

Prevalence of diabetes and determinants: evidence from a minority region in People's Republic of China

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Background: This study aimed to examine the prevalence of diabetes mellitus and other categories of glucose intolerance (impaired glucose tolerance and impaired fasting glucose) and explore the risk factors in an ethnic minority region, Guangxi Zhuang Autonomous Region, People's Republic of China.

Methods: A population-based study enrolled 53,270 residents older than 5 years in Guangxi, People's Republic of China. The prevalence of diabetes was calculated using the 1999 World Health Organization (WHO) oral glucose tolerance test diagnostic criteria.

Results: Among 53,270 individuals, the prevalence of diabetes, impaired glucose tolerance, and impaired fasting glucose was 5.96%, 7.36%, and 2.62%, respectively. Of the 3,173 individuals with diabetes mellitus, 696 (21.94%) were found to have a history of diabetes and 2,477 (78.06%) were newly diagnosed. A lower prevalence was found in Zhuang ethnic minority people compared with the majority of Han people. The prevalence was significantly associated with age, body mass index, waist-to-hip ratio, dyslipidemia, medical history of hypertension, and family history of diabetes.

Conclusion: Guangxi shows a rapidly rising prevalence of diabetes. Weight control and blood lipid control are important to decrease the rapidly increasing prevalence of diabetes in Guangxi, an ethnic minority region.

Keywords: diabetes mellitus, ethnic minority, OGTT, diagnosis, factors, prevalence

Background

Diabetes is the major cause of morbidity and mortality in developed and developing countries. Based on the past survey conducted in 2010, 346 million people worldwide have diabetes, and an estimated 6 million are newly diagnosed annually.^{1,2}

A previous study suggested that risk factors such as overeating, lack of physical activity, and obesity have led to a dramatic increase in the prevalence of diabetes, with very high rates in the Chinese population in the recent 30 years.³ However, it has been ~20 years since the first and second surveys of diabetes, 1980 and 1996, respectively, were conducted in Guangxi. Since China is a populous country with different ethnic groups and economic levels, the prevalence of diabetes varies widely between populations, reflecting differences in both regions and ethnicities.

Located in the south of People's Republic of China, Guangxi Zhuang Autonomous Region (hereafter referred to as Guangxi) is a multiethnic area.⁴ Bordering Vietnam to the south, Guangxi has eleven ethnic minority groups, including Zhuang, Yao, Miao, Dong, Mulao, and other ethnic groups, accounting for 38% of its population, or 19.57 million people.⁵ The Zhuang is People's Republic of China's largest ethnic minority

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group living mainly in Guangxi. Under such context, the objectives of this study were to examine the prevalence of diabetes, impaired glucose tolerance (IGT), and impaired fasting glucose (IFG), and explore the determinants in an ethnic minority region.

Methods

Study site and study population

This survey was conducted during the period from July 2003 to December 2005 in Guangxi, and included a representative sample of the Guangxi population. Survey areas included cities (city districts) and rural areas (townships) of Nanning, Baise, Hezhou, Qinzhou, Nandan, Fengshan, Luzhai, and Longan, which are geographically distributed in the east, south, west, north, and middle parts of Guangxi. People living in their current residence for at least 5 years were included in the study.

Data collection and measurement

Trained staff collected data pertaining to demographic characteristics, personal and family medical history, and lifestyle risk factors through a questionnaire survey. The interview included questions for the diagnosis and treatment of diabetes, hypertension, dyslipidemia, and cardiovascular disease, and on the duration and amount of cigarette smoking and alcohol consumption. Blood pressure, body weight, height, waist circumference, and hip circumference were measured using standard diagnostic criteria.⁶ The Ethics Committee of the Guangxi Medical University approved the study protocol and written informed consent was obtained from the participants.

All the participants were required to fast overnight for more than 10 hours (if their reported fasting time was less than 10 hours, they were asked to return on another day), and were tested for fasting plasma glucose (FPG), blood serum lipid, uric acid, and fasting insulin. Plasma glucose and uric acid levels were measured using glucose oxidase method, and serum cholesterol and triglyceride levels were measured using commercially available reagents. Radioimmunoassay was used to measure blood serum insulin at the central laboratory of Guangxi Medical University. All the study laboratories were standardized and certified by the government.

Oral glucose tolerance test

After more than 3 days of dietary control, an oral glucose tolerance test (OGTT) was performed in all the participants. Participants without a medical history of diabetes were given a standard 75 g glucose solution. After 120 ± 5 minutes, venous

blood samples were collected to measure 2-hour postprandial plasma glucose level, and 2-hour postprandial capillary blood glucose level was measured using capillary fingertip blood sample. Immediate venous blood samples were collected if the capillary blood glucose was equal to or above 6.70 mmol/L. For safety reasons, participants with a medical history of diabetes were tested for FPG and/or 2-hour free-diet PPG, but OGTT was not performed in these patients. Furthermore, glucose oxidase method was used to measure plasma glucose levels.

Diagnostic criteria

The following diagnostic criteria were used to diagnose diabetes mellitus (DM), IFG, and IGT:

1. The 1999 World Health Organization (WHO) diagnostic criteria were used to diagnose DM, IFG, and IGT.⁷ Results of plasma glucose testing were categorized as follows: normal glucose tolerance: FPG < 6.1 mmol/L and 2-hour plasma glucose (2 h PG) < 7.8 mmol/L; DM: FPG ≥ 7.0 mmol/L, 2 h PG ≥ 11.1 mmol/L, and with DM medical history; IFG: FPG ≥ 6.1 and < 7.0 mmol/L with the exclusion of cases with DM history or 2 h PG ≥ 11.1 mmol/L; IGT: FPG < 7.0 mmol/L and 2 h PG ≥ 7.8 and < 11.1 mmol/L with the exclusion of cases with DM history.
2. The Chinese obesity diagnostic criteria was used as the following: body mass index (BMI) < 18.5 kg/m² is regarded as emaciation, 18.5 kg/m² $\leq$ BMI < 24.0 kg/m² as normal body weight, 24.0 kg/m² $\leq$ BMI < 28.0 kg/m² as overweight, and BMI ≥ 28.0 kg/m², as obese. Central obesity is defined according to the WHO standards. Males with waist-to-hip ratio (WHR) < 0.90 and females with WHR < 0.85 are regarded as normal, while males with WHR ≥ 0.90 and females with WHR ≥ 0.85 are regarded as having central obesity.

Statistical analysis

Age and sex-standardized prevalence were calculated by the direct method.⁷ Descriptive data were presented in frequency and percentage, followed by chi-square test or Fisher's test as appropriate. Logistic regression was used to examine demographic, lifestyle, and metabolic factors accounting for diabetes and prediabetes. Data analyses were performed using R language and environment (version 3.1.0)⁸ and Epicalc package.⁹

Results

General population distribution

A total of 54,098 persons were eligible to participate in the survey. Eight hundred and twenty-eight individuals were

excluded from the analysis according to inclusion criteria. The remaining 53,270 individuals were included in the data analysis. Of these individuals, 28,979 (54.4%) were men, while 24,291 (45.6%) were women. The age and sex of all individuals are summarized in Table 1. Among the 53,270 individuals, ethnical identity of 50,150 subjects was known: 15,226 (30.36%) belonged to Zhuang ethnicity, 33,347 (66.49%) to Han ethnicity, and 1,577 (3.14%) to other ethnic minorities.

Prevalence of DM, IGT, and IFG

The 53,270 individuals were divided into nine groups at a 10-year interval. The prevalence rates of DM, IGT, and IFG were 5.96% (standardized rate: 3.70%), 7.36% (standardized rate: 4.86%), and 2.62% (standardized rate: 1.88%), respectively. The prevalence rates were higher in men than in women ($P<0.01$) (Table 1). Among the 3,173 individuals with DM, 696 (21.94%) had a medical history of diabetes and 2,477 (78.06%) were newly diagnosed with diabetes.

Comparisons of prevalence in different ages

The study showed that the prevalence of DM, IGT, and IFG increased with age (Figure 1), but the prevalence of IFG was far less than that of DM and IGT. The difference in the prevalence of DM, IGT, and IFG among people with different age groups was statistically significant ($P<0.01$) (Table 1).

Comparisons of prevalence in different ethnic groups

There were obvious differences in the prevalence of DM, IGT, and IFG among Han, Zhuang, and other ethnicities. The prevalence of DM, IGT, and IFG in Han ethnicity was 6.45%, 7.39%, and 2.69%, respectively, while in Zhuang ethnicity was 4.48%, 5.16%, and 2.09%, respectively. The related data showed the prevalence was higher in Han ethnicity than in Zhuang ethnicity ($P<0.01$). Furthermore, the prevalence was significantly higher in men than in women in Han and Zhuang ethnic groups (Table 2).

Risk factors of diabetic prevalence

Table 3 summarizes the association between risk factors and DM using a multivariable nonconditional logistic regression analysis. There was an evident age-dependent relationship between age groups and the prevalence of DM. The risks increased remarkably with old age. The association between risk factors such as hyperlipidemia history, hypertension history, and diabetes mellitus was also strong,

Table 1 Comparison of the prevalence rate (%) of DM, IGT, and IFG among the residents in Guangxi

Age (years)	People surveyed			Prevalence of DM			Prevalence of IGT			Prevalence of IFG		
	Sex		Total, N	Sex		Total, N (%)	Sex		Total, N (%)	Sex		Total, N (%)
	Male, n	Female, n		Male, n (%)	Female, n (%)		Male, n (%)	Female, n (%)		Male, n (%)	Female, n (%)	
<10	1,286	1,170	2,456	2 (0.16)	1 (0.09)	3 (0.12)	1 (0.08)	0 (0.00)	1 (0.04)	0 (0.00)	2 (0.17)	2 (0.08)
10	2,560	2,426	4,986	12 (0.47)	8 (0.33)	20 (0.40)	20 (0.78)	28 (1.15)	48 (0.96)	11 (0.43)	8 (0.33)	19 (0.38)
20	2,676	2,753	5,429	27 (1.01)	39 (1.42)	66 (1.22)	54 (2.02)	74 (2.69)	128 (2.36)	43 (1.61)	29 (1.05)	72 (1.33)
30	4,585	3,730	8,315	128 (2.79)	80 (2.14)	208 (2.50)	206 (4.49)	117 (3.14)	323 (3.88)	99 (2.16)	52 (1.39)	151 (1.82)
40	5,880	5,388	11,268	380 (6.46)	238 (4.42)	618 (5.48)	509 (8.66)	369 (6.85)	878 (7.79)	227 (3.86)	132 (2.45)	359 (3.19)
50	6,245	4,866	11,111	600 (9.61)	347 (7.13)	947 (8.52)	734 (11.75)	456 (9.37)	1,190 (10.71)	245 (3.92)	156 (3.21)	401 (3.61)
60	3,535	2,659	6,194	478 (13.52)	342 (12.86)	820 (13.24)	498 (14.09)	315 (11.85)	813 (13.13)	146 (4.13)	111 (4.17)	257 (4.15)
70	1,870	1,095	2,965	253 (13.53)	158 (14.43)	411 (13.86)	325 (17.38)	134 (12.24)	459 (15.48)	77 (4.12)	37 (3.38)	114 (3.84)
80 $\geq$	342	204	546	52 (15.20)	28 (13.73)	80 (14.65)	63 (18.42)	16 (7.84)	79 (14.47)	13 (3.80)	7 (3.43)	20 (3.66)
Total	28,979	24,291	53,270	1,932 (6.67)*	1,241 (5.11)	3,173 (5.96)	2,410 (8.32)*	1,509 (6.21)	3,919 (7.36)	861 (2.97)*	534 (2.20)	1,395 (2.62)

Notes: The prevalence rates of DM, IGT, and IFG were compared between males and females; prevalence in males was higher than that of females. * $P<0.01$.
Abbreviations: DM, diabetes mellitus; IGT, impaired glucose tolerance; IFG, impaired fasting glucose.

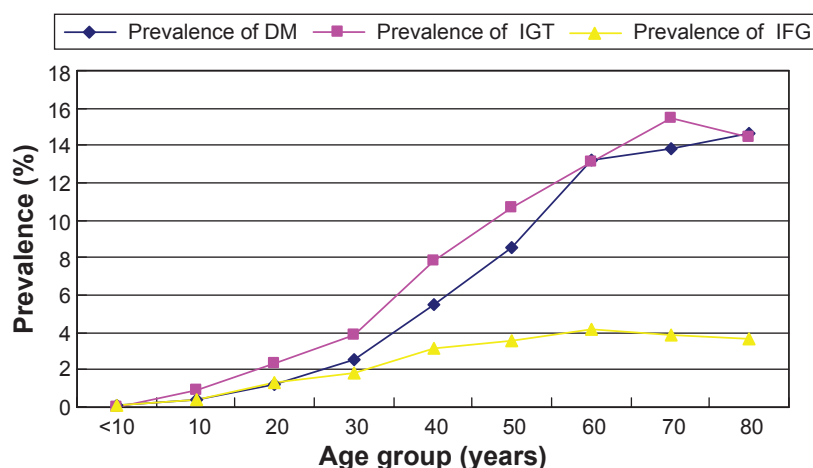


Figure 1 The distribution of the prevalence rate of DM, IGT, and IFG in Guangxi district.

Abbreviations: DM, diabetes mellitus; IGT, impaired glucose tolerance; IFG, impaired fasting glucose.

which increased the risk by 1.85, 1.39, times compared those without the history. In addition, factors such as high BMI and abnormal WHR were also independent factors. Abnormal total cholesterol and triglyceride as well as high low-density lipoprotein levels were associated with increased risk of diabetes. People with a family history of diabetes were 3.2 times more likely to have diabetes compared with those without a family history. After adjusting for all the factors, this study showed that sex and ethnic groups were not significant risk factors for diabetes.

Discussion

Tendency of DM prevalence in Guangxi in 20 years

This was a large-scale epidemiological survey on DM in Guangxi, People's Republic of China. Our survey found that the general prevalence of DM was 5.96% (taking the Chinese population in 2000 as reference) among people older than 5 years in Guangxi. For comparison, if the Chinese population in 1990 is taken as reference, the general prevalence was 0.98% in the first survey, 2.11% in the second survey, and 3.25% in the current (third) survey.⁶ The data presented from these surveys showed a substantial increase in the prevalence of total diabetes over these years. Increase in the prevalence of DM in Guangxi was related to the changes in lifestyle and other factors. Of the 3,173 individuals, 696 (21.94%) were found with a medical history of DM and 2,477 (78.06%) were newly diagnosed.

The general prevalence of IGT was 7.36% in this study. Compared with the past two surveys, the prevalence tendency of IGT was consistent with that of DM over the past 30 years.

The general prevalence of IFG was 2.62% (the standardized prevalence was 1.88% in 2000), which was statistically significantly lower than that of IGT, indicating that the prevalence of islet function impairment was lower than that of insulin resistance.

Among people older than 15 years, the general prevalence of DM, IGT, and IFG was 6.46% (standardized rate: 4.72%), 8.00% (standardized rate: 6.08%), and 2.83% (standardized rate: 2.27%), respectively. Compared to the survey in 2002,¹⁰ the prevalence of DM and IGT was 2.52% (standardized rate: 1.43%) and 1.21% (standardized rate: 0.89%), respectively. The present standardized prevalence of DM and IGT in Guangxi is 3.3 and 6.8 times, respectively, higher than that observed in 2002. FBG testing was mainly performed in the previous study, while OGTT was performed on most participants in the present study, which improved the accuracy of diagnosis. The results of this study clearly showed that the prevalence of IGT was significantly much higher than that of IFG. The prevalence of IFG in Korea in 2001 was 23.9%.¹¹ The difference of prevalence indicated that the increase in FPG and 2-hour postprandial blood glucose values varies across nations and districts.

The relationship between the prevalence of DM and demographic characteristics

The prevalence of DM, IGT, and IFG substantially increases with age.^{12–14} Söderberg et al¹⁴ reported that the peak onset time of DM was ~45–54 years, which was consistent with the findings of this study.

The body weight index including BMI and WHR had a close relationship with increase in the prevalence of

Table 2 Comparison of the prevalence rate (%) of DM, IGT, and IFG between different ethnic nationalities in Guangxi

Ethnic nationalities	Surveyed people			DM			IGT			IFG		
	Male, n	Female, n	Total, N	Male, n (%)	Female, n (%)	Total, N (%)	Male, n (%)	Female, n (%)	Total, N (%)	Male, n (%)	Female, n (%)	Total, N (%)
Han people	18,029	15,318	33,347	1,258 (6.98 ^{*,**})	894 (5.84 ^{*,*})	2,152 (6.45 ^{*,**})	1,472 (8.16 ^{*,**})	994 (6.49 ^{*,*})	2,466 (7.39 ^{*,**})	532 (2.95 ^{*,**})	365 (2.38 ^{*,*})	897 (2.69 ^{*,**})
Zhuang people	8,156	7,070	15,226	432 (5.3 [*])	250 (3.54)	682 (4.48)	455 (5.58 [*])	330 (4.67)	785 (5.16)	199 (2.44 [*])	119 (1.68)	318 (2.09)
Other ethnicities	786	791	1,577	37 (4.71)	26 (3.29)	63 (3.99 [*])	50 (6.36)	37 (4.68)	87 (5.52 [*])	24 (3.05)	13 (1.64)	37 (2.35 [*])

Notes: The comparison of the prevalence rates of DM, IGT, and IFG between Han and Zhuang people, ^{*} $p < 0.05$; the comparison of the prevalence rates of DM, IGT, and IFG between Han people and other ethnic minorities, ^{*} $p < 0.01$; the comparison of the prevalence rates of DM, IGT, and IFG between different ethnic nationalities, ^{*} $p < 0.01$.

Abbreviations: DM, diabetes mellitus; IGT, impaired glucose tolerance; IFG, impaired fasting glucose.

DM, hypertension, and cardiovascular disease.^{15,16} The fact that participants with higher education level was less likely to have DM in this research was different to other studies.¹⁷

The DM prevalence was associated with ethnicity in a univariate analysis. Of 50,150 individuals in our study, 30.4% belonged to Zhuang ethnicity, 66.5% to Han ethnicity, and 3.1% to other ethnic minorities. However, after adjusting for other factors, the differences among the ethnic groups and sexes were not significant, which would merit further studies.

Risk factors of diabetic prevalence

The data showed that age, family history of diabetes, medical history of hypertension and hyperlipidemia, BMI, WHR, total cholesterol, triglyceride, and low-density lipoprotein were contributing factors to DM. High-density lipoprotein cholesterol was the protective variable of DM prevalence. Previous study also showed that excessive abdominal fat had more impact on cardiovascular disease than that in buttocks.¹⁸ WHR was the strongest independent obesity indicator associated with self-reported hypertension and diabetes.¹⁹

This study found that, despite genetic factors, the prevalence of DM in people with DM family history was 3.2 times higher than in those without DM family history. Similar results were reported in another research, which showed that the DM prevalence in immediate family relatives was 3.94%, while in the control group was 1.09%, and the relative risk was 3.62.²⁰

Although evidence demonstrated that smokers are more likely to be diagnosed with DM than nonsmokers,²¹ our study showed that smoking was not a significant factor, after adjusting for other factors.

The rapid increase in the prevalence of DM, IGT, and IFG in Guangxi suggests that measures to control body weight and blood lipids would help prevent further deterioration in DM epidemiology.

Strengths and limitations

As a large-scale population-based study recently conducted in Guangxi, this study provided a strong evidence for governments and public health planners to adapt strategies for the prevention of diabetes in countries or communities with similar conditions, especially ethnic minority regions. Further studies should be conducted to learn the context factors in different ethnic groups in such an ethnic minority autonomous region with multilevel analysis.

Table 3 Association between risk factor and diabetes mellitus

Variables	Crude OR (95% CI)	AOR (95% CI)	P-value (Wald's test)	P-value (LR test)
Sex: female vs male	0.84 (0.71, 1.00)	0.86 (0.67, 1.10)	0.23	0.23
Age group, years (reference age group: 5–14 years)				<0.001
15–29	2.47 (0.51, 11.93)	2.59 (0.51, 13.06)	0.25	
30–44	16.15 (3.98, 65.55)	11.47 (2.66, 49.49)	0.001	
45–59	42.21 (10.47, 170.07)	23.24 (5.44, 99.26)	<0.001	
≥60	63.2 (15.67, 254.85)	34.78 (8.16, 148.17)	<0.001	
Ethnic reference: Zhuang				0.33
Han	1.25 (1.03, 1.52)	1.17 (0.95, 1.45)	0.14	
Other ethnicities	1.03 (0.71, 1.50)	1.06 (0.71, 1.59)	0.76	
Education reference: illiterate				0.01
Low education	0.69 (0.48, 0.99)	1.03 (0.69, 1.54)	0.89	
Middle education	0.51 (0.34, 0.75)	0.78 (0.5, 1.22)	0.28	
High education	0.28 (0.18, 0.46)	0.61 (0.36, 1.06)	0.08	
HBP history: yes vs no	3.19 (2.62, 3.89)	1.39 (1.1, 1.77)	0.01	0.01
CHD history: yes vs no	2.97 (1.92, 4.59)	1.05 (0.65, 1.71)	0.84	0.84
CVD history: yes vs no	2.86 (1.61, 5.11)	1.1 (0.59, 2.05)	0.77	0.77
HLP history: yes vs no	3.64 (2.62, 5.06)	1.85 (1.29, 2.66)	<0.001	0.00
Smoking history: yes vs no	1.55 (1.28, 1.88)	1.15 (0.88, 1.50)	0.31	0.31
Drinking history: yes vs no	1.28 (1.06, 1.54)	0.99 (0.76, 1.30)	0.99	0.99
SBP: SBP ≥140 mmHg vs SBP <140 mmHg	2.56 (2.09, 3.15)	1.13 (0.87, 1.47)	0.34	0.35
DBP: DBP ≥90 mmHg vs DBP <90 mmHg	1.67 (1.27, 2.18)	0.71 (0.52, 0.98)	0.04	0.03
BMI reference: BMI <18.5 kg/m ²				0.00
18.5 kg/m ² ≤ BMI <24.0 kg/m ²	2.7 (1.74, 4.17)	0.95 (0.58, 1.53)	0.83	
24 kg/m ² ≤ BMI <28.0 kg/m ²	5.62 (3.63, 8.70)	1.17 (0.72, 1.93)	0.52	
BMI ≥28.0 kg/m ²	9.34 (5.80, 15.04)	1.77 (1.03, 3.05)	0.04	
WHR (male): WHR ≥0.90 vs WHR <0.90	3.01 (2.53, 3.58)	1.46 (1.19, 1.79)	<0.001	<0.001
WHR (female): WHR ≥0.85 vs WHR <0.85				
TC: TC ≥5.72 mmol/L vs TC <5.72 mmol/L	2.48 (2.02, 3.05)	1.52 (1.20, 1.92)	<0.001	<0.001
TG: TG ≥1.70 mmol/L vs TG <1.70 mmol/L	3.19 (2.68, 3.78)	1.87 (1.54, 2.28)	<0.001	<0.001
HDL: HDL ≥0.91 mmol/L vs HDL <0.91 mmol/L	0.51 (0.42, 0.62)	0.77 (0.62, 0.95)	0.02	0.02
LDL: LDL ≥3.12 mmol/L vs LDL <3.12 mmol/L	1.58 (1.33, 1.87)	1.23 (1.01, 1.49)	0.04	0.04
UA (male): UA >420 μmol/L vs UA ≤420 μmol/L	2 (1.64, 2.44)	1.10 (0.89, 1.37)	0.38	0.38
UA (female): UA >350 μmol/L vs UA ≤350 μmol/L				
DMFH: yes vs no	1.75 (1.23, 2.48)	3.20 (2.14, 4.77)	<0.001	<0.001

Abbreviations: OR, odds ratio; CI, confidence interval; AOR, adjusted odds ratio; LR, likelihood ratio; HBP, high blood pressure; CHD, coronary heart disease; CVD, cerebrovascular disease; HLP, hyperlipidemia; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; WHR, waist-to-hip ratio; TC, total cholesterol; TG, triglyceride; HDL, high-density lipoprotein; LDL, low-density lipoprotein; UA, uric acid; DMFH, diabetes mellitus family history.

Conclusion

This study showed an increasing prevalence of DM, IGT, and IFG in Guangxi. Weight control and blood lipid control are important to decrease the rapidly increasing prevalence of diabetes in an ethnic minority region.

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Disclosure

The authors report no conflicts of interest in this work.

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