Changing trends of birth weight with maternal age: a cross-sectional study in Xi'an city of Northwestern China

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Abstract

Background: Most studies have shown that maternal age is associated with birth weight. However, the specific relationship between each additional year of maternal age and birth weight remains unclear. The study aimed to analyze the specific association between maternal age and birth weight.

Methods: Raw data for all live births from 2015 to 2018 were obtained from the Medical Birth Registry of Xi'an, China. A total of 490143 mother-child pairs with full-term singleton live births and the maternal age ranging from 20 to 40 years old were included in our study. Birth weight, gestational age, birth date of the newborns, maternal birth date, residence and ethnicity were collected. Generalized additive model and two-piece wise linear regression model were used to analyze the specific relationships between maternal age and birth weight, risk of low birth weight, and risk of macrosomia.

Results: The relationships between maternal age and birth weight, risk of low birth weight, and risk of macrosomia were nonlinear. Birth weight increased 16.204 g per year when maternal age is less than 24 years old (95%CI: 14.323, 18.086), and increased 12.051g per year when maternal age ranged from 24 to 34 years old (95%CI: 11.609, 12.493), then decreased 0.824g per year (95% CI: -3.112, 1.464). The risk of low birth weight decreased with the increase of maternal age until 36 years old (OR= 0.917, 95%CI: 0.903, 0.932 when maternal age younger than 27 years old; OR= 0.965, 95%CI: 0.955, 0.976 when maternal age ranging from 27 to 36 years old), then increased when maternal age older than 36 years old (OR=1.133, 95%CI: 1.026, 1.250). The risk of macrosomia increased with the increase of maternal age (OR=1.102, 95%CI: 1.075, 1.129 when maternal age younger than 24 years old; OR=1.065, 95%CI: 1.060, 1.071 when maternal age ranged from 24 to 33 years old; OR=1.029, 95%CI: 1.012, 1.046 when maternal age older than 33 years old).

Conclusions: For women of childbearing age (20-40 years old), the threshold of maternal age on low birth weight was 36 years old, and the risk of macrosomia increased with the increase of maternal age.

Background

Birth weight (BW) is the most important index reflecting intrauterine growth and development, and also a vital index to evaluate the health status of the newborn [1]. Abnormal BW, including low birth weight (LBW, BW < 2500 g) and macrosomia (BW ≥ 4000 g), significantly increases the risk of perinatal mortality and morbidity [2]. It is considered a marker of age-related disease and longevity risk, as LBW has been associated with increased cardiovascular disease and type 2 diabetes mellitus in adulthood, and macrosomia infants has been highly predisposed to metabolic syndrome in adulthood [3, 4]. As the most common adverse birth outcome, the incidence of abnormal BW is generally high in the world. It was estimated that the incidence of LBW was about 5–7% in developed countries and as high as 19% in developing countries [5], and in mainland China it was 6.1% [6]. Furthermore, the incidence of macrosomia also has increased over the past two to three decades in both developed and developing countries [7]. It is likely that LBW and macrosomia might remain a major public health issue over the next few years in China [3].

With the development of society and the change of people's conception of procreation, it is reported that the global trend of delayed childbirth is increasing, while the rate of teenage pregnancy is on the decline, eg United States and Korean [8, 9]. With the delayed childbirth age and the increase of mothers with two children, the mean maternal age and the proportion of elderly pregnant women are increasing in China [10]. In 2011, a survey of 14 provinces in China showed that the average delivery age of pregnant women was 28 ± 5 years, the proportion of maternal age older than 35 was 7.8%, and the proportion of maternal age younger than 20 was 1.4% [7, 11]. While the proportion of babies born to women older than 35 was 12.3% in Nanjing, China in 2017 [10]. Pregnancy risks rose with the maternal age rising [12], such as the increased risk of chromosomal aneuploidy associated with increased maternal age [13]. At the same time, adolescent pregnancy is also associated with abnormal child birth [9].

Previous studies indicated that the relationship between maternal age and birth weight was inconsistent [4, 12, 14–16]. Most of the previous studies focused on the incidence of LWB and macrosomia in different age groups by fixed classification of maternal age[14, 16], which might underestimate age-related risk for women in younger age groups and overestimate risks for mothers in older age groups [17]. There is no sufficient evidence to assess the appropriateness of using this artificial traditional age classification to assess their impacts on BW. Further, the specific relationships between each additional year of maternal age and the change of BW remain unclear, and the threshold maternal age on BW is unknown in China. Therefore, we conducted a cross-sectional study to figure out the relationship between maternal age and BW in Xi'an, China.

Materials And Methods

Study design

A large sample study was conducted to figure out the relationship between maternal age and BW with dose-response analyses. The data were obtained from The Birth Registry Database in Xi'an city, which covered all midwifery clinics and hospitals in the city. We collected the birth information of all full-term singleton live births born from Jan 2015 to Dec 2018 in Xi'an city of Shaanxi province in China, and the data contained the number of total births, birth weight, gestational age, birth date of the newborns, maternal birth date, residence and ethnicity. And the study protocol was approved by the Medical Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (No.XJTU1AF2017LSK-106).

Study Population

This was a retrospective cross-sectional study. In a total of 536993 newborns, we only selected newborn who was term birth (gestational age 37 to 41^{+6} weeks), singleton live births, and whose BW ≥ 1000 g and maternal age at birth ranged from 20 to 40 years old. The flow chart of including criteria could be seen in Fig. 1.

Data used in the study were all anonymous, so individual consent was not required. And in the process of this study, all data were only used to conduct research, not for other purposes, which can ensure that the privacy of patients was fully protected.

Study covariates

Our main independent variable maternal age calculated from the birth time of the fetus minus the birth time of the mother. Our main outcome was term birth weight, which was measured by electronic scale within 2 hours after birth when the baby was undressed. And based on it, low birth weight (LBW) was defined as BW less than 2500 g [18], macrosomia was defined as BW greater than or equal to 4000 g [19]. At the same time, gestational age, maternal residence, ethnicity and birth date of the newborns were all collected as confounding variables. All data were collected by delivery hospitals and centrally completed by midwives with double checks, who had been unified trained by Xi'an health and family planning commission.

Statistical Analysis

All analyses were conducted using the statistical packages R (R Foundation; http://www.r-project.org; version 3.6.3) and Empower Stats (www.empowerstats.com; X&Y Solutions Inc.).

Maternal age at birth was studied as a continuous variable, which was expressed as means ± standard deviation (means ± SD). We used pregnancy age at birth and women's characteristics as categorical variables to examine the association with BW by one-way ANOVA and risk of LBW and macrosomia by Chi-square Test. We described the distribution of each group with the number and proportion of births. The season of birth was divided into 4 groups (spring, summer, autumn and winter) according to the birth time. The maternal residence was divided into 3 groups (urban, suburb, countryside). Maternal ethnicity was divided into 2 groups (Han and other).

Generalized additive model was conducted to see whether there were nonlinear relationships between maternal age and BW and risk of LBW and macrosomia respectively, and to verify whether the relationships still existed by adjusting some potential confounders which were found by the One-way ANOVA and Chi-square Test.

Two-piece wise linear regression model was used to examine the threshold effect of the maternal age on BW and the risk of LBW and macrosomia with an adjustment for potential confounders. The turning point of maternal age was defined, where the relationship between maternal age and BW and the risk of LBW and macrosomia started to change. $P < 0.05$ was considered as statistically significant.

Results

Related factors of the mother-child pairs

A total number of 536993 mother-child pairs was abstracted from the Medical Birth Registry of Xi'an, born from Jan 2015 to Dec 2018. After removing those failing to meet the requirements and unreasonable records, 490143 mother-child pairs (91.3%) were included in the analysis. The basic characteristics of the mother-child pairs were shown in Table 1. The mean BW of those infants was 3364.937 ± 420.528 g, and the mean age of mothers was 28.728 ± 4.134 years old. The incidence of LBW was 1.5%, and the incidence of macrosomia was 6.0%. The one-way ANOVA and chi-square test results indicated that BW and the risk of LBW and macrosomia were all associated with gestational age, the season of birth and maternal residence, except for maternal ethnicity.

Table 1
Basic characteristics of the mother-child pairs

Variables	*N* (%)	Birth weight			Low birth weight			Macrosomia		
		Mean ± SD(g)	*F*	*P* value	N(%)	$\chi 2$	*P* value	N(%)	$\chi 2$	*P* value
Total	490143(100)	3364.937 ± 420.528			7146(1.5)			29457(6.010)		
Gestational age(weeks)			51543	<0.001		15294	<0.001		7197.400	<0.001
$37–37^{+6}$	36138(7.4)	3020.404 ± 422.075			3125(8.6)			498(1.4)		
$38–38^{+6}$	98636 (20.1)	3247.870 ± 396.350			1994(2.0)			2946(3.0)		
$39–39^{+6}$	162966 (33.2)	3369.093 ± 394.169			1312(0.8)			8442(5.2)		
$40–40^{+6}$	138209 (28.2)	3462.910 ± 400.804			590(0.4)			11373(8.2)		
$41–41^{+6}$	54194(11.1)	3545.406 ± 395.768			125(0.2)			6198(11.4)		
Season of birth			24.007	<0.001		13.970	0.003		36.509	<0.001
Spring	119481(24.4)	3363.061 ± 422.333			1806(1.5)			7137(5.9)		
Summer	121425(24.8)	3360.024 ± 18.322			1859(1.5)			6932(5.7)		
Autumn	128548(26.2)	3367.011 ± 419.182			1773(1.4)			7806(6.1)		
Winter	120689(24.6)	3369.533 ± 422.324			1708(1.4)			7582(6.3)		
Maternal residence			243.76	<0.001		58.415	<0.001		40.423	<0.001
Urban	245250(50.1)	3372.876 ± 416.985			3370(1.4)			15193(6.2)		
Suburb	128008(26.1)	3363.916 ± 422.330			1800(1.4)			7648(6.0)		
Countryside	116885(23.8)	3349.401 ± 425.485			1976(1.7)			6616(5.7)		
Ethnicity			0.975	0.327		0.265	0.566		1.165	0.267
Han	485192(99.0)	3364.998 ± 420.453			7069(1.5)			29141(6.0)		
Other	4951 (1.0)	3359.067 ± 427.861			77(1.6)			316(6.4)		

The relationship between maternal age and birth weight.

A nonlinear relationship between maternal age and BW was observed by generalized additive model (Fig. 2a). After adjusting for gestational age, the season of birth and maternal residence, the nonlinear relationship still remained (Fig. 2b) and two turning points value of maternal age for BW were found at 24 and 34 years by two-piece wise linear regression model (Table 2). The BW increased 16.204 g per year increase of maternal age when maternal age younger than 24 years old (Adjusted Effect size (β) = 16.204, 95%CI: 14.323, 18.086, P < 0.001). The BW increased 12.051 g per year increase of maternal age when maternal age ranged from 24 to 34 years old (β = 12.051, 95%CI: 11.609, 12.493, P < 0.001). But there was a marginal significantly negative association between maternal age and BW when maternal age ranged older than 34 years old (β= -0.824, 95% CI: -3.112, 1.464, p = 0.480).

(The black curves represented the association between maternal age and BW, and lines were the corresponding 95% CI. The abscissa was the maternal age. The vertical axis represented BW, risk of LBW and macrosomia, respectively. a: The relationship between maternal age and BW when no confounding factor was adjusted; b: The relationship between maternal age and BW adjusting for potential confounders, including gestational

age, season of birth and maternal residence. c: The relationship between maternal age and risk of LBW adjusting for potential confounders, including gestational age, the season of birth and maternal residence. d: The relationship between maternal age and risk of macrosomia adjusting for potential confounders, including gestational age, the season of birth and maternal residence)

Table 2
The effect of maternal age on BW in two-piece wise linear regression model.

Inflection point of maternal age	Maternal age	Adjusted *β/OR* (95%CI)	*P* value
Birth weight			
24y,34y	20 ≤ and < 24 y	16.204 (14.323, 18.086) [a]	< 0.001
	24 ≤ and ≤ 34 y	12.051 (11.609, 12.493) [a]	< 0.001
	34 < and ≤ 40 y	-0.824 (-3.112, 1.464) [a]	0.480
Risk of low birth weight			
27y,36y	20 ≤ and < 27 y	0.917 (0.903, 0.932)[b]	< 0.001
	27 ≤ and ≤ 36 y	0.965 (0.955, 0.976) [b]	< 0.001
	36 < and ≤ 40 y	1.133 (1.026, 1.250) [b]	0.013
Risk of macrosomia			
24y,33y	20 ≤ and < 24 y	1.102 (1.075, 1.129) [c]	< 0.001
	24 ≤ and ≤ 33 y	1.065 (1.060, 1.071) [c]	< 0.001
	33 < and ≤ 40 y	1.029 (1.012, 1.046) [c]	0.001
Adjusted confounding factors: gestational age, season of birth, maternal residence.			

a: Adjusted β coefficient and 95%CI for each additional year of maternal age on BW. b: Adjusted OR and 95%CI for each additional year of maternal age on the risk of LBW. c: Adjusted OR and 95%CI for each additional year of maternal age on the risk of macrosomia.

The relationship between maternal age and low birth weight

A nonlinear relationship between maternal age and the risk of LBW was observed by generalized additive model, adjusted for gestational age, the season of birth and maternal residence (Fig. 2c). Two turning points value of maternal age for LBW were found at 27 and 36 years old by two-piece wise linear regression model (Table 2). The risk of LBW decreased by 8.3% per year increase of maternal age when maternal age younger than 27 years old (Odds Ratio (OR) = 0.917, 95%CI: 0.903, 0.932, P < 0.001). The risk of LBW decreased by 3.5% per year increase of maternal age when maternal age ranged from 27 to 36 years old (OR = 0.965, 95%CI: 0.955, 0.976, P < 0.001). The risk of LBW increased by 13.3% per year increase in maternal age when maternal age older than 36 years old (OR = 1.133, 95%CI: 1.026, 1.250, P = 0.013).

The relationship between maternal age and macrosomia

A nonlinear relationship between maternal age and macrosomia was observed by generalized additive model, adjusting for gestational age, the season of birth and maternal residence (Fig. 2d). Two turning points value of maternal age for macrosomia were found at 24 and 33 years by two-piece wise linear regression model (Table 2). The risk of macrosomia increased by 10.2% per year increase of maternal age when maternal age ranged younger than 24 years old (OR = 1.102, 95%CI: 1.075, 1.129, P < 0.001). The risk of macrosomia increased by 6.5% per year increase of maternal age when maternal age ranged from 24 to 33 years old (OR = 1.065, 95%CI: 1.060, 1.071, P < 0.001). The risk of macrosomia increased by 2.9% per year increase of maternal age when maternal age older than 33 years old (OR = 1.029, 95%CI: 1.012, 1.046, P = 0.001).

Discussion

Main results

Our research indicated the specific relationships between each additional year of maternal age (20–40 years old) at birth and the change of BW and abnormal BW for the full-term (37 to 41^{+6} weeks) live singletons. BW increased gradually until age 34, then decreased. The risk of LBW decreased gradually until age 36, then increased. The risk of macrosomia was increasing with the increase of maternal age. Our findings provided the absolute risk of abnormal BW by maternal age, which would be useful for patient fertility counseling.

Interpretation

A nonlinear relationship between maternal age and BW was observed and two inflection points of maternal age at 24 and 34 years were found. The BW increased faster from age 20 until age 23 than from age 24 until age 34. The curve was consistent with the findings of the previous studies [12, 14]. But no research provided the threshold maternal age on BW was 34 years old [12, 20, 21]. We observed a marginal significantly negative association between maternal age and birth weight when maternal age ranged from35 to 40years, which was consistent with the findings of the previous studies [22, 23].

The mechanism of the effect of maternal age on BW is still unclear. Relevant research showed that most of the effects on the offspring of intrauterine exposure to maternal age-related obstetric complications might be induced by epigenetic DNA reprogramming during critical periods of the embryo or fetal development[13]. The quality of woman's eggs declined dramatically with increasing age, leading to an increased risk of pregnancy-related complications among older women [12].

A nonlinear relationship between maternal age (20–40 years) and the risk of term LBW was found in our study. The curve was the same as the previous study [14, 24]. As LBW infants may be premature with other risk factors [25], we restricted our study population to term infants. The etiology of LBW was intrauterine growth restriction [18]. The prevalence of term LBW in our study was 1.5%, which was lower than 2% reported by the other study [26], which suggesting there was a good perinatal care system in Xi'an, China. Term LBW can lead to adverse pregnancy outcomes, as severe neonatal asphyxia [27]. The threshold maternal age on the risk of term LBW was 36 years old, fewer studies have been reported it [6, 7, 15]. However, the biological mechanisms by which maternal age cause the term LBW are unclear. The increased risk of LBW among younger maternal age can be explained by the low socioeconomic conditions of the younger mothers and increased nutritional demands of pregnancy [28].

With the increase of maternal age (20–40 years old), the risk of macrosomia was increasing and two inflection points of maternal age were found at 24 and 33 years. The curve was the same as the previous studies [29]. The incidence of macrosomia was 6.0% in our study, which was approximate with the previous study [15]. The risk of macrosomia increased faster from age 20 until age 23 than from age 24 until age 33, which was the same as the change of BW. Term macrosomia is influenced by maternal hyperglycemia and endocrine status through placental circulation [30]. The increased risk is partly explained by the increased prevalence of diabetes and hypertension with the increased maternal age [14].

Strengths and limitations

Our research has some advantages: first, our study was large sample research based on four years records. Besides, our study has very strict inclusion and exclusion criteria and the data was also carried on the strict cleaning and so on. However, there were some potential limitations in this study. First, some potential confounders, such as fetus gender, parity, medical history, economic condition and paternal age, were not adjusted because of limited data. Second, the mother-child pairs were not included when the maternal age was younger than 20 years old or older than 40 years old, because of the small proportion of them. Therefore, our research could only reflect the changing trend of BW when the maternal age ranged from 20 to 40 years old. In order to ensure the accuracy of our research results, we limited the subjects to full term singleton live birth, which could eliminate some potential influencing factors [26], as serious pregnancy complications. Although the large sample size might increase potential confounding, we can estimated the relationship between maternal age and BW, LBW and macrosomia in detail with generalized additive model and two-piece wise linear regression model.

Conclusions

Our research indicated the specific relationships between each additional year of maternal age and the change of BW, LBW and macrosomia in full-term singleton live birth when maternal age ranged from 20 to 40 years old. Birth weight increased gradually until age 34, then decreased. The threshold maternal age for low birth weight was 36 years old, and the risk of macrosomia was increasing with the increase of maternal age. These results should be carefully taken into account by maternal care providers in order to inform women adequately, support them in understanding potential risks of BW associated with their age, and the importance of prenatal care. However, optimized maternal age should be determined individually for different pregnancy complications and adverse neonatal outcomes. The mechanism between maternal age and BW is not clear. Therefore, further studies are needed to examine the relationship between maternal age and BW.

Abbreviations

BW: Birth weight; LBW:Low birth weight;β:Adjusted Effect size; OR:Odds Ratio; CI:Confidence intervals.

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The Ethics Committee for the Science of Medical center, at the First Affiliated Hospital of the Xi'an Jiaotong University approved all study protocols on 23 October, 2017 (No.XJTU1AF2017LSK-106). Data used in the study were all anonymous, so individual consent was not required. And in the process of this study, all data were only used to conduct research, not for other purposes, which can ensure that the privacy of patients was fully protected.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

S.W., W.Y., M.C.C, L.Y., L.S., L.H., conceived the study; S.W., L.Y. analyzed, interpreted of data, S.W. wrote the manuscript; S.W., L.Y., L.S., C.Q., R.W., G.X. collated data. All authors have been involved in revising the manuscript critically for important intellectual content; and they have given final approval of the version to be published.

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Figures

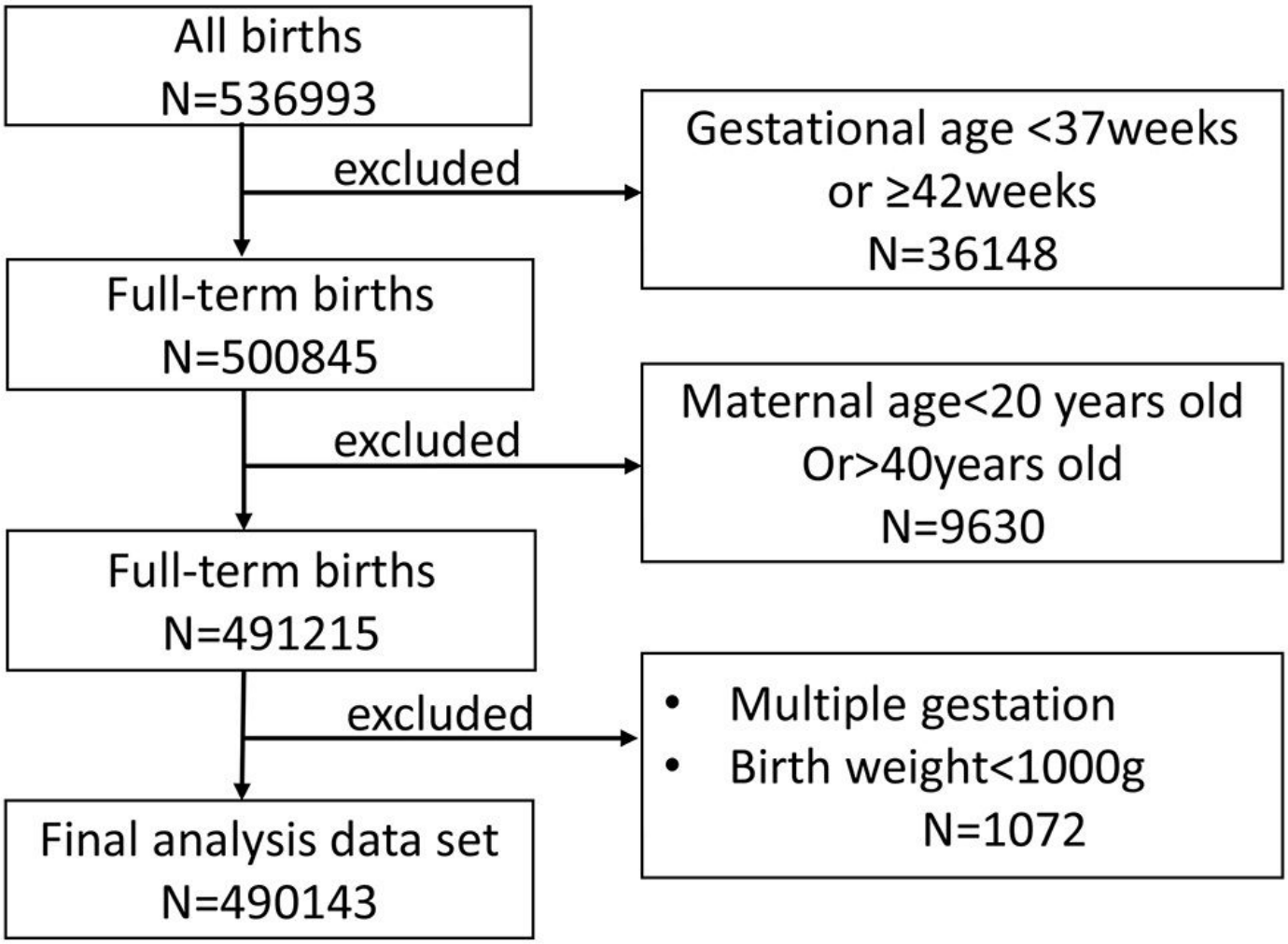

Figure 1

Flow chart of including criteria.

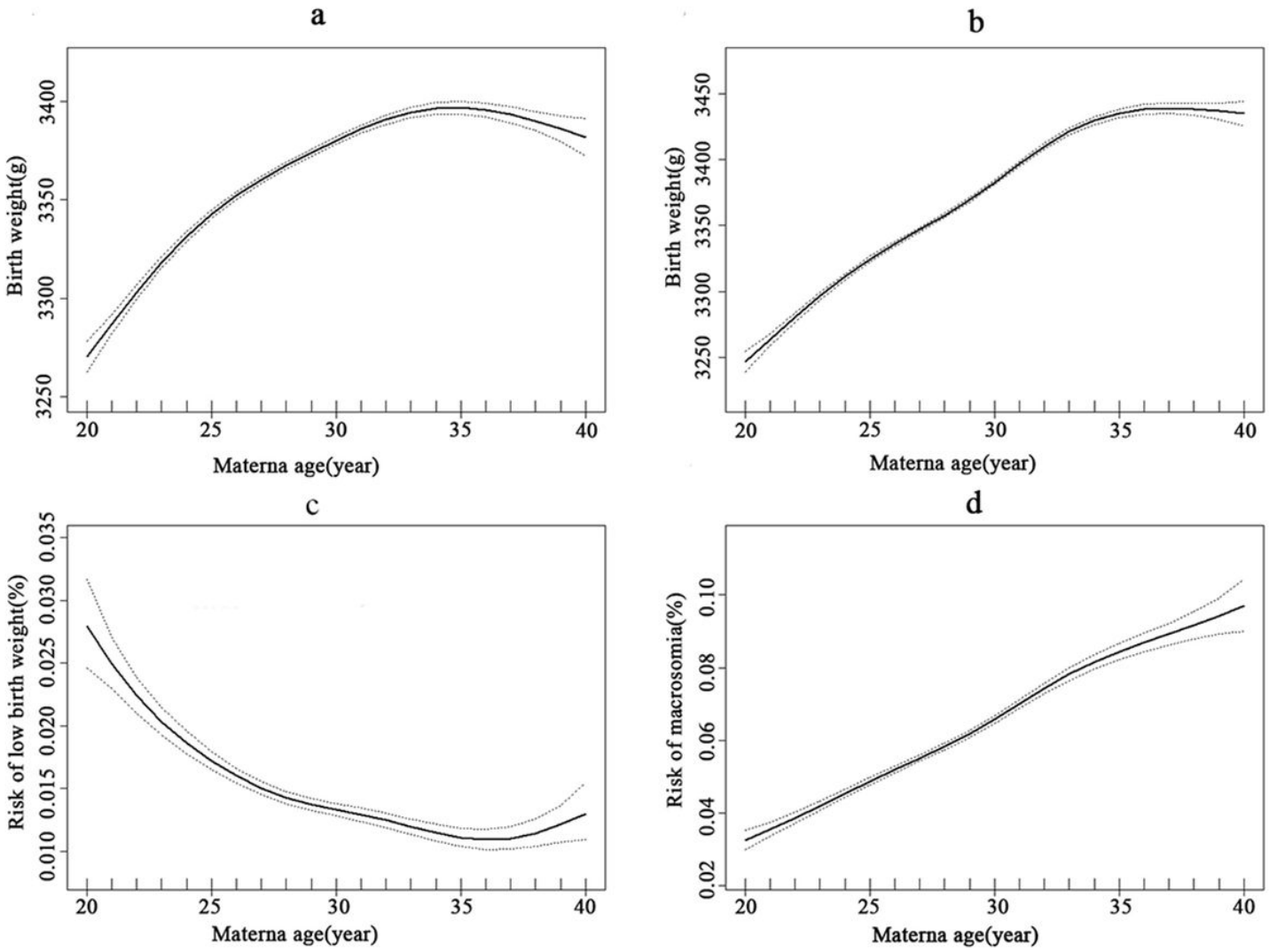

Figure 2

Generalized additive model for the relationships of maternal age and BW, risk of LBW, and risk of macrosomia.