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Research Article

Maternal Factors Associated with Mode of Delivery in a Population with a High Cesarean Section Rate

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ABSTRACT

We sought to identify factors associated with mode of delivery in a peri-urban Indian population with a high cesarean section rate. Poisson regression with robust error variance was applied to model factors associated with cesarean compared to vaginal delivery in a prospective, preconception pregnancy cohort study in Telangana State, India. Adjusted relative risks and 95% confidence intervals from multivariable models are presented. Among 1164 singleton births between 2010 and 2015, 46% were delivered by cesarean. In multiparous women (n = 674), prior cesarean delivery (4.2, 3.2–5.6), prior twin delivery (1.4, 1.1–1.9), diagnosis of hypertension (1.4, 1.0–2.0), or preeclampsia (3.5, 2.1–5.7) in a prior pregnancy independently increased the risk of cesarean. Prepregnancy overweight/obesity (1.4, 1.0–1.9), a composite of prenatal complications (1.3, 1.0–1.7), a composite of labor complications (1.5, 1.0–2.3), nonreassuring fetal heart rate (2.3, 1.3–4.1), and breech position (2.6, 1.4–5.0) also increased the cesarean risk. Among nulliparous women (n = 233), cephalo–pelvic disproportion (1.9, 1.2–3.0), a composite of labor complications (2.9, 1.8–4.9), and breech position (3.4, 1.9–6.2) increased the risk of cesarean. The high rate of cesarean delivery in this peri-urban Indian population is attributed to history of pregnancy complications, history of prior cesarean, prepregnancy body mass index, and medical indications at delivery.

1. INTRODUCTION

The rate of cesarean section delivery is increasing globally, with an estimated annual increase of 4% [1]. Yet, the increase in surgical deliveries has not coincided with a global improvement in maternal and infant outcomes, particularly maternal mortality and severe morbidity [2,3]. Furthermore, cesarean delivery without medical indication is associated with adverse maternal and infant outcomes compared to spontaneous vaginal delivery, including higher rates of maternal admittance to the intensive care unit postpartum and higher incidence of respiratory distress in infants [3–6]. In light of this, it is important to identify modifiable factors associated with cesarean deliveries in order to guide public health programs to reduce the rate of cesareans.

In India, approximately 17.2% of all births nationwide are delivered by cesarean [7]. This rate varies widely by geographic location and type of health-care facility, ranging from 9.3% in rural public hospitals to 44.8% in urban private hospitals [7]. Between the dichotomy of rural and urban are populations residing in "peri-urban" areas, which have their own social and economic environments that may influence health outcomes, yet are understudied in relation to mode of delivery [8]. Furthermore, like many countries, India is undergoing an epidemiologic transition, a shift in the burden of mortality from communicable diseases to noncommunicable diseases, in addition to economic growth, and few studies have been conducted investigating modifiable factors associated with mode of delivery in these populations [9].

Globally, women who deliver by cesarean have been found to differ from women who deliver vaginally in characteristics such as prepregnancy obesity, parity, and prior cesarean delivery [10–13]. Other characteristics pertain to medical indications for cesarean that arise during labor and delivery, including failure to progress in labor, dystocia, and fetal malpresentation [10]. The purpose of this analytic study is to identify maternal factors associated with mode of delivery in a peri-urban, southern Indian population with a high cesarean delivery rate.

2. MATERIALS AND METHODS

2.1. Study Population

This study was a secondary analysis of the Longitudinal Indian Family Health (LIFE) study, a prospective cohort study of reproductive aged women residing in a peri-urban area in Telangana

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State, India. The study sample primarily comprised of three categories of historically economically disadvantaged communities for whom the Indian government has provided special concessions and social welfare programs—scheduled caste, scheduled tribe, and other backward class [14]. Details of the LIFE study design have been previously described [15]. Briefly, the LIFE study was established to assess the effect of the maternal environment on birth outcomes and child development. Informed consent was obtained and the overall research protocol was approved by the SHARE INDIA/MediCiti Institute of Medical Sciences (MIMS) Ethics Committee. About 1227 married women aged 15–35 years were enrolled preconception (80%) or in the first trimester of pregnancy (20%) between October 2009 and August 2011 [15]. Women were recruited from a region with 40 villages by community health volunteers, and follow-up is ongoing and includes developmental assessment of children born to study participants. The study is based at the MIMS, a private hospital and health sciences college. Maternal demographic data were collected on hard copy questionnaires at enrollment, health assessments were conducted in the first and third trimesters of pregnancy, and details from labor and delivery were abstracted from medical records.

2.2. Outcomes and Covariates

We analyzed data from singleton births delivered in the LIFE study between March 2010 and December 2015. The primary outcome in this analysis was mode of delivery as indicated on the LIFE study labor and delivery abstraction form. Vaginal deliveries included spontaneous vaginal deliveries (n = 586), vaginal deliveries with forceps assist (n = 39), vaginal deliveries with vacuum assist (n = 2), or vaginal deliveries with breech extraction (n = 4).

Potential predictors were obtained by self-report on enrollment questionnaires, first- and third-trimester questionnaires during pregnancy, labor and delivery medical record abstraction, and anthropometric assessments at enrollment. These variables were selected a priori and were categorized into six groups: *Demographics* (religion, caste/tribe, age at delivery, education, and occupation), *Reproductive history* (parity, number of live births, age at first pregnancy, prior delivery of twins, diagnosis of gestational diabetes, hypertension, preeclampsia, or anemia in a prior pregnancy), *Anthropometrics* (prepregnancy Body Mass Index (BMI) using the World Health Organization (WHO) recommended cutoff points for public health action in Asian populations [16]—underweight: ≤18.49 kg/m^2, normal: 18.5–22.99 kg/m^2, and overweight/obese: ≥23.0 kg/m^2), *Antenatal care* (ANC; any ANC visits with a health-care professional and number of ANC visits), *Prenatal health* (abdominal pain with fever, vaginal bleeding, abnormal vaginal discharge, and/or pain during urination in third trimester, nausea in first and/or third trimester, diagnosis of any health conditions in third trimester, composite prenatal complications, Intrauterine Growth Restriction (IUGR)), and *Labor and delivery* (private or public health-care facility, composite labor complications, nonreassuring heart rate pattern, cephalo–pelvic disproportion, fetal position, and fetal shoulder dystocia).

Maternal prenatal and labor complications recorded on the labor and delivery abstraction form were grouped into composite variables measuring report of one or more prenatal complications, or one or more labor complications (see Table 1 for conditions in the composite measures). The fetal indications IUGR (diagnosed prenatally by ultrasound biometry or fetal Doppler), cephalo–pelvic disproportion (diagnosed by clinical pelvimetry using Muller-Munro Kerr's method), and nonreassuring fetal heart rate were examined as individual predictors.

2.3. Statistical Analysis

Proportions of each maternal factor were calculated to characterize all births by mode of delivery (vaginal vs. cesarean) in the entire cohort. Unadjusted risk ratios and 95% Confidence Intervals (CIs) of each factor predicting mode of delivery were obtained with bivariate analyses using modified Poisson regression with robust error variance, an analysis method appropriate to estimate the common outcome [16]. The predictors found to be statistically significant in the bivariate analyses were included in a forward-selection stepwise regression model, adding variables with a statistical significance level of $p < 0.2$. A final regression model with the selected variables provided Adjusted Risk Ratios (aRR) and 95% CI. For all study participants, missing data mostly occurred in labor and delivery variables from deliveries outside MIMS, the study site; thus, we restricted our multivariable regression analysis to multipara who delivered at MIMS. In addition, we conducted multivariable regression analysis in a subset of nulliparous women (those who reported not having a previous pregnancy at the first-trimester study visit) to identify significant factors in the absence of confounding by reproductive history. All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC, USA) and STATA 12 (StataCorp, College Station, TX, USA).

Table 1 | Prenatal and labor complications abstracted from labor and delivery records in the LIFE study.

Prenatal complications

Fetal growth
- Intrauterine Growth Restriction (n = 18)

Composite prenatal complications
- Preeclampsia (n = 48)
- Pre-existing hypertension (n = 7)
- Pregnancy Induced Hypertension (without protein in urine) (n = 42)
- Oligohydramnios (n = 51)
- Polyhydramnios (n = 12)
- Gestational diabetes (n = 13)
- Placenta previa (n = 2)
- Preterm labor (n = 48)
- Other significant vaginal bleeding (n = 3)

Labor complications

Fetal conditions
- Cephalo-Pelvic Disproportion (CPD) (n = 98)
- Non-reassuring fetal heart rate pattern (n = 47)

Composite labor complications
- Abruption (n = 5)
- Maternal hemorrhage (n = 7)
- Cord prolapsed (n = 2)
- Maternal fever (n = 4)
- Arrest of labor (n = 8)
- Hypertension (without protein in urine) (n = 5)
- Hypotension (n = 2)

3. RESULTS

The overall rate of cesarean delivery was 45.8%; by parity, of the 674 multipara, 44.7% delivered by cesarean while 46.4% of the 233 births to nulliparous women were delivered by cesarean. Of all cesarean deliveries, 60% were recorded as emergency cesareans (25% of all births).

For all singleton births in the cohort between March 2010 and December 2015 (n = 1164), women who delivered by cesarean reported higher levels of education compared to women who delivered vaginally (Table 2). More women who delivered by cesarean were older than 25 years at their first pregnancy (including

Table 2 Characteristics of all 1164 singleton deliveries in the Longitudinal Indian Family Health (LIFE) study from 2010 to 2015, by mode of delivery

Characteristic	Vaginal delivery, *n* (%)[a]	Cesarean delivery, *n* (%)[a]
	N = 631	*N* = 533
Demographics		
Religion		
Hindu	558 (88.4)	478 (89.7)
Muslim	55 (8.7)	31 (5.8)
Christian	18 (2.9)	24 (4.5)
Caste and tribe		
Scheduled caste	126 (20.0)	116 (21.8)
Scheduled tribe	53 (8.4)	44 (8.3)
Backward caste	349 (55.3)	302 (56.7)
None of the above	103 (16.3)	71 (13.3)
Age at delivery (years)		
≤19	69 (10.9)	43 (8.1)
20–24	407 (64.5)	331 (62.1)
25+	155 (24.6)	159 (29.8)
*Level of education[b]		
None	107 (17.0)	65 (12.2)
Primary/middle school	172 (27.3)	123 (23.1)
Secondary school	307 (48.6)	286 (53.7)
Higher education	45 (7.1)	59 (11.1)
Works outside the home	141 (22.3)	128 (24.0)
Reproductive history[c]		
Parity		
Multiparous	506 (80.2)	425 (79.7)
Nulliparous	125 (19.8)	108 (20.3)
Total number of live births		
0	30 (6.4)	25 (6.6)
1	299 (63.8)	262 (69.5)
≥2	140 (29.8)	90 (23.9)
*Age at first pregnancy (years)		
≤19	194 (41.4)	128 (33.9)
20–24	260 (55.4)	225 (59.7)
25+	15 (3.2)	24 (6.4)
*Prior delivery of twins	0 (0)	4 (0.87)
*Diagnosis of gestational diabetes in prior pregnancy	2 (0.4)	8 (2.1)
*Diagnosis of hypertension in prior pregnancy	15 (3.2)	39 (10.4)
Diagnosis of preeclampsia in prior pregnancy	1 (0.2)	4 (1.1)
*Diagnosis of anemia in prior pregnancy	21 (4.5)	29 (7.7)

(*Continued*)

Table 2 Characteristics of all 1164 singleton deliveries in the Longitudinal Indian Family Health (LIFE) study from 2010 to 2015, by mode of delivery—*Continued*

Characteristics	Vaginal delivery, *n* (%)[a]	Cesarean delivery, *n* (%)[a]
	N = 631	*N* = 533
Repeat cesarean (multiparous deliveries at MIMS)	0 (0)	109 (40.0)
Anthropometrics		
*Body mass index—WHO Asian cutoff points		
Underweight (≤18.49 kg/m^2)	274 (43.4)	174 (32.6)
Normal (18.5–22.99 kg/m^2)	288 (45.6)	236 (44.3)
Overweight/obese (≥23.0 kg/m^2)	69 (10.9)	123 (23.1)
Antenatal care (ANC)		
Attended an ANC visit with a health-care professional	580 (99.3)	497 (98.6)
*Number of ANC visits reported at third trimester		
<5	198 (34.2)	131 (26.4)
≥5	381 (65.8)	366 (73.6)
Prenatal health		
Experience of lower abdominal pain with fever, vaginal bleeding, abnormal vaginal discharge, and/or pain during urination	23 (3.9)	20 (4.0)
Experiencing nausea and/or vomiting in first trimester	262 (44.1)	243 (50.1)
Experiencing nausea and/or vomiting in third trimester	161 (27.2)	128 (25.3)
Diagnosed with any health conditions in third trimester[d]	111 (18.7)	115 (22.8)
*Composite prenatal complications[e]	133 (28.6)	150 (40.8)
*Intrauterine growth restriction	6 (0.9)	12 (2.2)
Labor and delivery		
*Delivered at MIMS or other private health facility	567 (92.6)	516 (96.8)
*Composite labor complications[f]	57 (9.2)	74 (17.5)
*Nonreassuring fetal heart rate pattern	12 (1.9)	35 (6.6)
*Cephalo–pelvic disproportion	1 (0.2)	97 (18.2)
*Fetal position		
Vertex	407 (98.8)	297 (94.9)
Breech	5 (1.2)	15 (4.8)
Transverse	0	1 (0.3)
Fetal shoulder dystocia	1 (0.2)	0 (0)

Note: *Statistically significant difference by mode of delivery determined by χ^2 test ($p < 0.05$). [a]Displaying column percent. [b]Level of education: primary/middle school: ≤Grade 7; Secondary school: Grades 8–12; higher education: ≥Grade 13. [c]Reproductive history missing for n = 322. [d]Health conditions diagnosed in third trimester including one or more of the following: sugar disease, high blood pressure, preeclampsia, feet swelling, face swelling, contractions, sore throat, anemia, genital sores, abnormal vaginal discharge, diarrhea, jaundice, burning on urination, goiter, any other condition. [e]Composite prenatal complications includes one or more of the following: preeclampsia, gestational diabetes, preexisting hypertension, pregnancy-induced hypertension (without protein in urine), placenta previa, other significant vaginal bleeding, oligohydramnios, polyhydramnios, preterm labor. [f]Composite labor complications includes one or more of the following: hypertension (without protein in urine), hypotension, preeclampsia, maternal fever, arrest of labor, cord prolapsed, abruption, maternal hemorrhage. MIMS, MediCiti Institute of Medical Sciences; WHO, World Health Organization; ANC, antenatal care.

pregnancies before enrollment in LIFE), had a prior delivery of twins, and had been diagnosed with gestational diabetes, hypertension, preeclampsia, or anemia in a prior pregnancy. More women who delivered by cesarean were in the overweight/obese BMI category before pregnancy (≥23.0 kg/m² using the WHO Asian BMI cutoffs), and had five or more ANC visits. More women who delivered by cesarean had one or more prenatal complications and IUGR. Similarly, more women who delivered by cesarean had one or more labor complications, Cephalic Disproportion (CPD), nonreassuring fetal heart rate pattern, and the fetus in breech or transverse position. More cesarean deliveries occurred at MIMS or other private health-care facilities compared with public health-care facilities.

Multivariable regression analysis among multiparous women included 674 deliveries at the study site. Previous lower segment cesarean increased the risk of cesarean fourfold in the multivariable model (aRR 4.2, 95% CI 3.2–5.6) (Table 3). Additional reproductive history factors independently associated with an increased risk of cesarean delivery include prior delivery of twins (aRR 1.4, 95% CI 1.1–1.9), diagnosis of hypertension (aRR 1.4, 95% CI 1.0–2.0), or preeclampsia (aRR 3.5, 95% CI 2.1–5.7) in a prior pregnancy. Prepregnancy overweight/obese (≥23.0 kg/m²) compared to normal (18.5–22.99 kg/m²) also independently increased the risk of cesarean (aRR 1.4, 95% CI 1.0–1.9). Furthermore, medical report of one or more prenatal complications (aRR 1.3, 95% CI 1.0–1.8), medical report of one or more labor complications (aRR 1.5, 95% CI 1.0–2.3), nonreassuring fetal heart rate (aRR 2.3, 95% CI 1.3–4.1), and a fetus in breech position compared to vertex position (aRR 2.6, 95% CI 1.4–5.0) were independently associated with an increased risk of cesarean delivery in multipara.

In the multivariable regression analysis for nulliparous women, medical report of one or more labor complications (aRR 2.9, 95% CI 1.8–4.9), CPD (1.9, 95% CI 1.2–3.0), or a fetus in breech position compared to vertex position (aRR 3.4, 95% CI 1.9–6.2) independently increased the risk of cesarean delivery (Table 4).

Table 3 | Crude and adjusted risk ratios (RR) predicting risk of cesarean vs. vaginal delivery in the 2010–2015 LIFE study deliveries to multipara at MIMS

Characteristics	Mullipara (*n* = 674)	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Demographics		
Age at delivery (years)		
≤19	0.5 (0.2–0.9)*	—
20–24	Ref.	
25+	1.1 (0.9–1.3)	
Reproductive history		
Prior delivery of twins	2.2 (2.0–2.4)*	1.4 (1.1–1.9)*
Diagnosis of gestational diabetes in prior pregnancy	1.7 (1.1–2.6)*	—
Diagnosis of hypertension in prior pregnancy	1.8 (1.5–2.2)*	1.4 (1.0–2.0)*
Diagnosis of preeclampsia in prior pregnancy	2.3 (2.1–2.5)*	3.5 (2.1–5.7)*
Previous lower segment cesarean	2.9 (2.6–3.3)*	4.2 (3.2–5.6)*
Anthropometrics		
Body mass index		
Underweight (≤18.49 kg/m²)	1.0 (0.7–1.2)	1.0 (0.7–1.3)
Normal (18.5–22.99 kg/m²)	Ref.	Ref.
Overweight/obese (≥23.0 kg/m²)	1.6 (1.3–2.0)*	1.4 (1.0–1.9)*
Prenatal health		
Composite prenatal complications[a]	1.3 (1.1–1.6)*	1.3 (1.0–1.7)*
Intrauterine growth restriction	1.7 (1.2–2.3)*	—
Labor and delivery		
Composite labor complications[b]	1.5(1.1–1.9)*	1.5 (1.0–2.3)*
Nonreassuring fetal heart rate pattern	1.7 (1.3–2.1)*	2.3 (1.3–4.1)*
Cephalo–pelvic disproportion	2.6 (2.4–2.9)*	0.9 (0.5–1.4)
Fetal position		
Vertex	Ref.	Ref.
Breech	1.7 (1.2–2.4)*	2.6 (1.4–5.0)*
Transverse	2.3 (2.1–2.5)*	—

[a]Composite prenatal complications includes one or more of the following: preeclampsia, gestational diabetes, preexisting hypertension, pregnancy-induced hypertension (without protein in urine), placenta previa, other significant vaginal bleeding, oligohydramnios, polyhydramnios, preterm labor. [b]Composite labor complications includes one or more of the following: hypertension (without protein in urine), hypotension, preeclampsia, maternal fever, arrest of labor, cord prolapsed, abruption, maternal hemorrhage. *p-value <0.05

4. DISCUSSION

In this study of a peri-urban southern Indian population, in which the overall rate of cesarean delivery was 46%, we identified maternal factors associated with mode of delivery. Our findings suggest that reproductive history, prepregnancy BMI, prenatal health complications, and labor and delivery factors independently increase

Table 4 | Crude and adjusted risk ratios predicting risk of cesarean vs. vaginal delivery in the 2010–2015 LIFE study deliveries to nulliparous women

Characteristics	Nullipara (*n* = 233)	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Demographics		
Age at delivery (years)		—
≤19	1.1 (0.8–1.5)	
20–24	Ref.	
25+	1.5 (1.1–2.2)*	
Anthropometrics		
Body mass index		
Underweight (≤18.49 kg/m²)	0.7 (0.5–1.0)*	1.3 (0.7–2.4)
Normal (18.5–22.99 kg/m²)	Ref.	Ref.
Overweight/obese (≥23.0 kg/m²)	1.1 (0.8–1.6)	1.7 (0.96–4.9)
Prenatal health		
Composite prenatal complications[a]	1.4 (1.0–2.1)*	—
Labor and delivery		
Composite labor complications[b]	2.0 (1.5–2.6)*	2.9 (1.8–4.9)*
Nonreassuring fetal heart rate pattern	1.8 (1.3–2.4)*	1.4 (0.8–2.2)
Cephalo–pelvic disproportion	2.4 (2.0–2.8)*	1.9 (1.2–3.0)*
Fetal position		
Vertex	Ref.	Ref.
Breech	2.0 (1.3–3.1)*	3.4 (1.9–6.2)*
Transverse	—	—

[a]Composite prenatal complications includes one or more of the following: preeclampsia, gestational diabetes, preexisting hypertension, pregnancy-induced hypertension (without protein in urine), placenta previa, other significant vaginal bleeding, oligohydramnios, polyhydramnios, preterm labor. [b]Composite labor complications includes one or more of the following: hypertension (without protein in urine), hypotension, preeclampsia, maternal fever, arrest of labor, cord prolapsed, abruption, maternal hemorrhage. *p-value <0.05

the risk for cesarean delivery in this population. Among multiparous women, despite the rarity of some reproductive history factors, prior delivery of twins and prior pregnancy complications independently increased the risk of cesarean delivery, as did prepregnancy overweight/obesity. Furthermore, fetal complications during delivery increased the risk of cesarean in multiparous women. Previous lower segment cesarean delivery increased the risk of cesarean fourfold after accounting for reproductive history, prepregnancy BMI, and labor and delivery factors. Among nulliparous women, as in multiparous women, labor and delivery complications increased the risk of cesarean delivery.

The finding that prior cesarean delivery is a major predictor of cesarean in subsequent deliveries in multiparous women, as is the majority of our study sample, is consistent with previous studies in other populations. MacDorman et al. [12] posit that the rise in repeat cesarean deliveries after 1996 in the United States is in part attributed to a decrease in the obstetric practice of vaginal birth after cesarean, coupled with an increase in primary cesarean deliveries. Furthermore, similar to our population, previous cesarean delivery was found to be the most common indication for subsequent cesarean delivery among multigravida in an analysis of data from southern Indian states, including Telangana [17].

Higher maternal BMI was associated with an increased risk of cesarean delivery in multivariable models for multiparous women and was borderline statistically significant in the multivariable model for nulliparous women, likely due to the small sample size. This is consistent with the other research showing the likelihood of primary cesarean delivery is increased in women with prepregnancy obesity compared to normal-weight women [12,18]. Obese women have been observed to have prolonged duration of labor compared to normal-weight women [18]. Although prepregnancy obesity was uncommon in our study population (the median BMI is 19.3 kg/m^2), the modest relationship between higher BMI and cesarean delivery indicates that prepregnancy weight is a potential target for intervention, particularly as studies have shown that rates of obesity are increasing in India and other South Asian populations [19,20].

We found that medical indications during labor and delivery increased the risk of cesarean delivery, particularly emergency cesarean, which is consistent with other studies in Asia [3,21]. A cross-sectional study conducted at a government hospital in Hyderabad found that women who experienced hypertensive disorders, fetal distress, and fetal breech presentation had a higher rate of cesarean deliveries and that 60% of cesarean deliveries were emergency [21]. Cephalo–pelvic disproportion is a common form of obstruction of labor and is a medical indication for cesarean delivery to avert maternal or infant mortality [22]. This might also be related to maternal stature as the average height in this population is 152 cm (5 ft), which is accounted for in the measure for BMI. Fetal distress in the form of nonreassuring fetal heart rate pattern is also a medical indication for cesarean delivery to prevent perinatal mortality. Finally, fetal breech position is also a medical indication for cesarean delivery, and cesarean delivery in breech pregnancies has been found to be protective against perinatal mortality [3].

The high cesarean delivery rate in this peri-urban population reflects the trend in Telangana State, which has the highest cesarean delivery rate in India [23]. An estimated 58% of births in Telangana State are delivered by cesarean, according to data from the 2015–2016 India National Family Health Survey-4, ranging from 40.6% in public hospitals to 74.9% in private hospitals [7]. While the estimated cesarean rate has increased nationally in India, from 8.5% in 2005 to 17.2% a decade later, the cesarean rate in Telangana State in comparison to the national cesarean rate is alarming [7,24]. Our study findings suggest that the cesarean delivery rate in peri-urban areas falls between the rates of rural and urban areas. Furthermore, the study site being a hospital affiliated with a teaching institute may be the factor keeping the cesarean rate in our study population lower than that of the state overall as other teaching institutes in Telangana state have been found to have lower cesarean delivery rates than other health facilities [17].

Suggestions for the rise in cesarean deliveries in India include reasons such as the greater uptake of institutional deliveries overall, physician convenience in part due to an imbalance in the ratio of obstetricians to patients, and financial gain for cesarean deliveries in private sector hospitals [25,26]. As 61% of all births in Telangana state are delivered at private health facilities, compared to 27% in India overall, this may be contributing to the high cesarean delivery rate in this particular region [23]. In addition, cultural factors have been suggested to play a role in the high cesarean rate; such as choice of a birth date due to belief in astrological auspicious days and increasing preference for medicalized births [27]. While we were not able to assess these factors in our study, they may have partially contributed to the high cesarean delivery rate observed. Further investigation is needed to elucidate the cause of the high cesarean rates in India, which exceed the WHO recommendation for cesarean deliveries to not surpass 15% of births within each region [28]. Other countries considered emerging global economies have high cesarean rates, likely corresponding with improved access to advanced health services in the general population. For example, the estimated national cesarean rates in Brazil and China are 55.4% and 41.3% of births, respectively [29,30].

Strengths of our study include using data from a population-based prospective cohort, which increases external validity of the findings to similar populations in India and other peri-urban settings. Second, we conducted analysis by parity, further distinguishing the factors associated with mode of delivery in these two subgroups and providing insight into the rate of primary cesarean delivery in this population. Finally, as labor and delivery data were abstracted from hospital records, there is a lower chance of misclassification of the outcome than if it were self-reported.

We acknowledge that there are limitations to our study. Some predictors were obtained by self-report, and therefore, there could be some misclassification of exposures. Additionally, not all women in the study deliver at MIMS, the study site, and the quality of labor and delivery data is not as complete for women who deliver elsewhere. As 72% of the study cohort delivered at MIMS, we were still able to conduct analysis within the larger subgroup of deliveries at MIMS to ascertain the effect of prior cesarean delivery, an important predictor for mode of delivery. Furthermore, as this is a secondary data analysis and the original purpose of the LIFE study was to assess infant development, not all data on reasons for cesarean delivery were collected. Thus, we are unable to assess the influence of other predictors that may be associated with high cesarean rates, such as maternal request, physician preference of cesarean, and the aforementioned cultural factors.

5. CONCLUSION

Women in a peri-urban Indian population who deliver by cesarean differed in reproductive history, prepregnancy BMI, prenatal, and labor and delivery factors compared to women who delivered vaginally. Medical indications contributed to the high rate of cesarean deliveries in both multiparous and nulliparous women. As the rate of primary cesarean was high, and as history of cesarean was strongly predictive of repeat cesarean, strategies to prevent primary cesarean may be the most effective intervention to decrease the overall cesarean rate in this population. Further studies are needed to elucidate causes of high cesarean delivery and to identify modifiable factors for nonmedically indicated cesarean deliveries in this and similar populations undergoing the epidemiologic transition.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

T.G., C.H.B., G.T., H.S. and C.L.H. conceptualized the study. T.G. and G.T. contributed to methodology and formal analyses. K.B., G.N.K., C.H.B., P.S.R. and C.L.H. contributed in studying cohort, funding acquisition, data curation, and country-specific content. All authors contributed to data interpretation. Review and editing of the final manuscript were done by T.G. and C.L.H.

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