ORIGINAL ARTICLE

Prevalence of diabetes and hypertension in ethnic minority adults living in rural Yunnan province, China

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Abstract Hypertension (HTN) and type 2 diabetes mellitus (DM) are risk factors for cardiovascular disease (CVD), which is increasing in rural China. Little data is available about their prevalence among ethnic minorities in rural China. Eleven villages were randomly selected from Yunnan province, China. Six hundred thirty-four randomly selected subjects from six ethnic minorities and the Han ethnic majority participated in a cross-sectional survey, which includ-ed blood pressure (BP) and HbA1c measurements. From each village, 70–90 men and women between the ages of 50 and 70 years were randomly selected. The prevalence and self-reported history of HTN and DM were evaluated in these seven ethnic groups. The prevalence of DM was 6.3 %, with variability between ethnic groups, ranging from 2.7 % in the Tibetan group to 9.8 % in the Han group (P=0.09). HTN prevalence also varied from 30.5 % in the Lisu group to 54.7 % in the Tibetan group (P=0.003). Only 22.5 % (9/40) and 47.7 % (112/235) of those diagnosed with DM and HTN, respectively, had reported a known history of their condition. The prevalence of DM varied across ethnic groups, with Han people having a greater prevalence than the ethnic minorities. As most subjects with DM or HTN were not actually aware of their condition, there is need for in-creased screening and education promotion in this region.

Keywords Hypertension · Blood pressure · Diabetes · HbA1c · Rural China · Ethnic minority

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Introduction

Chronic diseases in China constitute approximately 80 % of total deaths and 70 % of total disability-adjusted life-years (DALYs) lost [1]. Cardiovascular disease (CVD) is one of the leading causes of death from chronic diseases in China [2]. During 2000, CVD resulted in a loss of 6.7 million years of productive life among people between the ages of 35 and 64 years in China [1]. This equates to approximately 30 billion US dollars, with only a quarter of this cost credited to direct health care costs [1].

Rural China is facing an increase in the incidence of CVD [3]. The mortality rate of CVD in rural China for 1999 was 279 per 100,000 deaths in women and 413 per 100,000 deaths in men [4]. Yunnan province, located in southwest China, is one of China's poorest provinces [5]. With residents from 52

ethnic groups, Yunnan's population has the most concentrated and diverse population of ethnic minorities [6].

Hypertension (HTN) and type 2 diabetes mellitus (DM) are key risk factors for CVD [7, 8]. In China, there has been an increase in the prevalence of DM and HTN over 20 years [3]. CVD risk factors, including DM and HTN, are associat-ed with ethnicity [2]. Among Chinese ethnic minorities, HTN is highly prevalent [6]. Among ten ethnic minorities in Yunnan province, prevalence of HTN was 64 % among Tibetan ethnic minority, compared to 25 % among the Han ethnic majority [6].

Those with DM have both higher risk and poorer progno-sis for CVD [7–9]. Among those with DM, each additional percentage point increase in glycosylated hemoglobin level is associated with a 15–18 % higher risk of cardiovascular disease [10]. The purpose of this study is to determine the prevalence of type 2 DM among Chinese adults between the ages of 50 and 70 years from rural Yunnan province (with a focus on ethnic minorities) and to examine potential DM correlates.

Methods

Study sample The target population was adults between the ages of 50 and 70 years living in rural Yunnan province. In this cross-sectional study, subjects were recruited by random cluster sampling at the village and individual level. First, the ministry of health identified four impoverished towns in Yunnan with large populations of ethnic minorities, from which 2 to 3 villages were randomly selected per town. Following, a list of all the residents aged 50–70 years was generated for each town. The random number generator in Microsoft Excel was then used to select 35 men and 35 women in each village. Seventy subjects were randomly selected within each village for 11 villages, with the exception of one Tibetan village where we oversampled (90 subjects instead of 70) in order to get better representation of the Tibetan minority group.

Village leaders informed all selected subjects of their random selection to participate in this research study, along with details of the dates, times, and locations of the data collection sites in each village. For selected subjects who lived far away, the research team traveled to an alternative location closer to their homes.

Health survey, blood pressure measurements, and HbA1c tests The study was approved by the Institutional Review Board of Chongqing Medical University and written in-formed consent was obtained from all participants. The self-reported health questionnaires were administered in spoken Chinese by trained personnel, with translations into local languages and dialects when necessary. The questionnaires included questions pertaining to subjects' sociodemographic information including ethnicity, history of HTN and DM, history of smoking, and use of alcohol (three or more drinks per week). Date of birth and ethnicity were recorded from the subjects' identity documents (identity card or "hu kou" booklet). With subjects seated with their arm at heart level, trained research staff also measured their blood pressure (BP) in either arm using an aneroid sphygmomanometer (made by Welch Allen Tycos in Shanghai, China). The measurements were repeated three times, with 1 min of rest and the mean value was taken. Weight was measured to the nearest half kilogram using a standard balance scale, height to the nearest centimeter using a rigid measuring ruler, and waist and hip circumference to the nearest centimeter at the level of the umbilicus and widest region of the buttocks, respectively. The body mass index (BMI) was calculated by dividing weight (kg) by height squared (m^2).

A random capillary blood sample was also taken to measure the percent of glycosylated hemoglobin A1c (using the Nyocard II Analyzer, Axis Shield Inc, Oslo, Norway). The HbA1c level was determined from the average of the two tests done. Subjects with an average HbA1c test result great-er than 37.7 mmol/mol (or 5.6 %) were asked to return the following morning to have their fasting blood glucose (FBG) measured through a capillary blood sample for further con-firmation of their diabetes status. The HbA1c test was used because it was a convenient and reliable method of deter-mining subjects' diabetes status, as it did not require fasting prior to taking the blood sample.

Definition of HTN and DM For non-diabetic research subjects, HTN was defined as having a mean systolic BP of at least 140 mm Hg or a diastolic BP of at least 90 mm Hg. For diabetic subjects, the criteria for HTN were a minimum systolic BP of 130 mm Hg and a minimum diastolic BP of 80 mm Hg [11]. We did not include in the definition of HTN those on anti-hypertensive medications when blood pressure was under control because these were few (8) in number and because in rural Yunnan, anti-hypertensive medications are often inappropriately prescribed for patients with symptoms, but normal blood pressure [6]. DM was defined as having an average HbA1c test result of 47.5 mmol/mol (6.5 %) or higher, or an average HbA1c test result between 37.7 mmol/mol and 47.5 mmol/mol (5.6–6.5 %) plus an FBG test result of 7 mmol/L or more [12]. Self-reported diabetics and those reported to be on treatment with anti-diabetic medications were also classified as having DM. Subjects identified as having HTN or DM were given medical advice and the appropriate medicines free of charge.

Statistical analysis Descriptive statistics were performed for the sociodemographic variables (e.g., age, sex, ethnicity, occupation, smoking history, and use of alcohol) and clinical

data (height, weight, BMI, waist and hip circumference, BP, and HbA1c). The means of the continuous variables were compared between those with DM and those without DM, using independent samples t-tests. For the categorical variables, frequencies of DM were compared using χ^2 tests. Variables that were significant at least at the P=0.05 level in the χ^2 and t-tests were then included as predictor variables in a multivariate logistic regression model with DM as the dependent variable. The prevalence of DM was calculated for each ethnic group. However, for the logistic regression analysis, ethnicity was recoded as a binary variable (Han vs. minority). All analyses were performed in SAS V9.2.

Results

The study sample consisted of 840 randomly selected men and women between 50 and 70 years of age, 634 (75.5 %) of who were available and provided consent to participate in the research study. Sociodemographic and clinical characteris-tics of the sample population are shown in Table 1. The sample included Han (38.8 %), Yi (20.0 %), Lisu (16.6 %), Tibetan (11.8 %), Naxi (9.0 %), Bai (3.6 %), and Pumi (0.2 %) ethnic groups and had a greater representation of females than males (52.5 % vs. 47.5 %). DM was prevalent among 6.3 % of subjects, although only 1.4 % reported a history of DM. Likewise, more than one-third of the sample had HTN, but only 17.7 % reported a history of HTN. Most were farmers and were married. Approximately 40 % and 35 % of the sample were smokers and drinkers, respectively.

Table 1 Sample sociodemographic and clinical characteristics (N=634)

	% (N)
Ethnicity	
Han	38.8 %(246)
Yi	20.0 %(127)
Lisu	16.%(105)
Tibetan	11.8 %(75)
Naxi	9.0 %(57)
Bai	3.6 %(23)
Pumi	0.2 %(1)
Occupation	
Farmer	98.6 %(625)
Other	1.5 %(9)
Female	52.5 %(333)
Marital status	
Single	1.9 %(12)
Married	97.8 %(620)
Divorced	0.3 %(2)
Present smoker	39.9 %(253)
Drink alcohol	35.2 %(223)
Diabetes mellitus (DM)	6.3 %(40)
History of DM	1.4 %(9)
Hypertension (HTN)	37.1 %(235)
History of HTN	17.7 %(112)

Table 2 shows the results of the χ^2 and independent samples t-tests comparing frequencies and means of various sociodemographic and clinical characteristics among those with and without DM and HTN. The prevalence of DM was highest in the Han (9.8 %) and Naxi (7.0 %) ethnic groups and lowest in the Tibetan (2.7 %) and Lisu (2.9 %) groups, although the difference was not statistically significant (χ^2 =9.6; P=0.09). However, DM prevalence was related to ethnic minority status, as ethnic minorities collectively had significantly higher DM prevalence than the Han ethnic majority (41.1 % vs. 30.9 %, χ^2 =8.1; P=0.004). HTN prevalence was also significantly different across ethnic groups (χ^2 =18.0; P=0.003), but unlike the case with DM, HTN is most prevalent among the Tibetans (54.7 %) and least prevalent among the Lisu (30.5 %) and Han (30.9 %) groups. These differences in HTN and DM prevalence across ethnic groups and minority status can be seen in Figs. 1 and 2. For the χ^2 test between HTN and ethnicity, the high prevalence of HTN in the Tibetan group was the primary driver of the significant χ^2 test.

Other variables that showed a significant association with DM were age, measured HTN, weight, BMI, waist to hip ratio, and SBP, as the proportions of diabetic individuals with those characteristics and their mean values of those charac-teristics were higher than those of non-diabetic individuals. All of the variables that were significantly related to DM also showed a significant relationship with HTN, along with DBP.

Because of the limited number of individuals with DM in some of the ethnic minority groups, we collapsed the Yi, Lisu, Tibetan, Naxi, and Bai groups into one collective minority group. Thus, in further analyses, ethnicity only consisted of two categories—Han and all minorities. Results of the logistic regression analysis are summarized in Table 3. When the significant variables (ethnicity, age, HTN, weight, BMI, and waist to hip ratio) from the prior analyses were included as independent variables in a multivariate forced-entry logistic regression model where DM was the dependent variable, we found that older aged and Han individuals were at highest risk for DM. (SBP was excluded from the regres-sion analysis because measured HTN was already included). DM, as determined by HbA1c and FBG measurements, was 2.3 times more likely in Hans than ethnic minorities (P=0.02). Each additional year of age was associated with a 6 % increase in the risk of DM, but this relationship was not statistically significant (P=0.10).

Further examination into the differences in characteristics between Han and ethnic minorities in this study revealed that

Table 2 Characteristics of Subjects with and without DM and HTN (n=630)

Characteristic	DM (N=40)	No DM (N=590)	P-value	HTN (N=234)	No HTN (N=396)	P-value
Female sex - % (n)	65.0 % (26)	51.7 % (305)	0.10	51.3 % (120)	53.3 % (211)	0.63
HTN by measurement - % (n)	72.5 % (29)	34.8 (205)	<0.001			
Mean age (years)	61.8	59.7	0.02	60.9	59.2	<0.001
Mean height (cm)	156.1	156.6	0.70	157.0	156.4	0.34
Mean weight (kg)	54.7	51.0	0.05	53.1	50.1	<0.001
Mean BMI (kg/ m^2)	22.4	20.8	0.02	21.5	20.5	<0.001
Mean waist to hip ratio	0.90	0.86	0.02	0.87	0.85	0.001
Mean SBP	141.1	131.0	0.01	155.9	117.3	<0.001
Mean DBP	87.8	81.1	0.09	92.9	74.5	<0.001

Four subjects (2 Han, 1 Tibetan, and 1 Pumi) of the total 634 people surveyed were excluded from this set of analyses due to missing data on their DM status.

relative to Han people, there was a greater proportion of minorities who drank alcohol (38.1 % vs. 30.5 %) and on average, they consumed a greater amount of alcohol (3.6 vs. 2.3 cups/day). The proportion of minorities who drink and/or smoke was also higher than that of Hans (55.9 % vs. 47.2 %). However, the Han group had statistically significantly higher mean age (60.7 vs. 59.2 years), weight (52.4 vs. 50.5 kg), BMI (21.3 vs. 20.6 kg/ m^2), and waist to hip ratio (0.87 vs. 0.85) than the minority groups. These differences are sum-marized in Table 4.

Discussion

Prevalence of DM The prevalence of DM in this sample of adults in rural Yunnan between the ages of 50 and 70 years was 6.3 %, with variation between ethnic groups, ranging from 2.7 % in the Tibetan group to 9.8 % in the Han group. The prevalence of DM among rural Hans (9.8 %) is almost equivalent to that of individuals aged 20 years and above in the overall Chinese population (9.7 %), but higher than that of rural China (8.2 %) [3]. When comparing rates in similar age groups, DM prevalence among rural Hans 50–70 years of age living in Yunnan (9.8 %) was lower relative to the national Chinese population in the 40–59 age range (11.5 %) and the 60 and above age range (20.4 %). Our data also reflects the upward trend of DM prevalence in China since 1980, when the prevalence was less than 1 % [13].

However, although the prevalence of DM among Hans was more than double that of ethnic minorities, prevalence of HTN was lower than other ethnic minority. If this dichotomy can be replicated, it suggests that while differences in HTN prevalence between Han and other ethnic groups might be due to their differential dietary intake [6], differences in their DM prevalence might be due to other factors that inde-pendently affect their risk for DM, such as genetic pre-dispositions and physical activity. Differences in smoking and drinking habits do not appear to be responsible for the

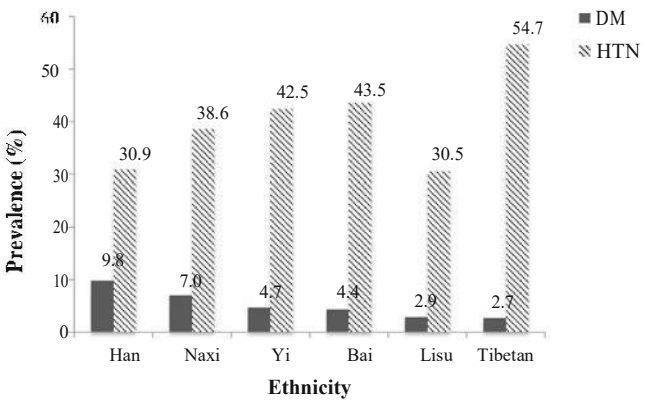

Fig. 1 Diabetes and hypertension prevalence, by ethnicity. Ethnicity was not significantly related to DM ($\chi2$=9.6; P=0.09). However, ethnicity was significantly related to HTN ($\chi2$=18.0; P=0.003)

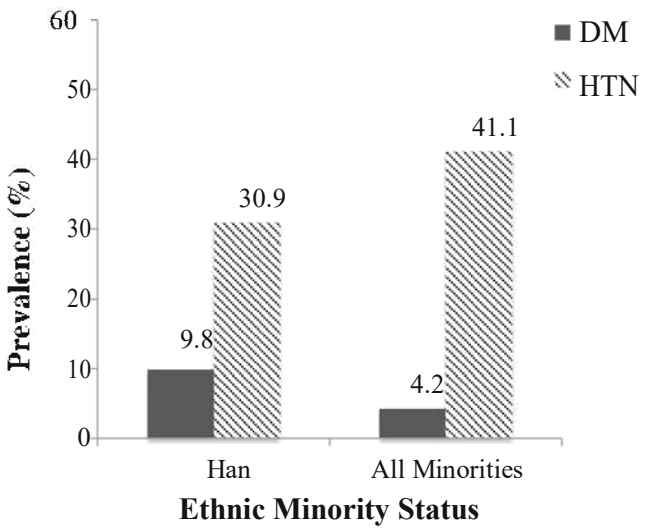

Fig. 2 Diabetes and hypertension prevalence, by ethnic minority sta-tus. Minority status was significantly related to both DM ($\chi2$=8.1; P=0.004) and HTN ($\chi2$=6.7; P=0.01)

Table 3 Results of the multivariate logistic regression, DV=positive DM status

Variable	Odds ratio (95 % CI)	P-value
Age	1.06 (0.99–1.12)	0.08
Weight	1.00 (0.95–1.06)	0.95
Measured HTN	1.54 (0.77–3.08)	0.23
BMI	1.10 (0.95–1.28)	0.21
Waist to hip ratio	27.52 (0.24–>1000)	0.17
Han vs. minority*	2.25 (1.14–4.45)	0.02

*P<0.05

higher prevalence of DM among Hans compared to the ethnic minorities. However, the Han participants' relatively higher age, weight, BMI, and waist to hip ratio may have played a role. Our finding that Han ethnicity is a predictor for DM corroborates with a previous study of DM in northeastern China, where Hans had a greater prevalence of DM than minority groups (the Manchus and Korean Chinese) [14].

Prevalence of HTN The prevalence of HTN, which was 37.1 %, showed variability between ethnic groups, similar to an earlier study [6].

Inadequate rural healthcare China is a rapidly developing country with a booming economy, advancing society, and improving health services and conditions [15]. However, if poverty still persists, especially in the western regions. In 1968, the Chinese government introduced the program of barefoot doctors to address the need for medical services in rural China [16]. Currently, the majority of the rural Chinese population has access to basic medical care through these village doctors. However, their medical knowledge and training is inadequate to tackle the growing prevalence of chronic diseases in rural China [16].

This study highlights the need for increased screening and education promotion for both DM and HTN, as only a minority of people with DM and HTN reported having DM or HTN. Therefore, primary prevention is critical not only to reduce the prevalence of DM in rural China, but also improving the prognosis of those who do develop DM.

Limitations A limitation of this study was the lack of random selection of townships. This sample was also restricted to adults between 50 and 70 years of age; therefore, the findings of this study may be generalizable to only the Chinese population within this particular age group living in rural Yunnan. Furthermore, because of Yunnan's mountainous topography, difficulty of travel and distance may have been barriers to participation, although we attempted to minimize this by traveling to subjects who lived very far from the primary data collection site and who expressed to the village leaders that distance was a barrier. We were therefore unable to further confirm BP measurements on a different day by requesting subjects to return on another day for repeat assessments. On the other hand, the study strengths were that it applied random selection where possible and was one of the few studies to our knowledge that assessed DM prevalence in this ethnic minority population from rural Yunnan.

Further research The prevalence of DM in our sample was slightly higher than the overall national rate, but varied across ethnic groups. Rural Han people and older individuals are at heightened risk of having DM, but further empirical research is required to determine the specific factors contrib-uting to these groups' higher risk. Increased community education of DM causes, signs/symptoms, and strategies for prevention and treatment by village doctors and other community health workers are also needed. Proactive public health interventions for DM are necessary in China, with a focus on vulnerable rural populations.

Table 4 Characteristics of Han vs. minority

Variable	Han (N=246)	Minority (N=388)	P-value
Drink alcohol - % (n)***	30.5 % (75)	38.1 % (148)	0.05
Present smoker - % (n)	39.0 % (96)	40.5 % (157)	0.72
Drink alcohol and present smoker - % (n)	22.4 % (55)	22.7 % (88)	0.92
Drink and/or smoke - % (n)**	47.2 % (116)	55.9 % (217)	0.03
Mean cigarettes smoked per day	15.8	14.0	0.21
Mean smoking duration (years)	30.6	28.5	0.19
Mean alcohol consumption (cups/day)*	2.3	3.6	0.007
Mean age (years)*	60.7	59.2	0.001
Mean weight (kg)*	52.4	50.5	0.009
Mean BMI (kg/ m^2)*	21.3	20.6	0.008
Mean waist to hip ratio*	0.87	0.85	0.004

*P<0.01, **P<0.05, ***P<0.10

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Conflict of interest The authors declared no conflict of interest.

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