

Preplanned Studies

Incidence and Risk Factors of Hypertensive Disorders of Pregnancy — 8 Provinces, China, 2014–2018

Wei Zhao¹; Jiangli Di^{1,*}; Aiqun Huang¹; Qi Yang¹; Huanqing Hu¹

Summary

What is already known about this topic?

As a major cause of maternal and neonatal mortality and morbidity, hypertensive disorders of pregnancy (HDP) are a global public health problem affecting maternal and children's health.

What is added by this report?

The incidence of HDP was 6.40% among 277,632 pregnant women. With the progress of pregnancy, the proportion of pregnant women with high normal blood pressure (BP) and the incidence of HDP increased gradually. The incidence of HDP increased with pregnancy age, body mass index, and BP of pregnant women during first trimester.

What are the implications for public health practice?

To reduce the incidence of HDP effectively, we should pay more attention to older women who plan to become pregnant, measures should be taken to control BP and weight in pre-pregnancy.

Hypertensive disorders of pregnancy (HDP) are a group of diseases associated with elevated blood pressure (BP). As a major cause of maternal and neonatal mortality and morbidity, HDP can trigger severe forms of maternal complications (1) and is a risk factor for hypertension (HTN) and other cardiovascular diseases after pregnancy (2), seriously affecting maternal and children's health. In China, most of the relevant literature has been focused on a small sample of individual hospitals or just one disease in HDP (3). This study is based on population monitoring data to obtain the BP level in pregnancy, the incidence of HDP in monitoring areas of China, and related influencing factors, so as to provide a

scientific basis for the development of HDP control and prevention.

Through the Maternal and Newborn Health Monitoring System* (MNHMS), a total of 277,632 single-fetus pregnant women that delivered during 2014–2018 in 16 counties of 8 provinces were monitored. The incidence of HDP was 6.40%. BP and the incidence of HDP increased with age, body mass index (BMI) and BP during the first trimester, and the gestational age. Primiparity, history of cesarean, lower education level, living in rural areas were the risk factors for HDP. Therefore, more measures should be taken to avoid advanced pregnancy and strengthen pre-pregnancy healthcare, so that pregnant women maintain their BP and weight within the normal range pre-pregnancy, which can reduce the occurrence of HDP effectively.

Data were obtained from the MNHMS set up by the National Center for Women and Children's Health (NCWCH) for Maternal and Newborn Health Monitoring Program† (MNHMP) in 2013. A total of 281,283 women (delivered between January 1, 2014 and December 31, 2018) had at least 1 record of BP during prenatal examination. Women with 2 or multiple fetuses (3,388 persons), with only 1 record but abnormal value of BP (263 persons), were excluded. Finally, the data of 277,632 registered pregnant women were analyzed in this study.

The highest value of BP readings in each antenatal examination during each trimester was documented and analyzed. According to "Diagnosis and Treatment of Hypertension and Pre-eclampsia in Pregnancy: A Clinical Practice Guideline in China (2020)" (4), "Internal Medicine (Ninth Edition)," and research needs, BP was divided into 5 categories: systolic BP (SBP) < 90 and/or diastolic BP (DBP) < 60 was low; 90 ≤

* The MNHMS was established to monitor the antenatal health care and pregnancy outcomes of pregnant women who had lived more than 6 months in the 16 districts/counties of 8 provinces. The 8 provinces (with the selected districts) are: Hebei (Xinhua and Zhengding), Liaoning (Lishan, Tiedong and Tai'an), Fujian (Haicang and Jimei), Hubei (Macheng and Luotian), Hunan (Yueyanglou and Yueyang), Guangdong (Zijin and Longchuan), Sichuan (Gongjing and Rong county), and Yunnan (Tonghai and Huaning). Among them, Macheng and Luotian in Hubei, Zijin and Longchuan in Guangdong, and Tiedong in Liaoning joined the project in 2016, and Tai'an in Liaoning withdrew in 2016.

† To ensure the quality of the information, the system set many logics checks to prevent wrong inputs. In addition, the staff of the NCWCH conducted field supervision on data accuracy every year. MNHMP was approved by the Ethics Committee of the NCWCH (No.FY2015-007).

SBP<120 and/or 60≤DBP<80 was normal; 120≤SBP<140 and/or 80≤DBP<90 was high normal; 140≤SBP<160 and/or 90≤DBP<110 was generally high; and SBP≥160 and/or DBP≥110 was severely high. The standard for HDP was at least 1 measurement of SBP≥140 mmHg and/or DBP≥90 mmHg.

The mean age of pregnant women was 28.0±4.7 years old. The mean number of antenatal examinations was 7.3±3.5 times, and the mean gestational week of delivery was 39.0±1.5 weeks. The mean max SBP during pregnancy was 120.4±11.0 mmHg, and the mean max DBP was 76.5±8.1 mmHg. The total incidence of HDP was 6.40%.

The rate of detection of HDP in first, second, and third trimester of pregnancy was 0.89%, 1.80%, and 5.62%, respectively. From the first trimester to third trimester, non-HDP pregnant women had an average increase of 11.7 mmHg in SBP and 6.8 mmHg in DBP, while HDP pregnant women had an average increase of 20.9 mmHg in SBP and 15.0 mmHg in DBP. The proportion of the low group and the normal group of SBP and DBP decreased, while the proportions of the high normal group, the generally high group, and the severely high group increased gradually. (Table 1)

There were statistically significant differences in the levels of BP and the incidence of HDP between

different provinces, ages, education levels, ethnicities, pregnancy histories, antenatal examination times, BMIs, and BPs during initial examination in first trimester and whether with gestational diabetes mellitus (GDM) ($P<0.05$). The highest age-standardized incidence of HDP was in Yunnan (8.42%), followed by in Hebei (7.99%), Liaoning (7.95%), Fujian (6.53%), Hubei (6.27%), Sichuan (5.20%), and Hunan (4.39%), and the lowest was in Guangdong (3.20%). The age-standardized incidence of HDP in ethnic minorities (7.43%) was higher than those with Han ethnicity (6.38%). Pregnant women with lower education, primiparity, history of abortion or cesarean section, and GDM had higher incidence of HDP. With an increase in age, BMI, and BP in the first trimester and the number of antenatal examinations, SBP, DBP, and the incidence of HDP increased (Table 2).

The multivariable logistic regression analysis showed that living in rural areas, older age, lower education, history of cesarean section, GDM, and high BMI in first trimester were risk factors for HDP. Taking 25–29 years old as reference, odds ratio (OR) values of 35–39 years old and over 40 years old were 1.832 and 2.650, respectively. Taking normal weight in first trimester as reference, OR values of overweight and obesity were 2.145 and 4.998, respectively (Table 3).

TABLE 1. BP levels and classification proportion in different trimesters of pregnant women — 8 provinces in China, 2014–2018 (95%CI).

Variables	N	BP (mmHg)			Classification proportion (%)				
		Total	Non HDP	HDP	Low	Normal	High normal	Generally high	Severely high
SBP									
First trimester	167,237	106.7 (106.7–106.8)	106.1 (106.0–106.2)	115.8 (115.6–116.1)	1.47 (1.41–1.53)	82.41 (82.23–82.59)	15.73 (15.56–15.90)	0.35 (0.32–0.38)	0.04 (0.03–0.05)
Second trimester	252,172	112.9 (112.9–113.0)	112.1 (112.1–112.2)	124.6 (124.4–124.8)	0.42 (0.39–0.45)	67.73 (67.55–67.91)	30.91 (30.73–31.09)	0.86 (0.82–0.90)	0.09 (0.08–0.10)
Third trimester	261,106	119.1 (119.0–119.1)	117.8 (117.8–117.8)	136.7 (136.5–136.9)	0.08 (0.07–0.09)	46.48 (46.29–46.67)	50.39 (50.20–50.58)	2.74 (2.68–2.80)	0.32 (0.30–0.34)
P value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
DBP									
First trimester	167,209	67.8 (67.8–67.9)	67.4 (67.3–67.4)	75.0 (74.8–75.2)	5.44 (5.33–5.55)	83.18 (83.00–83.36)	10.64 (10.49–10.79)	0.71 (0.67–0.75)	0.03 (0.02–0.04)
Second trimester	252,168	70.7 (70.7–70.7)	70.1 (70.0–70.1)	80.0 (79.8–80.2)	3.77 (3.70–3.84)	77.91 (77.75–78.07)	16.98 (16.83–17.13)	1.30 (1.26–1.34)	0.04 (0.03–0.05)
Third trimester	261,109	75.3 (75.3–75.3)	74.2 (74.2–74.3)	90.0 (89.9–90.1)	1.31 (1.27–1.35)	62.46 (62.27–62.65)	31.81 (31.63–31.99)	4.22 (4.14–4.30)	0.20 (0.18–0.22)
P value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

Note: Related definitions: first trimester is from the beginning of pregnancy to the end of the 12th week, second trimester is from the 13th week of pregnancy to the end of the 27th week, and third trimester is from the 28th week of pregnancy to the end of childbirth.

Classification of SBP: SBP<90 is low, 90≤SBP<120 is normal, 120≤SBP<140 is high normal, 140≤SBP<160 is generally high, SBP≥160 is severely high.

Classification of DBP: DBP<60 is low, 60≤DBP<80 is normal, 80≤DBP<90 is high normal, 90≤DBP<110 is generally high, DBP≥110 is severely high.

Abbreviations: BP=blood pressure, SBP=systolic blood pressure, DBP=diastolic blood pressure,

* the P value of linear trend test.

TABLE 2. BP levels and incidence of HDP among different factors of pregnant women in 8 provinces in China, 2014–2018 (95%CI).

Variables	N	SBP (mmHg)	DBP (mmHg)	Incidence of HDP (%)	
				Roughness	Age-standardized
Province					
Hebei	61,270	120.0(119.9–120.0)	76.8(76.8–76.9)	7.95(7.74–8.16)	7.99(7.78–8.20)
Liaoning	18,482	119.0(118.9–119.2)	77.1(77.0–77.2)	8.32(7.92–8.72)	7.95(7.56–8.34)
Fujian	56,672	124.4(124.3–124.5)	76.3(76.2–76.3)	6.53(6.33–6.73)	6.53(6.32–6.74)
Hubei	32,058	115.6(115.4–115.7)	75.1(75.0–75.2)	6.17(5.91–6.43)	6.27(6.00–6.54)
Hunan	40,122	120.1(120.0–120.2)	75.9(75.8–75.9)	4.47(4.27–4.67)	4.39(4.19–4.59)
Guangdong	21,771	121.2(121.0–121.3)	74.6(74.5–74.7)	3.27(3.03–3.51)	3.20(2.97–3.43)
Sichuan	21,835	119.2(119.0–119.3)	76.9(76.8–77.0)	5.13(4.84–5.42)	5.20(4.90–5.50)
Yunnan	25,422	120.5(120.3–120.6)	79.7(79.6–79.8)	8.05(7.72–8.38)	8.42(8.08–8.76)
<i>P</i> value		<0.001	<0.001		<0.001
Area type					
Urban	136,832	121.5(121.5–121.6)	76.4(76.3–76.4)	6.52(6.39–6.65)	6.42(6.29–6.55)
Rural	140,800	119.3(119.2–119.3)	76.6(76.5–76.6)	6.28(6.15–6.41)	6.38(6.25–6.51)
<i>P</i> value		<0.001	<0.001		0.675
Age of pregnancy (y)					
≤19	5,598	118.7(118.4–119.0)	75.6(75.4–75.8)	4.50(3.96–5.04)	–
20–24	56,228	119.8(119.7–119.9)	76.3(76.2–76.3)	5.45(5.26–5.64)	–
25–29	124,225	120.1(120.0–120.1)	76.3(76.3–76.4)	5.87(5.74–6.00)	–
30–34	63,191	120.9(120.8–121.0)	76.6(76.6–76.7)	6.93(6.73–7.13)	–
35–39	22,649	122.0(121.8–122.1)	77.3(77.2–77.4)	9.29(8.91–9.67)	–
≥40	4,417	123.8(123.4–124.2)	78.5(78.3–78.8)	13.06(12.07–14.05)	–
<i>P</i> value		<0.001*	<0.001*	<0.001*	–
Education level					
Junior high school or lower	94,482	120.5(120.4–120.5)	76.8(76.7–76.8)	6.83(6.67–6.99)	6.83(6.67–6.99)
Senior high	79,642	119.7(119.6–119.7)	76.4(76.3–76.4)	6.20(6.03–6.37)	6.30(6.13–6.47)
University or above	89,357	121.1(121.0–121.2)	76.4(76.3–76.4)	6.05(5.89–6.21)	5.96(5.80–6.12)
<i>P</i> value		<0.001	<0.001		<0.001*
Ethnicity					
Han	260,306	120.3(120.3–120.4)	76.5(76.4–76.5)	6.39(6.30–6.48)	6.38(6.29–6.47)
Others	8,011	119.7(119.5–119.9)	78.2(78.0–78.3)	7.05(6.49–7.61)	7.43(6.85–8.01)
<i>P</i> value		<0.001	<0.001		<0.001
Parity					
0	148,878	120.1(120.0–120.1)	76.6(76.6–76.7)	6.60(6.47–6.73)	7.05(6.92–7.18)
≥1	120,059	120.9(120.9–121.0)	76.4(76.4–76.4)	6.37(6.23–6.51)	5.81(5.68–5.94)
<i>P</i> value		<0.001	<0.001		<0.001
History of cesarean section					
No	223,153	120.3(120.3–120.3)	76.4(76.4–76.5)	6.27(6.17–6.37)	6.37(6.27–6.47)
Yes	45,787	121.2(121.1–121.3)	76.9(76.9–77.0)	7.57(7.33–7.81)	6.96(6.73–7.19)
<i>P</i> value		<0.001	<0.001		<0.001

TABLE 2. (Continued)

Variables	N	SBP (mmHg)	DBP (mmHg)	Incidence of HDP (%)	
				Roughness	Age-standardized
History of abortion					
No	136,853	121.0(120.9–121.0)	76.7(76.7–76.7)	6.36(6.23–6.49)	6.53(6.40–6.66)
Yes	79,257	120.8(120.7–120.9)	77.0(77.0–77.1)	7.12(6.94–7.30)	6.75(6.57–6.93)
<i>P</i> value		<0.001	<0.001		0.049
GDM					
No	128,533	121.3(121.3–121.4)	76.6(76.5–76.6)	6.29(6.16–6.42)	6.18(6.05–6.31)
Yes	6,930	126.1(125.9–126.4)	78.4(78.2–78.6)	10.29(9.57–11.01)	9.73(9.03–10.43)
Unchecked	142,169	119.3(119.2–119.3)	76.3(76.3–76.4)	6.30(6.17–6.43)	6.46(6.33–6.59)
<i>P</i> value		<0.001	<0.001		<0.001
BMI in first trimester (kg/m ²)					
Lean	25,772	118.4(118.3–118.6)	75.3(75.2–75.4)	3.29(3.07–3.51)	3.36(3.14–3.58)
Normal	108,384	120.1(120.1–120.2)	76.3(76.3–76.4)	4.87(4.74–5.00)	4.87(4.74–5.00)
Overweight	24,151	124.0(123.8–124.1)	79.4(79.3–79.5)	10.89(10.50–11.28)	10.61(10.22–11.00)
Obesity	7,096	127.8(127.5–128.0)	82.9(82.7–83.1)	22.82(21.84–23.80)	22.45(21.48–23.42)
Unchecked	112,229	119.9(119.8–119.9)	75.9(75.8–75.9)	6.57(6.43–6.71)	6.57(6.42–6.72)
<i>P</i> value		<0.001*	<0.001*		<0.001*
BP in first trimester					
Low	11,056	116.8(116.6–117.0)	72.0(71.8–72.1)	2.17(1.90–2.44)	2.17(1.90–2.44)
Normal	124,036	119.2(119.2–119.3)	76.0(75.9–76.0)	4.10(3.99–4.21)	4.12(4.01–4.23)
High normal	29,850	127.6(127.5–127.7)	81.8(81.8–81.9)	12.77(12.39–13.15)	12.58(12.20–12.96)
High	1,308	141.3(140.5–142.1)	94.9(94.4–95.4)	100	100
Unchecked	111,382	119.9(119.8–120.0)	75.9(75.8–75.9)	6.56(6.41–6.71)	6.55(6.40–6.70)
<i>P</i> value		<0.001*	<0.001*		<0.001*
Number of antenatal examinations					
1–3	36,067	114.0(113.9–114.1)	71.7(71.6–71.7)	3.30(3.12–3.48)	3.27(3.09–3.45)
4–6	91,579	118.8(118.8–118.9)	75.8(75.7–75.8)	5.12(4.98–5.26)	5.12(4.98–5.26)
7–9	73,980	122.0(121.9–122.0)	77.5(77.5–77.6)	7.60(7.41–7.79)	7.54(7.35–7.73)
≥10	76,006	123.8(123.7–123.9)	78.7(78.6–78.7)	8.23(8.03–8.43)	8.30(8.10–8.50)
<i>P</i> value		<0.001*	<0.001*		<0.001*

Note: first trimester is from the beginning of pregnancy to the end of the 12th week; “-” means the variable needn't to be age-standardized. Classification of BMI: $18.5 \leq \text{BMI} < 24 \text{ kg/m}^2$ is normal, $\text{BMI} < 18.5 \text{ kg/m}^2$ is lean, $24 \leq \text{BMI} < 28 \text{ kg/m}^2$ is overweight, $\text{BMI} \geq 28 \text{ kg/m}^2$ is obesity. Abbreviations: BP=blood pressure, HDP=hypertensive disorders of pregnancy, SBP=systolic blood pressure, DBP=diastolic blood pressure, GDM=gestational diabetes mellitus, BMI=body mass index.

* the *P* value of linear trend test.

TABLE 3. Multivariate logistic regression model for HDP — 8 provinces in China, 2014–2018.

Variables	β	S.E.	Wald χ^2	<i>P</i> value	OR	95%CI
Province						
Hunan					Ref	
Hebei	0.356	0.035	105.215	<0.001	1.428	1.334–1.528
Liaoning	0.181	0.043	17.820	<0.001	1.198	1.102–1.303
Fujian	0.153	0.039	15.633	<0.001	1.166	1.080–1.257
Hubei	0.271	0.042	41.107	<0.001	1.311	1.207–1.424
Guangdong	-0.405	0.051	64.011	<0.001	0.667	0.604–0.737

TABLE 3. (Continued)

Variables	β	S.E.	Wald χ^2	P value	OR	95%CI
Sichuan	-0.224	0.044	25.727	<0.001	0.799	0.733–0.872
Yunnan	-0.002	0.041	0.003	0.953	0.998	0.920–1.082
Areas						
Urban					Ref	
Rural	0.220	0.023	88.876	<0.001	1.246	1.190–1.304
Age of pregnancy (y)						
≤19	-0.392	0.071	30.714	<0.001	0.676	0.588–0.776
20–24	-0.136	0.024	31.356	<0.001	0.873	0.833–0.916
25–29					Ref	
30–34	0.226	0.022	110.058	<0.001	1.253	1.202–1.307
35–39	0.606	0.028	455.792	<0.001	1.832	1.733–1.937
≥40	0.975	0.050	373.888	<0.001	2.650	2.401–2.925
Education						
Junior high school or lower	0.135	0.021	41.739	<0.001	1.144	1.098–1.192
Senior high					Ref	
University or above	-0.237	0.023	109.753	<0.001	0.789	0.755–0.825
Parity						
0					Ref	
≥1	-0.432	0.023	350.459	<0.001	0.649	0.620–0.679
History of cesarean section						
No					Ref	
Yes	0.130	0.025	26.108	<0.001	1.139	1.083–1.197
GDM						
No					Ref	
Yes	0.307	0.044	48.353	<0.001	1.359	1.247–1.482
Unchecked	-0.026	0.018	2.006	0.157	0.974	0.939–1.010
BMI in first trimester (kg/m ²)						
Lean	-0.365	0.039	85.992	<0.001	0.694	0.643–0.750
Normal					Ref	
Overweight	0.763	0.026	838.535	<0.001	2.145	2.037–2.258
Obesity	1.609	0.034	2285.146	<0.001	4.998	4.679–5.339
Unchecked	0.451	0.021	459.159	<0.001	1.571	1.507–1.637
Number of antenatal examinations						
1–3	-0.569	0.035	261.247	<0.001	0.566	0.528–0.606
4–6					Ref	
7–9	0.382	0.023	278.406	<0.001	1.465	1.401–1.533
≥10	0.621	0.026	589.2	<0.001	1.861	1.770–1.957

Note: first trimester is from the beginning of pregnancy to the end of the 12th week.

Classification of BMI: $18.5 \leq \text{BMI} < 24 \text{ kg/m}^2$ is normal, $\text{BMI} < 18.5 \text{ kg/m}^2$ is lean, $24 \leq \text{BMI} < 28 \text{ kg/m}^2$ is overweight, $\text{BMI} \geq 28 \text{ kg/m}^2$ is obesity.

Abbreviations: BP=blood pressure, HDP=hypertensive disorders of pregnancy, GDM=gestational diabetes mellitus, BMI=body mass index, β =regression coefficient, S.E.=standard error, OR=odds ratio, CI=confidence interval.

DISCUSSION

The increase of BP in normal ranges during

pregnancy may be an adaptive physiological response. However, excess increase in BP would lead to HDP and endanger maternal and infant health. This study

showed that with the progress of pregnancy, SBP and DBP increased gradually in HDP pregnant women or non-HDP pregnant women, and the proportion of pregnant women with high normal BP and the incidence of HDP were also increased, which is consistent with a previous study (5). However, some studies believed that BP was lowest in the second trimester, then rose in the third trimester (6–7). A study by Wang et al. (8) showed that the SBP/DBP of 18–24 and 25–34-year-old was 117.4/71.4 mmHg and 118.9/73.2 mmHg, respectively, and the corresponding prevalence of HTN was 4.0% and 6.1%, respectively. In this study, the SBP/DBP of pregnant women under 24 years old and 25–34 years old was 119.7/76.2 mmHg and 120.3/76.4 mmHg, respectively, and the incidence of HDP was 5.45% and 6.23%, respectively, which were higher than the BP level and the prevalence of HTN in the total women population of the same age group in the above study. Therefore, we should pay more attention to control BP when women become pregnant.

Many studies have shown that the incidence of HDP in different countries was 5%–10% (1,9–10). The incidence of HDP was 6.40% in this study. This is consistent with a cross-sectional survey conducted by Ye et al. in 2011 based on about 110,000 Chinese people, in which the prevalence of HDP in China was 5.22% (3). In this study, the age-standardized incidence of HDP was highest in Yunnan, followed by Hebei, Liaoning, Fujian, Hubei, and Sichuan, and lowest in Hunan and Guangdong, part of which were consistent with the Ye et al. study on HDP (3) and the Wang et al. study on HTN (8). This indicated that regional differences were important factors affecting HDP.

This study concluded that the incidence of HDP increased with age, BP, and BMI in the first trimester. The age-standardized incidence of HDP with high normal BP in the first trimester (12.58%) was about 3 times higher than that with normal BP (4.12%). Compared with pregnant women aged 25–29 years old, the risk of HDP was nearly doubled over 35 years old (OR=1.832) and increased up to 2.7 times over 40 years old (OR=2.650). Taking pregnant women with normal weight in first trimester as reference, pregnant women with overweight had a doubled risk for HDP (OR=2.145) and with obesity increased the risk up to 5 times (OR=4.998), which were similar to the results of several related studies (3,8,10). Another important finding of this study was that, although the incidence of HDP in urban areas had no difference with that in

rural areas, rural areas became a risk factor in multivariable analysis. Lower education was a risk factor for HDP, which was similar to some of the results of related studies (3,8). This may be related to pregnant women living in rural areas or with lower education having lower levels of pregnancy health knowledge and more unhealthy behavior.

In conclusion, although BP during pregnancy increases are expected, important risk factors for the occurrence of HDP include area types (rural or urban residence), maternal age, early pregnancy weight, and BP. Therefore, we should pay more attention to high-risk groups, especially to older women who plan to become pregnant, and strengthen pre-pregnancy healthcare so that more pregnant women can maintain their BP and weight within normal ranges before pregnancy, thereby reducing the occurrence of HDP effectively.

One of the strengths of this study is using the BP data from individual clinical data of pregnant women in all midwifery institutions in the monitoring areas during 2014–2018, thereby reducing the time bias and institution selection bias. However, this study was subject to some limitations. First, the monitoring area was limited to 16 counties/districts in 8 provinces, so the results might not be representative of the regional and national levels. Second, due to the limited data, BP and weight before pregnancy, history of HTN, smoking and drinking, family history, and other pregnancy complications with a high rate of being missing from the data were not included as influencing factors, so it was impossible to further analyze the incidence of each group of HDP diseases.

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Corresponding author: Jiangli Di, dijiangli@chinawch.org.cn.

¹ National Center for Women and Children's Health, Chinese Center for Disease Control and Prevention, Beijing, China.

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