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Factors Influencing Mode of Delivery: A Case-Control Study

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Abstract

The primary objective of this investigation was to scrutinize the prepregnancy conditions and lifestyles of 2046 women residing in Liuzhou City, with the aim of delineating the determinants of delivery methods. Evidently, the study unearthed substantial correlations between prepregnancy body mass index, educational attainment, exposure to passive smoking, medical history, and other variables with the mode of delivery. Furthermore, a predictive nomogram model was formulated to accurately forecast the likelihood of cesarean section. These discernments equip pertinent authorities with the means to institute targeted screening and supportive measures for women contemplating pregnancy based on these identified factors. Moreover, provision of services such as prepregnancy counseling and clinical risk assessments could be instrumental in curbing the incidence of cesarean section.

Keywords

Mode of Delivery, Cesarean Section, Influencing Factors, Nomograph

1. Introduction

The choice of delivery mode has a significant impact on the health of both mothers and infants. With the continuous advancement of medical technology, the global utilization rate of cesarean section as a crucial delivery method is increasing [1]. However, cesarean section carries risks, and potential maternal and infant complications (such as postoperative infection, bleeding, perinatal as-

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phyxia [2] [3]) have become a public health concern. Therefore, it is essential to deeply understand the factors influencing the mode of delivery for predicting and preventing cesarean section.

In recent years, numerous studies have explored various factors affecting the mode of delivery including prepregnancy status, lifestyle habits, and medical history [4] [5]. However, regional and population differences may lead to varying results [6] [7] [8]. As an important city in China with consistently high rates of cesarean sections performed in Liuzhou specifically this study aims to analyze specific factors influencing delivery mode through questionnaire follow-ups with women examined before pregnancy in order to provide theoretical support for predicting and preventing cesarean sections.

Through literature review [5] [9] [10] [11] we found that prepregnancy obesity，passive smoking，previous history of cesarean section，gestational diabetes，gestational hypertension，fetal distress are reported as important factors affecting delivery mode but their specific mechanisms in different populations are not fully understood. Therefore based on previous studies this research further discusses how these factors influence pregnant women in Liuzhou by building a nomogram model to effectively predict the risk of cesarean section.

2. Material and Methods

2.1. Population Sampling and Methods

The pregnant women who had prepregnant checkups in the Liuzhou Maternal and Child Health Hospital between February 2016 and November 2018 were recruited for the Liuzhou Birth Cohort Study (LZBCS) in Guangxi, Liuzhou, China. The age of the subjects was 18 - 45 years old, and they had continuously lived in the Guangxi province for 5 years or above. The exclusion criteria were people with anorexia nervosa, malignant tumors, and serious infectious diseases. After the excluding 6 cases of stillbirth, a total of 2046 pregnant women were finally included in this study.

Firstly, "Liuzhou Birth Cohort Maternal Information Form" was compiled in the research, and uniformly trained investigators conducted face-to-face questionnaire surveys on the research subjects on the site of prepregnant health check. The content includes (1) Basic demographic information; (2) Pregnant women's living habits and environment; (3) Pregnant women's past disease history, etc. Secondly, the routine examination records and delivery information of pregnant women were retrieved through the Guangxi Autonomous Region Maternal and Child Health Network System.

2.2. Definition of Terms

Prepregnancy Body Mass Index (BMI) was calculated (kg/m^2). According to the standards of the China Obesity Working Group, BMI < 18.5 kg/m^2 is considered underweight, 18.5 ≤ BMI ≤ 23.9 kg/m^2 is considered normal weight, 24.0 ≤ BMI ≤ 27.9 kg/m^2 is considered overweight, and BMI ≥ 28.0 kg/m^2 is considered as

obesity.

Passive smoking: In addition to the pregnant woman herself, if other family members living together smoke and/or colleagues staying in the same office smoke will be considered as passive smoking in the gestation.

Strenuous exercise: Exercise that takes more than 6 times of the energy of basal metabolism, or exercise that exceeds 60% of the individual's maximum functional ability level , such as playing ball, exercising with high-impact fitness apparatus, etc. Moderate-intensity activity: Exercise that consumes 3-6 times the energy of basal metabolism, or exercise with an intensity range close to 40%-60% of the individual's maximum functional ability level , such as jogging, bicycling, etc.

Electromagnetic radiation: refers to man-made electromagnetic radiation sources, such as computers, microwave ovens and other household appliances, as well as medical equipment that uses microwaves and X-rays.

2.3. Statistical Analysis

Delivery was categorized as natural delivery and cesarean section. Measurement data was expressed as mean (standard deviation, SD), and enumeration data was expressed as frequency (%). χ^2 test or Fisher exact probability method were used for single-factor analysis (both sides $\alpha < 0.05$). With delivery mode as the outcome variable and natural delivery as the control, variables with $P < 0.05$ in the univariate analysis was incorporated into Logistic Regression to construct a risk model for factors affecting C-section. ROC curves were made and the Homer-Lemeshow goodness-of-fit was used to test the predictive power of the risk model. SPSS 16.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Characteristics of the Study Population

A total of 2046 objects with an average age of 31.6 ± 4.4 years were investigated in this study. The BMI of prepregnancy of pregnant women was 14.2 - 35.7 kg/m^2, and the average BMI was 22.2 ± 3.3 kg/m^2. The household registration of pregnant women was mainly Liuzhou, accounting for more than 70% of the total group (Table 1).

Univariate analysis showed that there were significant differences in delivery mode among various age, education, occupation, and BMI (Table 1). Specifically, advanced age, employment in agriculture, forestry or fishery sectors, and higher BMI were found to be positively correlated with cesarean section rates. Conversely, a higher level of education was negatively correlated with cesarean section rates (all $P < 0.05$). No significant differences were observed in cesarean section rates among pregnant women based on province, city, ethnicity, or annual income ($P > 0.05$) (Table 1).

Table 1. Demographic characteristics of the research objects.

Characteristics		Vaginal delivery (%)	Cesarean delivery (%)	χ^2	P
Province of domicile	Guangxi	1299 (66.0)	668 (34.0)	1.517	0.218
	Others	40 (74.1)	14 (25.9)		
City of domicile	Liuzhou	971 (65.3)	516 (34.7)	2.296	0.130
	Others	368 (68.9)	166 (31.1)		
Ethnicity	Han	787 (65.1)	421 (34.9)	1.315	0.518
	Zhuang	450 (67.8)	214 (32.2)		
	Others	92 (66.2)	47 (33.8)		
Age (years)*	≤30	564 (73.8)	200 (26.2)	30.687	<0.001
	>30	793 (61.9)	489 (38.1)		
Education*	Junior high school or below	159 (58.7)	112 (41.3)	13.540	0.001
	Senior high school	302 (63.0)	177 (37.0)		
	College or above	851 (69.1)	381 (30.9)		
Annual household income (CNY)	<10000	48 (65.8)	25 (34.2)	1.629	0.653
	10000 - 49999	330 (67.9)	156 (32.1)		
	50000 - 99999	741 (66.5)	373 (33.5)		
	≥100000	238 (63.8)	135 (36.2)		
Occupation*	Administrative Staff	320 (71.9)	125 (28.1)	16.664	0.005
	Professional & Skilled Workers	292 (65.8)	152 (34.2)		
	Business and service personnel	345 (63.0)	203 (37.0)		
	Agricultural personnel	21 (53.8)	18 (46.2)		
	Operators	36 (80.0)	9 (20.0)		
	Others	201 (63.4)	116 (36.6)		
Prepregnancy BMI (kg/m^2)*	Underweight	174 (77.0)	52 (23.0)	48.013	<0.001
	Normal	892 (69.1)	399 (30.9)		
	Overweight	231 (56.5)	178 (43.5)		
	Obesity	60 (50.0)	60 (50.0)		

BMI: Body mass index. *P < 0.05.

3.2. The Relationship between Pregnant Women's Living Habits, Living Environment and Delivery Methods

The results of the univariate analysis show that there were statistical differences between the participation in moderate-intensity activities, the number of days per week of walking duration above 10 min/times, the consumption of caffeinated drinks during pregnancy, and passive smoking (Table 2).The cesarean section rate was higher in those who did not participate in moderate intensity exercise weekly and regularly consumed caffeinated beverages (all P < 0.05).

Table 2. Distribution of living habits, environment and delivery mode of pregnant women.

Factors		Vaginal delivery (%)	Cesarean delivery (%)	χ^2	P
Electromagnetic radiation	No	1211 (66.2)	619 (33.8)	0.174	0.677
	Yes	146 (67.6)	70 (32.4)		
Participated in strenuous exercise every week	No	1314 (66.4)	664 (33.6)	0.301	0.584
	Yes	43 (63.2)	25 (36.8)		
Participated in moderate-intensity activities every week*	No	1214 (65.6)	638 (34.4)	5.236	0.022
	Yes	143 (73.7)	51 (26.3)		
The number of days that each walk lasts more than 10 minutes*	<2	396 (62.1)	242 (37.9)	7.978	0.019
	2 - 6	551 (67.5)	265 (32.5)		
	7	410 (69.3)	182 (30.7)		
Sedentary time per day during the workday (hours)	<6	311 (64.4)	172 (35.6)	1.702	0.427
	6 - 7	788 (66.8)	399 (33.6)		
	>7	256 (68.6)	117 (31.4)		
Sleep Quality	Very poor	29 (54.7)	24 (45.3)	6.913	0.141
	poor	156 (65.0)	84 (35.0)		
	Moderate	817 (68.2)	381 (31.8)		
	Good	314 (64.3)	174 (35.7)		
	Very good	41 (61.2)	26 (38.8)		
Smoking#	No	1344 (66.2)	685 (33.8)	-	0.449
	Yes	13 (76.5)	4 (23.5)		
Passive smoking*	No	527 (71.5)	210 (28.5)	13.847	<0.001
	Yes	830 (63.4)	479 (36.6)		
Drinking#	Never	1177 (65.5)	621 (34.5)	-	0.076
	Occasionally	178 (72.7)	67 (27.3)		
	Regularly	2 (66.7)	1 (33.3)		
Tea-drinking habit	No	1224 (66.3)	623 (33.7)	0.026	0.873
	Yes	133 (66.8)	66 (33.2)		
Caffeinated drinks intake*	No	1111 (65.6)	582 (34.4)	6.256	0.044
	Occasionally	238 (70.8)	98 (29.2)		
	Frequently	8 (47.1)	9 (52.9)		

*$P < 0.05$. #Using Fisher's exact probability method. "-" The theoretical basis of Fisher's exact probability is hypergeometric distribution, which is not within the scope of the chi-square test, so there is no chi-square value.

3.3. The Relationship between Pregnant Women's Health History, Pregnancy History and Mode of Delivery

Univariate analysis showed that previous cesarean section history, infertility history, adverse pregnancy history, hypertension, gestational diabetes mellitus, gestational hypertension, preeclampsia, threatened preterm delivery, fetal distress were positively correlated with cesarean section rate ($P < 0.05$). No correlation was found between the history of allergy, diabetes, hyperlipidemia, threatened abortion, anemia during pregnancy and the mode of delivery ($P > 0.05$) (Table 3).

Table 3. Distribution of maternal past medical history, pregnancy history, pregnancy complications and mode of delivery.

Variables		Vaginal delivery (%)	Cesarean delivery (%)	χ^2	P
Allergic history	No	1153 (66.5)	581 (33.5)	0.146	0.703
	Yes	204 (65.4)	108 (34.6)		
History of cesarean section*	No	1308 (77.9)	370 (22.1)	564.518	<0.001
	Yes	49 (13.3)	319 (86.7)		
History of infertility*	No	1202 (68.2)	560 (31.8)	20.375	<0.001
	Yes	155 (54.6)	129 (45.4)		
History of adverse pregnancy or childbirth*	No	1223 (67.7)	583 (32.3)	13.399	<0.001
	Yes	134 (55.8)	106 (44.2)		
Birth parity*	≤2	950 (72.3)	364 (27.7)	58.682	<0.001
	>2	407 (55.6)	325 (44.4)		
Hypertension*	No	1351 (66.7)	675 (33.3)	11.932	0.001
	Yes	6 (30.0)	14 (70.0)		
Diabetes	No	1343 (66.5)	676 (33.5)	2.566	0.109
	Yes	14 (51.9)	13 (48.1)		
Hyperlipidemia	No	1330 (66.3)	675 (33.7)	0.004	0.949
	Yes	27 (65.9)	14 (34.1)		
Ovarian cyst or Polycystic ovary syndrome	No	1242 (66.5)	626 (33.5)	0.258	0.612
	Yes	115 (64.6)	63 (35.4)		
Hypothyroidism	No	1303 (66.4)	659 (33.6)	0.163	0.686
	Yes	54 (64.3)	30 (35.7)		
Hyperthyroidism	No	1335 (66.4)	677 (33.6)	0.041	0.840
	Yes	22 (64.7)	12 (35.3)		
Depression	No	1342 (66.2)	684 (33.8)	0.681	0.409
	Yes	15 (75.0)	5 (25.0)		
Anxiety	No	1327 (66.1)	680 (33.9)	2.000	0.157
	Yes	30 (76.9)	9 (23.1)		

Continued

Hepatitis B *	No	1274 (67.1)	626 (32.9)	6.320	0.012
	Yes	83 (56.8)	63 (43.2)		
Thalassemia	No	1234 (66.7)	615 (33.3)	1.475	0.225
	Yes	123 (62.4)	74 (37.6)		
Gestational diabetes mellitus *	No	1094 (69.9)	471 (30.1)	38.191	<0.001
	Yes	263 (54.7)	218 (45.3)		
Gestational hypertension *	No	1336 (67.1)	656 (32.9)	18.692	<0.001
	Yes	21 (38.9)	33 (61.1)		
Preeclampsia *	No	1351 (67.1)	662 (32.9)	34.806	<0.001
	Yes	6 (18.2)	27 (81.8)		
Threatened premature labor *	No	1300 (67.0)	640 (33.0)	7.885	0.005
	Yes	57 (53.8)	49 (46.2)		
Premature rupture of membranes *	No	1177 (65.5)	620 (34.5)	4.516	0.034
	Yes	180 (72.3)	69 (27.7)		
Fetal distress *	No	1291 (67.8)	613 (32.2)	26.907	<0.001
	Yes	66 (46.5)	76 (53.5)		
Threatened miscarriage	No	1331 (66.5)	670 (33.5)	1.505	0.220
	Yes	26 (57.8)	19 (42.2)		
Pregnancy anemia	No	1232 (66.5)	622 (33.5)	0.141	0.707
	Yes	1125 (65.1)	67 (34.9)		

*$P < 0.05$.

3.4. Logistic Regression of Factors Affecting Cesarean Section

To account for the confounding factors, we conducted a multivariate logistic regression analysis, incorporating variables with a significance level of $P < 0.05$ in the univariate analysis. The findings revealed that a prior history of cesarean section (OR = 28.97), infertility history (OR = 2.89), gestational diabetes mellitus (OR = 1.67), gestational hypertension (OR = 2.48), preeclampsia (OR = 7.93), threatened preterm delivery (OR = 1.78), fetal distress (OR = 3.64), prepregnancy obesity (OR = 1.55), and passive smoking (OR = 1.29) emerged as risk factors for cesarean delivery. Conversely, prepregnancy emaciation (OR = 0.64) and possession of a college degree or higher (OR = 0.62) were identified as protective factors (all $P < 0.05$) (**Figure 1**).

3.5. Construction and Evaluation of the Nomogram Prediction Model

According to the logistic regression equation, 10 variables including previous cesarean section history, infertility history, gestational diabetes, gestational hypertension, preeclampsia, threatened premature labor, fetal distress, passive smoking, prepregnancy BMI, and educational level were used as independent

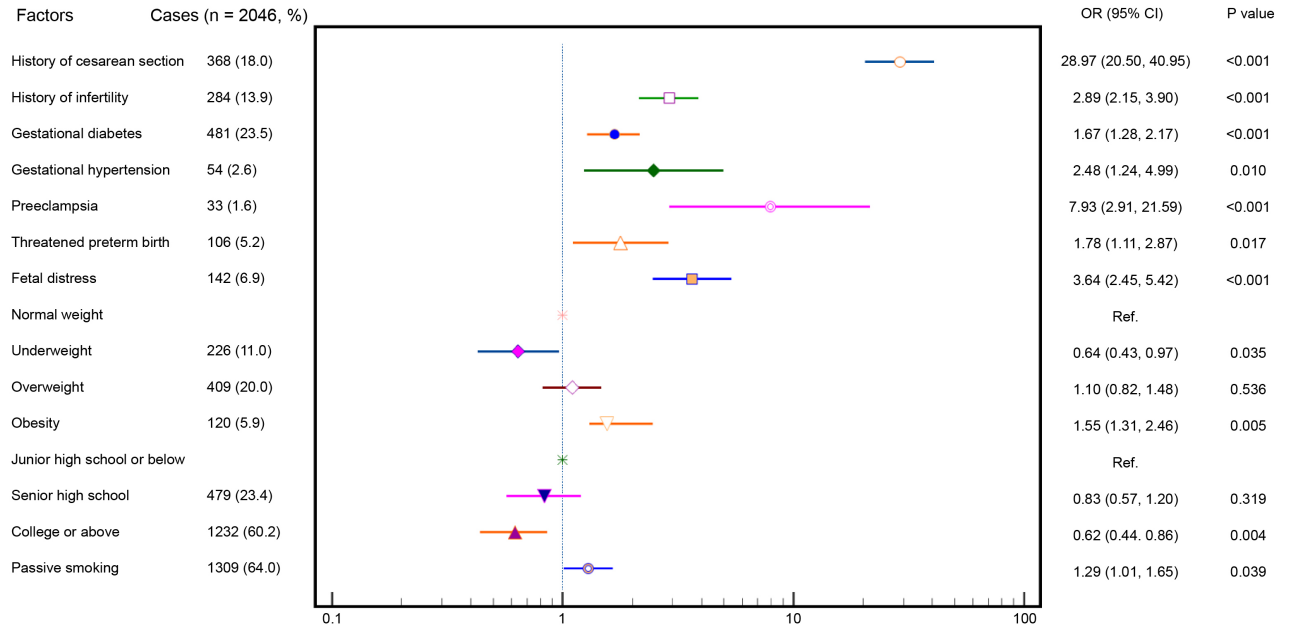

Figure 1. Results of multifactor analysis of influencing factors of cesarean section.

predictors for the cesarean section to conduct ROC curve analysis (**Figure 2**) and establish a nomogram model for predicting the specific risk of the cesarean section (**Figure 3**). The results showed that the area under the ROC curve was 0.840 (95% CI: 0.791, 0.836), $P < 0.001$. While the Homer-Lemeshow goodness of fit test result was $P = 0.808$, and the nomogram model correction C-index was 0.812. The prediction results of the risk prediction model for cesarean section were in good agreement with the actual situation (**Figure 4**).

4. Discussion

4.1. Main Influencing Factors of Delivery Mode

In this examination of a segment of the Liuzhou populace, the aggregate proportion of cesarean deliveries amounted to 33.7%, surpassing the World Health Organization's suggested threshold of 15% per district [12]. We explored factors related to delivery mode, and the results showed that history of cesarean section, prepregnancy BMI, prenatal health complications, and passive smoking all independently increased the risk of cesarean section in this population.

Aligned with existing literature [9], this study identified a heightened likelihood of cesarean section among pregnant women with a history of previous cesarean section (OR = 28.97) and infertility (OR = 2.89), potentially influenced by emotional distress such as tension and anxiety during pregnancy [13] [14], impacting their preparedness for natural delivery. In addition, the study showed that patients with gestational diabetes were 1.67 times more likely to have a cesarean section than those without diabetes (95% CI: 1.28, 2.17) and those with gestational hypertension were 2.48 times more likely to have a cesarean section than those without hypertension (95% CI: 1.24, 4.99), which is similar to the

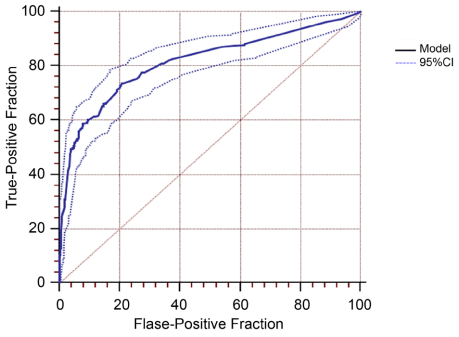

Figure 2. ROC curve of the combined prediction model for cesarean delivery.

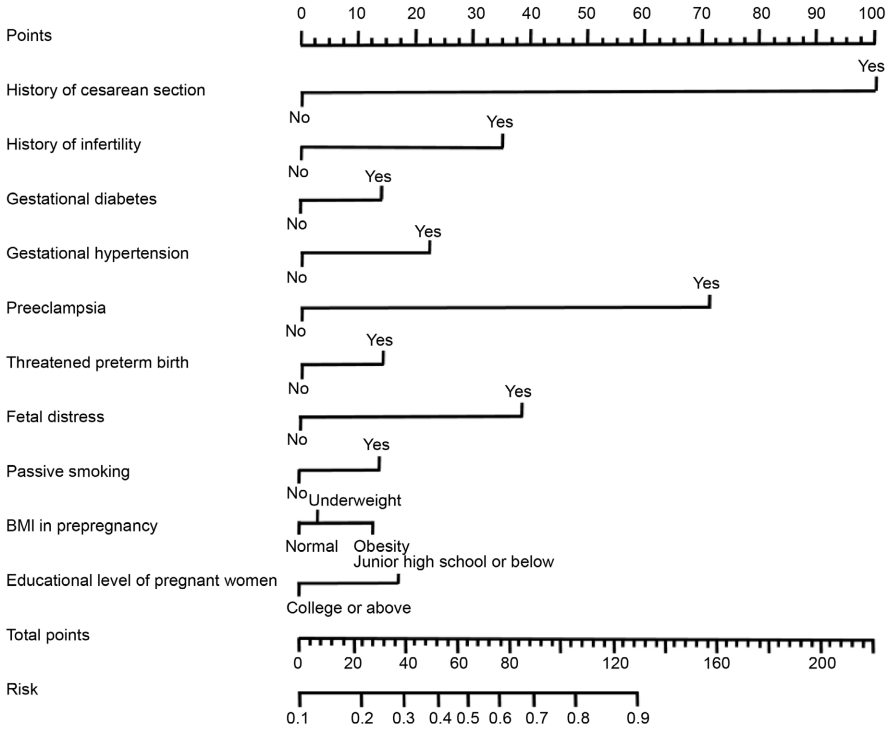

Figure 3. Nomogram of risk prediction model for cesarean section.

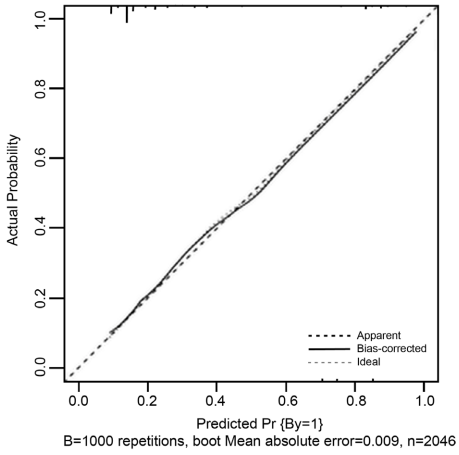

Figure 4. Nomogram model correction curve.

results of Dong *et al*. [5] The connection between gestational diabetes mellitus and gestational hypertension with delivery mode warrants attention. Given the profound risks and adverse outcomes associated with cesarean section for both the fetus and the mother [2] [3] [15] [16], proactive public health strategies such as lifestyle adjustments, prepregnancy counseling, clinical risk assessments, and pre-delivery screenings are imperative to mitigate the impact of pregnancy complications and reduce the occurrence of cesarean section.

Preeclampsia (OR = 7.93), threatened preterm birth (OR = 1.78), and fetal distress (OR = 3.64) are associated with an increased risk of cesarean section, with our results aligning with prior research in the field [4] [10] [17] [18]. Notably, complications such as threatened preterm birth and fetal distress contribute to a higher cesarean section rate, a trend possibly attributed to the procedure's ability to significantly lower neonatal asphyxia and intracranial hemorrhage risks, potentially enhancing premature infant survival rates [17]. Consequently, a critical evaluation of cesarean section indications is essential when selecting the mode of delivery, particularly for individuals with elevated risk profiles, necessitating proactive development and implementation of preventive measures to effectively mitigate cesarean section prevalence.

Cultural factors are thought to play a role in high cesarean section rates. Our study found that there were differences in the rate of cesarean section in pregnant women with different education levels, and the rate of cesarean section in college and above group was the lowest ($P < 0.05$). This may be related to: first, pregnant women with low education level have weak learning ability of pregnancy health knowledge and weak awareness of receiving health care services [14] [19]; Second, because families with lower levels of education are more likely to believe in astrological auspicious days and choose birth dates, they tend to prefer cesarean sections [20]. However, whether education level is a risk factor for cesarean section delivery is still controversial. For example, the study by Fond [6] did not find a correlation between cesarean section delivery and education level, Sharifi *et al*.'s study [7] found that more maternal preferred cesarean section procedures as their level of education increased. The inconsistencies of the research conclusions may be related to the different regions, ages and lifestyles of the study subjects, which need further research and discussion.

Our study reveals that pregnant women who were exposed to passive smoking had a 1.29 times higher risk of cesarean section compared to non-passive smokers. Long-term exposure to tobacco smoke during pregnancy can cause DNA damage, uterine contractions, and intrauterine distress, leading to premature delivery and premature rupture of membranes, which increases the likelihood of cesarean section [10] [21]. Furthermore, smoke contains harmful substances that can cause pathological changes in the placenta, such as the shortening of microvilli on the villus surface and reduced blood vessel formation. These changes can result in premature calcification of the placenta, infarction, stillbirth, and other perinatal complications, which may directly affect the delivery

method [21]. To ensure the healthy development of maternal and infants, it is recommended that pregnant women and their families avoid exposure to cigarette smoke as much as possible. In addition, relevant departments should strictly implement non-smoking and tobacco control policies in public places to minimize the impact of environmental tobacco smoke on pregnant women and their fetuses.

Similar to the findings of Dong [5] and Tamala Gondwe [11], our study found that pregnant women with obesity in prepregnancy have a higher risk of cesarean section (OR = 1.55), indicating a correlation between abnormal weight in prepregnancy and cesarean section. However, this study did not find a statistical difference between overweight and cesarean section rates. Additionally, our study found that pregnant women who were underweight in prepregnancy had a lower risk of cesarean section (OR = 0.64), which is contradictory to previous studies [5] [8] [22]. It is important to note that direct comparisons between studies may have limitations due to changes in methods, environment, genetic variation, and population age structure, indicating the need for further research. Currently, the mechanism by which prepregnancy overweight or obesity affects the incidence of cesarean section remains unclear. Studies suggest that this may be related to adverse factors that occur during delivery. For instance, obesity alters the structure of the pelvic cavity, abdominal wall, uterine muscle fibres, and other tissues, which is not conducive to vaginal delivery in pregnant women [23] [24]. Secondly, the thickness of the upper edge of the abdominal wall transverse incision can cause difficulties in delivering the infant. Improper handling of this situation may lead to neonatal asphyxiation, maternal organ damage, uterine incision tearing, and even massive bleeding, which can increase the possibility of cesarean section [23] [24]. To avoid these complications, it is important to carefully manage the delivery process. Overall, prepregnancy BMI has a significant impact on the normal delivery of pregnant women. It is recommended that more attention be given to pregnant women to maintain a healthy weight during pregnancy to prevent the adverse effects of abnormal BMI on the maternal and the fetus.

In recent years, researchers have introduced predictive models in maternal and infant-related fields to explore the relationship between potential risk factors and maternal and infant health. Which aim to find ways to effectively reduce the occurrence of adverse maternal and infant outcomes. In this study, the influencing factors of delivery mode were excavated, and the risk model of cesarean section was built. The fitted model was visualized through the nomograph, so as to provide reference for clinical judgment. The sensitivity, specificity and AUC of the cesarean section risk prediction model were 73.0%, 79.8% and 0.840 in our study, higher than those of Zhou (AUC = 0.73) [25], Hernandez-Martinez (AUC = 0.77) [26] and Rossi (AUC = 0.78) [27], indicating a high level of accuracy in predicting actual outcomes. The effect of cesarean section risk score model on correctly predicting adverse pregnancy outcomes in women in the third trimes-

ter seems to be feasible. However, we should be aware that the nomograph was constructed to help patients consult, rather than directly make clinical decisions, and its discriminative and predictive ability is always limited, which needs further verification and improvement in practical application.

4.2. Limitations

The main limitation of this study is retrospective design, and recall bias is inevitable. Secondly, the constructed cesarean section risk prediction model has not been externally verified, and the application of the nomogram should be limited to patients who meet the inclusion criteria of this study, which is difficult to extrapolate.

5. Conclusion

The cesarean section rate was high in Liuzhou, and the previous history of cesarean section, preeclampsia, fetal distress and other factors affected the delivery mode. For pregnant women with high risk factors, relevant departments can intervene and manage them in advance to reduce the occurrence of adverse birth outcomes. Moreover, future studies can further expand the sample size, and explore the interaction mechanism among various factors, as well as the differences in the influencing factors of delivery modes in different regions, so as to provide a more comprehensive and scientific basis for improving maternal and child health.

Authors' Contributions

Yonghua He conceived and designed the study. Linfeng Mo, Na Wang and Bin Peng recruited the participants, and analyzed the data. Jiwei Wu, Han Liu and Jie Hu collected data of the patients. Linfeng Mo and Na Wang wrote the manuscript. Linfeng Mo, Lishan Tang and Yonghua He edited the manuscript and provided response to comments. Yonghua He, Bin Peng and Jiwei Wu supervised the study. All authors read and approved the final manuscript.

Ethical Considerations & Disclosure(s)

This study obtained the approval of the Medical Ethics Committee of Guilin Medical University Affiliated Hospital and the informed consent of the research subjects. The study was conducted in accordance with the local legislation and institutional requirements.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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