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Factors Associated with Caesarean Delivery in Nigeria: a Generalized Linear Mixed Logistic Regression Analysis Using Adaptive Gaussian Quadrature Technique

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Abstract

Background: There has been an increase in the prevalence of caesarean births in recent decades, a development that has assumed a public health issue of global concern. An analytical technique that reduces loss of information in caesarean section modeling by accounting for grouping effect is of great need. This study assessed the correlates of caesarean deliveries in Nigeria using a generalized logistic mixed model and adopted the Adaptive Gaussian Quadrature estimation techniques.

Methods: The study extracted data on women of childbearing age from the Nigerian Demographic and Health Survey (NDHS) 2013. Generalized logistic mixed model was used to assess the correlates of caesarean deliveries. Data was analyzed using SPSS version 23.

Results: The overall prevalence of caesarean section delivery is 6.8% and in keeping with the WHO recommendation for caesarean section birth rates. The predictors of caesarean section were history of caesarean section, ever having a termination of pregnancy, maternal age, birth order, if current pregnancy is a twin, size of the baby and distance of clients' residence to the health facility. The prevalence of caesarean section births was higher among mothers living in urban communities, mothers with higher educational attainments and those with high ranks in the wealth index. The covariates found to significantly influence caesarean births in this study are in line with WHO recommendations.

Conclusion: Wide variations exist in the predictors of caesarean section births, and this calls for a region-specific programme design aimed at ensuring rational indications for caesarean section delivery, hence avoiding preventable caesarean section.

Keywords: Caesarean births; Adaptive Gaussian Quadrature; Generalized logistic mixed model;

Introduction

Caesarean section (CS) is one of the strategies to prevent complications related to childbirth and intrapartum deaths of mothers and children. A gradual increase in caesarean births over the past 30 years has been reported in many developed and developing countries.[1] The perceived rise and medicalization of CS have also been a major concern to public health practitioners and obstetricians. The World Health Organization (WHO) recommends that member countries keep the CS below 15%, partly because of the associated high risk, which is higher in developing countries.[2] In reality, factors linked with CS birth vary widely in different parts of the world. The rates are associated with different variables even within countries, which span mothers' socio-demographics, maternal factors, infant factors, health facility capacity, and technical know-how.[3] Increased rates of CS delivery have been attributed to multiple risk factors, including maternal, socio-demographic, socio-economic, and institutional factors.[4] Maternal age at birth, the order of birth/total children ever born, baby birth weight, socio-economic status, high levels of maternal education, obstetrics complications and previous CS are the leading factors.[5]

Analytical consideration of models seeking to predict a nonnormal response variable is a major concern in applied research because of violation of normally distributed response variable assumption in statistical models. However, it must be noted that it is a common practice to come across a health variable that is binary as in the case of CS, presence or absence of a disease, the infection status of individuals and so on, and an alternative approach is needed to ensure the robustness of the model estimates. Aside from this, the problem is multifaceted if the interest is beyond quantifying the exact effects of each predictor variable on the response variable, as in the case of linear regression. For instance, if the response variable is taken from a survey with nested grouping effects (municipality, state, cluster, etc), the focus is to evaluate the variation among the units or groups in addition to the exact effects (fixed effects). The variation due to grouping effects is often referred to as random effects.

The best choice of the statistical approach in any applied research is using the methods that fit into the data. A generalized linear mixed model (GLMM) is a statistical methodology that works well for nonnormal data with grouping effects. GLMM combines the properties of two statistical frameworks widely used in many applied epidemiology and medical researches, i.e. linear mixed models (which incorporate random effects) and generalized linear models (which handle nonnormal data by using link functions and exponential family). However, it requires that one specifies the distribution, link function, and random effects structure. For example, to establish probable risk factors of caesarean delivery, we select a Bernoulli distribution with logit link function (purely for binary outcome) and specify that the response variable varies across clusters.

Few studies seeking to know the predictors of caesarean delivery have used logistic regression, even with nested data.[6-9] Logistic regression is a good choice when it is desirable to model a nonnormal binary response variable. However, its estimates are unreliable when the model fails to account for the nested or grouping effect of the data generating process (DGP). To account for grouping effect in a model seeking to predict CS, Amini *et al*[10] applied a multilevel logistic regression model (MLLRM), a type of GLMM that incorporates both fixed and random effects into the model specification and adopted a penalized quasi-likelihood (PQL) estimation method introduced by Breslow and Clayton.[11]

The GLMM likelihood function is expressed as integral to the random effects and does not have a close form, unlike the linear mixed models where the likelihood function can be expressed in closed form. PQL is one of the proposed alternatives to approximate the likelihood to ensure the estimation of GLMM parameters. Other approximation methods are Pseudo-likelihood (PL) and Laplace approximation and Adaptive Gaussian Quadrature (AGQ). The PQL and PL are equivalent even though they were derived through different expansions. Evidence has shown that both methods are prone to yielding biased parameters if the standard deviations of the random effects are larger, especially in clustered binary data with single or few individuals per cluster.[12-15] Other authors have noted that the challenge of biased estimates common to these methods had led to developing a series of modifications and proposals such as the correction of PQL, modified Laplace approximations, AGQ and higher-order Laplace approximations, among others.[16] Detailed reviews and advances on these approximations are presented in several studies.[17-21]

Comparison of these approximation methods has shown that AGQ is more accurate and performs better than others. The performance of AGQ and other approximation methods were compared in a simulation study and found that AGQ had almost unbiased regression coefficients and that the variance component estimates were closer to the true values than for the other methods investigated.[16] The alternative approach to likelihood-based approximations available in the literature to tackle the analytical complexity of GLMMs is a Bayesian method. This method was implemented and applied Markov Chain Monte Carlo (MCMC) to make inferences based on the posterior distribution of the parameters.[22] It has been confirmed that both the AGQ and Bayesian methods have good performance in terms of bias and accuracy of estimates.[16] Still, the Bayesian approach has a drawback of specialized software and code that is not yet available in standard statistical software packages. Consequently, this study assessed the correlates of Caesarean deliveries in Nigeria using a Generalized Logistic Mixed Model and adopted the AGQ estimation technique to approximate the likelihood function.

Methods

The study was conducted in Nigeria, with approximately 40 million women of childbearing age, 7 million annual deliveries of babies, and an annual CS delivery rate of 4.3%. We extracted data on women of childbearing age from the Nigerian Demographic and Health Survey (NDHS) 2013. The NDHS is a nationally representative survey sponsored by United States Agency for International Development (USAID). It aims at providing updated and reliable data on fertility levels, marriage, fertility preferences, awareness and the use of family planning methods, child feeding practices, nutritional status of women and children, adult and childhood mortality, awareness and attitudes regarding HIV/AIDS, female genital mutilation, and domestic violence.

The sample was collected using a stratified three-stage cluster design consisting of 904 clusters, 372 in urban area and 532 in rural area. A fixed sample of 45 households was selected per cluster, yielding a total representative sample of 40,680 households. Of this total, only 40,320 households were captured at the field, producing a household response rate of 99.1%. Structured questionnaires were used to gather information from all women age 15-49 years who were either permanent residents of the households or visitors present in the households the night preceding the survey. Out of the total 39,902 women aged 15-49 years who were eligible for the survey, 38 944 (97.6%) completed the interview with a non-response rate of 2.4%.

Selected predictors of caesarean delivery were classified into three: the child characteristics, mother characteristics and cluster characteristics. Variables under each classification and their definitions are presented in appendix 1. Based on this classification, four separate generalized linear mixed logistic regression model were estimated. In the first model, the effect of the child characteristics was examined on the likelihood of caesarean delivery. The second model examined the predictors of caesarean delivery among mother characteristics. Equally, the impact of variables at the cluster level on the chance of caesarean delivery was investigated in the third model. The fourth model combined the child, maternal and cluster characteristics to investigate significant predictors of caesarean delivery. Each model was estimated using an AGQ, and due to the spatial nature of the data, each model was diagnosed for residual spatial autocorrelation. Before model estimation, a preliminary analysis was carried out using cross-tabulation and bivariate Chi-square test to establish categorical variables that are significantly related to caesarean delivery. The results of the bivariate Chi-square test and logistic regression are presented in Tables 1-3.

Model Specification and Estimation Techniques: The likelihood of caesarean delivery *(Y)* in the study population is expressed as a function of a vector of fixed and random effects predictor variables. Because the response vector *Y* is an independently distributed random variable of an exponential family with density $p(.|\delta,\alpha,G)$, then a GLMM representation of *(Y)* conditional on the random effects $E[Y|\delta] = g^{-1}(X\alpha + Z\delta) = g^{-1}(\eta) = \mu,$

such that $Var[\delta] = G,$ $ar[Y|\delta] = R_{\mu}^{\frac{1}{2}} R R_{\mu}^{\frac{1}{2}},$

(1) Equation (1) indicates that X and Z are matrices of the fixed and the random effects predictor variables, respectively and their coefficients are α and δ However, has a normal distribution with mean 0 and variance matrix G. Besides, the function g (.) is a differentiable monotonic link function which is a logit for a binary response variable as in the case of this study. Also, R_{μ} is a diagonal matrix containing the variance functions of the model evaluated at $\mu,$ and R is unknown. In the settings investigated here, we assume G is a q x q diagonal matrix with the diagonal element called random effects variance components, τ_i while the residual variance component is the common diagonal element of the diagonal matrix R. For clustered data with a binary outcome, the mixed logit regression model is given by: $Y_{ij}|u_{ij}, x_{ij}, \delta_i \overset{i.d}{\sim} Bernoulli(\mu_{ij}),$ $logit(\mu_{ij}) = u_{ij}^T + x_{ij}^T \delta_i,$

(2) with $\delta_i \sim N(0, G)$ for subject (cluster) $i = 1, \dots, q,$ and $j = 1, \dots, n_i$. If p(.) is used as a generic term for the probability density function, then the marginal distribution of the data in a mixed model can be expressed as: $p(y|\alpha, G) = \int p(y|\delta, \alpha, G) p(\delta) d\delta.$

(3) The mixed-effects model is one in which the integrals over the random effects in the definition of the marginal log-likelihood cannot be solved analytically, and needed to be approximated. The function works under the assumption of normally distributed random effects with mean zero and variance-covariance matrix D. These integrals are approximated numerically using an adaptive Gauss-Hermite quadrature rule.

Data was analyzed using SPSS version 23. The bivariate cross tabulation and chi-square test were applied to all categorical variables before model estimation. All significant categorical variables were included in the GLMM model as well as other continuous variables. The models were estimated in R software package version 4.0.2 using "glmmadaptive" function. Statistical significance was taken at p-value ≤ 0.05.

Results

There was a statistically significant relationship between delivery by CS and type of place of residence, educational attainment and wealth index of patients ($p<0.05$). However, there was no relationship between CS delivery and geopolitical region within Nigeria ($p>0.05$). Table 1

From Table 2, a statistically significant relationship existed between delivery by CS and having the last birth by CS, ever having a termination of pregnancy, if current pregnancy is a twin, size of the baby at birth, and distance of clients' residence to the health facility ($p<0.05$). Conversely, there was no statistically significant association between caesarean delivery and patients getting permission to go to the health facility for medical attention, not wanting to go alone, the problem of getting money for treatment, and attitude of health care workers ($p>0.05$).

To assess the effect of birth size on caesarean births (Model 1), we used '*very small*' as the reference category. People with newborns who were of average, larger-than-average and very large birth sizes were found to be 79%, 82% and 79% less likely to have a caesarean birth respectively, compared to those with very small-sized newborns and these were statistically significant. Equally, those with smaller than average newborn were 43% less likely to have caesarean birth compared to those with a very small sized newborn, but this was not statistically significant. Following adjustment for twin births, mothers' level of education, birth order, previous pregnancy termination, number of trips during pregnancy, age at first intercourse, preceding birth interval, wealth index, distance to a health facility and urban residence (Model 4), results and level of statistical significance remain unchanged (Table 3). Furthermore, women who had multiple births were 6 times more likely to have CS than those with single birth and this was highly significant (P-value= <0.001). This was found to be higher (OR-10.8) after adjusting for other predictors. Increasing maternal age was significantly associated with caesarean birth when used both as a single predictor and sequel to adjustment for other predictors (Model 2 & 3).

There was no statistically significant association between different levels of education and the risk of having caesarean birth even after adjusting for other predictors. Women who had terminated pregnancy in the past were 67% times more likely to have caesarean birth compared to those who never terminated a pregnancy, and this was found to be statistically significant even after adjusting for other predictors (P=0.017 & 0.019), respectively. A woman's birth order was found to be associated with the risk of caesarean birth. Although women who had problems with the distance of health facility to their residence were 37% less likely to have caesarean birth, it was not statistically significant (P=0.139) when considered as a single predictor. Following adjustment for other predictors, however, it was found to be statistically significant (P=0.033) with a 52% less likelihood of having caesarean birth than those in the reference category.

There was no association between having caesarean birth and residential area, wealth index, age at first sex, number of the trip even after adjusting for other predictors. Also, all the models showed that spatial dependence is not statistically significant with low-level Moran's I statistic value. This shows absence of spatial autocorrelation problem in the models used in this study. Using the AIC, BIC and log-likelihood test of model fit, model 4 which adjusted for other predictors was found to be a better fit than the others and should be looked at critically. Going by model 4, the study established that birth weight, maternal size at birth, multiple births, maternal age, birth order, cases of terminated pregnancy and problem of distance to health facility are the significant predictors of having a caesarean delivery among the population under consideration in this study.

Table 1: Association between selected socio-demographic characteristics and having a caesarean delivery

Socio-demographic profile	**Delivery by caesarean section**			
	No	**Yes**	**Total**	**X^2 (*p*)**
Region				
North Central	315(93.2)	23(6.8)	338(100.0)	1.846
North East	169(93.4)	12(6.6)	181(100.0)	(0.870)
North West	152(95.0)	8(5.0)	160(100.0)	
South East	453(93.4)	32(6.6)	485(100.0)	
South-South	268(94.0)	17(6.0)	285(100.0)	
South West	685(92.4)	56(7.6)	741(100.0)	
Total	2042(93.2)	148(6.8)	2190(100.0)	
Type of place of residence				
Urban	1441(92.0)	126(8.0)	1567(100.0)	14.386
Rural	601(96.5)	22(3.5)	623(100.0)	(<**0.001**)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Educational attainment				
No education	136(97.8)	3(2.2)	139(100.0)	24.995
Incomplete primary	61(96.8)	2(3.2)	63(100.0)	(<**0.001**)
Completed primary	315(95.2)	16(4.8)	331(100.0)	
Incomplete secondary	300(96.2)	12(3.8)	312(100.0)	
Completed Secondary	750(92.0)	58(7.2)	808(100.0)	
Higher	480(89.4)	57(10.6)	537(100.0)	
Total	2042(93.2)	148(6.8)	2190(100.0)	
Wealth index				
Poorest	17(100.0)	0(0.0)	17(100.0)	25.544
Poorer	102(97.1)	3(2.9)	105(100.0)	(<**0.001**)
Middle	266(96.4)	10(3.6)	276(100.0)	
Richer	612(95.6)	28(4.4)	640(100.0)	
Richest	1045(90.7)	107(9.3)	1152(100.0)	
Total	2042(93.2)	148(6.8)	2190(100.0)	

Table 2: Association between selected maternal and child characteristics and having a caesarean delivery

Childbirth and health-seeking variables	Delivery by caesarean section			X^2
	No	Yes	Total	(p)
Last birth a caesarean section				
No	2042(100.)	0(0.0)	2042(100.0)	2190.000
Yes	0 (0.0)	148(100.0)	148(100.0)	(<**0.001**)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Ever had a terminated Pregnancy				
No	1749(93.9)	113(6.1)	1862(100.0)	9.373
Yes	293(89.3)	35(10.7)	328(100.0)	(**0.002**)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Child is twin				
Single birth	2006(93.7)	135(6.3)	2141(100.0)	31.097
2nd of Multiple	36(73.5)	13(26.5)	49(100.0)	(<**0.001**)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Size of the child at birth				
Very large	306(90.8)	31(9.2)	337(100.0)	12.723
Large than average	716(94.0)	46(6.0)	762(100.0)	(**0.013**)
Average	874(94.4)	52(5.6)	926(100.0)	
Smaller than average	119(89.5)	14(10.5)	133(100.0)	
Very small	27(84.4)	5(15.6)	32(100.0)	
Tota1	2042(93.2)	148(6.8)	2190(100.0)	
Getting medical help for self: getting permission to go				
Big problem	86(93.5)	6(6.5)	92(100.0)	0.009
Not a big problem	1956(93.2)	142(6.8)	2098(100.0)	(0.927)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Getting medical help for self: getting the money needed for treatment				
Big problem	607(94.7)	34(5.3)	641(100.0)	3.040
Not a big problem	1435(92.6)	114(7.4)	1549(100.0)	(0.081)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Getting medical help for self: distance to				
HF	306(96.2)	12(3.8)	318(100.0)	
Big problem	1736(92.7)	136(7.3)	1872(100.0)	5.258
Not a big problem	2042(93.2)	148(6.8)	2190(100.0)	(**0.022**)
Total				
Getting medical help for self : not wanting to go alone				
Big problem	105(96.3)	4(3.7)	109(100.0)	1.736
Not a big problem	1937(93.1)	144(6.9)	2081(100.0)	(0.188)
Total	2042(93.2)	148(6.8)	2190(100.0)	
Getting medical help for self: the attitude of HCWs				
Big problem	240(94.5)	14(5.5)	254(100.0)	0.708
Not a big problem	1802(93.1)	134(6.9)	1936(100.0)	(0.400)
Total	2042(93.2)	148(6.8)	2190(100.0)	

Table 3: Predictors of having a caesarean birth

	Model 1		Model 2		Model 3		Model 4	
Predictors	**OR**	**PV**	**OR**	**PV**	**OR**	**PV**	**OR**	**PV**
(Intercept)	0.04	<0.001	0	<0.001	0.02	<0.001	0	0.001
Birth weight	1.9	<0.001					2.1	<0.001
Size at birth								
Very small (ref)	1.00						1.00	
Smaller than Average	0.57	0.369					0.46	0.232
Average	0.21	0.008					0.15	0.002
Larger than Average	0.18	0.004					0.11	0.001
Very larg e	0.21	0.013					0.15	0.004
Is child twin?								
Single birth (ref)	1.00						1.00	
Multiple births	6.05	<0.001					10.78	<0.001
Maternal age			5.34	0.027			5.50	0.032
Maternal Highest Education								
No education (ref)			1.00				1.00	
Incomplete primary			1.38	0.737			1.84	0.549
Complete primary			2.02	0.282			2.42	0.195
Incomplete secondary			1.45	0.567			1.23	0.769
Complete secondary			2.67	0.110			2.2	0.230
Higher			3.34	0.053			2.79	0.125
Birth order			0.81	0.005			0.76	0.001
Had terminated pregnancy								
No			1.00				1.00	
Yes			1.67	0.017			1.7	0.019
Number of trips			0.59	0.162			0.59	0.182
Age at first sex			1.27	0.657			1.02	0.962
Preceding birth interval			1.27	0.187			1.22	0.307
Wealth index								
Poorest/Poorer (ref)					1.00		1.00	
Middle					1.28	0.719	1.14	0.869
Richer					1.37	0.618	1.04	0.972
Richest					2.70	0.111	1.63	0.491
Distance to a health facility is a big problem								
No (ref)					1.00		1.00	
Yes					0.63	0.139	0.48	0.033
Urban Residence					1.63	0.068	1.59	0.096
Random Effects								
σ^2		3.29		3.29		3.29		3.29
Cluster variance	0.30		0.21		0.18		0.18	
ICC		0.08		0.06		0.05		0.05

Discussion

Caesarian section is a life-saving obstetric surgery whose prevalence has increased in recent years. The overall prevalence of CS delivery in this study was 6.8% which is in keeping with the WHO recommendation for CS birth rates. There is a significantly higher prevalence of delivery via CS for mothers living in urban communities than those in rural communities. This may be due to better health care facility availability and accessibility in most urban communities compared to their rural counterparts. The mother's level of educational attainment is significantly associated with a higher rate of delivery by CS as those with more than a secondary level of education have the highest percentage of caesarean births. According to a previous study, socio-demographics associated with increased choice of caesarean birth are age, income per capita, and educational level of the respondents.[23] This study shows that the percentage of caesarean births increases steadily from the poorest wealth index reaching its highest in those with the richest wealth index. This may be connected to the fact that wealthier mothers have more choices available and are better screened during ante-natal visits. This is similar to what was reported in southern Ethiopia where those with monthly income above the poverty line are associated with higher caesarean births,[24] although, lower socioeconomic and educational conditions was found to increase the risk for emergency CS operations in a similar study in Bangladesh.[25] Likewise, a study in Iran showed that a better socio-economic status increased the odds ratio of CS.[10] The main reasons may be the availability of facilities and finances for the costs of caesarean delivery.

In terms of maternal and infant characteristics, all mothers whose last births were via CS were delivered by caesarean birth. This is very significant as it is 100% related giving the impression that once a respondent's last delivery ends in CS, the next birth is very likely via the same route. This is similar to another study in Ethiopia that mothers who underwent previous CS were 6.93 times more likely to deliver by CS for the consecutive birth compared with those who gave birth via vaginal delivery.[26] Also, mothers with a previous history of pregnancy termination have a significantly higher rate of associated CS births compared with those without such history.

Mothers with singleton babies have four times lower rate of CS compared with those with twins. This is a similar to findings from a study in Italy which reported a higher rate of CS in multiple-birth pregnancy.[27] This study also showed that mothers with very small babies and those with very large babies have an associated increased rate of caesarean births than those with average babies. This is possible because very small babies and large ones face difficulties during vaginal deliveries. According to an Ethiopian study, neonatal birth weight ≥4000gm was more likely to deliver through CS than the birth weight of 2500–4000gm.[26] Mothers who have no barrier to getting medical help for themselves are more likely to undergo a caesarean delivery than those who find it difficult. This is probably because they are more likely to get quality health care on time.

Conclusion

The prevalence of caesarean delivery has been rising in many developed and developing countries in recent years, Nigeria inclusive. The covariates found to be significantly associated with the overall prevalence of CS delivery in this study include mothers living in urban communities with a higher educational attainment level and high wealth index. Others are those whose last births were via CS, mothers with a previous history of pregnancy termination, multiple-birth pregnancy, mothers with very small babies, and very large babies. After adjusting for covariates and accounting for clusters, random effects using generalized logistic mixed model, birth weight, size at birth, multiple births, maternal age, birth order, cases of terminated pregnancy and problem of distance to health facility are the significant predictors of having a caesarean delivery among the population under consideration.

Given the wide regional variations in the variables that predict CS delivery, region-specific programmes aimed at avoiding preventable and ensuring rational indications for CS delivery should be developed, if the rising trend observed in the choice of CS delivery is to be curtailed within the recommended WHO limits. The programmes should consider the socio-demographic, cultural, religious, and health institution peculiarities of each region. High-level advocacy and sensitization campaign programmes targeted at religious leaders, policymakers, traditional rulers, etc. with appropriate communication messages to avoid preventable CS should be put in place. Also, health institutions should be appropriately staffed and equipped and the technical capacity of health care providers continually strengthened especially in the use of alternative invasive delivery procedures where applicable and in making a rational decision for CS delivery.

What does this study add?

Neglecting hierarchy configuration of the data in modeling leads to loss of information and often biased parameter estimates. This study used a robust estimation technique to model Caesarean section while allowing the grouping effects to be random as against previous studies. Also, attempt was made to check out for the presence of spatial autocorrelation which was not present.

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Conflict of Interest

The authors have none to declare

References

1. Leung GM, Lam TH, Thach TQ, Wan S, Ho LM. Rates of caesarean birth in Hong Kong: 1987-1999. Birth Issues in Perinatal Care 2001; 28:166-172.
2. Betran AP, Merialdi M, Lauer JA, Shun WB, Thamas J, Look PV, Wagner M. Rates of caesarean section: analysis of global, regional and national estimates. Paediatric and Perinatal Epidemiology 2007; 21(2):98-113.
3. Shobhit S, Himanshu C, KH Jiten, Kumar S, Pratishtha C. Exploring the spatial patterns of caesarean section delivery in India: Evidence from National Family Health Survey-4. Clinical Epidemiology and Global Health 2020; 8:414–422
4. Gomes UA, Silva AA, Bettiol H, Barbieri MA. Risk factors for the increasing caesarean section rate in Southeast Brazil: a comparison of two birth cohorts, 1978–1979 and 1994. International Journal of Epidemiology 1999; 28(4):687-694.
5. Kim H, Fangbiao T, Brian F, Joanna R, Rachel T, Shenglan T. A mixed-method study of factors associated with differences in caesarean section rates at community level: the case of rural China. Midwifery 2013;

29(8):911-920.
6. Biplab B, Murad H, Mohammad KH. Application of Binary Logistic Regression Model for Assessing the Caesarean Risk Factors in Bangladesh. A Case Study of Khulna and Gopalganj District. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) 2016; 26(4):1-16.
7. Amjad A, Amjad U, Zakar R, Usman A, Zakar MZ , Fischer F. Factors associated with caesarean deliveries among child-bearing women in Pakistan: secondary analysis of data from the Demographic and Health Survey, 2012–13, BMC Pregnancy and Childbirth 2018; 18:113 https://doi.org/10.1186/s12884-018-1743-z
8. Wang L, Xu X, Baker P, Tong C, Zhang L, Qi H, et al. Patterns and Associated Factors of Caesarean Delivery Intention among Expectant Mothers in China: Implications from the Implementation of China's New National Two-Child Policy. International Journal of Environmental Research Public Health 2016; 13:686; doi:10.3390/ijerph13070686
9. Rahman M, Shariff AA, Shafie A, Saaid R, Tahir RM. Caesarean delivery and its correlates in Northern Region of Bangladesh: application of logistic regression and cox proportional hazard model, Journal of Health, Population and Nutrition, 2015; 33:8 DOI 10.1186/s41043-015-0020-2
10. Amini P, Mohammadi M, Omani-Samani R, Almasi-Hashiani A, Maroufizadeh S. Factors Associated with Caesarean Section in Tehran, Iran using Multilevel Logistic Regression Model. Osong Public Health Res Perspect 2018; 9(2):86−92
11. Breslow NE, Clayton DG. Approximate inference in generalized linear mixed models. Journal of the American Statistical Association 1993; 88(421):9–25.
12. Rodriguez G, Goldman N. Improved Estimation Procedures for Multilevel Models with Binary Response: a Case Study. Journal of the Royal Statistical Society. Series A (Statistics in Society), 2001; 164(2):339-355.
13. Goldstein H, Rasbash J. Improved approximations for multilevel models with binary responses. Journal of the Royal Statistical Society, 1996 Series A, 159:505-513
14. Bolker BM, Brooks ME, Clark CJ, Geange SW, Poulsen JR, Stevens MHH, White JS. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in Ecology and Evolution 2009; 24(3) doi: 10.1016/j.tree.2008.10.008
15. Okunlola OA, Olapade EO, Mathenge GW, Folorunso SA. Multilevel Analysis on the Determinants of Birth Registration in Nigeria. Science and Technology Publishing (SCI & TECH) 2017; 1(8).
16. Capanu M, Gönen M, Begg CB. An assessment of estimation methods for generalized linear mixed models with binary outcomes. Stat Med. 2013; 32(26): doi:10.1002/sim.5866
17. McCullagh P, Searle SR. Generalized, linear and mixed models. Wiley; New York. 2001
18. Demidenko, E. Mixed models: Theory and Applications. Wiley; New York. 2004.
19. Hedeker D, Gibbons RD. Longitudinal data analysis. Wiley;

New York. 2006.

20. Lee Y, Nelder JA, Pawitan Y. Generalized linear models with random effect: unified analysis with H-likelihood. Chapman and Hall; London: 2006.
21. Wolfinger R, O'Connell M. Generalized linear mixed models: a pseudo-likelihood approach. Journal of Statistical Computation and Simulation 1993; 48:233–243.
22. Browne WJ, Draper DA. Comparison of Bayesian and likelihood-based methods for fitting multilevel models. Bayesian Analysis 2006; 1:473–514.
23. Ahmad M, Ahmad MQ, Sohail CS, Abdullah M, Allahyar. Social and Demographic Determinants of Mode of Delivery among Pregnant Women Visiting Gynecology Department of Jinnah Hospital Lahore, Pakistan. J Family Med Community Health 2018; 5(4):1156.
24. Tenaw Z, Kassa ZY, Kassahun G, Ayenew A. Maternal Preference, Mode of Delivery and Associated Factors among Women Who Gave Birth at Public and Private Hospitals in Hawassa City, Southern Ethiopia. Annals of Global Health 2019; 85(1):115, 1–7. DOI: https://doi.org/10.5334/aogh.2578
25. Sultana R, Banu DS, Khatun M, Dolon F, Nahar M, Sultana N. Socio-demographic Factors Associated with Emergency Caesarean Section Cases admitted at Tertiary Care Hospital in Dhaka City. Journal of Current and Advance Medical Research 2017; 4(1):23-26.
26. Areaya GH, Tsegaye KF, Fissaha TW, Natnael EA, Surafel AH, Gebrekiros AG, et al. Determinants of Caesarean Section Deliveries in Public Hospitals of Addis Ababa, Ethiopia, 2018/19: A Case-Control Study. Hindawi Obstetrics and Gynecology International 2020, ID 9018747 https://doi.org/10.1155/2020/9018747
27. Cegolon L, Mastrangelo G, Maso G, Dal Pozzo G, Ronfani L, Cegolon A, et al. Understanding Factors Leading to Primary Cesarean Section and Vaginal Birth After Cesarean Delivery in the Friuli-Venezia Giulia Region (North-Eastern Italy), 2005–2015; 2020. https://doi.org/10.1038/s41598-019-57037-y