. Fisher's exact test is a statistical test used to determine if there are nonrandom associations between two categorical variables [27]. Consider two variables X and Y with m and n observed states, respectively. For $m \times n$ contingency table, the generalize form of hyper-geometric probability function is

$$P_{cutoff} = \frac{(R_1!R_2!\ldots R_m!)(C_1!C_2!\ldots C_m!)}{N!\prod_{i,j} a_{ij}!} \quad (3)$$

Where, a_{ij} is the number of observations in the (i,j)th cell, R_i and C_j are the row and column total respectively, N is the total number of observations. Now find all possible contingency table consistent with the row and column total. For each one, calculate the probability using the hyper-geometric probability function and each of them consider as a p-value. Then p-value of the test can be simply computed by the sum of all p-values which are $\leq P_{cutoff}$ .There would be a significant association between two variables if the p-value less than the level of significance.

2.5.3 Binary Logistic Regression Model

Logistic regression model is useful to find out the best fitting, reasonable model to establish the relationship between dependent variable or response variable (dichotomous) and set of explanatory or independent variable (dummy or categorical) [28]. It is a multivariate technique for finding the probability that an event occur. For single variable the model can be defined as

$$Prob(event) = \frac{1}{1+e^{-(\beta_0+\beta_1 x)}} \quad (4)$$

Where β_0 and β_1 are regression coefficients estimated from the data and x is the independent variable. For more than one independent variable the model is

$$Prob(event) = \frac{1}{1+e^{-(\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots\ldots\ldots\ldots+\beta_p x_p)}} \quad (5)$$

The log-odds and odds ratio can be defined

$$ln\left(\frac{prob(event)}{Prob(nonevent)}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \ldots \ldots \ldots + \beta_p x_p \quad (6)$$

$$Odds\ Ratio = \frac{Prob(event)}{Prob(nonevent)} = e^{\beta_0} e^{\beta_1 x_1} \ldots \ldots \ldots e^{\beta_p x_p} \quad (7)$$

Odds Ratio changes when the i[th] independent variable increases by one unit. If β_i is positive then the odds Ratio are increased which indicates that the probability of occur an event is greater than the probability of occur non-event. If β_i is negative then odds Ratio are decreased which specifies that the probability of occur an event is smaller than the probability of occur non-event. The Fadden and Nagelkerke test were also used to assess the

overall goodness of fit of the logistic regression model. Finally, a best regression model was estimated by using Stepwise variable selection techniques. The data were analyzed using the Statistical R Packages.

3. Result and Discussion

We conducted our study in the south-west region of Bangladesh and our sample data were contained of 600 mothers with the combined caesarean and non-caesarean rates among the contestants were 72.5% and 27.5% respectively. Simple frequency table and graphical representation are very widely used to identify the nature and various pattern of maternal, socio-demographic and other characteristic which is useful to clarify the relation with delivery type. From Table 1, we see that maximum of mother's are lies between the age group 20-24 years and from Table 3, caesarean delivery rate is increasing before age 29, after that decrease it. From Figure1, it is found that 39% of mother education level is SSC and 24% are primarily educated which indicate most of the mothers are less educated.

Table 1: Percentage distribution of mother's according to their age group.

Age interval of mother's (in year)	Frequency	%
<20	150	25.0
20-24	220	36.7
25-29	155	25.8
30+	75	12.5
Total	600	100

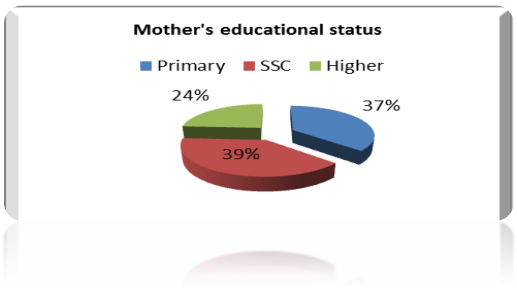

Figure 1: Percentage distribution of mother's educational status**.**

Table 2: Percentage distribution of respondent husband occupation

Husband Occupation	Frequency	%
Service holder	234	39.0
Businessman	160	26.7
Farmer	90	15.0
Other	116	19.3

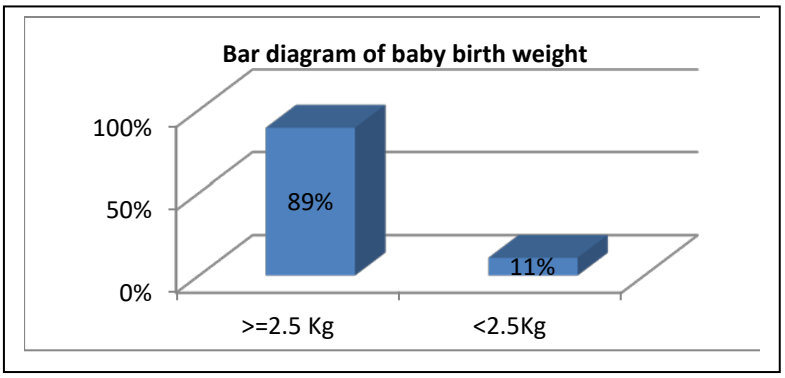

Figure 2: Percentage distribution of baby birth weight.

From Table 2 and Table 3, it is evident that largest numbers of respondent husbands are those with service holder and 26.7% are businessman. So it may be said that caesarean delivery tendency more for higher class family. From Figure 2 and Figure 3, it is obvious that about 89.2% baby weight more than 2.5 kg and most of the family monthly income less than 15000. In recent years, recorded numbers of pregnant women go to clinic or hospital and facing with ultrasonography (Figure 4). From Table 3, maternal body mass index is one of the main factors for caesarean delivery and it also depend for previous delivery type (99% respondents in front of C-section whose were caesarean delivery in previous).

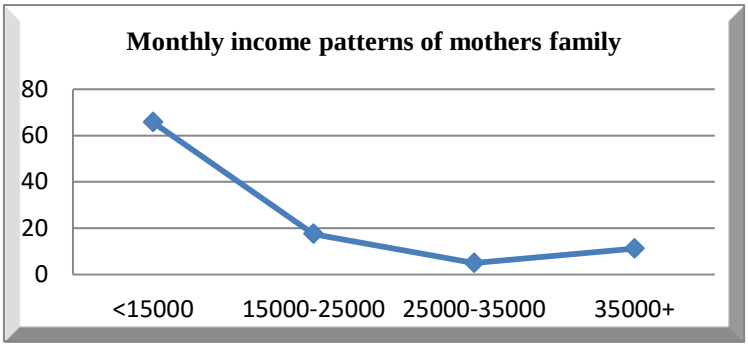

Figure 3: Percentage distribution of mother's family income.

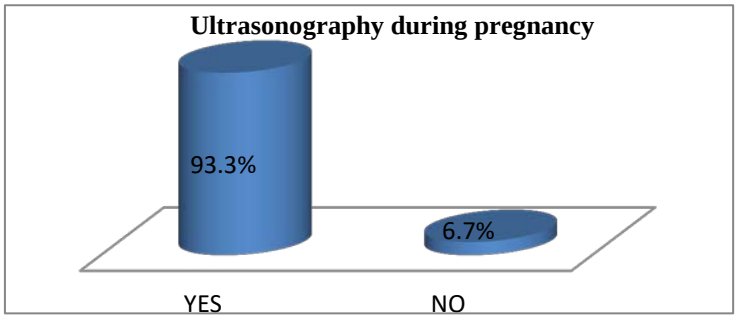

Figure 4: Percentage distribution of ultrasonography during pregnancy.

Table 3 shows the percentage distribution of delivery type according to different variables with their categories and also assessing the association between delivery type and patients characteristics (maternal variables, socio-demographic variables and socio-economic variables). Here, we have considered the H_0: There is no association between delivery type and selected variables VS H_1: There is association between delivery type and selected variables. Table 3 also shows that out of 21 factors (variables) observed, 15 were statistically associated with the delivery type. Among all the maternal variables baby birth weight (P<0.001), previous delivery type (P<0.001), ultrasonography during pregnancy (P=0.002), Senseless During pregnancy (P=0.013), high blood pressure during pregnancy (P=0.001), Balanced Diet During Pregnancy (P<0.001), breast feeding (P<0.001) were highly significant and Medicine During Pregnancy (P=0.81), Pregnancy induced swollen of leg (P=0.78), Asthma during pregnancy (P=0.40) were not statistically associated with delivery type. Among the socio-demographic factors maternal age at birth (P=0.004), maternal body mass index (P=0.001), husband age at birth (P<0.001), pregnant before age 18 (P=0.002) were significant and some others factors were not associated. All the socio-economic variables were associated with delivery type.

The odds ratios with 95% confidence intervals are obtained from the logistic regression model (for all variables) of caesarean delivery were obtained. From this analysis, we found that caesarean delivery rises significantly with having the maternal age at birth (most effective age group 25-29), baby birth weight, mother's occupation (housewife), husbands age at birth, husband occupation, pregnant before age 18, death of previous children,

Table 3: Percentage distribution of selected variables according to delivery type and test of association

Selected variables	Delivery Type				p-value
	Caesarean Delivery		Non-caesarean Delivery		
	n	%	n	%	
Maternal Age at Birth					
<20	95	63.3	55	36.7	
20-24	165	75.0	55	25.0	
25-29	125	80.7	30	19.3	0.004
30+	50	66.7	25	33.3	
Maternal Body Mass Index (BMI)					
Under Weight (<18.5)	55	61.1	35	38.9	
Normal Weight (18.5-24.9)	240	70.6	100	29.4	
					0.001
Over Weight (25-29.9)	125	80.7	30	19.3	
Obese (30+)	14	93.3	1	6.7	
Baby Birth Weight					

< 2.5 kg	25	38.5	40	61.5	<0.001
Maternal Education Status					
Primary	150	68.2	70	31.8	
SSC	190	80.9	45	19.1	0.001
Higher	95	65.5	50	34.5	
Maternal Occupation					
Housewife	425	74.6	145	25.4	
Service Holder	10	40.0	15	60.0	<0.001
Businessman	1	20.0	4	80.0	
Husband Age at Birth					
<25	30	50.0	30	50.0	
>=25	405	75.0	135	25.0	<0.001
Husband Occupation					
Service Holder	175	74.8	59	25.2	
Businessman	130	81.3	30	18.7	
Farmer	55	61.1	35	38.9	0.001
Other	75	64.7	41	35.3	
Husband Income					
<15000	290	73.4	105	26.6	
15000-25000	85	80.9	20	19.1	
25000-35000	15	50.0	15	50.0	0.003
35000+	42	62.7	25	37.3	
Early Age of Marrige					
<18	245	70.0	105	30.0	
18+	190	76.0	60	24.0	0.12
Order of Birth					
One	260	73.2	95	26.8	

Two	130	74.3	45	25.7	0.23
Three	30	60.0	20	40.0	
Four	15	75.0	5	25.0	
Pregnant Before Age 18					
No	235	78.3	65	21.7	0.002
Yes	200	66.7	100	33.3	
Ultrasonography During Pregnancy					
No	20	50.0	20	50.0	0.002
Yes	415	74.1	145	25.9	
Previous Delivery Type					
Caesar	109	99.1	1	0.9	<0.001
Normal	80	53.3	70	46.7	
Senseless During pregnancy					
No	390	74.3	135	25.7	0.013
Yes	45	60.0	30	40.0	
Pregnancy induced swollen of leg					
No	230	73.1	85	26.9	0.784
Yes	205	71.9	80	28.1	
Asthma During Pregnancy					
No	355	71.7	140	28.3	0.400
Yes	80	76.2	25	23.8	
High Blood Pressure					
No	265	67.9	125	32.1	0.001
Yes	170	80.9	40	19.1	
Death of Previous Children					
No	375	70.3	160	29.7	0.001
Yes	60	92.3	5	7.7	
Balanced Diet During Pregnancy					
No	125	86.2	20	13.8	<0.001
Yes	310	68.1	145	31.9	

Medicine During Pregnancy					
No	360	71.4	30	28.6	0.81
Yes	75	72.7	135	27.3	
Breast Feeding					
No	195	92.8	15	7.2	<0.001
Yes	240	61.5	150	38.5	
Family Planning					
No	165	75.0	55	25.0	0.342
Yes	270	71.1	110	28.9	

high blood pressure. The results are interpreted as maternal and his husband motivated to caesarean delivery when mother's and father's age become more than 25, for avoiding risk (if previous child were died). Early marriage and high blood pressure are most important cause of caesarean delivery. Balanced diet during pregnancy, family planning and breast feeding are effective factor of non-caesarean delivery.

Table 4: Fitted logistic regression model by using stepwise variable selection techniques, odds ratio and their confidence interval.

Selected Variables	Odds Ratio[Exp(coefficients)]	95% Confidence Interval
Maternal age at birth		
(<20)	1.000	
20-24	12.39**	4.065-39.29
25-29	94.67**	19.88-504.9
30+	26.71**	5.003-152.2
Baby Birth Weight		
(< 2.5 kg)	1.000	
>=2.5 kg	15.98**	7.113-38.15
Mothers Occupation		
(Service Holder)	1.000	
Housewife	6.632**	1.841-25.35
Businessman	0.312*	0.012-3.924

Husband Age at Birth		
(<25)	1.000	
>=25	2.836**	1.033-8.101
Husband Occupation		
(Other)	1.000	
Farmer	2.045**	0.903-4.776
Businessman	6.446**	2.813-15.47
Service Holder	2.251**	1.080-4.725
Order of Birth		
(One)	1.000	
Two	0.176**	0.068-0.439
Three	0.033**	0.007-0.154
Four	0.066**	0.012-0.384
Pregnant Before Age 18		
(No)	1.000	
Yes	2.879*	1.109-7.519
Senseless During pregnancy		
(No)	1.000	
Yes	0.387*	0.181-0.826
Pregnancy induced swollen of leg		
(No)	1.000	
Yes	0.583	0.328-1.029
High Blood Pressure		
(No)	1.000	
Yes	1.356*	0.327-1.163
Death of Previous Children		
(No)	1.000	
Yes	3.417*	1.232-11.34
Balanced Diet During Pregnancy		

(No)	1.000	
Yes	0.177**	0.084-0.352
Breast Feeding		
(No)	1.000	
Yes	0.053**	0.022-0.119
Family Planning		
(No)	1.000	
Yes	0.332**	0.178-0.604
Intercept	0.167	
Fadden $\boldsymbol{R^2}$	0.381	
Nagelkerke $\boldsymbol{R^2}$	0.523	

*, ** indicate significant factors in the model, parenthesis indicates the reference category.

To identify the most influential risks factors for caesarean delivery, we conducted a stepwise regression analysis on the variables and results are shown in the Table 4. By stepwise selection, the analysis discloses that fourteen remained significant independent variables to predict which patients were at high risk of caesarean delivery. These variables were maternal age at birth, baby birth weight, mother's occupation, husband age at birth, husband occupation, order of birth, pregnant before age 18, senseless during pregnancy, pregnancy induced swollen of leg, high blood pressure, death of previous children, balanced died during pregnancy, breast feeding and family planning. In previous research, mother's age at birth, husband occupation, Pregnancy induced swollen of leg, mother's age, high blood pressure, order of birth, balanced diet during pregnancy were most influential factors of caesarean delivery. This evidence conform our study and also we have found some new most influential factor's which were absent in the past study.

4. Conclusion and Recommendations

From the above discussion, we have to conclude that caesarean delivery is one of the most serious health issues. To reduce the caesarean delivery rate in developing countries as well as south-west region of Bangladesh especially in Khulna and Gopalganj district will require widespread tactics to introduce maternal variables, proper care practices and government policies to control the health facility of public and private hospitals. In our study, fourteen significant factors can be considered to predictors of caesarean delivery which were notified in the above discussion. Finally, from the statistical point of view, this study suggests that our finding factor may influence the health of mother. The following suggestions may be recommended in view of our observation:

- In this study, the rate of caesarean delivery is higher for the maternal whose age at birth less than 18 years and more than 25 years. This indication may suggest that government should take necessary steps

to prevent early marriage.

- Balanced and nutritional diet may be beneficial for pregnant women. For this purpose Govt. and non Govt. organization should conduct healthcare programs.
- Increasing awareness of women on suitable delivery type may influence the motive of caesarean delivery.
- Provide complete and reliable information to the mothers so that they do not opt for caesarean section in a state of panic or ignorance.
- Moreover, public awareness of harmful and long term effects of caesarean deliveries are needed to conform a stable mother's health.

5. Limitations of the Study

The study has been conducted in a small region of Bangladesh especially in Khulna and Gopalganj district for some public and private hospitals and the sample size is relatively small. It may be possible to get better and more reliable result to increase the sample size. We have tried to recognize a good questionnaire but there may be missing some variables or factors which are associated with delivery type. There may be some ethical questions in our questionnaire. In this case, the respondents were not spontaneously answers these questions.

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