Maternal age and adverse pregnancy outcomes: a population-based register study in Wuhan, China, 2011-2016

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Abstract

Background A trend towards increasing maternal age has been witnessed in China. Evidence from high-income countries has shown that older women have higher risks of various adverse pregnancy outcomes. However, few large, contemporary, population-based studies have adjusted for potential confounders in examining the association between maternal age and adverse pregnancy outcomes in China. **Methods** Data from the Wuhan Maternal and Child Health Management Information System including all women aged ≥ 20 years with live singleton pregnancies in 2011-2016 were analyzed. A range of adverse pregnancy outcomes including pregnancy induced hypertension disorder (PIH), gestational diabetes mellitus (GDM), cesarean delivery, postpartum hemorrhage, preterm birth, small-for-gestational age (SGA), large-for-gestational age (LGA), and 5-min Apgar score < 7 among women aged 20-24, 30-35 and ≥ 40 years were compared with women aged 25-29 years using binary logistic regression models, with social-demographic characteristics, pre-pregnancy BMI, parity, and fetal gender adjusted. Subgroup analyses by stratifying on parity were also performed. **Results** 415,632 women were included during the study period. Among them, 91,536 (22.0%) were aged 20-24 years, 203,687 (49.0%) were aged 25-29 years, 89,883 (21.6%) were aged 30-34 years, 26,271 (6.3%) were aged 35-39 years, and 4,255 (1.0%) were aged ≥ 40 years. After adjusting for the potential confounders, older maternal age (≥ 30 years) was associated with higher risks of PIH, GDM, cesarean delivery, preterm birth, LGA, and 5-min Apgar score < 7 , but not with SGA. Relative to older multiparous women, older nulliparous women were more likely to experience cesarean delivery, preterm birth, and 5-min Apgar score < 7 . **Conclusion** Older maternal age is independently associated with various adverse pregnancy outcomes. The risks may occur earlier than the commonly used definition of advanced maternal age, and may also differ by parity. Ensuring age and parity specific clinical counseling, antenatal surveillance, and health interventions may be of great significance to improve older mother's pregnancy outcomes.

Plain English Summary

Advanced maternal age, commonly defined as pregnancy in women aged 35 years or more. Evidence from high-income countries has shown that older women have higher risks of various adverse pregnancy outcomes. However, few large, contemporary, population-based studies have adjusted for potential confounders in examining the association between maternal age and adverse pregnancy outcomes in China, in which a trend towards increasing maternal age has been witnessed.

The aim of the present study was to elucidate the association between advanced maternal age and a range of pregnancy outcomes with social-demographic characteristics and pregnancy complications adjusted, using a large, contemporary and population-based sample ($n=415,632$) in Wuhan City, China.

The key finding of our study is that older maternal age (≥ 30 years) is independently associated with higher risks of pregnancy induced hypertension disorder, gestational diabetes mellitus, cesarean delivery, large-for-gestational age, and 5-min Apgar score < 7 , but not with small-for-gestational age. Relative to older multiparous women, older nulliparous women were more likely to experience cesarean delivery, preterm birth, and 5-min Apgar score < 7 .

Our findings suggest that older maternal age is independently associated with various adverse pregnancy outcomes. The risks may occur earlier than the commonly used definition of advanced maternal age, and may also differ by parity. Our findings emphasize the importance of ensuring age and parity specific clinical counseling, antenatal surveillance, and health interventions to improve older mother's pregnancy outcomes.

Background

Advanced maternal age is commonly defined as pregnancy in women aged 35 years or more [1, 2]. A trend in delayed childbearing has been witnessed over the past decades in many countries. In England and Wales, the mean age at childbearing rose from 27.7 in 1990 to 30.5 in 2017, with the percentage of women delivering live infants with advanced maternal age increased from 8.7% to 22.7% [3]. In United States, the proportion of births to women aged 35-39 years increased by 5%, and 8% to women aged 40-44 years, from 2006-2007 to 2014-2015. 15.7% of deliveries occurred on women aged ≥ 35 years in 2015 [4].

An array of studies in high-income countries have found that women with advanced maternal age are at higher risks for a range of adverse pregnancy outcomes, including caesarean section [5-7], gestational hypertension [5, 8], gestational diabetes mellitus (GDM)

[5, 9], preterm birth [1, 7, 10], stillbirth [1, 11], low Apgar score [1, 10], small-for(SGA) [2, 6] or large-for-gestational age(LGA) [6, 11]. However, other studies challenge these findings [12, 13]. These discrepancies could be attributed to the heterogeneity among studies in the characteristics of the study population, definitions of reference groups and outcomes, and the control of important confounders (e.g. socioeconomic status, parity and body mass index).

There is also a trend towards delayed childbirth in China [14]. Fertility rate among women aged 35-39 years increased from 10.98‰ in 2005 to 18.6‰ in 2015, and from 2.05‰ to 5.37‰ among women aged 40-44 years [15]. Recent studies in China showed the proportion of women with advanced maternal age was between 10.0% and 20.24% [16-18]. In 1979, China launched a nationwide family planning program, and most couples were allowed to have only one child [19]. The one-child policy was relaxed in 2015, allowing all couples to have two children [20]. This recent relaxation will contribute to the rising of maternal age at childbirth. To date, few studies with large populations have investigated pregnancy outcomes for older women in the Chinese context [21], which differs significantly in sociodemographic characteristics of the antenatal population and availability of health care from high-resource countries. A large retrospective cohort study conducted in 2011 in China have found that women with advanced maternal age carry a higher risk of a range of adverse pregnancy outcomes, however, it failed to control for potential confounders [22].

A better knowledge of association between advanced maternal age and pregnancy outcomes is warranted in the provision of appropriate support and care to significant number of women with advanced maternal age in China. The purpose of the present study was to elucidate the association between advanced maternal age and a range of pregnancy outcomes in China adjusted for various confounders, using a large, contemporary and population-based sample drawn from the Wuhan Maternal and Child Health Management Information System (WMCHMIS).

Methods

Data resource

This was a retrospective cohort study. Data were derived from the WMCHMIS, which was begun in 2003 and is managed by Wuhan Children's Hospital. WMCHMIS links information on maternal demographic characteristics, medical history, prenatal examinations and delivery information from all the maternal and child health agencies, midwifery hospitals and community health centers in Wuhan (including city and rural areas). Data were prospectively collected from the first prenatal visit (usually during the 1st trimester) to delivery by trained personals and underwent strict quality control procedure, and details of the system have been described previously [23]. Women who delivered a single infant (live or dead) at ≥ 20 gestational weeks between 1 January 2011 and 31 December 2016 were included (n=627,548). The information were matched through ID card. Excluded were women whose records lacked information on ID number (n=838), maternal age (n=237), delivery mode (n=239), those which could not be linked to their information the prenatal visits (n=187,528), those aged less than 20 years (n=5,266), or those had a stillbirth (n=1,546). During the study period, 16,184 women delivered more once (32,446 deliveries). To avoid the possibility of repeatedly including the same women more than once, only one pregnancy was randomly selected. Thus, a total of 415,632 women were included in the final analysis.

Assessment of study variables

Information regarding the educational level, household registration, ethnic, history of chronic hypertension, pre-gestational diabetes mellitus, height, and pre-pregnancy weight were asked by health service providers during the first prenatal visit. Pre-pregnancy BMI was calculated as pre-pregnancy weight (kg)/height (m^2) and then classified into underweight ($<18.5 \text{ kg}/m^2$), normal ($18.5\text{-}23.9 \text{ kg}/m^2$), overweight ($24.0\text{-}27.9 \text{ kg}/m^2$), and obese ($\geq 28.0 \text{ kg}/m^2$) [24]. Maternal age was defined as age at the time of delivery.

Assessment of outcomes.

Information on the gestational diabetes mellitus, gestational hypertension, gestational age, delivery mode (vaginal deliveries, cesarean section), the amount of postpartum bleeding, birth weight, fetal gender and Apgar score were obtained from birth records, and the pregnancy co-morbidities were diagnosed by doctors of delivery facilities. Pregnancy-induced hypertension disorder was defined as the occurrence of gestational hypertension, pre-eclampsia, or eclampsia [25]. Postpartum hemorrhage was defined as

blood loss of ≥ 500 mL following vaginal delivery or ≥ 1000 mL following cesarean section [26]. Preterm birth is defined as the birth at <37 complete gestational weeks. Small for gestational age (SGA) and large for gestational age (LGA) were defined as birthweight below the 10th percentile or above the 90th percentile of the gestational age and sex-specific distributions respectively [27].

Statistical Analysis

Women were divided into 5 age groups: 20-24 years, 25-29 years, 30-34 years, 35-39 years and ≥ 40 years. Our analysis strategy consisted of four steps. First, the proportion of maternal characteristics were compared using *chi-square* analysis based on maternal age categories, with a correction for multiple comparison. These characteristics included household registration (city, rural), ethnic (han, others), education level (middle school/lower, high school, college, master's degree/higher), pre-pregnancy BMI (underweight, normal, overweight, obese), parity (nulliparous, multiparous), chronic hypertension (yes, no), and pre-gestational diabetes mellitus (yes, no). Second, descriptive statistics of pregnancy outcomes were generated for each maternal age categories. Univariate and multivariate logistic regression analyses were performed to investigate the association between maternal age and each of pregnancy outcomes using women aged 25-29 years used as the reference, and odds ratios (ORs) with corresponding 95 % confidence intervals (CIs) were estimated. Several potential confounders were included in the multivariate logistic regression models, including household registration, ethnic, educational level, pre-pregnancy BMI group, parity and fetal gender. Third, subgroup analyses by stratifying on parity were also performed to evaluate the association between maternal age and pregnancy outcomes in nulliparous and multiparous women, respectively. Fourth, we performed univariate logistic regression analyses and subgroup analyses using both linked and unlinked subjects, to evaluate the potential effect of the unmatched population. All analyses were performed using IBM® SPSS Statistics® 17.0 (IBM, Inc., New York, New York).

Results

Table 1 presents basic demographic characteristics of the study population. On average, older women (≥ 30 years) were more likely to have urban household registration, lower educational level, and higher prevalence of overweight/obese, chronic hypertension and pre-existing diabetes mellitus. During 2011 to 2016, the proportion of women aged 35-39 years increased from 4.9% to 8.9%, and the proportion of women aged 40 years or more increased from 0.9% to 1.4% (Fig.1).

The prevalence of each obstetric complications and adverse perinatal outcomes by maternal age categories is listed in Table 2. Unadjusted analysis showed that older women (≥ 30 years) were at higher risks of PIH, GDM, cesarean delivery, postpartum hemorrhage, preterm birth, SGA, LGA, and 5-min Apgar score <7 (Fig.2). After adjusted for social-demographic characteristics, pre-pregnancy BMI, parity, and fetal gender, the effect of maternal age on those adverse pregnancy outcomes remained largely unchanged. However, the association between older maternal age and SGA were attenuated and became non-significant after the adjustment for these confounders (Fig.3). Subgroup analysis showed that older nulliparous women were more likely to experience cesarean delivery, preterm birth and delivery babies with 5-min Apgar score <7 than older multiparous mothers. Older multiparous women were more likely to experience PIH, GDM, postpartum hemorrhage, and LGA than older first mothers (Table 3). Results of unadjusted analysis (Fig.4) and subgroup analysis among both linked and unlinked subjects were similar to those only among linked subjects (Table 4).

Discussion

This study examined the association between advanced maternal age and a range of pregnancy outcomes, using a large, contemporary and population-based sample in China. After adjusting for a variety of potential confounders, older women remained at increased risk of PIH, GDM, cesarean delivery, postpartum hemorrhage, preterm birth, LGA and low 5-min Apgar score, compared with women aged 25-29 years. We also found that older nulliparous women had a higher risk of caesarean section, preterm birth, and 5-min Apgar score <7 than older multiparous women.

A large body of studies have reported that age of ≥ 35 or ≥ 40 years is associated with adverse pregnancy complications and adverse perinatal outcomes [2, 6, 28], however, several studies suggest the risk occurs earlier than the traditional cutoff age [11, 29]. In the present study, we found that women aged 30-34 years were also at higher risk of a variety of adverse pregnancy outcomes.

Our findings emphasize the need to increase the antenatal surveillance and health education targeting women who are not older according to the commonly used definition of advanced maternal age, so as to improve their pregnancy outcomes.

Our finding that increased age was associated with higher risks of pregnancy induced hypertension disorder [30, 31], gestational diabetes mellitus [2, 32], and postpartum hemorrhage [33] is in general agreement with previous studies. The mechanism underlying the increased risks for these adverse pregnancy outcomes among older women is uncertain. The higher prevalence of pre-gestational chronic diseases among women with advanced maternal age may partly explain the increased risks. A direct effect of aging may also exist. Biological ageing has been proposed to be associated with reduced nitric oxide availability and increased production of oxidative stress, which may lead to impaired uterine and endothelial vascular function [34]. Insulin resistance also increase with age, because of the alteration of insulin receptor number and the dysfunction of insulin receptor signal transduction [35].

Some studies have indicated that women with advanced maternal have higher risk of SGA [2, 36, 37], however, other evidence challenge these findings [6, 11, 14]. In the present study, we found a decrease in the risk of SGA births with maternal age in the univariate analysis, which may be partly attributable to the higher prevalence of pre-pregnancy overweight and obese among older women. Recent studies in China [38] and Finland [6] both have found pre-pregnancy overweight or obese reduced the risk of delivery of SGA infants. After adjusting for pre-pregnancy and other potential confounding factors, older maternal age was no longer significantly associated with SGA in our study.

There is evidence suggesting that the effect of maternal age differs by parity. Previous studies have found preterm birth [11] and low Apgar score [39, 40] are more common among nulliparous women with advanced maternal age, compared to those older multiparous women. In accordance with previous research, older first mothers also exhibited a higher risk of preterm birth and 5-min Apgar score <7 than older multiparous women in the present study. The mechanism behind the increased risk is beyond the scope of our study but may partly be related to the permanent modification of maternal vessels occurring during the first pregnancy, which could decrease the vascular resistance and facilitate uterine artery flow in the next pregnancy [41, 42]. We also found that women aged 35-39 and women aged ≥ 40 years carried over threefold and over fivefold risk of caesarean section respectively, when compared to women aged 25-29 years. This finding has significant public health implications against a backdrop of the trend towards increasing adoption of caesarean delivery in China [43]. Our data suggest that age and parity-based counselling service may be needed.

The strength of the present study was that it used a large, contemporary and population-based cohort including data from over two hundreds hospitals, midwifery institutions and community health service centers in Wuhan. The data stored in these registries were prospectively collected by trained personals. The large population also made it feasible to investigate the difference between different parity groups and between various age categories. Our findings would be more likely to be generalized in contemporary China.

Limitations in the present study should be considered when interpreting these results. First, only limited socioeconomic and obstetric characteristics which may influence pregnancy outcomes were included in the multivariate analysis, because many relevant variables are not include in WMCHMIS. Second, medical service providers' and women's perception towards the risk of maternal age may influence the decision of delivery mode and the occurrence of iatrogenic preterm delivery, however, we could not differentiate between elective caesarean delivery and emergency caesarean delivery, nor differentiate between spontaneous preterm birth and medically indicated preterm birth. Third, appropriately 30% women who delivered a single infant in Wuhan could not be matched with their social-demographic characteristics because they did not provide their ID number when they attended prenatal care or did not receive prenatal examination in Wuhan. Though results of unadjusted analysis and subgroup analysis among both linked and unlinked subjects were similar to those only among linked subjects, the large amount of missing could also bias our results.

Conclusion

Our findings suggest that older maternal age is associated with higher risk of PIH, GDM, cesarean delivery, postpartum hemorrhage, preterm birth, LGA and 5-min Apgar score<7, but not with SGA. The risks may occur earlier than the traditional cutoff

advanced maternal age (≥ 35 years) and differ by parity. Ensuring age and parity specific clinical counseling, antenatal surveillance, and health interventions may be of great significance to improve older mothers' pregnancy outcomes.

Abbreviations

PIH: pregnancy induced hypertension disorder; GDM: gestational diabetes mellitus, SGA: small-for- gestational age; LGA: large-for-gestational age; WMCHMIS: Wuhan Maternal and Child Health Management Information System; OR: odds ratio; CI: Confidence interval.

Declarations

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Availability of data and materials

The ethical permission for this study is limited to the previously defined study plan and making individual data available to the public is beyond the ethical permission. All inquiries about access to the data should be sent to the corresponding author.

Authors' contribution

BZ and YLZ conceptualised the research question. JXC, BZZ, YL and YMZ drafted the analysis plan. JXC, BZZ and TY participated in the analyses and interpretation of the data. JXC and BZZ drafted the article. BZ, YLZ, KW, TY, WLX, XL, LWC, YTD and YMZ contributed to revision of the article. KW provided language help. All authors critically reviewed and approved the final version of the article.

Ethics approval and consent to participate

This study was approved by the Wuhan Medical and Healthcare Center for Women and Children Ethical Review Board, March 2018 (reg.no. 2018015).

Consent for publication

Not applicable.

Competing interests

None.

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Tables

Table1

Table1 Maternal characteristics by maternal age

Characteristic	Maternal age (years)					χ^2	P
	20-24	25-29	30-34	35-39	40-		
All subjects(n)	91536(22.0)	203687(49.0)	89883(21.6)	26271(6.3)	4255(1.0)		
Household registration						23714.7	<0.001
City	40412(44.1) *	140156(68.8) *	67628(75.2) *	19123(72.8) *	3017(70.9) *		
Rural	51124(55.9)	63531(31.2)	22255(24.8)	7148(27.2)	1238(29.1)		
Ethnic						57.1	<0.001
Han	90439(99.7)	201242(99.6)	88684(99.5)	25916(99.6)	4203(99.6)		
Others	252(0.3)	884(0.4)	437(0.5)	102(0.4)	15(0.4)		
Education level						32739.3	<0.001
Middle school/lower	52042(56.9) *	67777(33.3)	29237(32.6)	10856(41.5) *	2220(52.5) *		
High school	23051(25.2) *	35332(17.4)	14958(16.7) *	5486(21.0) *	847(20.0) *		
College	16248(17.8) *	93773(46.1)	39678(44.3) *	8844(33.8) *	1075(25.4) *		
Master's degree/higher	97(0.1)	6516(3.2)	5737(6.4) *	986(3.8)	86(2.0) *		
Pre-pregnancy BMI						78954.9	<0.001
Underweight	20091(22.5) *	37082(18.4)	11213(12.6) *	2161(8.3) *	282(6.7) *		
Normal	64926(72.8) *	150094(74.5)	68390(76.7) *	20462(78.4) *	3362(79.7) *		
Overweight	3821(4.3)	12900(6.4)	8518(9.5)	3127(12.0) *	525(12.4) *		
Obese	390(0.4) *	1405(0.7) *	1091(1.2) *	350(1.3) *	50(1.2) *		
Nulliparity	84155(91.9) *	172040(84.5)	50995(56.7) *	7466(28.4) *	815(19.2) *	78954.9	<0.001
Chronic hypertension	733(0.8) *	2044(1.0)	1132(1.3) *	454(1.7) *	82(1.9) *	238.8	<0.001
Pre-gestational diabetes mellitus	229(0.3)	540(0.3)	362(0.4) *	140(0.5) *	24(0.6) *	99.5	<0.001

* vs. 25-29 years adjusted $P < 0.05$.

Table2

Table2 Prevalence of pregnancy outcomes in each maternal age group

Outcomes	Maternal age (years)				
	20-24	25-29	30-34	35-39	40-
PIH	1272(1.4)	4133(2.0)	2386(2.7)	978(3.7)	238(5.6)
GDM	698(0.8)	5165(2.5)	4047(4.5)	1521(5.8)	261(6.1)
Cesarean delivery	55507(60.6)	126163(61.9)	62816(69.9)	19837(75.5)	3235(76.0)
Postpartum hemorrhage	667(0.7)	2078(1.0)	1137(1.3)	395(1.5)	85(2.0)
Preterm birth (<37 weeks)	2685(2.9)	6845(3.4)	4285(4.8)	1765(6.7)	353(8.3)
SGA	8429(9.2)	14879(7.3)	5529(6.2)	1515(5.8)	269(6.3)
LGA	5973(6.5)	16992(8.4)	9569(10.7)	3229(12.3)	541(12.7)
5-min Apgar score <7	353(0.4)	720(0.4)	400(0.4)	196(0.7)	47(1.1)

PIH: Pregnancy-induced hypertension disorder, GDM: Gestational diabetes mellitus, SGA: Small-for-gestational age, LGA: Large-for-gestational age.

Table3

Table 3 Association between maternal age and pregnancy outcomes according to parity^a

Outcomes	Maternal age (years)				
	20-24 OR(95% CI)	25-29 OR(95% CI)	30-34 OR(95% CI)	35-39 OR(95% CI)	40- OR(95% CI)
Pregnancy-induced hypertension disorders					
Nulliparous	0.73(0.68-0.78) *	1	1.42(1.34-1.50) *	2.06(1.85-2.30) *	3.01(2.30-3.93) *
Multiparous	0.53(0.38-0.75) *	1	1.61(1.40-1.84) *	2.94(2.56-3.38) *	4.86(4.03-5.87) *
Gestational diabetes mellitus					
Nulliparous	0.43(0.39-0.47) *	1	1.79(1.71-1.88) *	2.88(2.65-3.14) *	3.45(2.73-4.35) *
Multiparous	0.35(0.23-0.52) *	1	1.92(1.70-2.17) *	2.92(2.58-3.32) *	3.63(3.02-4.37) *
Cesarean delivery					
Nulliparous	0.88(0.87-0.90) *	1	1.53(1.49-1.56) *	3.31(3.11-3.52) *	5.22(4.15-6.55) *
Multiparous	0.64(0.61-0.68) *	1	1.21(1.17-1.25) *	1.33(1.28-1.39) *	1.37(1.27-1.48) *
Postpartum hemorrhage					
Nulliparous	0.80(0.72-0.88) *	1	1.23(1.12-1.35) *	1.35(1.09-1.67) *	1.53(0.84-2.79)
Multiparous	0.68(0.50-0.91) *	1	1.19(1.03-1.37) *	1.44(1.22-1.69) *	1.92(1.49-2.48) *
Preterm birth (<37 weeks)					
Nulliparous	0.97(0.92-1.02)	1	1.35(1.29-1.42) *	2.21(2.01-2.42) *	3.03(2.40-3.82) *
Multiparous	1.14(1.01-1.29) *	1	1.15(1.07-1.24) *	1.44(1.33-1.56) *	1.81(1.57-2.07) *
Small-for-gestational age					
Nulliparous	1.14(1.11-1.18) *	1	0.97(0.93-1.01)	1.00(0.91-1.09)	0.83(0.62-1.11)
Multiparous	1.44(1.31-1.58) *	1	0.88(0.82-0.94) *	0.91(0.84-0.99) *	1.12(0.97-1.30)
Large-for-gestational age					
Nulliparous	0.82(0.79-0.85) *	1	1.18(1.14-1.22) *	1.21(1.12-1.31) *	1.16(0.93-1.46) *
Multiparous	0.67(0.60-0.74) *	1	1.31(1.25-1.38) *	1.47(1.39-1.56) *	1.49(1.34-1.66) *
5-min Apgar score <7					
Nulliparous	1.04(0.90-1.20)	1	1.30(1.12-1.52) *	2.47(1.91-3.19) *	3.97(2.23-7.07) *
Multiparous	1.08(0.73-1.59)	1	1.12(0.89-1.42)	1.73(1.34-2.22) *	2.50(1.71-3.65) *

* $P < 0.05$ ^a Adjusted for education, registered residence, ethnic, pre-pregnancy BMI, and fetal gender.

Table4

Table 4 Association between maternal age and pregnancy outcomes according to parity among linked and linked subjects ^a

Outcomes	Maternal age (years)				
	20-24 OR(95% CI)	25-29 OR(95% CI)	30-34 OR(95% CI)	35-39 OR(95% CI)	40- OR(95% CI)
Pregnancy-induced hypertension disorders					
Nulliparous	0.72(0.68-0.75) *	1	1.52(1.45-1.60) *	2.31(2.12-2.52) *	3.43(2.81-4.19) *
Multiparous	0.53(0.42-0.68) *	1	1.73(1.57-1.92) *	3.25(2.94-3.59) *	5.40(4.74-6.15) *
Gestational diabetes mellitus					
Nulliparous	0.28(0.26-0.30) *	1	2.06(1.98-2.14) *	3.13(2.92-3.36) *	3.29(2.74-3.96) *
Multiparous	0.28(0.20-0.38) *	1	2.40(2.19-2.64) *	3.97(3.61-4.38) *	4.80(4.20-5.48) *
Cesarean delivery					
Nulliparous	1.02(1.01-1.04) *	1	1.44(1.41-1.47) *	3.33(3.16-3.50) *	4.57(3.90-5.36) *
Multiparous	0.62(0.60-0.65) *	1	1.23(1.20-1.26) *	1.38(1.34-1.43) *	1.47(1.39-1.56) *
Postpartum hemorrhage					
Nulliparous	0.74(0.69-0.80) *	1	1.18(1.10-1.28) *	1.14(0.96-1.36)	1.56(1.03-2.36) *
Multiparous	0.79(0.64-0.98) *	1	1.15(1.03-1.28) *	1.57(1.39-1.77) *	2.14(1.79-2.57) *
Preterm birth (<37 weeks)					
Nulliparous	1.01(0.98-1.05)	1	1.39(1.34-1.45) *	2.42(2.26-2.59) *	3.30(2.80-3.90) *
Multiparous	1.10(1.01-1.19) *	1	1.13(1.08-1.19) *	1.56(1.47-1.65) *	2.13(1.96-2.32) *
Small for gestational age					
Nulliparous	1.29(1.26-1.33) *	1	0.91(0.88-0.94) *	0.93(0.87-1.01)	0.87(0.70-1.08)
Multiparous	1.47(1.36-1.58) *	1	0.83(0.79-0.87) *	0.90(0.84-0.95) *	1.08(0.97-1.20)
Large for gestational age					
Nulliparous	0.77(0.75-0.80) *	1	1.24(1.21-1.28) *	1.36(1.28-1.45) *	1.25(1.05-1.49) *
Multiparous	0.72(0.67-0.78) *	1	1.31(1.26-1.36) *	1.49(1.42-1.56) *	1.56(1.44-1.69) *
5-min Apgar score <7					
Nulliparous	1.34(1.22-1.48) *	1	1.33(1.19-1.49) *	2.89(2.42-3.45) *	3.13(1.98-4.95) *
Multiparous	0.87(0.68-1.12)	1	1.08(0.94-1.24)	1.68(1.45-1.94) *	2.29(1.85-2.85) *

* $P < 0.05$.

Figures

Figure 1

Proportion of births by maternal age group, 2011-2016

Figure 2

Crude association between maternal age and pregnancy outcomes * P<0.05

Figure 3

Adjusted association between maternal age and pregnancy outcomes * $P < 0.05$, adjusted for household registration, ethnic, educational level, pre-pregnancy BMI group, parity and fetal gender

Figure 4

Crude association between maternal age and pregnancy outcomes among both linked and unlinked subjects * P<0.05