


Assessment of the risk factors associated with type 2 diabetes and prediabetes mellitus

A national survey in Vietnam

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Abstract

This study aims to estimating the prevalence of type 2 diabetes and prediabetes among adult from 30 to 69 years old and assess the association of risk factor with the conditions. A total of 5244 aged 30 to 69 years old were participated in this cross-sectional study, using nationally representative sampling frame. All participants were taking blood sample to measure fasting blood glucose level and 2-hour postload oral glucose tolerance test by National Hospital of Endocrinology, Vietnam. Multinomial logistic regressions with baseline-category logit models were conducted to identify factors associated with diabetes and prediabetes among respondents. The prediabetes prevalence was in 17.9% and diabetes in 7.3%. Patients who were male (reference group vs female OR = 0.79; 95% CI: 0.64, 0.97), in the 50 to 59 years old group (OR = 1.60; 95% CI: 1.28, 2.00), have hypertension and WHR risk have higher prevalence to have prediabetes (OR = 1.31; 95% CI: 1.12, 1.53; OR = 1.37; 95% CI: 1.11, 1.70, respectively). Male patients (reference group vs female OR = 0.62; 95% CI: 0.45, 0.84), patients who were in 40 to 49; 50 to 59; 60 to 69 years old, those who were housewife (OR = 2.17; 95% CI: 1.43, 3.28; OR = 2.85; 95% CI: 1.91, 4.27; OR = 3.12; 95% CI: 2.08, 4.69; OR = 1.71; 95% CI: 1.22, 2.40, respectively). Diabetes have significant associated with participants have hypertension (OR = 1.19; 95% CI: 1.72, 2.70). The common factor directly related to prediabetes and diabetes in both genders is age. Other factors directly associated with prediabetes and diabetes include BMI, WHR, hypertension, educational level, and job.

Abbreviations: BMI = body mass index, FPG = fasting plasma glucose, OGTT = oral glucose tolerance test, T2DM = type 2 diabetes mellitus, WC = waist circumference, WHR = waist hip ratio.

Keywords: associated factor, prediabetes, risk factor, type 2 diabetes

1. Introduction

Diabetes mellitus has become a major public health problem. Type-2 diabetes mellitus (T2DM) is a chronic disease characterized by high levels of sugar in the blood and used to start almost always in the middle- and late-adulthood. T2DM is the most prevalent form of diabetes, accounting for an estimated 95% of the global diabetic population.^[1] There were 425 million people diagnosed with T2DM around the world in 2017.^[1] It is predicted that the number of adults with T2DM will increase to 629 million by 2045.^[1] T2DM causes approximately 12% of the economic burden from diabetes treatment and its complications.^[2] Moreover, T2DM is also a major risk factor for cardiovascular diseases, which increases morbidity and mortality rates.^[2]

In Vietnam, the prevalence of T2DM increased double in 10 years, from 2.7% in 2002 to 5.4% in 2012.^[3] The national survey on the risk factors of non-communicable diseases (STEPS) Vietnam in 2015 reported there was a high increase in the rate of impaired fasting glucose (3.6%), and raised blood glucose

(4.1%).^[4] According to the International Diabetes Federation, the estimated number of Vietnamese people aged 20 to 79 with diabetes in 2019 was 3,779,600 cases.^[5]

T2DM is affected by lifestyle that includes many risk factors. The consequences of diabetes can be reduced by determining and controlling the modifiable risk factors. A study in Pakistan in 2016 to 2017 showed that older age, family history of diabetes, hypertension, obesity, and dyslipidemia were associated with T2DM.^[6] The National Health and Nutrition Examination Survey in Korea from 2005 to 2015 also showed similar results.^[7] In addition, according to the 2019 American Association of Diabetes, there are several risk factors for type 2 diabetes, including body mass index (BMI) score, waist-hip ratio, and high blood pressure.^[8]

The last comprehensive national survey to evaluate the prevalence of T2DM in Vietnam among people from 30 to 69 years old was implemented in 2012 by the National Hospital of Endocrinology of Vietnam in 6 ecological regions of Vietnam, which is too old.^[4] The lack of such update information might lead to outdated and ineffective public health strategies to

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

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prevent diabetes. Therefore, we conducted this study to explore the T2DM prevalence and associated factors with T2DM in 2020/2021. The result will help evaluate the change and the trend of increasing T2DM in Vietnam. Moreover, the study finding also provides evidence for the Ministry of Health to operate policy and intervention plans to prevent T2DM in Vietnam.

2. Materials and Methods

2.1. Design and setting

This cross-sectional study was conducted in six areas (Red River Delta, Northwest – Northeast, North Central – South Central Coast, Central Highlands, Southeast, Mekong River Delta) and two major cities of Vietnam (Hanoi and Ho Chi Minh City), which cover national representative for Vietnamese population. All the participants will be randomly selected by local authorities from representative ward of each city/provinces.

2.2. Sampling and data collection

An equal number of participants was selected using the basic equation in random sampling: type I error rate = 0.05; $P = 4.1\%$ (Rate of fasting hyperglycemia according to the 2015 STEPS survey); relative marginal error $\epsilon = 20\%$ and design effect = 2. Under these conditions, the minimum number of participants was 4494. Assuming the non-response rate of 15%, the final sample size needed was 5376. Among 5376 participants recruited, there were 132 peoples who were reject to participate. In final, our study had 5244 participants met the selection criteria and completed the entire questionnaire. The sample was collected stratified by gender and age groups (30–39, 40–49, 50–59, and 60–49 years old).

The inclusion criteria of this study were Vietnamese people from 30 to 69 years old, having the ability to answer the questionnaire verbally.

2.3. Variables

2.3.1. Outcome. The primary outcome of this study was diabetes and pre-diabetes.

Participants visited the National Hospital of Endocrinology will attend the morning examination session for measurement of fasting plasma glucose (FPG) levels after fasting for at least 8 hours. Immediately after taking blood for the first fasting blood glucose test, the patient was given 75g of glucose (pure) mixed with 250 to 300 mL of purify water, the participants were asked to drink it all within 5 minutes. After exactly 120 minutes, the participants had a second blood glucose test by the medical staff to give the test results of 2-hour postload oral glucose tolerance test (OGTT). Diabetes was determined as FPG ≥ 7.0 mmol/L or OGTT ≥ 11.1 mmol/L. Prediabetes was defined as FPG of 5.6 to 6.9 mmol/L or a OGTT level of 7.8 to 11.1 mmol/L.^[9]

2.3.2. Independent variables. The independent variables included hypertension, waist circumference (WC), waist hip ratio (WHR), and BMI. Blood pressure measurements were performed with a standardized sphygmomanometer in the sitting position after 10 minutes of rest. Participant's hypertension status also grouped into yes (blood pressure $\geq 140/90$ mm Hg); and no.^[10] WC was measured using a wire gauge at the midpoint between the lowest rib and the anterior iliac crest in the standing position. Large WC was grouped to yes (male ≥ 0.9 m and female ≥ 0.8 m); and no.^[11] Hip circumference measurement was taken around the abdomen at the level of the umbilicus (belly button). WHR was categorized to yes; and no, with the cutoff for males was above 0.95 and females was above 0.8.^[11]

Bodyweight was measured using a digital weight scale with participants wearing only underwear beneath the examination

gown. Standing height was measured using a stadiometer with a fixed vertical backboard and adjustable headpiece. BMI was calculated as participant weight in kilograms divided by the square of height in meters. BMI was classified into 3 categories following the WHO criteria of BMI cutoff points for Asia-Pacific peoples: underweight (<18.5), normal (18.5–24.9), and overweight-obese (>25.0).^[12]

2.3.3. Other covariates. The survey was conducted in face-to-face interviews using a designed questionnaire. The questionnaire sought 'participants' information on their demographic, knowledge about diabetes, and hypertension history. The covariates included demographic information collected from the participants included: age, sex, residential area, education, and job.

2.4. Data analysis

Descriptive statistics were used to summarize the data, with frequencies and percentages for categorical variables and means with standard deviations (SD) or median with inter-quartile ranges (IQR) for quantitative variables. Multinomial logistic regressions with baseline-category logit models were conducted to identify factors associated with diabetes and prediabetes among respondents. A significant level of $P < .05$ was used for all statistical tests. All analyses were carried out using Stata v16 (Stata Corp, College Station, TX).

2.5. Ethics

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethical Committee in Biomedical Research at the National Hospital of Endocrinology, No.308/QD-BVNTTW. All participants provided signed informed consent.

3. Results

A total of 5244 participants enrolled in the study, among them 17.9% have prediabetes and 7.3% have diabetes. Participant's demographic characteristics are shown in Table 1. The mean age of participants was 49.62 ± 0.15 years. More than half of participants were female (52.0%) and finished secondary to high school. About 36.1% of male participants were farmers, and this prevalence among female was 37.7%. There were 23.7% overweight-obese and 6.6% underweight among male group, which is higher than the female group (19.9% overweight-obese and 5.0% underweight). WHR risk of male participants was lower than that of female participants was (20.2% vs 88.4%). The hypertension prevalence among male participant was 38.5% and among female were 26.8%. The proportions of male and female participants with prediabetes and diabetes were 7.2% and 6.4%, 6.2%, and 4.5%, respectively.

Figure 1 shows percentage of diabetes status among participants by age groups. The highest proportion of diabetes was in 60 to 69 age groups (10.8%), followed by 50 to 59 age groups (8.8%), 40 to 49 age groups (6.4%) and the lowest was in 30 to 39 (2.7%).

The association between several risk factors to diabetes status are summarized in Table 2. When analyze the BMI factor, among patients who have diabetes, there were 66% underweight, 5% normal and 29.1% overweight-obese; 56.5% have WHR risk (WHR > 0.95 in male and WHR > 0.8 in female); 53.7% have hypertension. Among patients who have pre-diabetes, 70.1% were underweight, 4.9% normal and 25% overweight-obese; 59.6% have WHR risk; 37.6% have hypertension.

The multinomial logistic of factors that related to diabetes and prediabetes showed in Table 3. Participants who were male (reference group vs female OR = 0.79; 95% CI: 0.64, 0.97), in

Table 1
General information of participants by gender, data from a national survey on type 2 diabetes and prediabetes mellitus in Vietnam 2021.

Factor	Male	Female
Total	n = 2514	n = 2730
Age groups		
30–39	590 (23.5)	686 (25.1)
40–49	612 (24.3)	660 (24.2)
50–59	646 (25.7)	692 (25.3)
60–69	666 (26.5)	692 (25.3)
Location		
Red River Delta	377 (15.0)	402 (14.7)
Northwest – Northeast	342 (13.6)	351 (12.9)
North Central – South Central Coast	518 (20.6)	569 (20.8)
Central Highlands	158 (6.3)	159 (5.8)
Southeast	235 (9.3)	253 (9.3)
Mekong River Delta	446 (17.7)	507 (18.6)
Hanoi – Ho Chi Minh City	438 (17.4)	489 (17.9)
Education		
Primary school	482 (19.2)	685 (25.1)
Secondary – high school	1519 (60.4)	1555 (57.0)
University/college and higher	513 (20.4)	490 (17.9)
Jobs		
Farmer	907 (36.1)	1028 (37.7)
Worker	346 (13.8)	160 (5.9)
Trade	228 (9.1)	367 (13.4)
Officer	460 (18.3)	418 (15.3)
Housewife	103 (4.1)	538 (19.7)
Unemployment	38 (1.5)	8 (0.3)
Others	432 (17.2)	211 (7.7)
History of family member have diabetes	350 (13.9%)	403 (14.8%)
BMI		
Underweight	167 (6.6)	137 (5.0)
Normal	1751 (69.6)	2049 (75.1)
Overweight—obese	596 (23.7)	544 (19.9)
Waist circumference		
No	2024 (80.5)	1614 (59.1)
Yes	490 (19.5)	1116 (40.9)
Waist hip ratio risk (Male > 0.95; Female > 0.8)		
No	2007 (79.8)	318 (11.6)
Yes	507 (20.2)	2412 (88.4)
Hypertension		
No	1546 (61.5)	1997 (73.2)
Yes	968 (38.5)	733 (26.8)
Blood glucose level		
Normal	1845 (73.4%)	2080 (76.2%)
Prediabetes	456 (18.1%)	481 (17.6%)
Diabetes	213 (8.5%)	169 (6.2%)

BMI = body mass index.

the 50 to 59 years old group (OR = 1.60; 95% CI: 1.28, 2.00) have higher odds of having prediabetes as compared to normal. Besides, prediabetes also correlated with patients who have hypertension and WHR risk (OR = 1.31; 95% CI: 1.12, 1.53; OR = 1.37; 95% CI: 1.11, 1.70, respectively).

Similarly, higher odds of diabetes as compared to normal were found in male patients (reference group vs female OR = 0.62; 95% CI: 0.45, 0.84), patients who were in 40 to 49; 50 to 59; 60 to 69 years old, those who were housewife (OR = 2.17; 95% CI: 1.43, 3.28; OR = 2.85; 95% CI: 1.91, 4.27; OR = 3.12; 95% CI: 2.08, 4.69; OR = 1.71; 95% CI: 1.22, 2.40, respectively). Diabetes have significant associated with participants have hypertension (OR = 1.19; 95% CI: 1.72, 2.70).

4. Discussion

In this study, 17.9% of participants have prediabetes, and 7.3% have diabetes. The prevalence of diabetes tended to increase

compared to the number in 2012 was 5.4%.^[3] Our results showed diabetes in Vietnam was lower than in India (8.0% from a national study from 2013–2019),^[13] higher than Laos (5.7% in 2016).^[14] This difference could occur due to the difference in population in each country. Moreover, our findings showed the growing trend of T2DM prevalence in Vietnam's population from 30 to 69 years old, similar to results from studies in several Asian countries, such as China,^[15] India,^[16] Sri Lanka, and Bangladesh.^[17]

Our results show that age is the common factor directly related to prediabetes and diabetes in both genders. Other factors directly associated with prediabetes and diabetes include BMI, WHR, hypertension, educational level, and job.

Regarding the non-modifiable risk factors of T2DM, including age, gender, and genetic factors, our findings show that diabetic patients were more likely to be male and have a family history of diabetes. Contrary to our finding, results from research in China on adults aged 45 to 75 years and Iran on adults aged 15 and 64 years reported that diabetes was predominant in female.^[18,19] However, our findings are similar to those of other authors who also reported diabetes to be more frequent in male.^[20–22] This contrast could be due to the different ethnic backgrounds (Vietnam population) to other countries, and the insulin resistance among non-diabetic males was generally higher than females.^[23]

In the current study, BMI is the most influential modifiable factor directly associated with diabetes. This could be explained by the obesity status leading to enhanced insulin resistance. Similar to our findings, previous studies showed a direct relationship between BMI and diabetes.^[24,25] Moreover, BMI has been proven as a risk factor that has a significant association with prediabetes.^[26] On the contrary, some studies show BMI only affects male patients with type 2 diabetes, such as the Roche et al study reported that being overweight-obese is the dominant risk factor for developing diabetes only in men.^[27] In addition, results from Njølstad et al^[29] study in Norway also showed BMI is only positively correlated with diabetes in men.

Besides BMI, WC, and Waist-Hip Ratio (WHR) are also predictors of the risk of developing T2DM. In the present study, WC risk is found to be higher in male and all female participants have normal WC. However, our result showed that WC risk have positively associated with prediabetes and diabetes status, which similar with study at Nepal in 2009.^[29] We conduct multinomial logistics in this study, and the results show the correlation of WHR with prediabetes and diabetes, respectively. High WHR means a higher risk to develop diabetes, which is consistent with the study of A Shah et al^[29] in Nepal and the study of Dalton et al^[11] in Australia. The increasing diabetes prevalence has been linked to overweight-obese status in Vietnam, which is a consequence of lifestyle change during urbanization. The promotion of fast food consumption and the change in diet and lack of physical activity caused weight gain, high BMI, and high WHR. In order to control the rising incidence of T2DM, we propose weight reduction, weight gain prevention, increased active physical activity. It is essential due to adult-onset diabetes not only linked to high BMI score, high WHR score but also associated with the duration of weight gain.^[30]

Moreover, the prevalence of T2DM also increases with age, as seen in the present study, which is consistent with other study in Vietnam, New South Wales and Germany.^[31–33]

In our current study, hypertension has a higher prevalence among prediabetes and diabetes patients. Previous medical literature also mentioned that hypertension is present in more than 50% of patients with diabetes mellitus, and having one of the two conditions increases the risk of developing the other by 1.5 to 2.0 times.^[34,35] Similarly, our multinomial logistic analysis reported that hypertension increases nearly 1.4 times the chance patients will have prediabetes and increases two times

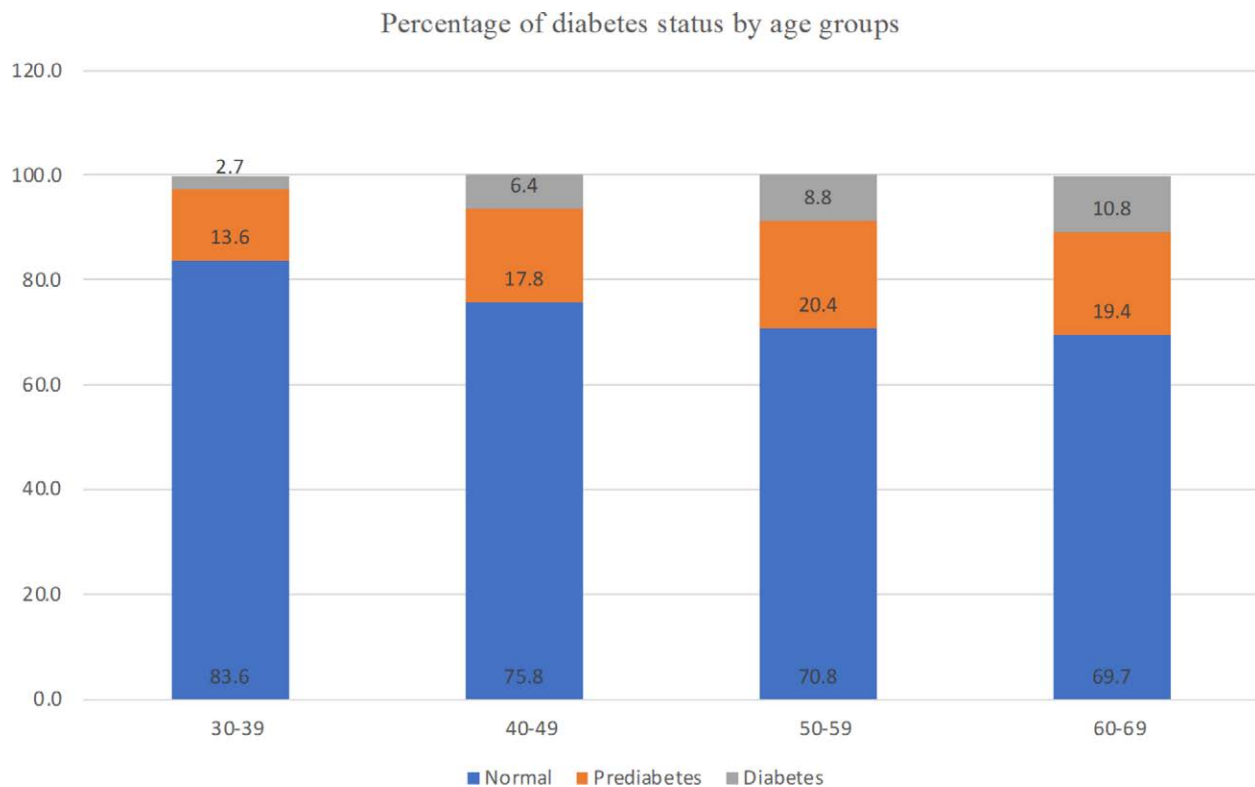


Figure 1. Percentage of prediabetes and diabetes status by age groups, data from a national survey on type 2 diabetes and prediabetes mellitus in Vietnam 2021.

Table 2

Risk factors of prediabetes and diabetes, data from a national survey on type 2 diabetes and prediabetes mellitus in Vietnam 2021.

Factor	Normal	Prediabetes	Diabetes
Total	3925	937	382
Jobs			
Farmer	1474 (37.6)	343 (36.6)	118 (30.9)
Worker	404 (10.3)	74 (7.9)	28 (7.3)
Trade	468 (11.9)	93 (9.9)	34 (8.9)
Civil servants/office workers	677 (17.2)	156 (16.6)	45 (11.8)
Housewife	453 (11.5)	120 (12.8)	68 (17.8)
Unemployment	32 (0.8)	9 (1.0)	5 (1.3)
Others	417 (10.6)	142 (15.2)	84 (22.0)
History of family member have diabetes	522 (13.3)	144 (15.4)	87 (22.8)
BMI			
Underweight	2891 (73.7)	657 (70.1)	252 (66.0)
Normal	239 (6.1)	46 (4.9)	19 (5.0)
Overweight – obese	795 (20.3)	234 (25.0)	111 (29.1)
Waist circumference			
No	2803 (71.4)	609 (65.0)	226 (59.2)
Yes	1122 (28.6)	328 (35.0)	156 (40.8)
Waist hip ratio			
No	1780 (45.4)	379 (40.4)	166 (43.5)
Yes	2145 (54.6)	558 (59.6)	216 (56.5)
Hypertension			
No	2781 (70.9)	585 (62.4)	177 (46.3)
Yes	1144 (29.1)	352 (37.6)	205 (53.7)

BMI = body mass index.

the odds of developing diabetes. However, the causal relationship between hypertension and T2DM is unclear and needs more future studies to identify.

Despite the advantage of the study's large sample size, our research still has several limitations. First, as a cross-sectional survey, the results will limit interpreting any causal inference. Second, our research has not been able to collect information about the lifestyle of people with diabetes. Further studies in

Vietnam are needed to explore the associated factor and detect modifiable factors with T2DM to thoroughly increase the quality of life among T2DM patients.

5. Conclusions

This study provides the national prevalence and association with type 2 diabetes and prediabetes risk factors among adults

Table 3**Multinomial logistic of factors related to diabetes and prediabetes, data from a national survey on type 2 diabetes and prediabetes mellitus in Vietnam 2021.**

Factors	Prediabetes vs Normal			Diabetes vs Normal		
	OR	95% CI	P value	OR	95% CI	P value
Age groups						
30–39	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
40–49	1.36*	[1.09, 1.70]	.007	2.17**	[1.43, 3.28]	.000
50–59	1.60**	[1.28, 2.00]	.000	2.85**	[1.91, 4.27]	.000
60–69	1.47*	[1.17, 1.85]	.001	3.12**	[2.08, 4.69]	.000
Gender						
Male	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Female	0.79*	[0.64, 0.97]	.025	0.62*	[0.45, 0.84]	.002
Education (primary school)						
Primary school	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Secondary – high school	1.04	[0.87, 1.25]	.666	0.83	[0.65, 1.08]	.164
University/college and higher	0.86	[0.64, 1.17]	.332	0.67	[0.43, 1.04]	.076
Jobs						
Farmer	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Worker	0.86	[0.65, 1.14]	.290	1.03	[0.66, 1.60]	.911
Trade	0.89	[0.69, 1.15]	.385	1.05	[0.70, 1.59]	.802
Civil servants/office workers	1.28	[0.96, 1.72]	.096	1.36	[0.85, 2.17]	.204
Housewife	1.06	[0.83, 1.35]	.646	1.71*	[1.22, 2.40]	.002
Unemployment	1.14	[0.53, 2.43]	.741	1.48	[0.55, 3.97]	.437
Others	1.47*	[1.16, 1.85]	.001	2.43**	[1.77, 3.35]	.000
History of family member have diabetes						
No	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Yes	1.19	[0.97, 1.46]	.089	1.99**	[1.52, 2.60]	.000
BMI						
Normal	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Underweight	0.90	[0.64, 1.25]	.517	0.96	[0.58, 1.59]	.871
Overweight – obese	1.15	[0.95, 1.40]	.162	1.19	[0.89, 1.58]	.235
Hypertension risk						
No	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Yes	1.31**	[1.12, 1.53]	.001	2.16**	[1.72, 2.70]	.000
Waist circumference risk						
No	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Yes	1.09	[0.90, 1.32]	.360	1.28	[0.96, 1.70]	.094
Waist hip ratio risk						
No	1.00	[1.00, 1.00]		1.00	[1.00, 1.00]	
Yes	1.37*	[1.11, 1.70]	.003	1.26	[0.91, 1.72]	.159

Exponentiated coefficients; 95% confidence intervals in brackets.

BMI = body mass index.

* $P < .05$ ** $P < .001$.

aged 30 to 69 years old in Vietnam. Type 2 diabetes has associated with other conditions such as hypertension, obesity, WC, and WHR. We suggested that further study explore the association with these risk factors to prevent and decrease the rising prevalence of diabetes among the population.

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