Risk Factors for Adverse Pregnancy Outcomes among Zhuang Ethnic Pregnant Women: A Cohort Study in Guangxi, China*

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Summary: Risk factors for adverse pregnancy outcomes among Zhuang ethnic pregnant women are unclear. This study analyzed the incidence and risk factors related to preterm birth (PB), low birth weight (LBW) and macrosomia in Zhuang population. We conducted a prospective cohort study of 9965 Zhuang pregnancy women in Guangxi, China. Information on mothers and newborns was obtained by using questionnaires and referring to medical records. Multivariate logistic regression analyses were used to evaluate the association between related factors and adverse pregnancy outcomes. Our results showed that the incidence of PB, LBW and macrosomia in Zhuang people was 5.55%, 5.64% and 2.19%, respectively. Maternal age ≥ 36 years (OR=2.22, 95% CI: 1.51–3.27) was related to a higher incidence of PB. Those with pre-pregnancy body mass index (BMI) < 18.5 kg/m² (OR=1.91, 95% CI: 1.45–2.51), and had a female fetus (OR=1.74, 95% CI: 1.36–2.23) were more likely to have LBW infants. Maternal age between 31 and 35 years (OR=1.76, 95% CI: 1.03–2.99) and pre-pregnancy overweight or obesity (OR=1.79, 95% CI: 1.15–2.80) were associated with a higher risk of macrosomia. The protective factors of macrosomia were maternal pre-pregnancy BMI < 18.5 kg/m² (OR=0.30, 95% CI: 0.15–0.60) and female fetus (OR=0.41, 95% CI: 0.28–0.59). Our study provided a reference for maternal and childcare administration among Zhuang population.

Key words: Zhuang ethnic; cohort study; low birth weight; preterm birth; macrosomia; risk factors

Preterm birth (PB), low birth weight (LBW) and macrosomia are common types of adverse pregnancy outcomes. According to an international study of 184 countries, the global incidence of PB was 11.1% in 2010, and it was 7.1% in China^[1]. PB remains a global problem associated with perinatal morbidity and adverse health outcomes^[2–5]. It has been reported that the risk factors of PB mainly include the following: maternal age, parity, maternal nutrition during pregnancy, smoking, and gestational diseases^[6–8].

LBW and macrosomia have been reported to be the risk factors of newborn illness and diseases in adulthood^[9–12]. One prior study reported that the worldwide prevalence of LBW was 14.6% in 2015^[9]. Some maternal factors such as maternal age, parity, hypertension, and pre-pregnancy body mass index (BMI) have been shown to be related to the risk of LBW^[13–16]. The rate of macrosomia increased over the past several decades in many countries. In China, Shan *et al* found that the percentages of macrosomia in Beijing increased from 6.6% in 1996 to 9.5% in 2000 and declined to 7.0% in 2010^[17]. While Zhang *et al* found an overall increase in frequency of macrosomia from 8.9% in 2010 to 10.1% in 2013, in Xi'an, China^[18]. Factors associated with macrosomia may include but not limited to parity, BMI, maternal age, and fetal sex^[19–21].

It has been reported that ethnic differences also have an impact on pregnancy outcomes. Diabelková *et al* analyzed the differences in pregnancy outcomes between Roma and non-Roma mothers, and found that

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the Roma mothers had a higher risk of giving birth to LBW babies^[22]. A study from the Xinjiang region in China showed that the incidence of LBW among Uighur, Hazakh and Hui ethnic groups was significantly higher than that of Han ethnic group, while the rate of macrosomia among Uighur was lower than that of Han^[23]. China is the largest developing country in the world with 56 ethnic groups. Zhuang is the most populous ethnic minority in China, mostly living in the Guangxi Zhuang Autonomous Region. However, to the best of our knowledge, there were few researches on the incidence and risk factors for adverse pregnancy outcomes in the Zhuang people.

In this study, we investigated and analyzed the incidence and risk factors of three adverse pregnancy outcomes (LBW, PB and macrosomia) in Zhuang ethnic mothers, and provided a reference for maternal and child care administration among the Zhuang population.

1 MATERIALS AND METHODS

1.1 Study Design and Study Population

This study was approved by the ethical committee of Guangxi Medical University (No. 20140305-001) and conducted under the Helsinki Declaration. Informed consent was obtained from all participants.

The present study was conducted as a part of the prospective Guangxi Zhuang Nationality Birth Cohort study which was initiated in 2015. This ongoing cohort enrolls participants at 13 hospitals in the counties of Jingxi, Longan, Tiandong, Tianyang, Pingguo, Wuming, and Debao, which are located in Guangxi Zhuang Autonomous Region in southern China. Pregnant women, who came for their first prenatal care before 12 gestational weeks, were asked to participate in the study. The eligibility criteria for participants are as follows: (1) the pregnant woman and/or her husband are ethnically Zhuang Chinese; (2) residence in the study area; (3) with an expectation to deliver at the collaborating hospital. Participants were invited to complete a questionnaire by a face-to-face interview. The questionnaire used was designed by epidemiologists. A total of 11 384 pregnant women were enrolled between June 2015 and July 2018. After excluding those who had multiple births ($n=549$), who gave birth to an infant with a birth defect ($n=128$), and who was not Zhuang ethnic herself ($n=742$), a total of 9965 Zhuang ethnic pregnancy women were eventually included in this analysis.

1.2 Pregnancy Outcomes

Information about the mothers' disease, history of pregnancy outcomes, and information regarding the infant sex, birth date, birth weight, and gestational age at birth were retrieved from medical records. Gestational age was determined by both the woman's last menstrual

period and ultrasound examination. PB was defined as infants born before 37 weeks of gestation^[24]. LBW and macrosomia were defined as birthweight < 2500 g and ≥ 4000 g, respectively^[9, 10]. Trained obstetric nurses measured birth weight immediately after delivery using a calibrated electronic scale.

1.3. Data Collection

The face-to-face interviews were conducted with the participants at the first antenatal care visit in the hospital by trained investigators. The interview collected a variety of information, including socio-demographic characteristics (maternal age and occupational status), lifestyle variables (alcohol use during pregnancy, smoking during pregnancy, passive smoking, folic acid intake, cooking fuels, and exercise) and the living conditions (natural ventilation of the house, natural lighting of the house and whether the house was decorated in the last five years). Pre-pregnancy BMI was calculated as weight (kg)/height (m^2).

1.4 Statistical Analysis

Categorical data were described as the percentage. All risk factor variables were first examined by univariate analysis to assess the importance of each of them on three adverse pregnancy outcomes. A Bonferroni test was used for Post-hoc pairwise comparison. When a variable was found to be significant at the 0.1 level or was reported to be associated with pregnancy outcomes in previous studies, it was entered into the multivariate model.

The correlation between risk factors and adverse pregnancy outcomes was estimated using logistic regression and expressed as odds ratios (OR) and 95% confidence intervals (CI). A two-tailed value of $P < 0.05$ was considered statistically significant. All statistical analyses were performed by IBM SPSS statistics (version 22.0).

2 RESULTS

2.1 Characteristics of Study Population

A total of 9965 Zhuang ethnic pregnant women were included in the study. The basic characteristics of the pregnant women are shown in table 1. Women enrolled had a mean age of 28.7 years ($SD=5.5$) and were predominantly non-drinkers and nonsmokers. Over half of infants were male. The incidence of PB, LBW, and macrosomia was 5.55%, 5.64% and 2.19%, respectively.

2.2 Univariate and Multiple Analyses of Factors Related to Adverse Pregnancy Outcomes

The associations of maternal and fetal factors with the risk of PB are presented in table 2. In univariate analyses, maternal age ≥ 36 years was associated with an increased risk of PB ($OR=1.43$, 95% CI: 1.09–1.88), and this association remained statistically significant in

Table 1 Characteristics of mothers and infants (n=9965)

Characteristics	n (%)
Maternal age (years)	
≤25	2849 (28.59)
26–30	3438 (34.50)
31–35	2555 (25.64)
≥36	1123 (11.27)
Occupational status	
Unemployed	1819 (18.25)
Employed	8146 (81.75)
Pre-pregnancy BMI (kg/m ²)	
Underweight (<18.5)	1464 (14.69)
Normal weight (18.5–24.9)	4697 (47.13)
Overweight or obesity (≥25)	589 (5.91)
Missing	3215 (32.26)
Smoking during pregnancy	
No	9958 (99.93)
Yes	7 (0.07)
Passive smoking	
No	5404 (54.23)
Yes	3905 (39.19)
Missing	656 (6.58)
Drinking during pregnancy	
No	9915 (99.50)
Yes	50 (0.50)
Folic acid intake	
No	3850 (38.64)
Yes	6089 (61.10)
Missing	26 (0.26)
Cooking fuels	
Clean fuels	8561 (85.91)
Non clean fuels	1378 (13.83)
Missing	26 (0.26)
Natural ventilation of house	
Poor or general ventilation	3103 (31.14)
Good ventilation	6853 (68.77)
Missing	9 (0.09)
Natural lighting of house	
Poor or general natural lighting	3148 (31.59)
Good natural lighting	6808 (68.32)
Missing	9 (0.09)
Decorated the house in the last five years	
No	8361 (83.90)
Yes	1599 (16.05)
Missing	5 (0.05)
Regular exercise	
No	9516 (95.49)
Yes	271 (2.72)
Missing	178 (1.79)
Gestational diabetes mellitus	
No	9510 (95.44)
Yes	455 (4.57)
Pregnancy induced hypertension	
No	9548 (95.82)
Yes	417 (4.18)
Parity	
Nulliparous	5349 (53.68)
Multiparous	4616 (46.32)
Infant sex	
Male	5266 (52.84)
Female	4699 (47.16)
Adverse pregnancy outcomes	
PB	553 (5.55)
LBW	562 (5.64)
Macrosomia	218 (2.19)

n, number; PB, preterm birth; LBW, low birth weight; BMI, body mass index

multivariate analyses (OR=2.22, 95% CI: 1.51–3.27). No other factors were found to be associated with PB.

Results of univariate and multivariate analyses of factors related to LBW are shown in table 3. In univariate models, those who were underweight (OR=1.87, 95% CI: 1.48–2.35), with gestational age < 37 weeks (OR=24.58, 95% CI: 20.08–30.09), and had a female fetus (OR=1.53, 95% CI: 1.29–1.82) were more likely to have LBW infants, while mothers with age between 31 and 35 years (OR=0.63, 95% CI: 0.50–0.80), and multiparous women (OR=0.74, 95% CI: 0.62–0.88) had a lower risk of having a LBW infant. In multivariate models, these associations remained statistically significant except for the association between maternal age and LBW.

The associations of maternal and fetal factors with the risk of macrosomia are presented in table 4. Maternal age between 31 and 35 years (OR=1.76, 95% CI: 1.03–2.99) and pre-pregnancy BMI ≥25 kg/m² (OR=1.79, 95% CI: 1.15–2.80) were risk factors for macrosomia; while pre-pregnancy BMI <18.5 kg/m² (OR=0.30, 95% CI: 0.15–0.60) and having a female fetus (OR=0.41, 95% CI: 0.28–0.59) were protective factors for macrosomia in multivariate analyses. Besides, gestational diabetes mellitus was associated with an increased risk of macrosomia at the brink of significance (OR=1.73, 95% CI: 0.97–3.09; *P*=0.063).

3 DISCUSSION

In this large population-based study, we examined the incidence of PB, LBW and macrosomia in Zhuang population, and identified the possible risk factors associated with the three adverse pregnancy outcomes. To the best of our knowledge, this is the first cohort study to investigate the incidence and risk factors for adverse pregnancy outcomes in the Zhuang population. The results of the present study suggested that in Zhuang population, maternal age ≥36 years was related to an increased risk of PB; pre-pregnancy underweight, gestational age <37 weeks, and having a female fetus were associated with the risk of LBW; maternal age between 31–35 years, pre-pregnancy overweight or obesity, and male fetus might be the risk factors of macrosomia.

In our study, the incidence of PB, LBW and macrosomia in Zhuang population was 5.55%, 5.64% and 2.19%, respectively. The results of previous studies about the incidence of adverse pregnancy outcomes are shown in table 5, and more than 97% of the pregnant women were ethnic Han in these studies^[18, 25–30]. The rate of PB in the present study was similar to that in other studies in China^[25–29]. The incidence of LBW in our study population was 5.64%, which was higher than the values of studies in Shanghai (2.9%), Ma'an Shan (1.9%), Wuhan (4.4%) and rural areas

Table 2 Association of maternal and fetal factors with the risk of PB

Factors	Univariate logistic regression		Multiple logistic regression ^a	
	OR (95% CI)	P	OR (95% CI)	P
Maternal age (years)				
≤ 25	Reference			
26–30	0.88 (0.70, 1.10)	0.269	0.96 (0.70, 1.31)	0.780
31–35	1.03 (0.82, 1.30)	0.797	1.24 (0.88, 1.75)	0.226
≥ 36	1.43 (1.09, 1.88)	0.010	2.22 (1.51, 3.27)	<0.001
Occupational status				
Employed	Reference			
Unemployed	0.96 (0.77, 1.20)	0.739		
Pre-pregnancy BMI (kg/m ²) ^b				
Underweight (<18.5)	1.08 (0.83, 1.40)	0.571	1.12 (0.85, 1.49)	0.410
Normal weight (18.5–24.9)	Reference			
Overweight or obesity (≥25)	0.93 (0.62, 1.39)	0.727	0.77 (0.50, 1.19)	0.246
Passive smoking ^c				
No	Reference			
Yes	1.02 (0.85, 1.22)	0.853	1.10 (0.87, 1.38)	0.420
Drinking during pregnancy				
No	Reference			
Yes	0.35 (0.05, 2.51)	0.294	0.53 (0.07, 3.87)	0.528
Folic acid intake ^d				
No	1.09 (0.92, 1.30)	0.333	1.10 (0.87, 1.39)	0.412
Yes	Reference			
Cooking fuels ^e				
Clean fuels	Reference			
Non clean fuels	1.13 (0.89, 1.43)	0.335	1.18 (0.86, 1.61)	0.310
Natural ventilation of house ^f				
Good ventilation	Reference			
Poor or general ventilation	1.04 (0.87, 1.26)	0.639	1.05 (0.83, 1.33)	0.692
Natural lighting of house				
Good natural lighting	Reference			
Poor or general natural lighting	1.03 (0.86–1.24)	0.744		
Decorated the house in the last five years ^g				
No	Reference			
Yes	1.03 (0.82, 1.30)	0.791	1.13 (0.85, 1.52)	0.404
Regular exercise ^h				
No	1.27 (0.71, 2.28)	0.423	1.66 (0.73, 3.80)	0.226
Yes	Reference			
Gestational diabetes mellitus				
No	Reference			
Yes	0.90 (0.59, 1.38)	0.637	1.21 (0.74, 1.97)	0.447
Pregnancy induced hypertension				
No	Reference			
Yes	1.14 (0.76, 1.71)	0.532	1.16 (0.76, 1.77)	0.493
Parity				
Nulliparous	Reference			
Multiparous	0.95 (0.80, 1.12)	0.530	0.81 (0.63, 1.05)	0.109
Infant sex				
Male	Reference			
Female	0.89 (0.75, 1.05)	0.167	0.86 (0.69, 1.08)	0.194

^aAdjusted for maternal age, pre-pregnancy BMI (kg/m²), passive smoking, drinking during pregnancy, cooking fuels, natural ventilation of house, decorated the house in the last five years, regular exercise, parity, gestational diabetes mellitus, pregnancy induced hypertension, parity, and infant sex.

^bInformation on pre-pregnancy BMI (kg/m²) missing for 3215 mothers;

^cInformation on passive smoking missing for 656 mothers;

^dInformation on folic acid intake missing for 26 mothers;

^eInformation on cooking fuels missing for 26 mothers;

^fInformation on natural ventilation of house missing for 9 mothers;

^gInformation on having decorated the house in the last five year missing for 5 mothers;

^hInformation on regular exercise missing for 178 mothers;

PB, preterm birth; OR, odds ratio; CI, confidence interval; BMI, body mass index

Table 3 Association of maternal and fetal factors with the risk of LBW

Factors	Univariate logistic regression		Multiple logistic regression ^a	
	OR (95% CI)	P	OR (95% CI)	P
Maternal age (years)				
≤25	Reference			
26–30	0.79 (0.64, 0.97)	0.024	1.10 (0.80, 1.50)	0.557
31–35	0.63 (0.50, 0.80)	<0.001	0.87 (0.59, 1.27)	0.463
≥36	0.88 (0.66, 1.17)	0.389	1.10 (0.69, 1.74)	0.685
Occupational status				
Employed	Reference			
Unemployed	1.02 (0.82, 1.27)	0.874		
Pre-pregnancy BMI (kg/m ²) ^b				
Underweight (<18.5)	1.87 (1.48, 2.35)	<0.001	1.91 (1.45, 2.51)	<0.001
Normal weight (18.5–24.9)	Reference			
Overweight or obesity (≥25)	0.68 (0.43, 1.10)	0.120	0.76 (0.44, 1.29)	0.300
Passive smoking ^c				
No	Reference			
Yes	1.08 (0.90, 1.29)	0.410	1.15 (0.90, 1.48)	0.271
Drinking during pregnancy				
No	Reference			
Yes	0.34 (0.05, 2.47)	0.286	0.50 (0.06, 4.11)	0.522
Folic acid intake ^d				
No	1.11 (0.93, 1.32)	0.236	1.16 (0.90, 1.50)	0.240
Yes	Reference			
Cooking fuels ^e				
Clean fuels	Reference			
Non clean fuels	1.20 (0.95, 1.52)	0.125	1.32 (0.95, 1.84)	0.100
Natural ventilation of house ^f				
Good ventilation	Reference			
Poor or general ventilation	1.165 (0.97, 1.39)	0.095	1.26 (0.98, 1.63)	0.072
Natural lighting of house				
Good natural lighting	Reference			
Poor or general natural lighting	1.159 (0.97, 1.39)	0.106		
Decorated the house in the last five years ^g				
No	Reference			
Yes	1.22 (0.98, 1.51)	0.081	1.14 (0.83, 1.56)	0.416
Regular exercise ^h				
No	1.56 (0.82, 2.95)	0.173	1.62 (0.66, 3.97)	0.294
Yes	Reference			
Gestational diabetes mellitus				
No	Reference			
Yes	0.72 (0.45, 1.15)	0.168	0.85 (0.45, 1.60)	0.610
Pregnancy induced hypertension				
No	Reference			
Yes	1.02 (0.67, 1.56)	0.917	0.99 (0.61, 1.61)	0.971
Parity				
Nulliparous	Reference			
Multiparous	0.74 (0.62, 0.88)	<0.001	0.73 (0.55, 0.96)	0.024
Infant sex				
Male	Reference			
Female	1.53 (1.29, 1.82)	<0.001	1.74 (1.36, 2.23)	<0.001
Gestational age				
≥37 weeks	Reference			
<37 weeks	24.58 (20.08, 30.09)	<0.001	25.77 (19.54, 33.99)	<0.001

^aAdjusted for maternal age, pre-pregnancy BMI (kg/m²), passive smoking, drinking during pregnancy, cooking fuels, natural ventilation of house, decorated the house in the last five years, regular exercise, gestational diabetes mellitus, pregnancy induced hypertension, parity, infant sex, and gestational age.

^bInformation on pre-pregnancy BMI (kg/m²) missing for 3215 mothers;

^cInformation on passive smoking missing for 656 mothers;

^dInformation on folic acid intake missing for 26 mothers;

^eInformation on cooking fuels missing for 26 mothers;

^fInformation on natural ventilation of house missing for 9 mothers;

^gInformation on having decorated the house in the last five year missing for 5 mothers;

^hInformation on regular exercise missing for 178 mothers;

LBW, low birth weight; OR, odds ratio; CI, confidence interval; BMI, body mass index.

Table 4 Association of maternal and fetal factors with the risk of macrosomia

Factors	Univariate logistic regression		Multiple logistic regression ^a	
	OR (95% CI)	P	OR (95% CI)	P
Maternal age (years)				
≤25	Reference			
26–30	1.95 (1.27, 3.00)	0.002	1.30 (0.78, 2.18)	0.316
31–35	3.23 (2.13, 4.92)	<0.001	1.76 (1.03, 2.99)	0.038
≥36	2.84 (1.73, 4.69)	<0.001	1.33 (0.70, 2.54)	0.380
Occupational status				
Employed	Reference			
Unemployed	0.94 (0.66, 1.34)	0.751		
Pre-pregnancy BMI (kg/m ²) ^b				
Underweight (<18.5)	0.24 (0.12, 0.48)	<0.001	0.30 (0.15, 0.60)	0.001
Normal weight (18.5–24.9)	Reference			
Overweight or Obesity (≥25)	1.97 (1.29, 3.01)	0.002	1.79 (1.15, 2.80)	0.010
Passive smoking ^c				
No	Reference			
Yes	0.87 (0.65, 1.15)	0.316	1.00 (0.71, 1.41)	0.989
Drinking during pregnancy				
No	Reference			
Yes	1.87 (0.45, 7.75)	0.388	1.31 (0.17, 9.92)	0.791
Folic acid intake ^d				
No	0.97 (0.74, 1.28)	0.839	0.91 (0.65, 1.29)	0.611
Yes	Reference			
Cooking fuels ^e				
Clean fuels	Reference			
Non-clean fuels	0.77 (0.50, 1.19)	0.238		
Natural ventilation of house ^f				
Good ventilation	Reference			
Poor or general ventilation	0.76 (0.56, 1.03)	0.078	0.90 (0.63, 1.29)	0.560
Natural lighting of house				
Good natural lighting	Reference			
Poor or general natural lighting	0.78 (0.58, 1.06)	0.108		
Decorated the house in the last five years				
No	Reference			
Yes	1.00 (0.69, 1.44)	1.000		
Regular exercise ^g				
No	1.00 (0.44, 2.28)	0.997	1.08 (0.39, 2.98)	0.882
Yes	Reference			
Gestational diabetes mellitus				
No	Reference			
Yes	2.16 (1.35, 3.46)	0.001	1.73 (0.97, 3.09)	0.063
Pregnancy induced hypertension				
No	Reference			
Yes	0.87 (0.43, 1.77)	0.701	0.76 (0.37, 1.57)	0.460
Parity				
Nulliparous	Reference			
Multiparous	1.51 (1.16, 1.98)	0.003	1.30 (0.88, 1.93)	0.192
Infant sex				
Male	Reference			
Female	0.45 (0.33, 0.60)	<0.001	0.41 (0.28, 0.59)	<0.001

^aAdjusted for maternal age, pre-pregnancy BMI (kg/m²), passive smoking, drinking during pregnancy, cooking fuels, natural ventilation of house, regular exercise, gestational diabetes mellitus, pregnancy induced hypertension, parity, and infant sex.

^bInformation on pre-pregnancy BMI (kg/m²) missing for 3215 mothers;

^cInformation on passive smoking missing for 656 mothers;

^dInformation on folic acid intake missing for 26 mothers;

^eInformation on cooking fuels missing for 26 mothers;

^fInformation on natural ventilation of house missing for 9 mothers;

^gInformation on regular exercise missing for 178 mothers;

LBW, low birth weight; OR, odds ratio; CI, confidence interval; BMI, body mass index.

Table 5 Comparison of the incidence of adverse pregnancy outcomes in the present study and other studies in China

Locations	Urban/Rural	Year	Total	PB (%)	LBW (%)	Macrosomia (%)	Reference
Guangxi	Rural	2015–2018	9965	5.55	5.64	2.19	Present study
Shanghai	Urban	2013–2016	4015	5.6	2.9	8.2	[25]
Ma'anshan, Anhui	Urban&Rural	2013–2014	3079	3.2	1.9	6.9	[26]
Wuhan, Hubei	Urban	2012–2014	10111	6.4	4.4	–	[27]
Guangzhou, Guangdong	Urban	2012–2016	14093	6.1	6.7	–	[28]
A nationwide study	Rural	2010–2012	367425	5.21	–	–	[29]
Shaanxi	Rural	2010–2013	809	–	3.6	–	[30]
Xi'an, Shaanxi	Rural	2010–2013	181	–	–	8.6	[18]

of Shaanxi province (3.6%), but lower than that in Guangzhou (6.7%)^[25–28, 30]. Compared to the previous studies, the Zhuang population in our study had a lower macrosomia incidence (8.2% in Shanghai, 6.9% in Ma'anshan, and 8.6% in rural areas of Xi'an)^[18, 25, 26].

It has been demonstrated that maternal pre-pregnancy BMI was associated with the infant birth weight: women with low pre-pregnancy BMI had a higher risk of giving birth to LBW babies; on the other hand, high pre-pregnancy BMI was a risk factor for macrosomia^[20, 31, 32]. The Zhuang women in our study had lower pre-pregnancy BMI (5.91% overweight or obesity) than women in other cohort study (9% overweight or obesity in Shanghai and 11.72% in Ma'anshan)^[26, 33]. Thus, the higher LBW incidence and the lower macrosomia incidence of Zhuang fetal may be related to the lower pre-pregnancy BMI of their mothers. Furthermore, some researchers suggested that maternal and child health outcomes may vary by health inequalities between different ethnic groups^[34]. The factors contributing to health inequalities between ethnic and non-ethnic minority populations are varied and complex, while some studies suggested that the income, education, employment, social policies, health care systems, health behaviors, cultural norms, and maternal and child health service coverage may all play a role^[34–36].

Our study showed that mothers with maternal age ≥ 36 years were more likely to deliver preterm babies. It is consistent with the previous studies^[37, 38]. Previous evidence showed that the risk of pregnancy outcome would be greater in advanced age due to placental physiological changes of aging^[37, 39]. It should be noted that the average age of childbearing in China has increased from 26.31 in 2000 to 29.13 in 2010^[38]. Therefore, clinical workers should strengthen the prevention and health care of pregnant women in advanced maternal age to avoid serious adverse pregnancy outcomes.

LBW remains an important public health issue for developing countries^[40]. Our study demonstrated that pre-pregnancy BMI < 18.5 kg/m², nulliparous, and female fetus were risk factors for LBW. The possible mechanism is as follows. Low pre-pregnancy weight women may not be able to provide adequate nutrients

to the fetus, ultimately leading to LBW^[41]. Increasing parity is related to a progressive increase in uterine blood flow, which leads to increased birth weight of subsequent offspring^[15]. In terms of infant sex, the weight difference between male and female infants may be associated with chromosomes and hormones^[42].

Maternal age between 31–35 years old and pre-pregnancy overweight or obesity were related to a higher risk of macrosomia, which is consistent with several other studies^[43, 44]. Both two factors can lead to macrosomia by affecting fetal fat and protein stores^[43, 44]. We also found that male fetuses were more likely to be macrosomia. This is consistent with differences in fetal growth between males and females^[42]. In addition, we found that gestational diabetes mellitus tended to be a risk factor for macrosomia. The excessive shunting of nutrients to the fetus and the acceleration of fetal growth trajectory may contribute to the increased risk of macrosomia in women with gestational diabetes mellitus^[45].

One of the strengths of our study is that the prospective cohort design was used. The information was collected in the early stages of pregnancy, which can reduce the recall bias. In addition, interviews conducted with all participants provided the opportunity to adjust for more potential risk factors for adverse pregnancy outcomes, such as maternal pre-pregnancy BMI, regular exercise, passive smoking, and cooking fuels. However, the study has some limitations. First, some variables have missing data, e.g. pre-pregnancy BMI, passive smoking, natural ventilation of house, and natural lighting of house. Second, maternal nutritional status was not addressed in this study. It is common knowledge that low maternal levels of nutrients are related to adverse effects on fetal development.

In conclusion, the incidence of PB, LBW and macrosomia in Zhuang people was 5.5%, 5.64% and 2.19%, respectively. In Zhuang pregnant women, maternal age ≥ 36 years was related to a higher incidence of PB. Mothers who were pre-pregnancy underweight, with gestational age < 37 weeks, and had a female fetus were more likely to have LBW infants. Maternal age between 31–35 years, pre-pregnancy overweight or obesity, and male fetus were linked to increased risk of macrosomia. Health service at the perinatal stage

should be strengthened for pregnant women with one of these risk factors to reduce the incidence of adverse pregnancy outcomes. The potential mechanism of these risk factors should be studied in future studies.

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Conflict of Interest Statement

The authors report no conflicts of interest in this study.

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