

# Home Quarantine: A Double-Edged Sword During COVID-19 Pandemic for Hypertensive Disorders of Pregnancy and the Related Complications

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**Object:** COVID-19 pandemic and worldwide quarantine seriously affected the physical and mental health of the general public. Our study aimed to investigate the effects of the COVID-19 quarantine on pregnancy outcomes among pregnant women with hypertensive disorders of pregnancy (HDP).

**Methods:** This single-center retrospective cohort study collected complete clinical data of HDP patients with a history of home quarantine in The First Affiliated Hospital of Chongqing Medical University (Chongqing, China) in 2020 as well as the patients without home quarantine in 2018 and 2019. Then, the maternal and neonatal outcomes of two subtypes of HDP, gestational hypertension (GH) and preeclampsia/eclampsia (PE/E), were analyzed over the three years.

**Results:** The incidence of HDP increased from 0.84% in 2018 and 0.51% in 2019 to 2.30% in 2020. The data suggested that home quarantine was associated with higher gestational weight gain, obesity rates, blood pressure, and uric acid among the patients with HDP in 2020. Furthermore, HDP patients with a history of home quarantine may have worse neonatal outcomes, including lower newborn weight, shorter body length, lower Apgar score, and higher risk of fetal growth restriction.

**Conclusion:** Our results suggested that COVID-19 quarantine may be a risk factor for poor pregnancy outcomes in HDP patients. Lifestyle guidance and antenatal care may be necessary for HDP patients with home quarantine in an epidemic outbreak.

**Keywords:** COVID-19, home quarantine, pregnancy outcomes, HDP, obesity

## Introduction

Since the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2, COVID-19) was first reported in Wuhan, China, in December 2019, it has rapidly swept the world and brought colossal morbidity and mortality to all humanity. Worse still, the continuous generation of new variants has caused wider transmissibility, especially variant B.1.617.2 (Delta), leading to the current wave of infection ravaging the Indian and becoming the dominant lineage in the United Kingdom.<sup>1</sup> The exponential growth of COVID-19 cases has forced many governments to impose a strict home quarantine.<sup>2</sup> This effectively slows down the widespread of the contagion, preventing the collapse of health care systems. Whereas the home quarantine measures have affected the general health of the population, including mental health, sleep, weight, dietary habits, and even some chronic diseases.<sup>3–7</sup>

However, limited data is available about how home quarantine affects the health and outcomes of pregnant women, especially for patients with pregnancy complications. Hypertensive disorders of pregnancy (HDP), including chronic hypertension, gestational hypertension (GH), preeclampsia (PE)/eclampsia (E), and PE/E variants superimposed on chronic hypertension, constitute one of the leading causes of maternal and perinatal mortality worldwide. Moreover, a history of HDP will lead to an elevated risk of clinical cardiovascular disease (CVD) or other chronic conditions in the future.<sup>8</sup> The

population-based cohort studies revealed that obesity and excessive weight gain during pregnancy were significant contributors to the increased risks of HDP, especially for PE/E, and are associated with various adverse maternal and neonatal outcomes.<sup>9,10</sup> Other risk factors were also reported to be associated with the increased incidence of PE/E, such as pregnant with older maternal age, multifetal pregnancy, and primiparity.<sup>11</sup> Cohort studies showed that both GH and PE might be more prevalent in gravidas with greater insulin resistance, and the association of gestational glucose intolerance with GH appears to be partly explained by insulin resistance and vascular dysplasia. Thus, nondiabetic women who have PE are more likely to develop gestational diabetes (GDM) during pregnancy.<sup>12</sup> In addition, women with GDM have an increased risk of PE, especially in the early stages, as indicated in the latest ISSHP.<sup>13,20,21</sup> HDP complicated with GDM will bring more serious adverse pregnancy outcomes, so paying attention to this kind of high-risk population and studying its risk factors should be one of the focuses of future research.<sup>14</sup> Meanwhile, some of these risk factors rose significantly during the COVID-19 quarantine. Home quarantine made people more vulnerable to overeating and intake of high-calorie food.<sup>15</sup> Adopting regular physical activity during pregnancy will benefit both mother and fetus, including attenuation of HDP, improved cardiovascular function, and limited pregnancy weight gain;<sup>16</sup> conversely, a sedentary lifestyle may lead to the deterioration of HDP.<sup>17</sup> Home quarantine limits physical activity, making sedentary daily life.<sup>18</sup> In addition, pregnant women with anxiety may contribute to the increased incidence of HDP.<sup>19</sup> Current studies confirmed that the general population suffers from increasing mental stress and anxiety during the COVID-19 quarantine.<sup>20,21</sup>

This study aimed to confirm whether home quarantine affects pregnant women with HDP and HDP patients complicated with GDM. We investigated the clinical indicators and pregnancy outcomes of HDP patients who had experienced a strict home quarantine for at least one month during the three-month from 24 January 2020 to 20 April 2020 in Chongqing, China, and also included information on patients without home quarantine during the same period of 2019 and 2018. Therefore, the present research attempts to provide evidence so that governments and hospitals can plan effective lifestyle management and prenatal care.

## Materials and Methods

### Ethics Approval

This study was approved by the ethics committee of the First Affiliated Hospital of Chongqing Medical University (ID: 20200501). To protect the privacy of patients, the personal identification information of all cases was deleted, and all data acquired was kept anonymized.

### Study Design and Participants

The present study was a single-center retrospective cohort analysis of data collected in the First Affiliated Hospital of Chongqing Medical University, a large comprehensive teaching hospital with 10,000 births per year. Our primary aim was to reveal the effects of home quarantine exposure on pregnancy outcomes in patients with HDP, including gestational hypertension (GH) and preeclampsia/eclampsia (PE/E). Therefore, the cohort included the GH patients and PE/E patients who experienced at least one month of home quarantine during the outbreak of COVID-19 in 2020, as well as the patients in the same period of 2019 and 2018 who were without home quarantine. Given the strict home quarantine in Chongqing, China, which ranges from 24 January 2020 to 20 April 2020, we inferred that the patients who deliver between 24 February 2020 to 24 November 2020 have a history of home quarantine for at least one month, according to their gestational weeks. Exclusion criteria were without hypertension, chronic hypertension, and other chronic Medical conditions except for GDM or the patients with incomplete clinical information. Additionally, the patients in 2020 diagnosed with COVID-19 by RT-PCR and clinical symptoms were excluded.

### Definitions

All participants strictly followed the diagnostic criterion, “the HDP: ISSHP classification, diagnosis, and management recommendations for international practice”, that GH was defined as systolic blood pressure (BP)  $\geq 140$  and/or diastolic BP  $\geq 90$  mm Hg arising de novo at  $\geq 20$  weeks’ gestation in the absence of proteinuria or other findings suggestive of PE.<sup>22</sup> PE (de novo) is gestational hypertension accompanied by one or more of the following new-onset conditions at  $\geq 20$  weeks’

gestation according to the latest ISSHP (2021): 1) proteinuria, 2) other maternal end-organ dysfunction, including neurological complications, pulmonary edema, hematological complications or liver involvement, 3) uteroplacental dysfunction.

Additionally, patients with GH or PE/E complicated with gestational diabetes (GDM) were also included in our study. All participants were offered a 75 g oral glucose tolerance test (OGTT) after 8–10 h of overnight fasting during the antenatal examination in early pregnancy and the time is before 24 weeks. With GDM diagnosed from venous samples according to the clinical guideline, IADPSG/WHO 2010 criteria (fasting plasma glucose  $\geq 5.1$  mmol/L, 1 h plasma glucose  $\geq 10.0$  mmol/L or 2 h plasma glucose  $\geq 8.5$  mmol/L), and at least one glucose threshold value must be equaled or exceeded to define the patient as having gestational diabetes.<sup>23</sup> Pregnant outcomes were divided into maternal outcomes and neonatal outcomes. Maternal outcomes contain delivery mode, Diastolic Pressure (DP), Systolic Pressure (SP), blood platelet, and uric acid. Fetal outcomes included neonatal weight, abdominal circumference, head circumference, body length, placental weight, thickness, length, width, one-minute Apgar scores, and the related obstetrical complications such as placental factors, umbilical factors, Fetal growth restriction (FGR), and premature delivery.

## Data Collection

All data were collected from the hospital electronic medical records (EMR) database, including basic maternal information, pregnancy outcomes, and neonatal outcomes.

## Statistical Analyses

During statistics analysis, Chi-square or Fisher's exact test was used for categorical variables, including the incidence of GH and PE/E. The population characteristics were performed to assess for differences between the home quarantine group and each control group. Continuous variables with normal distribution were presented as mean  $\pm$  SD, including age, gestational age, and gestational weight gain. The median plus 25–75 interquartile range (IQR) was used to show non-normally distributed variables, such as parity, gravidity, and fetal number. Additionally, categorical variables were presented as percentages and counts, including pre-pregnancy BMI and BMI after pregnancy. The *P*-values were obtained via one-way analysis variance that was used to compare continuous variables in the basic characteristics of the pregnant woman in different groups, while the Mann–Whitney test for categorical variables. The L-S-D correction results were used to post hoc analysis of pairwise comparisons and indicated the significant differences between the two groups in Tables 1 and 2.

**Table 1** Sociodemographic and Obstetric Histories of Patients with HDP

Variables	2018 (N=60)	2019 (N=74)	2020 (N=142)	$\chi^2/F$	P
Age (years)	31.80 $\pm$ 5.03	29.38 $\pm$ 4.76	30.68 $\pm$ 4.13	1.787	0.174
Gestational age (week)	38.00 $\pm$ 1.86	38.59 $\pm$ 1.60	38.06 $\pm$ 2.65	0.689	0.505
Gestational weight gain <sup>†§</sup>	13.35 $\pm$ 3.51	14.03 $\pm$ 5.87	17.16 $\pm$ 6.37	3.683	0.031*
Parity <sup>†§</sup>	1.00(0.00, 1.00)	0.00(0.00, 1.00)	1.00(1.00, 1.25)	10.926	<0.001**
Gravidity	2.00(1.00, 3.00)	1.50(1.00, 3.00)	2.00(1.00, 3.00)	0.895	0.412
Fetal sex				2.726	0.256
Male	21(35.0%)	42(56.8%)	73(51.4%)		
Female	39(65.0%)	32(43.2%)	69(48.6%)		
Fetal number	1.00(1.00, 1.00)	1.00(1.00, 1.00)	1.00(1.00, 1.00)	1.033	0.360
Pre-pregnancy BMI (kg/m <sup>2</sup> )				1.971	0.373
<18.5	5(8.3%)	3(4.0%)	6(4.2%)		
18.5–23.9	39(65.0%)	36(48.7%)	84(59.2%)		
24–27.9	9(15.0%)	24(32.4%)	35(24.6%)		
>28	7(11.7%)	11(14.9%)	17(12.0%)		
BMI after pregnancy (kg/m <sup>2</sup> ) <sup>†§</sup>				6.794	0.033*
18.5–23.9	9(15.0%)	8(10.8%)	15(10.6%)		
24–27.9	27(45.0%)	30(40.5%)	35(24.6%)		
>28	24(40.0%)	36(48.7%)	92(64.8%)		

**Notes:** <sup>†</sup>There was statistically significant difference between 2018 and 2020. <sup>§</sup>There was statistically significant difference between 2019 and 2020. \**P*<0.05, \*\**P*<0.001.

**Table 2** Sociodemographic and Obstetric Histories of Patients with HDP-GDM

Variables	2018 (N=40)	2019 (N=52)	2020 (N=105)	$\chi^2/F$	P
Age (years) <sup>†</sup>	34.90±4.36	29.81±5.22	30.68±4.13	4.496	0.015*
Gestational age (week)	37.50±2.27	38.67±1.65	38.05±2.65	0.939	0.396
Gestational weight gain <sup>†</sup>	12.75±4.34	14.21±4.57	17.13±5.43	3.183	0.048*
Parity <sup>§</sup>	1.00(0.00, 1.00)	0.00(0.00, 1.00)	1.00(1.00, 1.25)	7.965	0.001**
Gravidity	2.50(1.00, 4.00)	2.00(1.00, 4.00)	2.00(1.00, 3.00)	1.749	0.175
Fetal sex				3.636	0.162
Male	6(30.0%)	14(46.7%)	27(57.1%)		
Female	14(70.0%)	16(53.3%)	18(42.9%)		
Fetal number	1(1.00, 1.00)	1(1.00, 1.00)	1(1.00, 1.00)	2.915	0.062
Pre-pregnancy BMI (kg/m <sup>2</sup> )				3.223	0.200
<18.5	4(10.0%)	0(0.0%)	2(1.9%)		
18.5~23.9	28(70.0%)	28(53.9%)	65(61.9%)		
24~27.9	4(10.0%)	18(34.6%)	22(21.0%)		
>28	4(10.0%)	6(11.5%)	16(15.2%)		
BMI after pregnancy (kg/m <sup>2</sup> ) <sup>†§</sup>				6.346	0.042*
<18.5	0(0.0%)	0(0.0%)	0(0.0%)		
18.5~23.9	4(10.0%)	4(7.7%)	5(4.8%)		
24~27.9	24(60.0%)	20(42.3%)	26(24.8%)		
>28	12(30.0%)	26(50.0%)	74(70.4%)		

**Notes:** <sup>†</sup>There was statistically significant difference between 2018 and 2020. <sup>§</sup>There was statistically significant difference between 2019 and 2020. \* $P < 0.05$ , \*\* $P < 0.001$ .

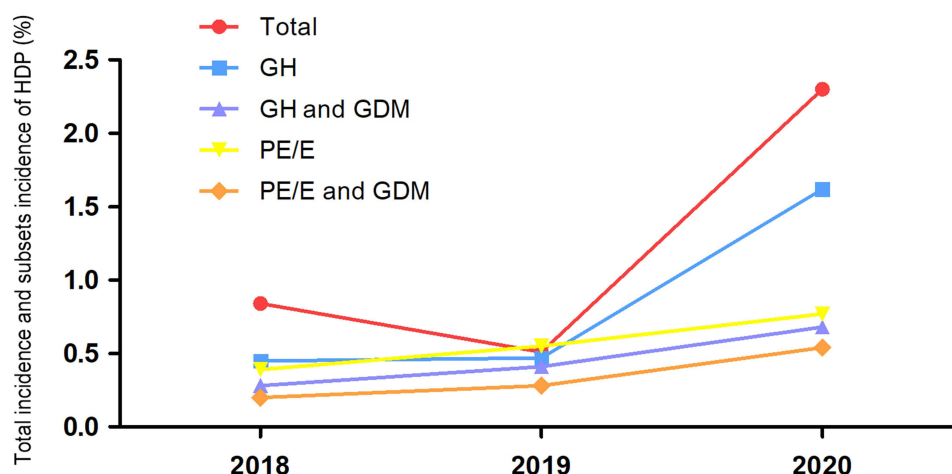
We performed further analysis on the outcomes of pregnant women and neonates. The obstetrical complications were analyzed by Logistic regression and presented as odds ratios (OR). In the study of HDP patients, multiple logistic regression was used to eliminate confounding factors, including parity and gestational weight gain, and adjusted odds ratios (AOR) were used as the results. The regression models for HDP complicated with GDM patients were adjusted according to the potential confounding effects of age, parity, and gestational weight gain, and presented as adjusted odds ratios (AOR). Significant analysis was performed on pregnant women-related indicators, including delivery pattern, OGTT biochemical criterion, HP, DP, blood platelet, and uric acid criterion.

In addition, significant analysis was performed on the neonatal index, including neonatal weight, body length, placental weight, length, weight, thickness, and size. Furthermore, obstetric complications of neonatal outcomes in different groups were also used logistic regression, such as placental implantation, umbilical cord wrap, fetal growth restriction, and premature delivery. No more than 5% of values missed in the variables used in the statistical analyses. Therefore, none of the imputations were done for the missing data. All analyses were performed using Statistical Package for the Social Sciences 22.0 (SPSS 22.0, IBM Corporation, Chicago, IL, USA) software.

## Results

### Clinical Characteristics of HDP Patients in 2018, 2019, and 2020

The total number of women delivered in the research center was 6166 in 2020, 7268 in 2019, and 7153 in 2018. After screening the electronic medical records according to the above inclusion and exclusion criteria, 6024 women were excluded in 2020, 7194 in 2019, and 7093 in 2018. Finally, a total of 276 women with HDP were used for subsequent analysis, including 142 women with HDP with COVID-19 quarantine history in 2020, 74 in 2019, and 60 in 2018. The analysis of HDP incidence in three years showed that the HDP incidence rate in 2020 was as high as 2.30%, significantly higher than that in 2018 (0.84%) and 2019 (0.51%) ( $P < 0.001$ , Figure 1). Additionally, the incidence of both GH (1.62%) and PE/E (0.68%) in 2020 were higher than that in 2018 (0.45%/0.39%) and 2019 (0.47%/0.55%) ( $P < 0.001$ / $P = 0.016$ ); the incidence of HDP complicated with GDM was also significantly increased in 2020 ( $P = 0.002$ ). A further study of the baseline clinical characteristics of 276 HDP patients showed that gestational weight gain of patients with



**Figure 1** Total incidence and subsets incidence of HDP. The total number of women delivered in the research center was 6166 in 2020, 7268 in 2019, and 7153 in 2018. After screening the electronic medical records according to the above inclusion and exclusion criteria, 6024 women were excluded in 2020, 7194 in 2019, and 7093 in 2018. Finally, a total of 276 HDP patients were used for subsequent analysis, including 142 HDP patients in 2020, 74 in 2019, and 60 in 2018. Additionally, a total of 197 women with HDP-GDM were included in our cohort, including 105 women in 2020, 52 women in 2019, and 40 in 2018. As for women with GH, there was 100 women in 2020, 32 women in 2018 and 34 women in 2019. Lastly, 42 women with PE/E in 2020 were enrolled in our cohort, 28 women in 2018 and 40 women in 2019.

HDP in 2020 was more than in 2018 and 2019 (2020:  $17.16 \pm 6.37$  kilograms; 2018:  $13.35 \pm 3.51$  kilograms; 2019:  $14.03 \pm 5.87$  kilograms;  $P = 0.031$ , Table 1). Body mass index (BMI) was divided into four categories based on the Chinese BMI classification standard,  $< 18.5$  (underweight),  $18.5\text{--}23.9$  (normal weight),  $24\text{--}27.9$  (overweight), and  $\geq 28$  (obesity). The data showed that there was no difference in patients with HDP of four pre-pregnancy BMI categories ( $P = 0.373$ ); nevertheless, the obesity ratio of patients with HDP increased significantly in 2020 (64.8%) than that in 2018 (40.0%) and 2019 (48.7%) ( $P = 0.033$ ). Additionally, the parity of patients with HDP in 2020 was significantly more than patients with HDP in 2018 and 2019 ( $P < 0.001$ ). Nevertheless, there is no difference in the number of fetuses among three years.

## Maternal Outcomes of HDP Patients in 2018, 2019, and 2020

Although the delivery pattern of pregnant women always attached obstetrical attention, multiple logistic regression showed no difference among the three years ( $P = 0.406$ ). Consistent with the above results, multiple logistic regression also showed that gestational weight gain of HDP patients in 2018 (AOR: 0.86, 95% CI, 0.76–0.98,  $P = 0.021$ ) and 2019 (0.89, 95% CI, 0.77–0.98,  $P = 0.026$ ) was less than 2020. The biochemistry indexes of HDP patients showed that DP in 2018 (AOR: 4.41, 95% CI, 1.13–17.23,  $P = 0.033$ ) and SP in 2019 (AOR: 2.80, 95% CI, 1.01–7.71,  $P = 0.047$ ) were lower than that in 2020. Moreover, the uric acid level of patients in 2019 (AOR: 3.50, 95% CI, 1.03–11.87,  $P = 0.045$ , Table 3) was lower than in 2020.

## Neonatal Outcomes of HDP Patients in 2018, 2019, and 2020

We next studied the effects of home quarantine on neonatal outcomes, logistic regression analysis showed that neonatal weight in 2020 was lower than that in both 2018 (AOR: 1.11, 95% CI, 1.02–1.32,  $P = 0.004$ ) and 2019 (AOR: 1.21, 95% CI, 1.10–1.42,  $P = 0.007$ ). Furthermore, neonatal abdominal circumference in 2018 was longer (AOR: 1.03, 95% CI, 1.01–1.06,  $P = 0.004$ ) than 2020; head circumference in both 2018 and 2019 were longer (2018: AOR: 1.05, 95% CI, 1.01–1.10,  $P = 0.024$ ; 2019: AOR: 1.06, 95% CI, 1.01–1.10,  $P = 0.010$ ) than 2020; as well as longer body length of 2018 and 2019 (2018: AOR: 1.42, 95% CI, 1.06–1.89,  $P = 0.017$ ; 2019: AOR: 1.34, 95% CI, 1.04–1.73,  $P = 0.022$ , Table 3). Additionally, the neonatal placenta in 2018 and 2019 was heavier (2018: AOR: 1.02, 95% CI, 1.01–1.03,  $P = 0.013$ ; 2019: 1.04, 95% CI, 1.02–1.05,  $P = 0.033$ ) and larger (2018: AOR: 1.92, 95% CI, 1.08–3.42,  $P = 0.027$ ; 2019: AOR: 1.61, 95% CI, 1.05–2.49,  $P = 0.031$ ) than that in 2020. Newborns in 2020 had lower one-minute Apgar scores than 2018 (AOR: 0.17, 95% CI, 0.04–0.70,  $P = 0.015$ , Table 3).



**Table 3** Pregnant Outcomes of HDP Patients

	2018				2019			
	Crude OR (95%-CI) <sup>†</sup>	P <sup>†</sup>	Adjusted OR (95%-CI) <sup>§</sup>	P <sup>§</sup>	Crude OR (95%-CI) <sup>†</sup>	P <sup>†</sup>	Adjusted OR (95%-CI) <sup>§</sup>	P <sup>§</sup>
Gestational weight gain	0.88(0.79, 0.99)	0.029*	0.86(0.76, 0.98)	0.021*	0.92(0.84, 1.01)	0.064	0.89(0.77, 0.98)	0.026*
Gestational age (week)	0.99(0.77, 1.26)	0.926	1.02(0.77, 1.36)	0.869	1.14(0.89, 1.46)	0.296	1.13(0.85, 1.51)	0.406
Delivery mode	1.44(0.38, 5.47)	0.592	2.76(0.56, 13.62)	0.212	1.29(0.41, 3.99)	0.664	3.74(0.87, 16.02)	0.076
DP	4.61(1.35, 15.78)	0.015*	4.41(1.13, 17.23)	0.033*	2.25(0.83, 6.07)	0.110	2.40(0.73, 7.90)	0.150
SP	0.82(0.26, 2.62)	0.749	0.79(0.22, 2.80)	0.711	2.65(0.83, 8.40)	0.098	2.80(1.01, 7.71)	0.047*
Blood platelet	3.00(0.57, 15.87)	0.196	3.59(0.58, 22.17)	0.169	2.25(0.60, 8.42)	0.229	2.00(0.43, 9.35)	0.381
Uric Acid	2.26(0.70, 7.19)	0.169	2.59(0.73, 9.25)	0.143	3.10(1.09, 8.83)	0.034*	3.50(1.03, 11.87)	0.045*
Neonatal weight (g)	1.10(1.01, 1.22)	0.011*	1.11(1.02, 1.32)	0.004**	1.21(1.10, 1.35)	0.006**	1.21(1.10, 1.42)	0.007**
Abdominal circumference (cm)	1.02(0.99, 1.04)	0.211	1.02(0.99, 1.05)	0.135	1.03(1.01, 1.05)	0.029*	1.03(1.01, 1.06)	0.004*
Head circumference (cm)	1.03(0.99, 1.07)	0.101	1.05(1.01, 1.10)	0.024*	1.04(1.01, 1.08)	0.024*	1.06(1.01, 1.10)	0.010*
Body length (cm)	1.30(1.10, 1.69)	0.047*	1.42(1.06, 1.89)	0.017*	1.28(1.02, 1.60)	0.031*	1.34(1.04, 1.73)	0.022*
Placental weight (g)	1.02(1.01, 1.03)	0.002**	1.02(1.01, 1.03)	0.013*	1.02(1.01, 1.03)	0.002**	1.04(1.02, 1.05)	0.033*
Placental thickness (mm)	0.24(0.04, 1.38)	0.110	0.31(0.05, 2.03)	0.221	0.93(0.31, 2.79)	0.891	1.63(0.41, 6.51)	0.491
Placental length (cm)	2.03(1.20, 3.43)	0.009**	1.92(1.08, 3.42)	0.027*	1.61(1.05, 2.49)	0.031*	1.44(0.86, 2.40)	0.164
Placental width (cm)	1.47(0.94, 2.28)	0.091	1.39(0.83, 2.33)	0.208	1.34(0.84, 2.14)	0.213	1.48(1.01, 2.19)	0.049*
Umbilical cord length (cm)	1.06(0.95, 1.19)	0.310	1.03(0.91, 1.17)	0.648	0.96(0.87, 1.06)	0.441	0.93(0.83, 1.05)	0.225
Amniotic fluid volume (mL)	1.00(0.99, 1.00)	0.262	1.00(0.99, 1.00)	0.446	1.00(1.00, 1.00)	0.648	1.00(1.00, 1.01)	0.931
One minute Apgar scores =9	0.20(0.06, 0.72)	0.013*	0.17(0.04, 0.70)	0.015*	0.48(0.17, 1.33)	0.155	0.47(0.14, 1.61)	0.230
One minute Apgar scores =10	Ref		Ref		Ref		Ref	
Placental factors	0.55(0.10, 3.02)	0.490	0.46(0.06, 3.31)	0.437	0.94(0.18, 5.01)	0.938	0.69(0.90, 5.24)	0.716
Umbilical factors	2.04(0.48, 8.65)	0.333	1.62(0.33, 7.90)	0.552	1.56(0.48, 5.03)	0.456	1.03(0.25, 4.20)	0.965
FGR	4.93(0.56, 43.40)	0.151	3.57(1.16, 5.81)	0.037*	8.04(0.93, 69.54)	0.058	7.88(1.46, 11.93)	0.024*
Premature delivery	1.23(0.32, 4.76)	0.763	1.60(0.36, 7.13)	0.538	1.66(0.48, 5.74)	0.422	1.96(0.45, 8.50)	0.369

**Notes:** 2020 was used as reference group. <sup>†</sup>Single variable logistic regression analysis. <sup>§</sup>Adjust: Parity, Gestational weight gain. \* $P < 0.05$ , \*\* $P < 0.001$ .

The labor complications were further analyzed to evaluate the effects of home quarantine on fetal outcomes. Multivariate logistic regression was used to control for the parity and gestational week. The data showed that a higher risk of FGR in 2020 than in 2018 and 2019 (2018: AOR: 3.57, 95% CI, 1.16–5.81,  $P = 0.037$ ; 2019: AOR: 7.88, 95% CI, 1.46–11.93,  $P = 0.024$ , Table 3) whether in univariate analysis or after adjusting for covariates.

## Clinical Characteristics of HDP Complicated with GDM Patients in 2018, 2019, and 2020

Notably, the data showed that the incidence of HDP complicated with GDM is increasing year by year from 2018 to 2020, and more than 70% of the total 276 HDP patients were complicated with GDM, thus making further analysis of maternal and neonatal outcomes of those patients. The mean age of HDP complicated with GDM (HDP-GDM) patients in 2020 was  $30.68 \pm 4.13$ , and they were younger compared to 2018 (2018:  $34.90 \pm 4.36$ ; 2019:  $29.81 \pm 5.22$ ;  $P = 0.015$ ). Although the gestational weight gain of HDP-GDM patients in 2020 was more than 2018 and 2019 (2020:  $17.13 \pm 5.43$  kilogram; 2018:  $12.75 \pm 4.34$  kilogram; 2019:  $14.21 \pm 4.57$  kilogram;  $P = 0.031$ , Table 2), there was no difference among the pre-pregnancy BMI, especially for the obese patients (2020: 15.2%; 2018: 10.0%; 2019: 11.5%;  $P = 0.200$ ). In contrast, BMI data after pregnancy demonstrated that home quarantine patients have a higher obesity rate than in 2018 and 2019 (2020: 70.4%; 2018: 30.0%; 2019: 50.0%;  $P = 0.042$ ). The parity of patients with HDP-GDM in 2020 was significantly more than in 2018 and 2019 ( $P = 0.001$ ). However, the number of fetuses within three years is not statistically significant.

## Effects of Home Quarantine on Pregnancy Outcomes in HDP Complicated with GDM Patients

While analyzing the maternal outcomes of HDP complicated with GDM patients, only DP and gestational weight gain had significant differences between 2018 and 2020, whereas other indexes, including delivery mode, blood platelet, uric acid, and OGTT, had no difference among the three years. Logistic regression showed that HDP-GDM patients had lower

**Table 4** Pregnant Outcomes of HDP with GDM Patients

	2018				2019			
	Crude OR (95%-CI) <sup>†</sup>	P <sup>†</sup>	Adjusted OR (95%-CI) <sup>§</sup>	P <sup>§</sup>	Crude OR (95%-CI) <sup>†</sup>	P <sup>†</sup>	Adjusted OR (95%-CI) <sup>§</sup>	P <sup>§</sup>
Gestational weight gain	0.86(0.71, 1.04)	0.110	0.85(0.72, 0.99)	0.044*	0.88(0.76, 1.02)	0.099	0.91(0.81, 1.01)	0.080
Gestational age (week)	0.91(0.70, 1.20)	0.527	1.07(0.77, 1.49)	0.695	1.15(0.87, 1.51)	0.325	1.23(0.89, 1.71)	0.206
Delivery mode	3.24(0.36, 29.30)	0.295	2.94(0.25, 34.47)	0.391	0.90(0.27, 3.03)	0.865	1.94(0.41, 9.24)	0.406
DP	8.85(1.56, 12.58)	0.018*	14.64(1.22, 17.64)	0.034*	2.50(0.81, 7.69)	0.110	2.40(0.62, 9.25)	0.203
SP	1.54(0.37, 6.38)	0.553	1.35(0.24, 7.58)	0.732	2.86(0.90, 9.06)	0.075	3.37(0.86, 13.20)	0.080
Blood platelet	3.00(0.33, 27.50)	0.331	4.42(0.40, 49.49)	0.227	1.89(0.44, 8.18)	0.395	1.68(0.29, 9.67)	0.559
Uric Acid	2.83(0.62, 13.04)	0.181	2.21(0.39, 12.52)	0.369	3.04(0.93, 9.90)	0.066	3.15(0.79, 12.58)	0.105
0 min OGTT	1.80(0.32, 10.20)	0.507	2.20(0.30, 15.99)	0.437	1.65(0.37, 7.37)	0.512	1.79(0.34, 9.39)	0.493
60 min OGTT	1.14(0.17, 7.60)	0.890	0.75(0.08, 6.87)	0.800	1.94(0.39, 9.70)	0.420	2.17(0.34, 13.92)	0.415
120 min OGTT	0.83(0.15, 4.64)	0.835	0.76(0.10, 5.61)	0.790	0.49(0.11, 2.20)	0.349	0.38(0.07, 2.14)	0.272
Neonatal weight (g)	1.10(1.01, 1.21)	0.176	1.11(1.01, 1.21)	0.048*	1.02(1.01, 1.03)	0.015*	1.02(1.01, 1.03)	0.006**
Abdominal circumference (cm)	1.00(1.00, 1.02)	0.858	1.02(0.99, 1.05)	0.329	1.03(0.99, 1.05)	0.057	1.14(1.10, 1.17)	0.032*
Head circumference (cm)	1.02(0.97, 1.06)	0.514	1.04(0.99, 1.10)	0.110	1.04(1.00, 1.08)	0.060	1.07(1.01, 1.12)	0.015*
Body length (cm)	1.13(0.84, 1.50)	0.426	1.58(1.00, 2.48)	0.047*	1.35(1.02, 1.78)	0.037*	1.91(1.21, 3.01)	0.006**
Placental weight (g)	1.12(1.10, 1.14)	0.007**	1.13(1.11, 1.15)	0.006**	1.12(1.11, 1.13)	0.002**	1.13(1.11, 1.15)	0.010*
Placental thickness (mm)	0.18(0.01, 2.28)	0.184	0.39(0.02, 7.56)	0.532	0.66(0.18, 2.46)	0.532	2.77(0.48, 16.01)	0.256
Placental length (cm)	1.92(0.93, 3.97)	0.079	2.24(0.94, 5.36)	0.069	1.59(0.94, 2.69)	0.082	1.53(0.80, 2.96)	0.202
Placental width (cm)	1.34(0.74, 2.42)	0.329	1.72(0.77, 3.87)	0.187	1.74(1.05, 2.89)	0.033*	2.07(1.04, 4.12)	0.039*
Umbilical cord length (cm)	1.06(0.92, 1.22)	0.428	1.04(0.89, 1.23)	0.627	1.00(0.90, 1.11)	0.997	0.96(0.85, 1.10)	0.532
Amniotic fluid volume (mL)	1.00(1.00, 1.00)	0.663	1.00(1.00, 1.01)	0.920	1.00(1.00, 1.00)	0.613	1.00(0.99, 1.01)	0.835
One minute Apgar scores =9	0.19(0.04, 0.92)	0.039*	0.19(0.10, 0.73)	0.025*	0.23(0.07, 0.75)	0.015*	0.20(0.04, 0.94)	0.042*
One minute Apgar scores =10	Ref		Ref		Ref		Ref	
Placental factors	0.87(0.08, 9.43)	0.919	1.06(0.05, 22.86)	0.969	0.92(0.14, 6.01)	0.930	0.54(0.05, 6.28)	0.619
Umbilical factors	3.24(0.36, 29.30)	0.295	10.23(0.63, 16.34)	0.102	1.53(0.41, 5.78)	0.531	1.83(0.35, 9.54)	0.473
FGR	2.33(2.52, 21.63)	0.456	13.08(0.65, 26.73)	0.093	5.19(0.59, 10.58)	0.138	4.29(1.01, 10.49)	0.049*
Premature delivery	0.46(0.10, 2.05)	0.310	0.60(0.11, 3.38)	0.566	1.85(0.43, 7.92)	0.409	2.23(0.40, 12.35)	0.360

**Notes:** 2020 was used as reference group. <sup>†</sup>Single variable logistic regression analysis. <sup>§</sup>Adjust: Parity, Age. \* $P < 0.05$ , \*\* $P < 0.001$ .

DP (AOR: 14.64, 95% CI, 1.22–17.64,  $P = 0.034$ ), SP (AOR: 2.86, 95% CI, 1.10–9.06,  $P = 0.045$ ) and less gestational weight gain (AOR: 0.85, 95% CI, 0.72–1.00,  $P = 0.044$ , Table 4) than 2020.

Logistic regression analysis showed that neonatal weight of HDP-GDM patients in 2020 was lower than that in both 2018 (AOR: 1.11, 95% CI, 1.01–1.21,  $P = 0.048$ ) and 2019 (AOR: 1.12, 95% CI, 1.11–1.13,  $P = 0.006$ ). Besides, neonate of HDP-GDM patients in 2019 had longer abdominal circumference (AOR: 1.14, 95% CI, 1.11–1.17,  $P = 0.032$ ), head circumference (AOR: 1.07, 95% CI, 1.01–1.12,  $P = 0.015$ ), and body length (AOR: 1.91, 95% CI, 1.21–3.01,  $P = 0.006$ ) than 2020. Neonate of HDP-GDM patients in 2020 also had lower one-minute Apgar scores than 2018 and 2019 (2018: AOR: 0.19, 95% CI, 0.10–0.73,  $P = 0.025$ ; 2019: AOR: 0.20, 95% CI, 0.04–0.94,  $P = 0.042$ ). The neonatal placenta in 2018 and 2019 was heavier (2018: AOR: 1.13, 95% CI, 1.11–1.15,  $P = 0.006$ ; 2019: 1.13, 95% CI, 1.11–1.15,  $P = 0.010$ ) than 2020, and larger in size than 2020 (AOR: 2.07, 95% CI, 1.04–4.12,  $P = 0.039$ , Table 4).

Similarly, the labor complications were also included in the analysis to validate the effects of home quarantine on HDP-GDM patients. After multivariate logistic regression analysis was used to control the age, parity, and gestational week, the results showed that there was a higher risk of FGR in 2020 than in 2018 and 2019, whether in multivariate analysis or after adjusting for covariates (AOR: 4.29, 95% CI, 1.01–10.49,  $P = 0.049$ , Table 4), while the prevalence of other labor complications has not noticed any difference.

## Discussion

Lockdown can effectively control rapid infectious diseases by cutting off the route of transmission and protecting susceptible people, and excellent results have been achieved during the outbreak of cholera or plague.<sup>24,25</sup> During the outbreak of COVID-19 and the recent onslaught of Delta, a more infectious mutant, local governments have been forced to adopt varying degrees and

forms of home quarantine, which effectively curbing the widespread spread of the virus. As a susceptible population to COVID-19, pregnant women are prone to develop moderate or severe disease once infected, and home quarantine has given better protection to those vulnerable groups.<sup>26,27</sup> However, home quarantine is a double-edged sword, leading to an increased risk of depression and anxiety in pregnant women.<sup>28</sup> In addition, in advance of conducting the present study, we have learned that a variety of risk factors for HDP increased significantly during home quarantine, including BMI, exercise, mental health, etc. Therefore, this study aimed to investigate the impacts of home quarantine on pregnant women and their pregnancy outcomes during the COVID-19 outbreak. Primarily, our results showed a significant increase in the incidence of HDP with a history of home quarantine, including GH, PE/E, and complicated with GDM. This is consistent with the recently reported significant increase in the incidence of various pregnancy complications, including HDP, during the blockade of the COVID-19 epidemic in Israel.<sup>29</sup> Although confirmation from a larger population cohort is still needed, we speculate that the increased prevalence of gestational hypertension caused by home quarantine may be widespread, which should capture the attention of the government, medical institutions, and pregnant women.

Studies have demonstrated that gestational weight gain and BMI after pregnancy are independent risk factors for HDP and GDM, and the risk of early-onset and late-onset HDP is progressively increased among women with the increase of the level of obesity.<sup>30</sup> More importantly, anxiety and reduced exercise may also be involved in the occurrence of HDP as independent risk factors. Pregnant women may be more likely to have anxiety and depression due to worries about working, finance, relationship, or housing problems and other problems during home quarantine. These negative emotions prompt them to overeating and eat more high-fat, high-carbohydrate, and high-energy foods.<sup>31,32</sup> Furthermore, overweight and obese patients tended to have high-calorie intake and gained weight frequently. The increased BMI was also related to less frequent consumption of vegetables, fruit, and legumes during home quarantine but higher adherence to meat, dairy, and fast foods.<sup>33</sup> Exercise habits changed during home quarantine further led to an increase in gestational weight gain and BMI after pregnancy, which was mainly characterized by reduced exercise time, a decrease in exercise intensity (PA) obviously, and a “sedentary pandemic”.<sup>34</sup> Comparatively, inactive individuals became less active and spent less time exercising, especially women during pregnancy.<sup>35</sup> Our results found that the incidence of obesity (BMI > 28) and gestational weight gain in pregnant women with HDP in 2020 was significantly higher than that in 2018 and 2019, which may be explained by the changes in living habits during home quarantine. Therefore, we speculated that the worse pregnancy outcomes of HDP patients with a history of home quarantine in 2020 than in 2018 and 2019 may be caused by the increased risk factors. However, more evidence is needed to support this inference.

Our findings verified that the DP of HDP patients in 2020 was significantly higher than that in 2018, and SP was significantly higher than that in 2019. We speculated that 1) “sedentary pandemic” and decreased exercise worsened cardiovascular function, leading to the development of HDP;<sup>16</sup> 2) Stress is one of the crucial causes of cardiovascular disease, especially hypertension, and the susceptibility of pregnant women to stress and the increased anxiety and depression significantly increased the risk and progression of HDP.<sup>36</sup> We also found higher uric acid levels in HDP patients in 2020. Studies indicated that uric acid is a risk factor for hypertension, and increased serum uric acid levels will accelerate hypertension.<sup>37</sup> In addition, uric acid is a reliable predictor of PE; high serum uric acid level may indicate an increased risk of PE and adverse fetal outcomes, such as fetal distress, FGR, and preterm or perinatal death.<sup>38,39</sup>

The weight, length, abdominal circumference, head circumference, and APGER score of newborns in 2020 were lower than in 2018 and 2019; meanwhile, the incidence of FGR increased significantly in 2020. These implied that the newborns in 2020 had worse development than in 2018 and 2019. First, GH is associated with an increased risk of adverse maternal and fetal outcomes, including preterm delivery, FGR, perinatal death, acute renal or liver failure, etc.<sup>40</sup> Moreover, excessive gestational weight gain, Obesity, and PE/E diseases will also lead to adverse maternal and fetal outcomes.<sup>10,41</sup>

In summary, our findings showed that home quarantine would increase the incidence of HDP and lead to adverse maternal and fetal outcomes in HDP patients, including worse biochemical indicators in pregnant women and worse physical condition of the fetus. These may be explained by the increase of HDP-related risk factors caused by the changes of lifestyle and mental health impairment during home quarantine. Thus, the government and the hospital should strengthen psychological counseling, exercise guidance, and dietary management for pregnant women and speed up the development of home quarantine guides.



## Limitations

Although the research clarified the impact of home quarantine on HDP patients, it has some limitations. Firstly, the sample only came from a single-center, and the sample size was relatively small. Secondly, obtaining quantitative data on diet, exercise, and mental state of HDP patients from the electronic medical records is hard.

## Ethics Approval and Consent to Participate

This study was approved by the ethics committee of the First Affiliated Hospital of Chongqing Medical University (ID: 20200501). All participants provided verbal informed consent, which was documented in an Excel file and saved with a security code. At that particular time in 2020, all hospital staff were busy doing clinical work and had no time to obtain written informed consent from all participants. In addition, the pregnant women in 2018 and 2019 included in our cohort were contacted by phone and obtained their verbal informed consent. The Ethics Committee also approved the procedure for verbal informed consent of our study. The Ethics Society of Clinical Scientific Research permitted the visiting and use of the medical records described in our study. All the procedures were performed following the ethical standards of the institutional research committee and the 1964 Helsinki declaration and its later amendments.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare that they have no conflicts of interest in this work.

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