

Sex and Gender Determinants of Increased Blood Pressure Among Women With Previous Gestational Diabetes Mellitus in Rural China

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Abstract

Background: Gestational diabetes mellitus (GDM) increases the long-term risk of hypertension and cardiovascular events for mothers later in life but has not been well recognized by nurses. The aims of the study were to describe the proportion of increased blood pressure in rural women with previous GDM and to explore the sex (biological) and gender (sociocultural) factors that contribute to the increased blood pressure.

Methods: A cross-sectional descriptive survey including 397 women with previous GDM was conducted in rural areas of Central South of China between November 2017 and June 2018. The variables of sex (e.g., age, ethnicity, family history of hypertension, time since delivery, 75-g oral glucose tolerance test, body mass index, and waist circumference) and gender (education, occupation, income, physical activity, fruit and vegetable intake, sedentary time, perceived stress, and general self-efficacy) were collected on research site. Increased blood pressure referred to systolic blood pressure of ≥ 130 mm Hg and/or diastolic blood pressure of ≥ 85 mm Hg. Logistic regression was performed to recognize the sex and gender factors associated with increased blood pressure.

Results: There were nearly 20% (78/397) of participants first found increased blood pressure. Among those participants who had increased blood pressure, advanced age, a family history of hypertension, and abnormal 2-h plasma glucose levels were sex-related factors associating with the increased blood pressure ($P < 0.05$), while obesity indicators (body mass index and waist circumference) were not associated ($P > 0.05$). General self-efficacy, a gender factor, had a protective relationship with increased blood pressure ($P < 0.05$).

Conclusions: Increased blood pressure is prevalent in rural Chinese women with previous GDM. Both sex and gender are determinants. Interventions promoting glycemic status and general self-efficacy are promising to improve their cardiovascular health later in life.

Background

Gestational diabetes mellitus (GDM) refers to glucose intolerance resulting in hyperglycemia which is founded during pregnancy for the first time (1). The prevalence of GDM varies across countries; its reported prevalence is 20% in Vietnam and Singapore (2), 11.1% in China (3), and 7.6% in the United States (4). Overall, the prevalence of GDM has been increasing worldwide (5), which significantly increases the rates of adverse pregnancy and birth outcome (6).

GDM also increases the long-term risk of type 2 diabetes mellitus (T2DM) and cardiovascular disease for mothers later in life (7). The risk of developing T2DM is over seven times higher (8) and the risk of developing hypertension and cardiovascular events is two times higher in women with previous GDM than without (9). Hyperglycemia is associated with increased risk of vascular endothelial injury and hypertension (10), which might interpret the mechanism of the high risk of both T2DM and

cardiovascular disease among this population. More studies on glycemic status and cardiovascular health after delivery among this population are needed.

Hypertension is one of the main risk factors of cardiovascular disease (11). Nearly 40% of people aged 25 and over suffered from hypertension all over the world (12). High normal blood pressure, as an important predictor of hypertension (13), refers to systolic blood pressure (SBP) of 130–139 mm Hg and/or diastolic blood pressure (DBP) of 85–89 mm Hg (14). There was a study reporting that 53% of adults aged 65–94 years who had baseline clinical high normal blood pressure developed hypertension within four years in the United States (15).

The sex and gender framework emphasizes the collective impact and influence of biological and genetic factors as well as healthy social environment factors on health outcomes and conditions (16). Cardiovascular health as one of the most common health conditions, is determined by both sex (biological) and gender (sociocultural) factors (17). Several sex-related risk factors of developing hypertension in women with GDM, such as ethnicity and advanced age, have been identified. For example, Hispanic women with previous GDM tend to be easier to develop hypertension than Caucasian women (18). In Taiwan, compared with younger women with previous GDM, women at an advanced age had a higher risk for hypertension (19).

Obesity is another important sex factor for the development of cardiovascular disease and related conditions (20). Women with previous GDM are easier to be obese than women with normal glycemic status during pregnancy (21). Obesity-related variables, such as body mass index (BMI) and waist circumference, were associated with hypertension (22). BMI is inversely associated with high-density lipoprotein cholesterol, which positively correlates with the risk of developing hypertension (23).

Gender-related factors, such as health behaviors and psychosocial factors, are closely related to the development of hypertension (24). There is evidence showing that daily physical activity can decrease the risk of hypertension among women (25). Whereas, due to the responsibilities of taking care of children and senior in families for women in rural China, they rarely have time to do enough daily physical activity which is not equal to house work (26).

Diet is another important component of guidelines for antihypertensive therapy in America and Europe (27–29). Fruit and vegetable consumption is negatively associated with increased blood pressure (30). Compared with the nutrition-oriented Western diet, people prefer delicious food in China (31). With the improvement of the economy and social life, the consumption of animal foods and oil/fat has been increased (32). This could be a reason for the increased risk of developing hypertension among the general population. However, the impacts of physical activity and diet on increased blood pressure in rural Chinese women with previous GDM has rarely been reported.

Psychosocial factors also have an influence on the development of hypertension among general women. High levels of perceived stress positively correlate with increased blood pressure among women in France (33). Perceived stress refers to the degree to which people perceive that they cannot meet their needs

(34). Further, work-related issues present challenges in balancing career and family responsibilities, which often disproportionately increase women's mental stress (35). General self-efficacy refers to a person's confidence in achieving self-management and behavioral change (36). Health behaviors (e.g., healthy dietary habits and physical activity) can be improved by increasing their general self-efficacy among women with previous GDM (37). However, the contribution of general self-efficacy and perceived stress to increased blood pressure among women with previous GDM is not well documented.

To our knowledge, the long-term risk of hypertension and cardiovascular events in this population later in life has not been well recognized by nurses in China. There are few studies exploring the factors associating with increased blood pressure in women with previous GDM from both sex and gender perspectives. The aims of this study were (1) to describe the proportion of rural Chinese women with previous GDM developing increased blood pressure within 4 years after delivery and (2) to explore the association of sex-related factors (age, ethnicity, family history of hypertension, time since delivery, obesity-related factors [BMI and waist circumference], and blood glucose [FBG and 2 h-OGTT]) and gender factors (education, occupation, income, health behaviors [physical activity, vegetable and fruit intake, and sedentary time], and psychosocial factors [stress and general self-efficacy]) with the increased blood pressure.

Methods

Study Design and Participants

The study was a cross-sectional survey. The inclusion criteria of the subjects were as follows: (1) diagnosed with GDM during a last pregnancy, (2) age of 18 years or older, (3) postpartum period of six weeks or above, 4) contacted either from family members, friends, or neighbors by telephone, and (5) ability to speak Chinese. The exclusion criteria were as follows: (1) ongoing pregnancy, (2) diagnosed with diabetes before pregnancy or after delivery, (3) previously diagnosed hypertension, or pre-existing obstetric related hypertension (e.g., preeclampsia and gestational hypertension), (4) physical or cognitive disabilities, (5) current take the blood pressure medicine, or addictive drug abuse (e.g., morphine or cocaine), and (6) severe psychiatric disorders.

Based on 15–30 subjects for each predictor in the logistic regression model, the sample size was calculated (38). Given that there were 15 predictors, the sample size was estimated at 225–450 participants. The final sample size was increased to 467 participants to adjust for a 10% attrition.

Data Collection

The participants were recruited from two county-level hospitals (Youxian and Zhangjiajie) of 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. Local physician or nurse called the candidates who conformed to the inclusion criteria to explain the purpose of the study and determine their willingness to participate. The purpose of the study and confidentiality principles

were detailed according to standard operating procedures. Informed consent was obtained before the survey was conducted. To avoid participants inadvertently skipping questions, the research assistant checked the questionnaire after they completed. Blood pressure, anthropometric variables (height, weight, and waist circumference), and blood glucose measurements were performed by nurses.

Measurements

Blood pressure was measured on site by registered nurses using electronic blood pressure monitors (HEM-7120; Omron, Tokyo, Japan) after 12-h fasting according to the criteria of the Chinese Hypertension League/National Center (39). Blood pressure was divided into two categories according to the criteria of the European Society of Cardiology and the European Society of Hypertension as follows: normal blood pressure (SBP < 130 mm Hg and DBP < 85 mm Hg) and increased blood pressure (high normal blood pressure: SBP \geq 130 mm Hg and/or DBP \geq 85 mm Hg, and hypertension: SBP \geq 140 mm Hg and/or DBP \geq 90 mm Hg) (14).

Partial sex (e.g., age, ethnicity, family history of hypertension, and time after delivery) and gender data (e.g., education, occupation, and monthly family income) were collected via a self-designed questionnaire. Ethnicity was categorized as Han and minority. According to the major periods for discerning glucose metabolic abnormality reported by previous studies, the time since delivery was classified into four categories: \leq 3 months, > 3 to \leq 12 months, > 12 to \leq 36 months, and > 36 months (40, 41). Education was categorized as junior high school and below (< 12 years of schooling) and senior high school and above (\geq 12 years of schooling). Occupation status was categorized as employed and unemployed. Based on the poverty line in China, poverty was defined as a monthly family income of less than \$145 (42). Accordingly, the monthly family income was divided into <\$145 and \geq \$145.

Sex-related variables also included obesity related factors (i.e., BMI and waist circumference) and blood glucose. Obesity-related anthropometric measurements included BMI and waist circumference. The BMI was calculated as weight in kilograms divided by height in meters squared and categorized into two levels based on the guidelines for the prevention and control of overweight and obesity in Chinese adults: underweight or normal (< 24 kg/m²) and overweight or obese (\geq 24 kg/m²) (43). According to criteria of the International Diabetes Federation (44) and the National Institute for Health and Care Excellence (25), waist circumference was divided into normal (< 80 cm) and central obese (\geq 80 cm).

Blood glucose included fasting blood glucose (FBG) and two-hour oral glucose tolerance tests (2 h-OGTT). After overnight fasting, venous blood samples were collected to measure the FBG. For the 2 h-OGTT, blood samples were collected after 12-h fasting followed by blood samples taken 2 h after consumption of 75 g of glucose. The hexokinase enzyme method was used to measure the blood glucose.

Gender-related variables included health behaviors (physical activity, vegetable and fruit intake, and sedentary time) and psychosocial factors (stress and general self-efficacy). Physical activity was measured by the following item of the Chinese version of the Canadian Diabetes Risk Questionnaire,

which was developed by Robinson, Agarwal, and Nerenberg (45) and revised and translated into Chinese by Guo (46): “Do you engage in a regular physical activity, such as brisk walking for at least 30 minutes each day?” The 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 (46).

Sedentary time was measured by the following item of the short form of the International Physical Activity Questionnaire (IPAQ-S) (Chinese version) (47): “How much time did you usually spend sitting?” The IPAQ-S has an intraclass correlation coefficient greater than 0.70.

Stress was measured by the Perceived Stress Scale, which was designed to assess the level of stress in life (48). This scale, including 14 items, was revised and translated into Chinese (49). The total score ranges from 0 to 56, with a score of 26 means high level stress(49). This scale has good internal consistency reliability with Cronbach’s α coefficient of 0.78 (49).

General self-efficacy was measured by the General Self-Efficacy Scale (Chinese version) (50), which includes 10 items. Higher scores indicates better general self-efficacy, and the score ranges from 10 to 40. The internal consistency coefficient of the scale was 0.87 (50).

Data Analysis

Data analyses were performed by IBM SPSS Statistics 23. Descriptive statistics were computed to describe the sample. The associations between sex and gender variables and increased blood pressure were determined by one-way analysis of variance (ANOVA) and chi-squared tests. In order to identify factors influencing increased blood pressure, multivariate logistic regression was conducted. The covariates of the logistic regression were selected based on the bivariate analysis (one-way ANOVA or chi-squared tests) and previous literature (e.g., ethnicity, obesity-related variables, FBG, education, income, occupation, stress, and lifestyle behaviors). A P value less than 0.05 was considered statistically significant.

Results

This survey recruited 467 women. Of those, 70 were excluded because they did not complete either the 2-h 75-g OGTT ($n = 40$, 8.6%) or the questionnaire ($n = 30$, 6.4%). Consequently, 397 women (85.0% recruitment yield) were included. There were no significant differences in sex and gender-related data (e.g., age, ethnicity, education, occupation, monthly family income, and time since delivery) between the included and excluded participants ($P > 0.05$).

The power of the current sample size was examined by a post-hoc power analysis. Assuming an α of 0.05, a base prevalence of 0.20, and the R-squared with other predictors is of 0.50, a two-tailed test of the null hypothesis of an odds ratio (OR) of 1.0 for a given predictor against an alternative odds ratio of 1.70 has a power of 0.83 in a logistic regression with $N = 397$ (G*Power 3.1).

Distribution of Blood Pressure Among Rural Women With Previous GDM

Nearly 20% (n = 78) of the women had increased blood pressure, of whom 30.7% (n = 24) had hypertension and 69.3% (n = 54) had high normal blood pressure. Of the 397 participants, 80.3% of the women (n = 319) had normal blood pressure. The mean SBP of high normal blood pressure were 129.11 mm Hg (SD 6.46), while the mean DBP was 80.72 mm Hg (SD 7.91). The details of the participants' blood pressure distribution are displayed in Table 1.

Table 1
Distribution of Blood pressure among rural women with previous GDM

Blood pressure	N (%)	SBP		DBP	
		Mean ± SD	Range	Mean ± SD	range
Normal	319(80.3)	112.29 ± 8.38	90–129	71.24 ± 7.64	46–84
High Normal	54(13.7)	129.11 ± 6.46	114–139	80.72 ± 7.91	57–89
Hypertension	24(6.0)	139.25 ± 11.22	120–170	92.75 ± 7.57	78–113

Abbreviations:; SD, standard deviation.

Sex Characteristics Among Rural Women With Previous GDM

The participants' mean age was 32.27 years (SD 5.2), with a range of 20–47 years. And 45.8% of the participants (n = 182) were Minority nationality. One-third (n = 137, 33.2%) had a family history of hypertension.

The mean time since delivery was 15.50 months (SD 12.46). Nearly a fifth (n = 73, 18.4%) of the participants had given birth less than 3 months previously, more than one-third (n = 136, 34.3%) 3–12 months previously, approximately 37.8% (n = 150) 12–36 months previously, and 9.5% (n = 38) over 36 months previously. Among the 78 women with increased blood pressure, more than a fifth (n = 18, 23.1%) had given birth less than 3 months previously, one-third (n = 27, 34.6%) 3–12 months previously, 35.9% (n = 28) 12–36 months previously, and 6.4% (n = 5) over 36 months previously.

The mean BMI was 23.85 kg/m² (SD 3.65) and 45.8% (n = 182) of the participants being overweight or obese (≥ 24.0 kg/m²). The mean waist circumference was 80.33 cm (SD 8.50) with 52.4% (n = 208) of the participants characterized by central obesity (> 80 cm).

The mean FBG level was 5.35 mmol/L (SD 1.28) with 10.7% of the participants exhibiting FBG levels higher than 6.1 mmol/L. The mean 2 h-OGTT was 6.55 mmol/L (SD 2.69) with 15.1% (n = 60) of the participants having glucose intolerance (2 h-OGTT > 7.8 mmol/L). Details of the participants' sex characteristics are displayed in Table 2.

Table 2

Sex and gender characteristics of rural women with previous GDM according to blood pressure (N = 397)

Variables	Total N(%)	Normal N = 319	HN & H N = 78	χ^2/t	P-value
Sex characteristics					
Age, mean(SD)		31.83(4.93)	34.05(5.98)	-3.038	0.003
Ethnic				1.455	0.228
Minority	182(45.8)	151(47.3)	31(39.7)		
Han	215(54.2)	168(52.7)	47(60.3)		
Family History of Hypertension				10.307	0.001
Yes	137(33.2)	98(30.7)	39(50.0)		
No	260(66.3)	221(69.3)	39(50.0)		
Time after delivery				2.269	0.518
≤ 3months	73(18.4)	55(17.2)	18(23.1)		
> 3 to ≤ 12months	136(34.3)	109(34.2)	27(34.6)		
> 12 to ≤ 36months	150(37.8)	122(38.2)	28(35.9)		
> 36months	38(9.5)	33(10.4)	5(6.4)		
BMI				1.156	0.282
Underweight or normal	215(54.2)	177(55.5)	38(48.7)		
Overweight or obese	182(45.8)	142(44.5)	40(51.3)		
Waist circumference				1.093	0.296
Normal	189(47.6)	156(48.9)	34(43.6)		
Obese	208(52.4)	163(51.1)	47(56.4)		
FBG				1.076	0.300
< 6.1	354(89.1)	287(90.0)	67(85.9)		
≥ 6.1	43(10.9)	32(10.0)	11(14.1)		

Abbreviations: GDM, gestational diabetes mellitus; FBG, fasting blood glucose; 2 h-OGTT, two-hour oral glucose tolerance tests; BMI, body mass index; SD, standard deviation.

Variables	Total N(%)	Normal N = 319	HN & H N = 78	χ^2/t	P- value
2 h-OGTT				12.969	0.000
< 7.8	337(84.9)	281(88.1)	56(71.8)		
≥ 7.8	60(15.1)	38(11.9)	22(28.2)		
Gender characteristics					
Education				3.675	0.054
Junior high school and below	94(23.7)	68(21.3)	26(33.3)		
Senior high school and above	303(76.3)	251(78.7)	52(66.7)		
Occupation				0.016	0.898
Employed	252(63.5)	202(63.3)	50(64.1)		
Unemployed	145(36.5)	117(36.7)	28(35.9)		
Monthly Family Income				0.225	0.636
< 145\$	12(3.0)	9(2.8)	3(3.8)		
≥ 145 \$	385(97.0)	310(97.2)	75(96.2)		
Regularly physical activity				0.909	0.340
Yes	130(32.9)	108(33.9)	22(28.2)		
No	267(67.3)	211(66.1)	56(71.7)		
Daily vegetables and fruit intake				0.999	0.318
Yes	77(19.4)	65(20.3)	12(15.4)		
No	320(80.6)	254(79.7)	66(84.6)		
Sedentary time				1.772	0.183
< 6 h	279(70.2)	229(71.7)	50(64.1)		
≥ 6 h	118(29.7)	90(28.2)	28(35.9)		
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
Abbreviations: GDM, gestational diabetes mellitus; FBG, fasting blood glucose; 2 h-OGTT, two-hour oral glucose tolerance tests; BMI, body mass index; SD, standard deviation.					

Gender Characteristics Among Rural Women With Previous 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 (i.e., \geq \$145). Approximately 36.5% (n = 145) of women were unemployed.

More than two-thirds (n = 267, 67.3%) of the participants engaged in physical activities for less than 30 min a day. Most participants (n = 320, 80.6%) did not consume fruit or vegetables every day, and more than two-thirds (n = 279, 70.2%) reported a sedentary time less than 6 h every day.

The mean perceived stress score was 23.92 (SD 6.40), with a range of 1–39. Of the 397 participants, 37.8% reported high stress levels. The mean score of general self-efficacy was 25.81 (SD 5.89), with a range of 10–40. The details of the participants' gender characteristics are displayed in Table 2.

Bivariate Analysis of Sex and Gender Factors and Increased Blood Pressure Among Rural Women With Previous GDM

Women with increased blood pressure were older than women with normal blood pressure ($P = 0.003$); Compared with those without family history of hypertension, women with a family history had higher rates of increased blood pressure ($P = 0.001$); and women with high 2 h-OGTT values had higher rates of increased blood pressure than those with normal 2 h-OGTT values ($P = 0.001$). There were no statistically significant differences in blood pressure related to ethnicity, time since delivery, obesity-related variables (BMI and waist circumference), and FBG between the participants ($P > 0.05$).

Bivariate analysis of gender variables indicated that women reporting lower self-efficacy had higher rates of increased blood pressure than those with higher self-efficacy ($P = 0.012$). There were no significant association between blood pressure and other gender variables (education, income, occupation, health behaviors [physical activity, fruit and vegetable intake, and sedentary time], and perceived stress) between the participants ($P > 0.05$).

Logistic Regression of Increased Blood Pressure Among Rural Women With Previous GDM

As shown in Table 3, women at an advanced age and those with a family history of hypertension more tend to develop blood pressure (OR: 1.070, 95% confidence interval [CI]: 1.015–1.128 and OR: 1.934, 95% CI: 1.128–3.317, respectively; $P < 0.05$). Similarly, women with abnormal 2 h-OGTT values had a higher risk of developing increased blood pressure (OR: 2.042, 95% CI: 1.053–3.958; $P < 0.05$). Moreover, self-efficacy was negatively related to increased blood pressure (OR: 1.070, 95% CI: 1.015–1.128; $P < 0.05$). The results of the logistic regression analyses are displayed in Table 3.

Table 3
Logistic regression of blood pressure among rural women with previous GDM

Variables	OR	CI	P value
Sex			
Age(year)	1.070	1.015–1.128	0.011
Ethnicity (vs Han)	0.796	0.449–1.409	0.433
Family history of hypertension (vs no)	1.934	1.128–3.317	0.017
Time since delivery (vs ≤ 3months)	0.921	0.682–1.243	0.590
BMI (vs underweight or normal)	1.125	0.535–2.366	0.757
Waist circumference (vs normal)	1.075	0.516–2.241	0.847
2 h-OGTT (vs < 7.8)	2.042	1.053–3.958	0.035
FBG (vs < 6.1)	1.304	0.586–2.901	0.516
Gender			
Education (vs Junior high school and below)	0.628	0.341–1.156	0.135
Monthly Family Income (vs > 145\$)	1.471	0.321–6.730	0.619
Occupation (vs unemployed)	1.029	0.582–1.818	0.922
Vegetables and fruits (vs yes)	0.971	0.465–2.030	0.938
Sedentary time(vs < 6h)	1.382	0.781–2.445	0.266
Physical activity (vs no)	0.757	0.418–1.370	0.358
Perceived stress	1.003	0.956–1.052	0.917
Self-efficacy	1.070	1,015-1.128	0.031
Abbreviations: GDM, gestational diabetes mellitus; BMI, body mass index; 2 h-OGTT, two-hour oral glucose tolerance tests; FBG, fasting blood glucose.			

Discussion

This cross-sectional survey involving 397 women obtained several key findings. First, at a mean time of 15.5 months after delivery, the prevalence of increased blood pressure among rural Chinese women with previous GDM was nearly 20%. Second, both sex and gender determinants were identified, such as advanced age, family history of hypertension, and low general self-efficacy. Surprisingly, in this sample, obesity indicators (BMI or waist circumference) were not significantly related to increased blood pressure, while abnormal 2 h-OGTT was an important associating factor.

The proportion of increased blood pressure in this study (19.6%) is similar to that of Spanish women with previous GDM (20%) (51) and slightly higher than that of Chinese women without GDM (16.9%) (52). The majority (90.5%) of women with increased blood pressure had given birth less than 36 months previously. This early development of increased blood pressure among women with previous GDM is alarming.

Regarding sex factors, women at an advanced age had a higher risk of increased blood pressure after delivery, which is consistent with findings concerning women with previous GDM in Taiwan (19). This might be because the metabolic and vascular environment deteriorate with age, thus increasing the risk of increased blood pressure (53). In this study, women with a family history of hypertension had a higher risk for increased blood pressure after delivery, which is consistent with findings regarding general populations in the US and Japan (54, 55).

Furthermore, women with abnormal 2 h-OGTT but not FBG were more likely to develop increased blood pressure, which is consistent with findings regarding women with previous GDM in Finland (56). Compared with abnormal FBG, abnormal glucose tolerance (e.g., 2 h-OGTT) leads to faster insulin resistance. This increases cardiac output and vascular resistance, ultimately leading to increased blood pressure (57).

Unexpectedly, in this study, neither BMI nor waist circumference was significantly related to increased blood pressure after delivery. This finding is inconsistent with previous studies on urban Chinese women with previous GDM (58), suggesting that obesity indicators may be risk factors for increased blood pressure among women with previous GDM in some regions but not in rural areas of central-south China. Other factors may be more important for the increased blood pressure in this population.

General self-efficacy was the only gender 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 among American adults (59). Accordingly, women with greater self-efficacy in our study may pursue healthy behaviors and coping strategies that reduce the risk of hypertension (37, 60).

There was no relationship between perceived stress and increased blood pressure after delivery. This is consistent with findings regarding a general adult population (61). This might be because short-term or relatively low levels of stress are unlikely to have sustained effects on behavioral and pathophysiological processes that contribute to hypertension (62, 63). To confirm this hypothesis, longitudinal cohort studies exploring the association between blood pressure and perceived stress among women with previous GDM are needed.

Limitations

Several limitations existed in our study. First, the difference of postpartum period, the according variation in glucose metabolism and perhaps influence the blood pressure of women. Another limitation is related

to the fact that a standard approach to measuring gender-related variables was not used. In fact, a lot of work is now being done to determine exactly what gender is and how it can be measured. The GENESIS-PRAXY questionnaire could be used in future studies. In this study, it might not be that variations exist by geography, but by gender and this can be evaluated in a future study using a better measurement of gender. Third, response bias cannot be ruled out in survey with self-reported questionnaires. Finally, the generality of our results may be limited, because all sample were enrolled in Hunan Province.

Implications

Despite its limitations, this study has several important clinical implications for preventing increased blood pressure among rural Chinese women with GDM. First, raising consciousness of risk for increased blood pressure in rural Chinese women with previous GDM is indicated. Nurses should pay particular attention to women at an advanced age and those with a family history of hypertension. Targeting these women will ensure that they are aware of their increased risk. Moreover, health-care 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 previous GDM are needed. Promoting health behavior-related general self-efficacy by mastering tasks or skills, exchanging experiences, and setting goals related to blood pressure (14, 64) and maintaining normal blood glucose levels by changing dietary habits (e.g., increasing the intake of fruit and vegetables and reducing the intake of food with high-fat and sugary) (65) are recommended. Finally, studies investigating more potentially influencing factors in more geographic locations and different cultural contexts are needed for this special population.

Conclusions

The early development of increased blood pressure in rural Chinese women with previous GDM is alarming. Both sex and gender factors are contributors. Strategies aimed at maintaining normal blood glucose tolerance and optimal general self-efficacy are crucial for reducing this risk for rural Chinese women with previous GDM, especially those at an advanced age and those with a family history of hypertension.

Abbreviations

GDM, gestational diabetes mellitus; FBG, fasting blood glucose; 2 h-OGTT, two-hour oral glucose tolerance tests; BMI, body mass index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure.

Declarations

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Author Contributions

Jia Guo designed the current study. Wencong Lv and Shan Jiang jointly defined the analytic strategy and analyzed the data. Wencong Lv drafted the manuscript. Jia Guo, Shan Jiang, Yujia Tang, Jundi Yang and Qing Long collected data. Jia Guo, Monica Parry and James Wiley reviewed and edited the manuscript. All authors have read and agreed to the final version of the manuscript.

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Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The Nursing and Behavioral medicine Institutional Review Board of Xiangya Nursing School of Central South University have granted ethical approval to the study (No. 2016034). Written informed consent is collected from participants in accordance with our IRB-approved protocol.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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