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Original Article

Factors Associated with Cesarean Section in Tehran, Iran using Multilevel Logistic Regression Model

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ABSTRACT

Objectives: Over the past few decades, the prevalence of cesarean sections (CS) have risen dramatically worldwide, particularly in Iran. The aim of this study was to determine the prevalence of CS in Tehran, and to examine the associated risk factors.
Methods: A cross-sectional study of 4,308 pregnant women with singleton live-births in Tehran, Iran, between July 6-21, 2015 was performed. Multilevel logistic regression analysis was performed using demographic and obstetrical variables at the first level, and hospitals as a variable at the second level.
Results: The incidence of CS was 72.0%. Multivariate analysis showed a significant relationship between CS and the mother's age, socioeconomic status, body mass index, parity, type of pregnancy, preeclampsia, infant height, and baby's head circumference. The intra-class correlation using the second level variable, the hospital was 0.292, indicating approximately 29.2% of the total variation in the response variable accounted for by the hospital.
Conclusion: The incidence of CS was substantially higher than other countries. Therefore, educational and psychological interventions are necessary to reduce CS rates amongst pregnant Iranian women.

Introduction

A cesarean section (CS) is defined as the delivery by a surgical incision into the mother's abdomen and uterus [1]. The global increase in the prevalence of CS has become a considerable public health issue and requires special attention according to its probable maternal and perinatal risks, cost issues, and inequity in access [2, 3]. Many countries have experienced a rise in the prevalence of CS over recent decades. However, a wide variation in CS rates are present amongst different countries. Based on the latest studies [4], 1.8% of live birth deliveries have been performed by CS in Central Africa, whilst in North and Central America this amount is 24.3% and 31%, respectively. According to the data from 150 countries, the worldwide CS rate was 18.6% [4].

Complications following CS can occur such as bleeding, infection, postpartum hemorrhage, wound infection, endometritis, infant breathing problems and low Apgar scores, which are some of the issues a mother and infant may suffer [5-7]. A large number of factors affect CS rates in comparison to vaginal delivery; these include; a bad experience of previous vaginal delivery, a lack of information about the adverse outcomes after a CS, baby's bad delivery position, a mother's medical condition, reduction in perinatal mortality and neonatal morbidity, twin pregnancy, fear of vaginal delivery and misconceptions about the superiority of a CS [8-12].

A variety of data in medical and clinical areas are clustered. For example, students may be clustered in schools, and patients may be clustered in hospitals. The most important feature of these types of data is the correlation amongst

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subjects in the same cluster, in which routine statistical methods do not take the association into account. Multilevel models are statistical approaches which can be used to analyze these types of data [13,14]. Most studies have applied multilevel modeling approaches for analyzing clinical data, such as multilevel logistic regression for assessing the relationships among neighborhood contexts, prenatal stress, and birth outcomes[15], and multilevel logistic regression for investigating the associations between pre-eclampsia/eclampsia and its risk factors [16].

This aims of this study were to determine and assess the potential risk factors for CS amongst pregnant women in Tehran.

Materials and Methods

1. Participants and study design

This cross-sectional study was performed with 4308 pregnant women that had been referred to the maternity clinic in Tehran, Iran, between 6 and 21 July 2015. These centers were under supervision of the following medical universities in Tehran; Tehran University of Medical Sciences, Shahid Beheshti University of Medical Sciences, Iran University of Medical Science, and Islamic Azad University (School of Medicine).

2. Ethical consideration

The study was approved by the Ethical Committee of Royan Institute. The aims of the study and the confidentiality of data were clearly explained to all the participants. Voluntarily completing the study questionnaire was considered as written informed consent.

3. Questionnaires

The questionnaire used in this survey was based on a check list that consisted of the demographics of the mother, infant, and midwifery information. The checklist was completed following an interview of the mother and medical file check in delivery room by midwife and a well-trained nurse. The checklist contained the mother's age (year), education (undergraduate and graduate), occupation (housewife or employed), socio-economic status, body mass index (BMI, kg/m^2), type of pregnancy (wanted, unwanted), type of delivery (Vaginal Delivery, CS), preeclampsia (yes or no), history of abortion (yes or no), history of stillbirth (yes or no), multiple (yes or no), and assisted reproductive techniques (yes or no).

Principal components analysis was used to indicate socio-economic status of a family through a checklist of home appliances and digital accessories.

4. Statistical analysis

Simple (single predictor variable) and multiple (several predictor variables) logistic regression modelling was performed. The dataset was hierarchical with 2 levels, so that the information from the pregnant women was nested in the hospitals (the second level). The use of logistic regression made it possible to estimate the odds ratio (OR) with a 95% confidence interval (95% CI). The model is specified as follows.

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \cdots + \beta_k x_{kij} + u_{0i}$$

$$u_{0i} \sim N(0, \sigma^2)$$

In the model, is the probability of CS for subject j at the hospital i. The x are the predictor variables and β is the estimated coefficient correspond to the predictor. The term e^{β} is the exponential of β indicating the odds ratio of CS for X=x+1 compared to X=x. The term u_{0i} is the hospital specific effect which follows a normal distribution with mean zero and variance σ^2.

The intraclass correlation coefficient (ICC) expresses the proportion of the total variance that is at the hospital level. The ICC in multilevel logistic regression can be estimated by different procedures. The ICC is determined as follows.

$$ICC = \frac{\sigma^2}{\sigma^2 + \frac{\pi^2}{3}}$$

To check the accuracy of the resulted estimates, indices such as sensitivity, specificity, diagnostic accuracy, positive predictive value, negative predictive value, and the area under curve (AUC) were calculated. Moreover, the Receiver Operating Characteristic (ROC) curve was plotted.

Data analysis was carried out using R software version 3.3.1., lme4 statistical programming. The second order penalized quasi-likelihood estimation method was applied to estimate the parameters. All statistical tests were 2-sided and probability values < 0.05 were considered statistically significant.

Results

The incidence of CS was observed as 72% of 4,308 deliveries. Women in the vaginal delivery group were significantly younger than in the CS group. The mean ± standard deviation ages of women in vaginal delivery and CS groups were 27.31 ± 5.44 years and 29.85 ± 5.11 years, respectively ($p < 0.001$). The parents in the vaginal group were significantly less academic (81.6%) than CS group (61.8%) ($p < 0.015$). . Also, a significantly higher rate of employed mothers were in the CS group (14.7%) compared to the vaginal delivery (5.1%) group ($p < 0.001$). The mothers in CS group had a better socioeconomic status (SES) ($p < 0.001$), higher BMI ($p < 0.001$), less parity ($p = 0.002$) and a larger baby's head circumference ($p = 0.012$). In addition, a history of abortion, assisted reproductive technology and preeclampsia were more common amongst the CS group. The distribution of case characteristics within the 2 groups: vaginal delivery and CS, are shown in Table 1.

The results of simple and multilevel logistic regression

Table 1. The distribution of women' characteristics in vaginal delivery and cesarian section groups.

	Total (n = 4308)	Vaginal (n = 1208)	Cesarean section (n = 3100)
Mother's age (y)	29.14 ± 5.33	27.31 ± 5.44	29.85 ± 5.11
Mother's education			
Non-Academic	2903 (67.4)	986 (81.6)	1917 (61.8)
Academic	1405 (32.6)	222 (18.4)	1183 (38.2)
Father's education			
Non-Academic	2935 (68.1)	989 (81.9)	1946 (62.8)
Academic	1373 (31.9)	219 (18.1)	1154 (37.2)
Mother's occupation			
Housewife	3790 (88.0)	1146 (94.9)	2644 (85.3)
Employed	518 (12.0)	62 (5.1)	456 (14.7)
SES	0.02 ± 2.03	-0.88 ± 1.63	0.37 ± 2.06
Mother's BMI (kg/m^2)	24.99 ± 5.57	24.27 ± 4.26	25.27 ± 5.98
Parity	1.65 ± 0.75	1.70 ± 0.85	1.62 ± 0.71
Type of pregnancy			
Wanted	3476 (80.7)	981 (81.2)	2495 (80.5)
Unwanted	832 (19.3)	227 (18.8)	605 (19.5)
History of abortion			
No	3477 (80.7)	998 (82.6)	2479 (80.0)
Yes	831 (19.3)	210 (17.4)	621 (20.0)
History of stillbirth			
No	4232 (98.2)	1183 (97.9)	3049 (98.4)
Yes	76 (1.8)	25 (2.1)	51 (1.6)
Preeclampsia			
No	4087 (94.9)	1164 (96.4)	2923 (94.3)
Yes	221 (5.1)	44 (3.6)	177 (5.7)
ART			
No	3995 (92.7)	1145 (94.8)	2850 (91.9)
Yes	313 (7.3)	63 (5.2)	250 (8.1)
Infant gender			
Male	2191 (50.9)	610 (50.5)	1581 (51.0)
Female	2117 (49.1)	598 (49.5)	1519 (49.0)
Infant weight (kg)	3.215 ± 0.443	3.233 ± 0.428	3.208 ± 0.449
Infant height (cm)	49.87 ± 2.46	49.97 ± 2.49	49.83 ± 2.45
Baby's head circumference (cm)	34.89 ± 4.88	34.59 ± 1.85	35.01 ± 5.64

Value are given as mean ± standard deviation or number (percentage).
ART = assited reproductive technology; BMI = body mass index; SES = socioeconomic status.

models are shown in Table 2. All the variables except for mother's education, history of stillbirth, infant gender, and weight, were entered into the multilevel logistic regression model. All the effect sizes (ORs) were adjusted.

Based on the multilevel logistic regression analysis results, increasing mother's age was significantly associated with undergoing a CS with an odds ratio of 1.070 (95% CI: 1.051-1.089; Table 2). A CS delivery was significantly more likely if an infant was taller (OR=0.921, 95% CI: 0.886-0.957). An increase in a baby's head circumference increased the odds of a CS significantly (OR=1.176, 95% CI: 1.112-1.243). The odds ratio of a CS for mothers with a higher SES was 1.182 (95% CI: 1.115-1.252). An increase in the mother's BMI was associated with increased odds of CS (OR=1.045, 95% CI: 1.025-1.065).

Table 2. The results of simple and multiple multilevel logistic regression determining cesarian section.

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Mother's age (y)	1.750 (1.059 – 1.091)	< 0.001	1.070 (1.051 – 1.089)	< 0.001
Mother's education				
Non-Academic	1		1	
Academic	1.290 (1.051 – 1.587)	0.014	1.023 (0.816 – 1.289)	0.839
Father's education				
Non-Academic	1		-	
Academic	1.078 (0.871 – 1.336)	0.479	–	–
Mother's occupation				
Housewife	1		1	
Employed	1.465 (1.076 – 2.015)	0.015	1.035 (0.744 – 1.440)	0.835
SES	1.196 (1.133 – 1.264)	< 0.001	1.182 (1.115 – 1.252)	< 0.001
Mother's BMI (kg/m^2)	1.066 (1.047 – 1.086)	< 0.001	1.045 (1.025 – 1.065)	< 0.001
Parity	1.138 (1.031 – 1.257)	0.010	0.847 (0.748 – 0.959)	0.008
Type of pregnancy				
Wanted	1		1	
Unwanted	1.346 (1.113 – 1.632)	0.002	1.334 (1.088 – 1.637)	0.005
History of abortion				
No	1		1	
Yes	1.188 (0.978 – 1.446)	0.080	1.023 (0.835 – 1.254)	0. 819
History of stillbirth				
No	1		-	
Yes	0.868 (0.497 – 1.537)	0.621	–	–
Preeclampsia				
No	1		1	
Yes	2.001 (1.395 – 2.922)	<0.001	1.729 (1.179 – 2.534)	0.004
ART				
No	1		1	
Yes	1.488 (1.089 – 2.054)	0.013	1.292 (0.930 – 1.793)	0.125
Infant gender				
Male	1		-	
Female	1.015 (0.872 – 1.180)	0.844	–	–
Infant weight (kg)	0.935 (0.788 – 1.107)	0.435	–	–
Infant height (cm)	0.967 (0.937 – 0.999)	0.043	0.921 (0.886 – 0.957)	< 0.001
Baby's head circumference (cm)	1.126 (1.076 – 1.181)	< 0.001	1.176 (1.112 – 1.243)	< 0.001

ART = assisted reproductive technology; BMI = body mass index; CI = confidence Interval; OR = odds ratio; SES = socioeconomic status.

Adjusted for other predictor variables, the results for parity in the multiple multilevel logistic regression is in contrast to the simple logistic model. A higher parity resulted in a lower odds ratio for vaginal delivery (OR=0.847, 95% CI: 0.748-0.959). The odds ratio of CS in the presence of preeclampsia and unwanted type of pregnancy was 1.729 (95% CI: 1.179-2.534) and 1.334 (95% CI: 1.088-1.637) compared to vaginal delivery, respectively. Other independent variables were not significant in predicting election of a CS. The variance for the hospital specific effect was estimated as 1.361 and hence the ICC was 0.292.

The estimation of accuracy of the predictions in Table 3 showed that the sensitivity was 0.704 (0.688 – 0.720) with a specificity of 0.79 (0.767 – 0.813). The positive predictive value 0.896 (0.884 – 0.908), the negative predictive value 0.510 (0.487 – 0.533), the accuracy 0.728 (0.715 – 0.742) and the AUC 0.824 (0.811 – 0.837) were observed, as confirmed by the ROC curve (Figure 1).

Table 3. The accuracy and 95% confidence interval of multiple multilevel logistic regression for predicting cesarian section.

Accuracy tools	Estimate	95% CI	
Sensitivity	0.704	0.688	0.720
Specificity	0.790	0.767	0.813
PPV	0.896	0.884	0.908
NPV	0.510	0.487	0.533
ACC	0.728	0.715	0.742
AUC	0.824	0.811	0.837

ACC = accuracy; AUC = area under curve; CI = confidence interval; NPV = negative predictive value; PPV = positive predictive value.

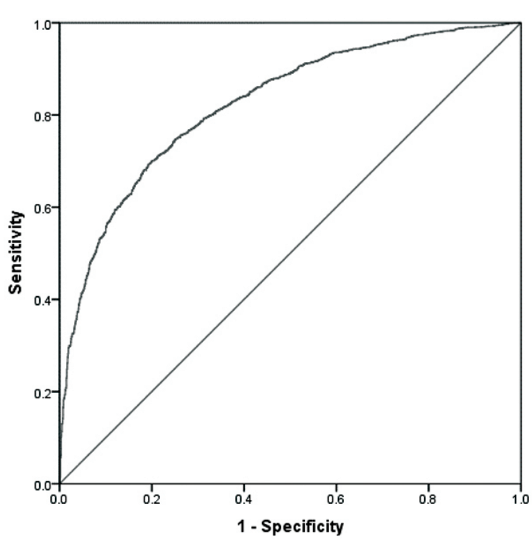

Figure 1. The ROC curve resulted from multiple multilevel logistic regression model for predicting caesarian section.

Discussion

The results in this study demonstrated a CS incidence of 72.0%. We showed that CS is associated with better socioeconomic conditions, maternal BMI, parity, type of pregnancy (wanted / unwanted), maternal age, gestational age, and baby's head circumference.

Accessibility of CS to mothers across the country, has increased the prevalence of CS during recent years. CS deliveries have also increased as a proportion of all deliveries in the United Kingdom during the past decade [17]. Amongst the Iranian community and over the last 2 decades, the incidence of CS has been reported as 26% and even as high as 60% in one study [18, 19]. In a systematic review, it has been shown that the prevalence and causes of CS in Iran in 2014 were due to the high prevalence of medical-midwifery and non-medical factors such as mothers requesting CS, doctor's recommendation, repeated CS, twinning, fetal displacement, fear of vaginal delivery pain, higher education, care at a private hospital, undeveloped delivery, pelvic stricture, hazardous childbirth, tendency to tube ligation, cephalopelvic disproportion, and decrease of amniotic fluid [20]. The review suggested that the incidence of CS ranged between 16.2% and 66.5% due to different sample sizes [20].

The present study showed that a better socioeconomic status increased the odds ratio of CS. The main reasons may be the availability of utilities and financing the costs of cesarean delivery. It has been demonstrated that women with lower socioeconomic status are not provided with the accessibility to CS delivery [21]. Access to the procedure is limited and has led to increases in maternal and neonatal mortality [22].

Our study showed that mothers with a higher BMI are more likely to have cesarean delivery. Weight loss can increase the chance of vaginal birth after cesarean among women who are overweight [23]. Obesity is a known risk factor for adverse obstetric outcomes and increased CS [23,25].

The current study revealed that regardless of other potential factors and variables, parity increases the odds ratio of CS compared to vaginal delivery. It has been reported that women with elective CS have a significantly higher mean parity compared to those with vaginal delivery [26]. However, the results from the adjusted analysis using a multilevel modeling approach showed a contrary association. Adjusting for other variables which may affect cesarean delivery, the model revealed that CS are more common amongst women with lower mean parity. In contrast to the results in this study, some studies have found that higher parity decreases the odds ratio of CS [27].

Our study also showed that women with unwanted pregnancy are more likely to experience CS. We have demonstrated that the presence of preeclampsia increases the odds ratio of CS. Similar to our findings, some authors have shown that preeclampsia is associated with a high prevalence of CS [28, 29].

Our study showed that increase in maternal age was associated with higher odds ratio for a CS. The most common causes of CS in advanced maternal age may be fetal distress, stress, fatigue and controlling the risks of mortality and morbidity for both mother and fetus. It has been indicated that the older the maternal age, the greater the risk of cesarean delivery in a population-based cohort study [30]. Others have shown that the overall prevalence of CS delivery for mothers ≥35 years old is almost twice that of mothers ≤20 [31].

In contrast to our results, some authors suggest that large infants (for gestational age) increase the risk of maternal and neonatal complications such as CS, perineal lacerations, postpartum hemorrhage and prolonged hospital stay [32, 33].

This study has shown that the larger a baby's head circumference, the more likely the chances of a CS being performed. Assisted vaginal births and emergency CS are the potential outcomes of a large fetal head circumference [34]. In a population-based retrospective cohort study, it has been reported that mothers carrying babies with a large fetal head circumference are at a higher risk of a CS. Moreover, it is suggested that maternal age can be a modifier of the association between fetal head circumference and primary CS [35].

Unadjusted analysis of data sometimes leads to misinterpreting the results so that the impact of predictor variables is assessed separately. Assuming no interaction amongst predictor variables causes illusive conclusions about the response variables. Multiple regression takes the association amongst the predictor variables and this leads to more realistic and valid results [36]. Moreover, a multilevel structure of a dataset causes some variances in which multilevel modeling approaches must be applied [37].

This study has several limitations that should be noted. First, due to the cross-sectional nature of the study, causal inferences cannot be made. Second, the current study was carried out only in Tehran; therefore, the results cannot be generalized to other regions of Iran with differing economic, cultural and health care systems.

In conclusion, there was a substantially high prevalence of CS in the capital city of Iran, which was different to other countries. Therefore, education and psychological interventions are necessary to reduce the prevalence of CS among Iranian pregnant women. Furthermore, the multilevel multiple logistic regression analysis identified certain related factors such as mother's age, SES, BMI, parity, type of pregnancy, preeclampsia, infant height and baby's head circumference.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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