Associations of COVID-19 Pandemic with Clinical Manifestations among the Uninfected Pregnant Women in China: A Combined Cohort Study

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Abstract

Objective: To investigate whether the COVID-19 pandemic would significantly affect pregnancy-associated factors in uninfected pregnant women in China.

Design: A combined cohort study

Setting: Six sites in China

Population: Uninfected pregnant women participating in the programs with a singleton birth and delivery or termination from January 1 to May 31 2019 (pre-pandemic period, P-2019) and from January 1 to May 31 2020 (pandemic period, P-2020) (n = 32,277).

Methods: The associations of pregnancy-associated outcomes and the COVID-19 were assessed by poisson regression, linear regression or log-binomial regression.

Main Outcomes Measures: The number of prenatal examinations (NPE), delivery gestational week (DGW), caesarean section (CS), preterm birth, macrosomia.

Results: For Hubei, the NPE and DGW were negatively associated with the COVID-19 pandemic, whereas the CS and preterm birth rates were positively associated with the COVID-19, with adjusted relative risks (aRRs) of 1.11 [95% confidence interval (CI) 1.06–1.17] and 1.37 (95% CI: 1.02–1.84) respectively. For Guangdong, the associations of CS and preterm birth with the COVID-19 were similar in Hubei. Limited associations were evident in other areas while a positive association with macrosomia was observed in Beijing [aRR = 1.26 (95% CI: 1.03–1.55)].

Conclusions: The CS and preterm birth rates increased slightly in areas that were more affected by the pandemic than other areas. NPEs were not significantly interrupted and most maternal and neonatal clinical characteristics were within the normal ranges. Appropriate interventions should be considered to protect pregnant women.

Keywords: COVID-19, pregnancy outcome, neonatal outcome, uninfected pregnant women

Tweetable Abstract: The caesarean section and preterm birth rates increased among uninfected women in areas more affected by COVID-19.

1. Introduction

Coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) has become a global pandemic. The effects on pregnant women have been of considerable concern. Infected women exhibited higher-than-normal rates of cesarean section (CS), preterm birth, low birth weight (LBW) infants, neonatal stillbirth, and maternal death[1-4]. Uninfected pregnant women may be affected by the generalized social panic, a lack of prenatal examinations, and delayed medical treatment. The pandemic increased the risks of mental illness (and self-harm thoughts) among pregnant Chinese women[5]. Similar results were found in Canada and the principal symptoms were depression and anxiety[6]. Prenatal depression is a risk factor for preterm birth[7, 8]. More maternal depressive symptoms were associated with elevated levels of maternal inflammation, adversely affecting the neonate[9]. We explored the effects of the COVID-19 pandemic on the clinical characteristics of pregnant women and their neonates.

From the middle of January 2020 to the end of February 2020, China suffered more from COVID-19 than did other countries; Wuhan City was most seriously affected. The largest “Travel Ban” in human history prevented about 700,000 infections[10]. We were concerned that the ban might compromise routine examinations or treatment of pregnant women. Less-affected Chinese areas embraced “social distancing”. Most pregnant women stayed at home unless an urgent prenatal examination or treatment was required. In addition, daily physical habits and diet were affected; these are closely related to maternal and prenatal clinical outcomes. It was reported that CS on maternal request and fetal distress were also significantly more common in the observation group before lockdown than that before lockdown in Wuhan City, China [11]. As of August 2020, the global COVID-19 prevalence is still

rising; some public health experts predict that the pandemic may persist to 2025[12]. Thus, the Chinese experience will be of interest to other countries requiring long-term policies to protect pregnant women and fetal development. We hypothesized that the pandemic significantly affected pregnancy-related factors among uninfected pregnant women.

2. Methods

2.1 Study design, study population and data collection

This population-based, retrospective cohort study was based on two ongoing multicenter programs including: (1) The Maternal and Newborn Health Monitoring Program (MNHMP) established in 2013 by the National Center for Women and Children's Health (NCWCH) of the Chinese Center for Disease Control and Prevention (CDC) which have been described in detail previously[13]; and, (2) a birth cohort of the Haidian Maternal and Child Care Hospital (HMCCH) in Beijing, supported by the National Science Foundation of China (CCC2018112301 of the China Cohort Consortium; see http://chinacohort.bjmu.edu.cn/project/36/). All women were enrolled during their first antenatal care examination. Antenatal data were collected in Maternal and Child Care Handbooks (these are routine in China). We gathered all information recorded in six areas, thus one or two local counties in the provinces of Hubei, Guangdong, Hebei, Shandong, Yunnan and Beijing(**Table S1)**.

For all areas, pregnant women who satisfied the following criteria were included: (1) delivery or termination from January 1 to May 31 2019 (pre-pandemic period; P-2019) and from January 1 to May 31 2020 (pandemic period; P-2020); (2) registered in the "Mother and Child Health Handbook" healthcare system, with completion of the first examination before 13 weeks; (3) a complete examination record in the local

hospital; and, (4) a singleton birth. We finally included 32,277 pregnant women, 6,449 from Hubei Province, 5,878 from Guangdong Province, 3,641 from Hebei Province, 6,328 from Shandong Province, 2,920 from Yunnan Province, and 7,061 from Beijing. Pandemic severity was graded Level 1 (Wuhan), Level II (Guangdong), Level III (Shandong and Beijing), and Level IV (Hebei and Yunnan) (**Figure S1).**

When conducting the MNHMS, all local healthcare workers were asked to follow standard guidelines. All pre- and post-natal data were collected by local healthcare departments who operated population-based monitoring systems. Executive departments must have the required equipment and offered safe working conditions. MNHMS workers were qualified in maternal health management, as required by national regulations. All the program items were free for all women, to encourage early registration and postpartum visits. All healthcare departments were required to arrange two visits in each of the second and third trimesters, and to record all data promptly. Trained NCWCH staff cleansed the data using a standard protocol. The HMCCH delivers most infants born in the Haidian District of Beijing; there are no bars to admission. Thus, the HMCCH study is effectively population-based.

2.2 Definitions and statistical Analysis

Table S2 defines the main outcomes, including the number of prenatal examinations (NPE), delivery gestational week (DGW), caesarean section (CS), stillbirth, neonatal weight (NW), preterm birth, macrosomia, small for gestational age (SGA), and large for gestational age (LGA). The gestational weeks used to produce preterm birth, stillbirth, SGA and LGA were all calculated by the women self-reported last menstrual period and the time of delivery.

For each characteristic, missing data are presented as missing numbers/total cases×100%. Means ± standard deviations (SDs) or medians (with the 25–75%

percentile ranges) are used to describe distributions. The associations of continuous variables such as DGW neonatal weight with the COVID-19 was assessed by linear regression. Poisson regression was used to assess the association between NPE and occurrence of the COVID-19. Log-binomial regression was conducted to analyze the associations with risk of CS, stillbirth, preterm birth, macrosomia, small for gestational age (SGA) and large for gestational age (LGA) and the COVID-19. The covariates included body mass index (BMI, categorical), age (categorical), parity, gravidity, ethnicity, and educational level. Parity data were unavailable for Hubei; BMI, ethnicity, and educational data were unavailable for Beijing. After adjusting for the covariates, and regression coefficient (β value) and adjusted relative risks (aRRs) were calculated to identify the influence of the COVID-19. P value <0.05 was considered of statistically significance. All data analyses were performed with the aid of R software ver. 3.6.0.

The corresponding authors had full access to all of the data in the study and had the final responsibility to submit the article for publication. Research data in this study are not shared and there was no patient and public involvement in this study.

3. Results

3.1 Maternal Characteristics

The demographic characteristics of all women are listed in **Table 1**, and their comparisons between the two periods in **Table S2**. Most data were complete; less than 5% of data on age, gravidity, parity, and BMI were missing. In Shandong and Hebei, 12–19% of educational data were missing. Again, Beijing lacked data on BMI, education, and ethnicity. The average maternal ages (years) in Beijing (31.5) and Shandong (31.3) were relatively high, followed by Hebei (29.5), Hubei (28.9),

Guangdong (28.1), and Yunnan (27.9). The mean ages differed between the two periods (P-2019 vs. P-2020) for Hubei (29.1 vs. 28.7), Guangdong (28.4 vs. 27.9), Beijing (31.6 vs. 31.4), and Hebei (29.8 vs 29.4). However, the differences were very small (maximum 1.7% in Guangdong). Most women [from 55% (Beijing) to 76% (Hubei)] had had more than two previous pregnancies. For Yunnan only, the proportion in P-2020 (77%) was higher than in P-2019 (72%). Parity distribution varied by location but did not differ between the two periods. The average BMI (kg/ m^2) ranged from 22.2 (Hubei) to 23.2 (Hebei). For Hebei alone, the average BMI increased slightly from 23.1 (P-2019) to 23.5 (P-2020). Educational levels differed greatly. For Hubei and Shandong, most women had finished high school (75%) and college or higher (80%) respectively; most women in Guangdong had finished junior high school only (55%). Although significant differences between the two periods were evident in Hubei and Guangdong, the overall pattern remained similar, as did ethnicity (≥98% Han in Hubei, Guangdong, Shandong, and Hebei; 78% in Yunnan).

3.2 Pregnancy-Related Clinical Characteristics

The maternal and neonatal clinical characteristics are listed in **Table 2** and their comparisons in **Table S3**. Maternal death data were lacking for Hubei, and the NPE and Apgar scores for Shandong. The missing levels were all close to 0%, except for the Apgar scores in Hubei (14-30%). The NPEs varied by location. No between-period changes in maternal death, stillbirth, neonatal gender, or normal weight or LBW status were evident. The maternal death and stillbirth rates were close to 0%. In Beijing, the average NPE was 14.5, followed by Yunnan (11.5), Hebei (5.8), Guangdong (5.3), and Hubei (5.1). The average NPE in Hubei (5.3 to 5.0) and Beijing (15.0 to 14.0) decreased from P-2019 to P-2020, but increased in Guangdong (5.2 to 5.4) and Hebei (5.5 to 6.3). Guangdong (28%) and Yunnan (27%) exhibited lower CS

rates than the other regions [40% (Hebei) to 51% (Hubei)]. The CS rates increased significantly between the two periods for Hubei (47% vs. 54%) and Guangdong (25% vs. 31%) only. In terms of the Apgar scores, differences were evident in Hubei (1, 5, and 10 min), Guangdong (1 min), and Yunnan (1, 5, and 10 min) between the two periods, but were very slight; most Apgar scores ranged from 9 to 10. The preterm birth rate increased between the two periods for Hubei (2% to 3%), and Guangdong (4% to 6%) only. The macrosomia rate in Beijing (only) increased from 4% (P-2019) to 6% (P-2020). The SGA rates decreased for Hubei (7% vs. 6%) and Guangdong (13% vs. 9%) only. The LGA rate in Hubei (only) increased from 8% to 10%.

3.3 Clinical Characteristics

The adjusted regression parameters of the clinical manifestations of the two periods are listed in **Table 3** and the crude regression parameters in **Table S4**. The regression results were consistent with and without adjustment for confounders. For Hubei, the NPE, DGW, and the SGA were negatively associated with the pandemic, and the CS and preterm birth rates positively associated. Guangdong was similar, but the NPE change lacked significance. In contrast, the only other significant associations were positive associations for the macrosomia risk in Beijing and the NPE in Hebei, and a negative association for the DGW in Yunnan.

4. Discussion

4.1 Main findings

We explored the effects of the pandemic on the rates of pregnancy-related clinical manifestations in uninfected women. Of all the 32,277 women, 12,327 (38%) were from comparatively heavily affected areas Hubei and Guangdong Province. Compared to pre-pandemic period, the CS increased significantly in pandemic period

for Hubei and Guangdong. We also found an increased risk of preterm birth was associated with COVID-19 pandemic in these two areas. Meanwhile, NPE decreased in pandemic period for Hubei. Overall, the effects were minor and such associations were not observed in less affected areas. However, the significant increased rates of the CS and preterm birth in Hubei and Guangdong (COVID-19 Levels I and II respectively) require attention, as does the increased risk of macrosomia in Beijing.

4.2 Strengths and limitations

Our study has two limitations. First, although we included "typical" areas, this was not a nationwide survey. Second, most participants entered the pandemic period in their late second or third trimesters; any effects of the pandemic on early pregnancies could not be investigated. However, the strengths of the work were that we employed a national population-based monitoring system. The HMCCH data are of very high quality. A pre-pandemic period of 2019 served as the reference. We included areas of four pandemic severity levels. The work will aid the management of pregnant women during any future pandemic.

4.3 Interpretation

Many reports on the pregnancy complications and neonatal birth outcomes of infected women have appeared; the preterm birth and CS rates increased significantly in counties with high COVID-19 burdens[1, 2, 4, 14, 15]. However, the effects on uninfected pregnant women have been rarely reported. The UK reported an increased stillbirth rate[1]; most affected women were infected. We found that the preterm birth rate and DGW were somewhat affected by the pandemic in Hubei and Guangdong, partly explained by the high CS rates. In China, inflexible prevention and control policies ensured social distancing. Therefore, in areas with low infection rates, all nonessential examinations were to be postponed or reduced. However, the NPE decreased only in

Hubei, and by only 5%; Hubei was a Level I area. In the other five areas, the NPEs did not fall, and even increased in Hebei. The pandemic did not compromise routine prenatal examinations.

Notably, the CS rate increased in Hubei and Guangdong in P-2020 compared to P-2019. We cannot explain this using the current data. However, the pandemic increased stress and anxiety. In Canada, women pregnant during the pandemic exhibited more distress and psychiatric symptoms than women assessed before the pandemic[6]. Similar results were found in China; 4,124 third-trimester women were surveyed in 25 hospitals of 10 provinces from January 1, 2020, to February 9, 2020[5]; the pandemic increased the risk of depressive and anxiety symptoms. Perhaps a CS is requested by a woman to ensure a live birth. The increased preterm birth risks in Hubei and Guangdong may reflect maternal stress. Both paternal and maternal prenatal depression are risk factors for preterm birth[7, 8]. It may be useful to investigate the effects of maternal mental health issues on preterm birth. Also, some pregnant women may postpone or cancel prenatal examinations to reduce the infection risk. Therefore, certain pregnancy complications, drug misuse, or abnormal syndromes cannot be treated in a timely manner, triggering preterm birth or a CS[16, 17].

The pandemic did not increase the stillbirth or LBW rates. Beijing (only) exhibited a slightly increased rate of macrosomia. The similar results were found in Wuhan City, China, that most of the clinical manifestations did not increased, except for that the weight of newborns was significantly heavier during the pandemic period [11]. All health services worked well, despite the fact that the pandemic consumed a great deal of medical resources. In the UK, it has been proposed that the stillbirth increase was caused by a reluctance to attend hospital for fear of contacting COVID-19, or an unwillingness to add to the National Health Service burden[1]. The abnormal

increase (16 cases) of maternal death from March to May in Indonesia may be similarly explained[18]. We found no such phenomenon in China. Since the outbreak, medical resources have been rationally allocated using a Joint Prevention and Control Mechanism prepared by the State Council of China. Guidelines protect pregnant women[19, 20]. Local healthcare services educate women on COVID-19; prenatal examinations and delivery are carefully arranged. Pregnant women with fever are to be treated separately, to avoid nosocomial infections. Pregnant women at high risk are to be treated in designated hospitals. However, outdoor activities during pregnancy may be reduced.

5. Conclusions

The CS and preterm birth rates increased slightly in Chinese areas badly affected by COVID-19. Prenatal examinations proceeded as normal and most maternal and neonatal clinical characteristics were within the normal ranges. Appropriate mental and physical interventions should be planned.

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Disclosure of interests

All authors declare that there is no conflict of interests regarding the publication of this paper.

Contribution to authorship

B.W., R.Y., J.D., X.L., and Z.L. conceived the study. B.J., H.H., HA, W.Z., and S.W. curated data. B.W. H.A., and T.X. performed the analysis. B.W. and H.A. wrote the first draft of the manuscript. B.J. and H.A. double-check the data clean process. B.J., S.W., J.W., J.C., M.L., Z.L., Y.J., Y.L., H.C., X.L., K.L., W.D., S.G.. reviewed and edited the manuscript. B.W. and Z.L. managed the whole study. Z.L. is guarantor.

Ethics approval

The study was approved by the Peking University ethics board (no. IRB00001052-20025).

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Table 1. Demographic characteristics of the participants recruited during the two periods of January 1st–May 31st, 2019 and January 1st–May 31st, 2020 in the concerned six provinces.

Characteristics	Hubei	Guangdong	Beijing	Shandong	Hebei	Yunnan
No. of subjects	6449	5878	7061	6328	3641	2920
Age (years)	28.9 ± 4.3 [a]	28.1 ± 5.0	31.5 ± 4.0	31.3 ± 4.2	29.5 ± 3.9	27.9 ± 4.7
< 20	64 (1) [b]	150 (3)	3 (0)	3 (0)	8 (0)	79 (3)
20-24	816 (13)	1290 (22)	154 (2)	344 (5)	350 (10)	650 (22)
25-29	2843 (44)	2390 (41)	2187 (31)	1790 (28)	1421 (39)	1136 (39)
30-34	2117 (33)	1397 (24)	3164 (45)	2824 (45)	1529 (42)	794 (27)
≥ 35	607 (9)	649 (11)	1553 (22)	1367 (22)	332 (9)	261 (9)
Gravidity						
1 time	2496 (39)	1582 (27)	3207 (45)	2185 (35)	879 (24)	764 (26)
≥ 2 times	3953 (61)	4296 (73)	3854 (55)	4143 (65)	2762 (76)	2156 (74)
Parity						
Nulliparous	/	2215 (38)	4575 (65)	3150 (50)	1229 (34)	1162 (40)
Multiparous	/	3663 (62)	2486 (35)	3178 (50)	2412 (66)	1758 (60)
BMI (kg/m^2)	22.2 ± 3.2 [a]	22.0 ± 3.4	/	22.8 ± 3.6	23.2 ± 4.1	22.1 ± 3.7
Education						
Primary or lower	41 (1)	111 (2)	/	18 (0)	23 (1)	285 (10)
Junior high	982 (16)	3216 (55)	/	375 (7)	734 (25)	1072 (37)
High school	4672 (75)	1326 (23)	/	717 (13)	789 (26)	853 (29)
College or higher	558 (9)	1225 (21)	/	4362 (80)	1446 (48)	686 (24)
Ethnicity						
Han	6334 (100)	5716 (98)	/	6115 (98)	2943 (98)	2258 (78)

Characteristics	Hubei	Guangdong	Beijing	Shandong	Hebei	Yunnan
Others	22 (0)	98 (2)	/	133 (2)	48 (2)	635 (22)

[a] Mean value ± standard deviation;

[b] Values may not sum to the total number because of missing data.

385 **Table 2.** Maternal and neonatal clinical characteristics recruited during the two periods of January 1st–May 31st, 2019 and January 1st–May 31st, 2020 in

386 the concerned six provinces.

Characteristics [a]	Category	Hubei	Guangdong	Beijing	Shandong	Hebei	Yunnan
N1		6449	5878	7061	6328	3641	2920
Number of prenatal examinations		5.1 ± 2.3 [b]	5.3 ± 2.5	14.5 ± 3.0	/	5.8 ± 2.9	11.5 ± 2.5
Delivery gestational weeks		39.0 ± 1.3	39.1 ± 1.4	39.1 ± 1.3	39.2 ± 1.3	39.1 ± 1.4	39.0 ± 1.4
Caesarean section	No	3187 (49)	4244 (72)	4077 (58)	3203 (51)	2189 (60) [c]	2132 (73)
	Yes	3262 (51)	1634 (28)	2984 (42)	3125 (49)	1451 (40)	786 (27)
Maternal death (%)	No	6449 (100)	5878 (100)	7061 (100)	6328 (100)	3639 (100)	2657 (100)
	Yes	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	2 (0)
Stillbirth (%)	No	6436 (100)	5875 (100)	7055 (100)	/	3637 (100)	2911 (100)
	Yes	13 (0)	3 (0)	6 (0)	/	4 (0)	9 (0)
N2		6436	5875	7055	6328	3637	2911
Neonatal gender	Male	2982 (46)	2753 (47)	3433 (49)	3055 (48)	1754 (48)	1380 (47)
	Female	3454 (54)	3121 (53)	3622 (51)	3270 (52)	1883 (52)	1531 (53)
	Unknown	0 (0)	1 (0)	0 (0)	3 (0)	0 (0)	0 (0)
Neonatal weight (kg)		3.33 ± 0.4	3.17 ± 0.4	3.33 ± 0.4	3.4 ± 0.4	3.32 ± 0.5	3.23 ± 0.4

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Characteristics [a]	Category	Hubei	Guangdong	Beijing	Shandong	Hebei	Yunnan
Apgar score	1 min	8.8 ± 0.7	9.4 ±0.6	9.9 ± 0.5	/	9.9 ± 0.4	9.4 ± 1.2
	5 min	9.5 ± 0.6	10 ± 0.2	10 ± 0.3	/	10 ± 0.3	9.8 ± 1.1
	10 min	9.7 ± 0.5	10 ± 0.1	10 ± 0.4	/	10 ± 0.2	9.8 ± 1.1
Preterm birth	No	6248 (97)	5579 (95)	6740 (96)	6069 (96)	3467 (95)	2774 (95)
	Yes	188 (3)	296 (5)	315 (5)	259 (4)	170 (5)	137 (5)
Low birth weight	No	6318 (98)	5628 (96)	6837 (97)	6187 (98)	3511 (97)	2797 (96)
	Yes	118 (2)	247 (4)	218 (3)	140 (2)	106 (3)	114 (4)
Macrosomia	No	6016 (94)	5706 (97)	6705 (95)	5792 (92)	3383 (94)	2796 (96)
	Yes	420 (6)	169 (3)	350 (5)	535 (8)	234 (6)	115 (4)
N3		6387	5851	6962	6325	2982	2853
Small for gestational age	No	5958 (93)	5208 (89)	6655 (96)	6071 (96)	2837 (95)	2592 (91)
	Yes	429 (7)	643 (11)	307 (4)	250 (4)	145 (5)	261 (9)
Large for gestational age	No	5824 (91)	5583 (95)	6342 (91)	5495 (87)	2686 (90)	2683 (94)
	Yes	563 (9)	268 (5)	620 (9)	826 (13)	296 (10)	170 (6)

[a] Abbreviations: N1: number of the total subjects, N2: Those N1 excluding those without delivering stillbirth, and N3: Those N2 delivering fetus at the 24th-42ed gestational weeks and without major birth defects;
[b] Mean value ± standard deviation;
[c] Values may not sum to the total number because of missing data.

391 **Table 3.** Adjusted relative risk associated with the occurrence of the COVID-19
392 between January 1st–May 31st, 2019 and January 1st–May 31st, 2020 in the concerned
393 six provinces.

Characteristics	Study areas		
	Hubei	Guangdong	Beijing
NPE [a, d]	0.95 (0.92, 0.99)**	1.03 (1.00, 1.07)	0.99 (0.96, 1.02)
DGW [b, d]	-0.15 (-0.22, -0.08)***	-0.16 (-0.23, -0.08)***	0 (-0.02, 0.02)
CS [c, d]	1.11 (1.06, 1.17)***	1.17 (1.08, 1.27)***	1.02 (0.97, 1.08)
NW [b, d]	0 (-0.02, 0.02)	0.01 (-0.01, 0.03)	-0.01 (-0.07, 0.05)
Stillbirth [c, d]	0.88 (0.30, 2.63)	1.5 (0.09, 24.47)	2.43 (0.44, 13.28)
Preterm birth [c, d]	1.37 (1.02, 1.84)*	1.34 (1.07, 1.67)*	1.03 (0.83, 1.28)
LBW [c, d]	1.08 (0.75, 1.58)	1.18 (0.92, 1.51)	1.16 (0.89, 1.50)
Macrosomia [c, d]	1.10 (0.91, 1.34)	1.18 (0.87, 1.59)	1.26 (1.03, 1.55)*
SGA [c, d]	0.81 (0.67, 0.98)*	0.71 (0.60, 0.83)***	1.01 (0.81, 1.25)
LGA [c, d]	1.17 (0.99, 1.38)	1.10 (0.87, 1.39)	1.11 (0.96, 1.29)
	Shandong	Hebei	Yunnan
NPE [a, d]	/	1.08 (1.03, 1.13)***	1.0 (0.96, 1.05)
DGW [b, d]	-0.02 (-0.09, 0.05)	0 (-0.11, 0.1)	-0.13 (-0.23, -0.02)*
CS [c, d]	0.99 (0.94, 1.04)	0.99 (0.92, 1.07)	1.05 (0.93, 1.19)
NW [b, d]	-0.01 (-0.03, 0.02)	-0.02 (-0.06, 0.01)	-0.01 (-0.04, 0.03)
Stillbirth [c, d]	/	0.58 (0.06, 5.55)	0.66 (0.13, 3.31)
Preterm birth [c, d]	0.85 (0.64, 1.11)	1.01 (0.72, 1.42)	0.73 (0.50, 1.06)
LBW [c, d]	0.98 (0.67, 1.43)	0.75 (0.48, 1.18)	0.77 (0.51, 1.16)
Macrosomia [c, d]	0.88 (0.73, 1.06)	0.86 (0.65, 1.14)	0.83 (0.56, 1.24)

SGA [c, d]	0.98 (0.74, 1.30)	1.13 (0.82, 1.55)	0.87 (0.67, 1.12)
LGA [c, d]	0.93 (0.81, 1.08)	0.82 (0.65, 1.03)	0.87 (0.63, 1.19)

Abbreviations: NPE, No. of prenatal examinations; DGW, delivery gestational weeks; CS, Caesarean section; NW, Neonatal weight, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

[a] Relative risk calculated by Poisson regression model;

[b] Regression coefficient (β value) calculated by linear regression model;

[c] Relative risk calculated by log-binomial regression model;

[d] Adjusted for BMI (categorical), age (categorical), parity, gravidity, ethnicity, and education. For Hubei Province, parity information is unavailable. For Beijing, the information of BMI, ethnicity, and education is unavailable.