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Biological and sociocultural determinants of increased blood pressure among women with a history of gestational diabetes mellitus in rural China: a retrospective cohort study

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ABSTRACT

Objectives Gestational diabetes mellitus (GDM) increases the risk of hypertension and cardiovascular events among mothers later in life. This risk has not been well recognised by healthcare professionals in rural China. Our objectives were to (1) describe the proportion of rural women with increased blood pressure and a history of GDM; and (2) explore the biological and sociocultural factors associated with increased blood pressure.

Design A retrospective cohort study using data from a cross-sectional survey.

Setting Data were collected in two county-level hospitals in the central south of China between November 2017 and June 2018.

Participants Postpartum women aged >18 years with a history of GDM (N=397).

Methods Biological and sociocultural variables were examined. We used bivariate analyses to examine the associations between time since delivery and 2-hour postload glucose, and logistic regression to determine the biological and sociocultural factors associated with increased postpartum blood pressure.

Results Approximately 20% (n=78) of women had increased blood pressure, defined as a systolic blood pressure ≥130 mm Hg and/or a diastolic blood pressure ≥85 mm Hg. The biological factors of advanced age, family history of hypertension and abnormal 2-hour postload plasma glucose levels were positively associated with increased blood pressure (p<0.05). General self-efficacy was the only sociocultural factor negatively associated with increased blood pressure (p<0.05).

Conclusions One in five rural Chinese postpartum women with a history of GDM were found to have increased blood pressure. Biological and sociocultural factors were associated with increased postpartum blood pressure; women with lower general self-efficacy were more likely to have increased blood pressure. Disseminating knowledge about the high risk of developing increased blood pressure among women with prior GDM in rural China is indicated. Diabetes prevention programmes could consider adding general self-efficacy promotion strategies in this population.

Strengths and limitations of this study

- This study explored the determinants of increased blood pressure in rural Chinese women with a history of gestational diabetes mellitus using a biological and sociocultural framework.
- Biological (eg, age, family history of hypertension and 2-hour postload plasma glucose levels) and sociocultural (eg, general self-efficacy) factors and their association with increased postpartum blood pressure were examined.
- International guidelines were used as references for variable cut-offs (eg, blood pressure, body mass index, waist circumference), which will allow for future knowledge syntheses and meta-analyses.
- The use of a one-time blood pressure measure is likely to have increased random error and reduced the power of our regression analyses.
- This retrospective cohort study used data from an established database and this means that additional risk factor variables not captured in the database (eg, high blood pressure before pregnancy) were not fully explored.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a glucose intolerance causing hyperglycaemia with onset or first recognition during pregnancy.[1] The prevalence of GDM varies across countries, with a reported prevalence of 20% in Vietnam and Singapore,[2] 11.1% in China,[3] and 7.6% in the USA.[4] Overall, the prevalence of GDM has been increasing worldwide,[5] which significantly increases the risk of adverse pregnancy and birth outcomes.[6]

GDM also increases the long-term risk of type 2 diabetes mellitus (T2DM) and cardiovascular disease of mothers later in life.[7] The risk of developing T2DM is over seven times higher in women with a history of GDM compared with women without a history of

GDM.[8] The risk of developing hypertension has been reported to be two times higher in the UK[9] and Canada[10] and 2.54%–14.9% higher among women with a history of GDM in Western countries.[9–12] Two studies from large urban cities in China reported hypertension rates after delivery in women with a history of GDM of 19.7% and 16.7%, which are five to eight times higher than of women without GDM (4.4% and 1.7%).[13 14] Hypertension rates in Chinese women living in urban centres are higher than that of Western countries. Moreover, large rural–urban gaps in income, education, health resources, and minority and majority groups in China[15] suggest more evidence focusing on equity, diversity and inclusion is needed.

Hyperglycaemia and insulin resistance accelerate atherogenesis, which increases the risk of hypertension.[16] Hypertension is one of the main risk factors of cardiovascular disease.[17] Globally, 40% of individuals aged 25 years and older have hypertension.[18] High normal blood pressure, an important predictor of hypertension,[19] is defined as a systolic blood pressure (SBP) of 130–139 mm Hg and/or a diastolic blood pressure (DBP) of 85–89 mm Hg.[20] In the USA, approximately 53% of individuals aged 65–94 years with high normal blood pressure developed hypertension within 4 years.[21] There is an urgent need to obtain data on increased blood pressure rates among rural women with a history of GDM in China.

Hypertension prevention is a global concern.[22] Identifying the factors that increase blood pressure after delivery is a preliminary step towards designing prevention programmes. The biological and sociocultural framework emphasises the collective impact and influence of biological/genetic factors as well as healthy social environmental factors on health outcomes and conditions.[23] Cardiovascular health, as one of the most common health conditions, is influenced by both biological and sociocultural factors.[24] Several biological risk factors (eg, ethnicity, age) contribute to risk of hypertension in women with GDM. For example, Hispanic women with a history of GDM have an increased risk of hypertension compared with white women,[25] and in Taiwan women at advanced age have a higher risk of hypertension compared with younger women with a history of GDM.[26] Obesity is another important biological factor that increases the risk of cardiovascular disease and related conditions.[27] Women with a history of GDM are more likely to be obese compared with women with normal glycaemic status during pregnancy.[28] Obesity-related variables (eg, body mass index (BMI), waist circumference) are also associated with hypertension.[29] BMI is inversely associated with high-density lipoprotein cholesterol, and low high-density lipoprotein levels increase the risk of hypertension.[30]

Sociocultural factors (eg, health behaviours) are closely related to the development of hypertension.[31] There is evidence supporting daily physical activity reduces the risk of hypertension among women.[32] Women in rural China rarely have time to do enough daily physical activity due to housework responsibilities, as well as the responsibilities of taking care of children and senior family members.[33] Diet is an important component of guidelines for antihypertensive therapy in America and Europe.[34–36] Low fruit and vegetable consumption is associated with increased blood pressure.[37] With the improvement of the economy and social life in China, the consumption of animal foods and oil/fat has increased,[38 39] leading to an increased risk of developing hypertension among the general population. However, the impact of physical activity and diet on increased blood pressure in rural Chinese women with a history of GDM has rarely been reported.

Psychosocial factors (eg, perceived stress) also impact the development of hypertension in women.[40] Perceived stress refers to the degree to which people perceive that they cannot meet their needs.[41] Work-related issues present challenges in balancing career and family responsibilities—issues which often disproportionately increase women's mental stress.[42] General self-efficacy is a person's confidence in achieving self-management and behavioural change.[43] Health behaviours (eg, healthy dietary habits and physical activity) can be improved by increasing general self-efficacy among women with a history of GDM.[44] However, the contribution of general self-efficacy and perceived stress to increased blood pressure among women with a history of GDM is not well documented.

To our knowledge, the long-term risk of hypertension and cardiovascular events later in life in women with a history of GDM has not been well recognised by healthcare professionals in China. There are very few studies exploring the factors associated with increased blood pressure in these women from both biological and sociocultural perspectives. The objectives of this study were to (1) describe the proportion of rural women with increased blood pressure and a history of history of GDM; and (2) explore the biological factors (eg, age, ethnicity, family history of hypertension, time since delivery, obesity-related factors (BMI and waist circumference) and blood glucose (fasting blood glucose (FBG) and 2-hour post-load plasma glucose (2hPG)) and sociocultural factors (eg, education, occupation, income, health behaviours (physical activity, vegetable and fruit intake, and sedentary time) and psychosocial factors (stress and general self-efficacy)) associated with increased blood pressure.

METHODS

Study design and participants

This study was a retrospective cohort study using data from a cross-sectional survey aimed to describe the levels and risk factors for postpartum abnormal glucose tolerance.[45] The inclusion criteria included women (1) diagnosed with GDM during the last pregnancy, (2) aged >18 years, (3) >6-week postpartum period, (4) available by telephone and (5) able to speak Chinese. The exclusion criteria included women who were (1) pregnant, (2) diagnosed with abnormal glucose tolerance (eg, impaired fasting glucose, impaired glucose tolerance or diabetes)

before pregnancy or after delivery, (3) previously diagnosed with hypertension or had pre-existing obstetric-related hypertension (eg, pre-eclampsia, eclampsia or gestational hypertension), (4) with physical or cognitive disabilities, (5) currently prescribed antihypertensive medication, (6) diagnosed with addictive drug abuse (eg, morphine or cocaine), and (7) showing severe psychiatric disorder.

Data collection

Participants were recruited from two county-level hospitals (Youxian and Zhangjiajie) in Hunan Province, China, between November 2017 and June 2018. Potential participants were identified through a review of the medical records of women who had given birth at the research sites. A local physician or nurse called potential participants who met the inclusion criteria to explain the purpose of the study and determine their willingness to participate. The objectives of the study and confidentiality principles were detailed according to standard operating procedures. Informed consent was obtained before the survey was administered. The research assistant checked all surveys immediately after completion in an attempt to reduce missingness of data due to skipped questions. Blood pressure, anthropometric variables (eg, height, weight, waist circumference) and blood glucose measurements were obtained by nurses.

Measurements

Blood pressures were measured on-site by registered nurses after a 12-hour fasting period using an electronic blood pressure monitor (HEM-7120; Omron, Tokyo, Japan) and the criteria recommended by the Chinese Hypertension League/National Center.[46] Blood pressures were divided into two categories according to the criteria of the European Society of Cardiology and the European Society of Hypertension as follows: (1) normal blood pressure (SBP <130 mm Hg and DBP <85 mm Hg) and (2) increased blood pressure (high normal blood pressure: SBP ≥130 mm Hg and/or DBP ≥85 mm Hg; hypertension: SBP ≥140 mm Hg and/or DBP ≥90 mm Hg).[20] Mean blood pressure (MBP) was calculated from SBP and DBP according to the following formula: MBP=1/3×(SBP−DBP)+DBP.

Partial biological (eg, age, ethnicity, family history of hypertension and time since delivery) and sociocultural (eg, education, occupation and monthly family income) data were collected via a self-reported survey. Ethnicity was categorised as Han or minority. Time since delivery was classified into ≤12 months and >12 months based on a meta-analysis suggesting that 12 months post partum is an important period for discerning risk of cardiovascular disease among women with a history of GDM.[47] Education was categorised as junior high school and below (<12 years of schooling) and senior high school and above (≥12 years of schooling). Occupation status was categorised as employed or unemployed. Poverty was defined using the current poverty line in China, which is based on a monthly family income of less than $145.[48] Monthly family income was then divided into <$145 and ≥$145.

Biological variables also included obesity-related factors (eg, BMI, waist circumference) and blood glucose. BMI was calculated as weight in kilograms divided by height in metres squared and categorised into two levels based on the guidelines for the prevention and control of overweight and obesity in Chinese adults: underweight or normal (<24 kg/m^2) and overweight or obese (≥24 kg/m^2).[49] According to the criteria of the International Diabetes Federation[50] and the National Institute for Health and Care Excellence,[32] waist circumference was divided into normal (<80 cm) and central obesity (≥80 cm). Blood glucose included FBG and 2hPG. After overnight fasting, venous blood samples were collected to measure the FBG. For 2hPG, blood samples were collected after fasting for 12 hours followed by blood samples taken 2 hours after consumption of 75 g of glucose. The hexokinase enzyme method was used to measure blood glucose.

Sociocultural variables included health behaviours (eg, physical activity, vegetable and fruit intake, sedentary time) and psychosocial factors (stress, general self-efficacy). Physical activity was measured using the Chinese version of the Canadian Diabetes Risk Questionnaire, which was developed by Robinson *et al*[51] and revised and translated to Chinese by Guo *et al*[52]: 'Do you engage in regular physical activity, such as brisk walking for at least 30 minutes each day?' Daily vegetable and fruit intake was measured by the following item: 'Do you eat vegetables or fruits every day?' The Chinese Diabetes Risk Questionnaire has good reliability and validity.[52]Sedentary time was measured using the following item of the Short-Form of the International Physical Activity Questionnaire (IPAQ-S) (Chinese version)[53]: 'How much time did you usually spend sitting?' The IPAQ-S has an intraclass correlation coefficient greater than 0.70. Stress was measured using the Perceived Stress Scale, which was designed to assess the level of stress in everyday life.[54] This 14-item scale was revised and translated to Chinese,[55] and total scores range from 0 to 56, with a score >26 representing higher level of stress.[55] This scale has good internal consistency reliability with Cronbach's α coefficient reported at 0.78.[55]

General self-efficacy was measured using the 10-item General Self-Efficacy Scale (Chinese version).[56] Higher scores represent greater general self-efficacy, with scores ranging from 10 to 40, and the internal consistency is reported at 0.87.[56]

Data analysis

Data analyses were performed using IBM SPSS Statistics V.23. Descriptive statistics were used to describe the sample. The associations between biological and sociocultural variables and increased blood pressure were determined by one-way analysis of variance (ANOVA) and χ^2 test. Multivariate logistic regression (ENTER) was used to identify factors influencing increased blood pressure . The multivariate logistic regression model included

variables that obtained values of p<0.05 in the bivariate analysis (one-way ANOVA or χ^2) and variables identified in existing literature (eg, ethnicity, obesity-related variables, FBG, education, income, occupation, stress and lifestyle behaviours). A two-sided p<0.05 was used to establish statistical significance, and the results were expressed as OR with 95% CI.

Patient and public involvement

Patients were not involved in developing the research questions, outcome measurements or design of the study. The findings of this retrospective cohort study will not be directly disseminated to study participants.

RESULTS

A total of 397 women were included in this study. Since this was a retrospective cohort study, a post-hoc power analysis was used to determine an adequate sample size to detect statistical differences in the logistic regression. Assuming an α of 0.05, a base prevalence of 0.20 and R-squared with other predictors of 0.50, a two-tailed test of the null hypothesis with an OR of 1.0 for a given predictor against an alternative OR of 1.70 has a power of 0.83 in a logistic regression, with N=397 (G*Power V.3.1).

Distribution of blood pressure among rural women with a history of GDM

Approximately 20% (n=78) of women had increased blood pressure, with 30.7% (n=24) having hypertension and 69.3% (n=54) having high normal blood pressure. The MBP of women with hypertension and high normal blood pressure was 108.25 mm Hg (SD 6.78) and 96.85 mm Hg (SD 4.76), respectively. Of the 397 participants, 80.3% (n=319) had normal blood pressure. The mean SBP of high normal blood pressure was 129.11 mm Hg (SD 6.46) and the mean DBP was 80.72 mm Hg (SD 7.91) (table 1).

Biological characteristics of rural women with a history of GDM

The participants' mean age was 32.27 years (SD 5.2), ranging from 20 to 47 years. Almost half of the participants (n=182, 45.8%) were of minority ethnicity and one-third (n=137, 33.2%) had a family history of hypertension. The mean time since delivery was 15.50 months (SD 12.46). Almost half (n=182, 45.8%) of the participants were overweight or obese (≥24.0 kg/m^2) and the mean BMI was 23.85 kg/m^2 (SD 3.65). The mean waist circumference was 80.33 cm (SD 8.50) and over half of the participants (n=208, 52.4%) had central obesity (>80 cm). The mean FBG level was 5.35 mmol/L (SD 1.28), with 10.9% of the participants exhibiting FBG levels greater than 6.1 mmol/L. The mean 2hPG was 6.55 mmol/L (SD 2.69), with 15.1% (n=60) of the participants having glucose intolerance defined as 2hPG >7.8 mmol/L (table 2).

Sociocultural characteristics of rural women with a history of GDM

Of the 397 participants, 76.3% (n=303) had completed more than 12 years of education and 97.0% (n=385) had a monthly family income above the Chinese poverty threshold (ie, ≥$145/month). Approximately 36.5% (n=145) of women were unemployed. More than two-thirds (n=267, 67.3%) of the participants engaged in physical activity for less than 30 min a day, most (n=320, 80.6%) did not consume fruit or vegetables every day, and more than two-thirds (n=279, 70.2%) of participants reported a sedentary time of less than 6 hours every day. The mean perceived stress score was 23.93 (SD 6.40), with a range of 1–39. Of the 397 participants, 37.8% reported high stress levels. The mean score for general self-efficacy was 25.81 (SD 5.89), with a range of 10–40. The details of participants' sociocultural characteristics are displayed in table 2.

Bivariate analysis of biological and sociocultural factors and increased blood pressure among rural women with a history of GDM

Women with increased blood pressure were older than women with normal blood pressure (p=0.003). Compared with women without a family history of hypertension, women with a family history of hypertension had higher rates of increased blood pressure (p=0.001) and women with high 2hPG values had higher rates of increased blood pressure compared with women with normal 2hPG values (p<0.001). There were no statistically significant differences in blood pressure related to ethnicity, time since delivery, obesity-related variables (eg, BMI, waist circumference) and FBG between the participants (p>0.05). Bivariate analysis of sociocultural variables indicated that women reporting lower general self-efficacy had higher rates of increased blood pressure (p=0.010). There were no significant associations between blood pressure and

Table 1 Distribution of blood pressure among rural women with a history of gestational diabetes mellitus

	Normal (mean±SD)		High normal (mean±SD)		Hypertension (mean±SD)	
Time since delivery	SBP	DBP	SBP	DBP	SBP	DBP
≤12 months	112.74±7.96	71.32±7.41	129.64±6.78	81.06±8.16	138.21±12.03	90.00±6.34
>12 months	110.81±8.80	71.15±7.90	128.39±6.07	80.26±7.73	140.70±10.41	96.60±7.76
Total	112.29±8.38	71.24±7.64	129.11±6.46	80.72±7.91	139.25±11.22	92.75±7.57

DBP, diastolic blood pressure; SBP, systolic blood pressure.

Table 2 Biological and sociocultural characteristics of rural women with a history of gestational diabetes mellitus according to blood pressure (N=397)

Variables	Total, n (%)	Normal, n=319	High normal and Hypertension, n=78	X^2/t	P value
Biological characteristics					
Age, mean (SD)		31.83 (4.93)	34.05 (5.98)	−3.038	0.003
Ethnicity				1.455	0.228
Minority	182 (45.8)	151 (83.0)	31 (17.0)		
Han	215 (54.2)	168 (78.1)	47 (21.9)		
Family history of hypertension				10.307	0.001
Yes	137 (33.2)	98 (71.5)	39 (28.5)		
No	260 (66.3)	221 (85.0)	39 (15.0)		
Time since delivery				0.992	0.192
≤12 months	209 (52.6)	164 (78.4)	45 (21.6)		
>12 months	188 (47.4)	155 (82.4)	33 (17.6)		
BMI				1.156	0.282
Underweight or normal	215 (54.2)	177 (82.3)	38 (17.7)		
Overweight or obese	182 (45.8)	142 (78.0)	40 (22.0)		
Waist circumference				1.093	0.296
Normal	189 (47.6)	156 (82.5)	34 (17.5)		
Obese	208 (52.4)	163 (78.4)	47 (21.6)		
FBG				1.076	0.300
<6.1	354 (89.1)	287 (81.1)	67 (18.9)		
≥6.1	43 (10.9)	32 (74.4)	11 (25.6)		
2hPG				12.969	0.000
<7.8	337 (84.9)	281 (83.3)	56 (16.7)		
≥7.8	60 (15.1)	38 (63.3)	22 (36.7)		
Sociocultural characteristics					
Education				3.675	0.054
Junior high school and below	94 (23.7)	68 (72.3)	26 (27.7)		
Senior high school and above	303 (76.3)	251 (82.8)	52 (17.2)		
Occupation				0.016	0.898
Employed	252 (63.5)	202 (80.1)	50 (19.9)		
Unemployed	145 (36.5)	117 (80.7)	28 (19.3)		
Monthly family income				0.225	0.636
<$145	12 (3.0)	9 (75)	3 (25)		
≥$145	385 (97.0)	310 (80.5)	75 (19.5)		
Regular physical activity				0.909	0.340
Yes	130 (32.9)	108 (83.1)	22 (16.9)		
No	267 (67.3)	211 (79.0)	56 (21.0)		
Daily vegetable and fruit intake				0.999	0.318
Yes	77 (19.4)	65 (84.4)	12 (15.6)		
No	320 (80.6)	254 (79.4)	66 (20.6)		
Sedentary time				1.772	0.183
<6 hours	279 (70.2)	229 (82.1)	50 (17.9)		
≥6 hours	118 (29.7)	90 (76.3)	28 (23.7)		
General self-efficacy	25.81 (5.89)	26.19 (5.85)	24.27 (5.83)	2.601	0.010
Perceived stress	23.93 (6.40)	23.72 (6.67)	24.66 (5.11)	−1.532	0.128

BMI, body mass index; FBG, fasting blood glucose; 2hPG, 2-hour postload plasma glucose.

Table 3 Relationship between time since delivery and 2hPG among rural women with a history of gestational diabetes mellitus

	2hPG, n (%)				
Time since delivery	Total	<7.8 mmol/L	≥7.8 mmol/L	X^2	P value
≤12 months	209 (52.6)	172 (82.3)	37 (17.7)	0.160	0.084
>12 months	188 (47.4)	165 (87.8)	23 (12.2)		

2hPG, 2-hour postload plasma glucose.

other sociocultural variables (eg, education, income, occupation, health behaviours (physical activity, fruit and vegetable intake, sedentary time) and perceived stress) (p>0.05) (table 2).

Bivariate analysis of time since delivery and 2hPG among rural women with a history of GDM

There were no significant associations between time since delivery and 2hPG among rural women with a history of GDM (p>0.05) (table 3).

Logistic regression of increased blood pressure among rural women with a history of GDM

Women at advanced age and those with a family history of hypertension were more likely to develop high blood pressure (OR: 1.070, 95% CI 1.015 to 1.128 and OR: 1.947, 95% CI 1.136 to 3.336, respectively; p<0.05). Similarly, women with abnormal 2hPG values had greater risk of developing increased blood pressure (OR: 2.055, 95% CI 1.061 to 3.982; p<0.05). Moreover, general self-efficacy was negatively associated with increased blood pressure (OR: 0.946, 95% CI 0.900 to 0.955; p<0.05). The results of the logistic regression analyses are displayed in table 4.

DISCUSSION

This retrospective cohort study obtained several key findings. First, the prevalence of increased blood pressure among rural Chinese women with a history of GDM was approximately 20% at 15.5 months after delivery. Second, both biological and sociocultural factors (eg, age, family history of hypertension, low general self-efficacy) were associated with increased blood pressure. Surprisingly, obesity indicators (eg, BMI, waist circumference) were not significantly related to increased blood pressure, although women with high 2hPG values had higher rates of increased blood pressure compared with women with normal 2hPG values.

The proportion of women with increased blood pressure was approximately 20%, which is similar to the proportion of women with hypertension and a history of

Table 4 Logistic regression of blood pressure among rural women with a history of gestational diabetes mellitus

Variables	OR	CI	P value
Biological			
Age (years)	1.070	1.015 to 1.128	0.012
Ethnicity (vs Han)	0.792	0.447 to 1.401	0.422
Family history of hypertension (vs no)	1.947	1.136 to 3.336	0.015
Time since delivery (vs ≤12 months)	0.930	0.541 to 1.599	0.794
BMI (vs underweight or normal)	1.131	0.537 to 2.383	0.746
Waist circumference (vs normal)	1.072	0.514 to 2.238	0.853
2hPG (vs <7.8)	2.055	1.061 to 3.982	0.033
FBG (vs <6.1)	1.306	0.587 to 2.906	0.513
Sociocultural			
Education (vs junior high school and below)	0.619	0.337 to 1.137	0.122
Monthly family income (vs >$145)	1.472	0.321 to 6.742	0.619
Occupation (vs unemployed)	1.038	0.588 to 1.832	0.899
Vegetables and fruits (vs yes)	0.972	0.464 to 2.034	0.940
Sedentary time (vs <6 hours)	1.390	0.787 to 2.458	0.257
Physical activity (vs no)	0.753	0.416 to 1.363	0.349
Perceived stress	1.002	0.955 to 1.051	0.926
Self-efficacy	0.946	0.900 to 0.995	0.031

BMI, body mass index; FBG, fasting blood glucose; 2hPG, 2-hour postload plasma glucose.

GDM within 1 year following delivery in two urban cities of China (19.7% and 16.7%).[13 14] The proportion of women with increased blood pressure in our retrospective cohort study is slightly higher than the proportion of hypertension reported among women with a history of GDM in Canada (15.8%).[10] According to the literature, the proportion of increased blood pressure among Chinese women without GDM living in large urban cities was 1.7%–4.4%.[13 14] Thus, the risk of increased blood pressure among rural Chinese women with a history of GDM is alarming.

Regarding biological factors, women at an advanced age had a higher risk of increased blood pressure after delivery, which is consistent with findings in women with a history of GDM in Taiwan.[26] This might be because the metabolic and vascular environments deteriorate with age, thus increasing the risk of increased blood pressure.[57] In this retrospective cohort study, women with a family history of hypertension also had higher risk of increased blood pressure after delivery, which is consistent with findings in general populations in the USA and Japan.[58 59]

Furthermore, women with isolated abnormal 2hPG after delivery were more likely to develop increased blood pressure, which is consistent with findings in women with a history of GDM in Finland.[60] Compared with abnormal FBG, abnormal glucose tolerance (eg, 2hPG) leads to faster insulin resistance; this increases cardiac output and vascular resistance and leads to increased blood pressure.[61]

Surprisingly, neither BMI nor waist circumference was significantly related to increased blood pressure after delivery. This finding is inconsistent with studies in urban Chinese women with a history of GDM,[3] suggesting that obesity indicators may be risk factors for increased blood pressure among women with a history of GDM in some regions but not in rural areas in the central south of China. There may be other important factors associated with increased blood pressure in this population.

General self-efficacy was the only sociocultural factor related to increased blood pressure. Women with greater general self-efficacy were less likely to develop hypertension after delivery. It has been reported that among American adults, high self-efficacy is strongly associated with confidence and the motivation to engage in activities related to reducing hypertension.[62] Women with greater self-efficacy in our study may have pursued healthy behaviours and coping strategies that reduced their risk of hypertension.[44 63] However, the levels of general self-efficacy are very similar between women, so the results should be generalised cautiously.

There was no association between perceived stress and increased blood pressure after delivery. This is consistent with findings from a general adult population.[64] This might be because short-term or relatively low levels of stress are unlikely to have sustained effects on behavioural and pathophysiological processes that contribute to hypertension.[65 66] To confirm this hypothesis, longitudinal cohort studies exploring the association between blood pressure and perceived stress among women with a history of GDM are needed.

Limitations

Several limitations existed in our study. First, random error due to the use of a one-time blood pressure measure is likely to have reduced the power of our regression analyses. Second, because this study was a retrospective cohort study, we could not measure all the potential risk factors (eg, multiple pregnancies affected by GDM, high blood pressure before pregnancy) for increased blood pressure after delivery, which could have enhanced interpretation of study findings. Third, the results of this study should be interpreted cautiously because we lack a control cohort of women post pregnancy without GDM. Also, response bias cannot be ruled out in survey designs with self-reported questionnaires. Finally, the generalisability of our results may be limited because all samples were enrolled from Hunan Province, China.

Implications

Despite these limitations, this study has several important clinical implications for preventing increased blood pressure among rural Chinese women with GDM. First, raising awareness of the risk of increased blood pressure in rural Chinese women with a history of GDM is indicated. Healthcare providers (eg, physicians, nurses) should pay particular attention to women at an advanced age and those with a family history of hypertension. Providing education to these women will help to ensure that they are aware of their increased risk for increased blood pressure in the future. Moreover, healthcare providers must ensure that blood pressure and blood glucose levels are adequately followed up.

Furthermore, interventions aimed at preventing the development of increased blood pressure in women with a history of GDM are needed. Promoting health behaviour-related general self-efficacy by mastering tasks or skills, exchanging experiences, and setting goals related to blood pressure[20 67] and maintaining normal blood glucose levels by changing dietary habits (eg, increasing intake of fruit and vegetables and reducing intake of high-fat and sugary food)[68] are recommended. More longitudinal controlled studies with larger samples are needed to evaluate the level of self-efficacy and explore the association between self-efficacy and increased blood pressure after delivery in this population. Finally, studies investigating other potential influencing factors in more diverse geographical locations with different cultural contexts are needed for this specialised population of women.

CONCLUSION

The early development of increased blood pressure in rural Chinese women with a history of GDM is alarming. Both biological and sociocultural factors were associated with increased blood pressure. Strategies to maintain

normal blood glucose tolerance and improve general self-efficacy may help reduce the risk of developing increased blood pressure, especially among those at an advanced age or those with a family history of hypertension.

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Contributors JG, as a guarantor, designed the current study. WL and SJ jointly defined the analytic strategy and analysed the data. WL drafted the manuscript. JG, SJ, YT, JY and QL collected the data. JG, MP and JW reviewed and edited the manuscript. All authors have read and agreed to the final version of the manuscript.

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REFERENCES

1 American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2012;35 Suppl 1:S64–71.
2 Xiong X, Elkind-Hirsch KE, Xie Y, *et al*. Periodontal disease as a potential risk factor for the development of diabetes in women with a prior history of gestational diabetes mellitus. *J Public Health Dent* 2013;73:41–9.
3 Mai C, Hou M, Chen R, *et al*. Cardiovascular risk factors in Chinese women with a history of gestational diabetes mellitus. *Int J Clin Exp Med* 2015;8:21694–8.
4 Casagrande SS, Linder B, Cowie CC. Prevalence of gestational diabetes and subsequent type 2 diabetes among U.S. women. *Diabetes Res Clin Pract* 2018;141:200–8.
5 American Diabetes Association. Gestational diabetes mellitus. *Diabetes Care* 2000;23 Suppl 1:S77–9.
6 Natamba BK, Namara AA, Nyirenda MJ. Burden, risk factors and maternal and offspring outcomes of gestational diabetes mellitus (GDM) in sub-Saharan Africa (SSA): a systematic review and meta-analysis. *BMC Pregnancy Childbirth* 2019;19:450.
7 Shostrom DCV, Sun Y, Oleson JJ, *et al*. History of gestational diabetes mellitus in relation to cardiovascular disease and cardiovascular risk factors in US women. *Front Endocrinol* 2017;8:144.
8 Bellamy L, Casas J-P, Hingorani AD, *et al*. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet* 2009;373:1773–9.
9 Daly B, Toulis KA, Thomas N, *et al*. Increased risk of ischemic heart disease, hypertension, and type 2 diabetes in women with previous gestational diabetes mellitus, a target group in general practice for preventive interventions: a population-based cohort study. *PLoS Med* 2018;15:e1002488.
10 Kaul P, Savu A, Nerenberg KA, *et al*. Impact of gestational diabetes mellitus and high maternal weight on the development of diabetes, hypertension and cardiovascular disease: a population-level analysis. *Diabetic Medicine* 2015;32:164–73.
11 Kul Şeref, Güvenç TS, Baycan Ömer Faruk, *et al*. Combined past preeclampsia and gestational diabetes is associated with a very high frequency of coronary microvascular dysfunction. *Microvasc Res* 2021;134:104104.
12 Goueslard K, Cottenet J, Mariet A-S, *et al*. Early cardiovascular events in women with a history of gestational diabetes mellitus. *Cardiovasc Diabetol* 2016;15:15.
13 Jin P. Research on the changes of postpartum metabolic indices and its influencing factors in the patients with gestational diabetes mellitus. *Modern Chinese Doctor* 2017;55:61–4.
14 CLHZZ B. The outcomes of glucose and lipid metabolism of women with gestational diabetes mellitus after 1 year of delivery and its relationship with postpartum hypertension. *Chinese Journal of Family Planning* 2019;27:729–37.
15 Xie Y, Zhou X. Income inequality in today's China. *Proc Natl Acad Sci U S A* 2014;111:6928–33.
16 Ferrannini E, Cushman WC. Diabetes and hypertension: the bad companions. *The Lancet* 2012;380:601–10.
17 Kearney PM, Whelton M, Reynolds K, *et al*. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005;365:217–23.
18 Idiculla T, Zachariah G, Br K, *et al*. The incidence and prevalance of idiopathic intracranial hypertension in South Sharaqiah region, Oman. *Oman J Ophthalmol* 2013;6:189–92.
19 Freiberg MS, Chang Y-F, Kraemer KL, *et al*. Alcohol consumption, hypertension, and total mortality among women. *Am J Hypertens* 2009;22:1212–8.
20 Williams B, Mancia G, Spiering W, *et al*. 2018 ESC/ESH guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of cardiology and the European Society of hypertension: the task force for the management of arterial hypertension of the European Society of cardiology and the European Society of hypertension. *J Hypertens* 2018;36:1953–2041.
21 Tsao CW, Vasan RS. Cohort profile: the Framingham heart study (FHS): overview of milestones in cardiovascular epidemiology. *Int J Epidemiol* 2015;44:1800–13.
22 Rossier BC, Bochud M, Devuyst O. The hypertension pandemic: an evolutionary perspective. *Physiology* 2017;32:112–25.
23 (CIHR) CIoHR. *Gender, sex, and health research guide: a tool for CIHR applicants*. Ottawa, 2014.
24 O'Neil A, Scovelle AJ, Milner AJ, *et al*. Gender/Sex as a social determinant of cardiovascular risk. *Circulation* 2018;137:854–64.
25 Bentley-Lewis R, Powe C, Ankers E, *et al*. Effect of Race/Ethnicity on hypertension risk subsequent to gestational diabetes mellitus. *Am J Cardiol* 2014;113:1364–70.
26 Hwu L-J, Sung F-C, Mou C-H, *et al*. Risk of subsequent hypertension and diabetes in women with hypertension during pregnancy and gestational diabetes. *Mayo Clin Proc* 2016;91:1158–65.
27 Gaillard R. Maternal obesity during pregnancy and cardiovascular development and disease in the offspring. *Eur J Epidemiol* 2015;30:1141–52.
28 Ratner RE. Prevention of type 2 diabetes in women with previous gestational diabetes. *Diabetes Care* 2007;30 Suppl 2:S242–5.
29 Hauspurg A, Countouris ME, Jeyabalan A, *et al*. Risk of hypertension and abnormal biomarkers in the first year postpartum associated with hypertensive disorders of pregnancy among overweight and obese women. *Pregnancy Hypertens* 2019;15:1–6.
30 Barter PJ. The causes and consequences of low levels of high density lipoproteins in patients with diabetes. *Diabetes Metab J* 2011;35:101–6.
31 Diaz KM, Shimbo D. Physical activity and the prevention of hypertension. *Curr Hypertens Rep* 2013;15:659–68.
32 Hegde SM, Solomon SD. Influence of physical activity on hypertension and cardiac structure and function. *Curr Hypertens Rep* 2015;17:77.

33 Qiao F, Rozelle S, Zhang L, *et al*. Impact of childcare and eldercare on Off-farm activities in rural China. *China & World Economy* 2015;23:100–20.
34 Mancia G, Fagard R, Narkiewicz K, *et al*. 2013 ESH/ESC guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of hypertension (ESH) and of the European Society of cardiology (ESC). *Eur Heart J* 2013;34:2159–219.
35 James PA, Oparil S, Carter BL, *et al*. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the eighth joint National Committee (JNC 8). *JAMA* 2014;311:507–20.
36 Mendis S, Davis S, Norrving B. Organizational update: the world Health organization global status report on noncommunicable diseases 2014; one more landmark step in the combat against stroke and vascular disease. *Stroke* 2015;46:E121–2.
37 Graudal NA, Hubeck-Graudal T, Jurgens G, *et al*. Effects of low sodium diet versus high sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride. *Cochrane Database Syst Rev* 2017;85:CD004022.
38 Yu Y. The analysis of diet culture differences between China and Western countries. *2016 Issgbm International Conference on Information, Communication and Social Sciences*, 2016:504–7.
39 Zhao W, Chen J. Implications from and for food cultures for cardiovascular disease: diet, nutrition and cardiovascular diseases in China. *Asia Pac J Clin Nutr* 2001;10:146–52.
40 Wiernik E, Nabi H, Pannier B, *et al*. Perceived stress, sex and occupational status interact to increase the risk of future high blood pressure: the IPC cohort study. *J Hypertens* 2014;32:1979–86.
41 Lee E-H. Review of the psychometric evidence of the perceived stress scale. *Asian Nurs Res* 2012;6:121–7.
42 Clougherty JE, Eisen EA, Slade MD, *et al*. Gender and sex differences in job status and hypertension. *Occup Environ Med* 2011;68:16–23.
43 Kim C, McEwen LN, Kieffer EC, *et al*. Self-Efficacy, social support, and associations with physical activity and body mass index among women with histories of gestational diabetes mellitus. *Diabetes Educ* 2008;34:719–28.
44 Pinidiyapathirage J, Jayasuriya R, Cheung NW, *et al*. Self-Efficacy and planning strategies can improve physical activity levels in women with a recent history of gestational diabetes mellitus. *Psychol Health* 2018;33:1062–77.
45 Mao P, Jiang S, Guo J, *et al*. Progression to abnormal glucose tolerance and its related risk factors among women with prior gestational diabetes in rural communities of China. *Diabetes Metab Syndr Obes* 2020;13:2259–68.
46 Kleman M, Dhanyamraju S, DiFilippo W. Prevalence and characteristics of pseudohypertension in patients with "resistant hypertension". *J Am Soc Hypertens* 2013;7:467–70.
47 Pathirana MM, Lassi Z, Ali A, *et al*. Cardiovascular risk factors in women with previous gestational diabetes mellitus: a systematic review and meta-analysis. *Rev Endocr Metab Disord* 2021;22:729–61.
48 Ma; S, Jin Z. Per capita disposable income of rural resident in China. *Technology Economics* 2018;37:131–7.
49 Chen C, Lu FC, Department of Disease Control Ministry of Health, PR China. The guidelines for prevention and control of overweight and obesity in Chinese adults. *Biomed Environ Sci* 2004;17 Suppl:1–36.
50 Alberti KGMM, Zimmet P, Shaw J. International diabetes Federation: a consensus on type 2 diabetes prevention. *Diabet Med* 2007;24:451–63.
51 Robinson CA, Agarwal G, Nerenberg K. Validating the CANRISK prognostic model for assessing diabetes risk in Canada's multi-ethnic population. *Chronic Dis Inj Can* 2011;32:19–31.
52 Guo J, Shi Z, Chen J-L, *et al*. Translation and validation of the Canadian diabetes risk assessment questionnaire in China. *Public Health Nurs* 2018;35:18–28.
53 Qu N-ning, Li K-ji. [Study on the reliability and validity of international physical activity questionnaire (Chinese Vision, IPAQ)]. *Zhonghua Liu Xing Bing Xue Za Zhi* 2004;25:265–8.
54 Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:385–96.
55 Yang T-zhong, Huang H-teng, T-z Y. [An epidemiological study on stress among urban residents in social transition period]. *Zhonghua Liu Xing Bing Xue Za Zhi* 2003;24:760–4.
56 Barlow JH, Williams B, Wright C. The generalized self-efficacy scale in people with arthritis. *Arthritis & Rheumatism* 1996;9:189–96.
57 Retnakaran R, Shah BR. Role of type 2 diabetes in determining retinal, renal, and cardiovascular outcomes in women with previous gestational diabetes mellitus. *Diabetes Care* 2017;40:101–8.
58 Liu J, Sekine M, Tatsuse T, *et al*. Family history of hypertension and the risk of overweight in Japanese children: results from the Toyama birth cohort study. *J Epidemiol* 2014;24:304–11.
59 Pettey CM, McSweeney JC, Stewart KE, *et al*. Perceptions of family history and genetic testing and feasibility of pedigree development among African Americans with hypertension. *Eur J Cardiovasc Nurs* 2015;14:8–15.
60 Pirkola J, Pouta A, Bloigu A, *et al*. Prepregnancy overweight and gestational diabetes as determinants of subsequent diabetes and hypertension after 20-year follow-up. *J Clin Endocrinol Metab* 2010;95:772–8.
61 Zheng R, Mao Y. Triglyceride and glucose (TyG) index as a predictor of incident hypertension: a 9-year longitudinal population-based study. *Lipids Health Dis* 2017;16.
62 Warren-Findlow J, Seymour RB, Brunner Huber LR. The association between self-efficacy and hypertension self-care activities among African American adults. *J Community Health* 2012;37:15–24.
63 Pienyu R, Thomas S, Rajan SK. History of gestational diabetes mellitus, self-efficacy and coping in postpartum women. *Asian Women* 2018;34:101–15.
64 Spruill TM, Butler MJ, Thomas SJ, *et al*. Association between high perceived stress over time and incident hypertension in black adults: findings from the Jackson heart study. *J Am Heart Assoc* 2019;8:e012139.
65 McEwen BS, Gianaros PJ. Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease. *Ann N Y Acad Sci* 2010;1186:190–222.
66 Gebreab SY, Diez-Roux AV, Hickson DA, *et al*. The contribution of stress to the social patterning of clinical and subclinical CVD risk factors in African Americans: the Jackson heart study. *Soc Sci Med* 2012;75:1697–707.
67 Davidson M, Boland EA, Grey M. Teaching teens to cope: coping skills training for adolescents with insulin-dependent diabetes mellitus. *J Soc Pediatr Nurs* 1997;2:65–72.
68 Chai S, Yao B, Xu L, *et al*. The effect of diabetes self-management education on psychological status and blood glucose in newly diagnosed patients with diabetes type 2. *Patient Educ Couns* 2018;101:1427–32.