

Postprint: Analysis of the Prevalence and Risk Factors of Dyslipidemia, Hypertension, and Diabetes Comorbidity among Kazakhs in Xinjiang

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Abstract

Background Cardiovascular disease is the leading cause of death among Chinese residents. Hypertension, hyperglycemia, and dyslipidemia (the “three highs”) are important risk factors for cardiovascular disease. Therefore, the state has proposed implementing integrated management of the three highs, but there is currently a lack of relevant research on the comorbidity of the three highs among the Kazakh population in Xinjiang. **Objective** To describe the prevalence and comorbidity of dyslipidemia, hypertension, and diabetes among the Kazakh population, and to explore the influencing factors of the three conditions’ comorbidity. **Methods** This study was a cross-sectional study. From March to June 2022, in Fuyun County, Altay Prefecture, Xinjiang, two populous towns predominantly inhabited by Kazakhs (Dure Town and Tuerhong Township) were selected to survey permanent Kazakh residents aged 18 years and above. Information was collected through questionnaires (general information, smoking and drinking history, disease status, etc.), physical examinations (waist circumference, hip circumference, height, weight, blood pressure, heart rate, etc.), and laboratory tests (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, and fasting blood glucose, etc.). Multivariate logistic regression analysis was used to explore the influencing factors of the three highs comorbidity among Kazakhs. **Results** A total of 4835 Kazakh residents were included, with males and females accounting for 48.2% (2231/4835) and 51.8% (2504/4835), respectively, and a mean age of (45.8 \pm 12.7) years. The standardized prevalence rates of dyslipidemia, hypertension, and diabetes were 37.9%, 21.1%, and 4.0%, respectively. Among patients with dyslipidemia, the standardized prevalence rates of hypercholesterolemia, elevated low-density lipoprotein cholesterol, reduced high-density lipoprotein cholesterol, and hypertriglyceridemia were 24.1%, 24.8%, 10.0%, and 7.3%, respectively. The stan-

standardized prevalence of the three highs comorbidity was 11.8%. Univariate logistic regression analysis showed that gender, age, BMI, waist circumference, hip circumference, heart rate, marital status, and education level were influencing factors of the three highs comorbidity ($P < 0.05$). After adjusting for gender, age, marital status, education level, BMI, waist circumference, hip circumference, waist-to-hip ratio, heart rate, smoking, and drinking, multivariate logistic regression analysis showed that gender, age, marital status, BMI, and heart rate were influencing factors of the three highs comorbidity ($P < 0.05$). Conclusion The prevalence of dyslipidemia among Kazakhs is higher than that of hypertension and diabetes, with hypercholesterolemia being the main type of dyslipidemia. The comorbidity of dyslipidemia and hypertension is the most common pattern among the three highs comorbidity. The elderly, males, and individuals with high BMI should be targeted as key populations for integrated management of the three highs.

Full Text

Status and Influencing Factors of Dyslipidemia, Hypertension and Diabetes Comorbidities among Kazakhs in Xinjiang

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Abstract

Background: Cardiovascular disease is the leading cause of death among Chinese residents. Hypertension, diabetes, and dyslipidemia (collectively termed the “three highs”) constitute major risk factors for cardiovascular disease. With rapid socioeconomic development in China, the prevalence of these conditions has increased dramatically. In response, the State Council issued the “Healthy

China Action (2019-2030)” in July 2019, explicitly promoting integrated management of the three conditions to reduce cardiovascular disease complications and overall mortality risk. However, relevant research on comorbidities among the Kazakh population in Xinjiang remains scarce.

Objective: To describe the prevalence and comorbidity patterns of dyslipidemia, hypertension, and diabetes among Kazakhs and to explore factors influencing their co-occurrence.

Methods: This cross-sectional study was conducted from March to June 2022. Kazakh residents aged 18 years and older from Dure Town and Tuerhong Township in Fuyun County, Altay Prefecture, Xinjiang—areas where Kazakhs constitute over 90% of the population and maintain traditional lifestyles—were selected as participants. Information was collected through questionnaires (covering demographics, smoking and alcohol consumption history, and disease status), physical examinations (including waist circumference, hip circumference, height, weight, blood pressure, and heart rate), and laboratory tests (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, and fasting blood glucose). Multivariate logistic regression analysis was used to identify factors associated with comorbidities of the three conditions.

Results: A total of 4,835 Kazakh residents were included, with males accounting for 48.2% (2,231/4,835) and females 51.8% (2,504/4,835). The mean age was (45.8±12.7) years. The standardized prevalence rates of dyslipidemia, hypertension, and diabetes were 37.9%, 21.1%, and 4.0%, respectively. Among individuals with dyslipidemia, the standardized prevalence rates of hypercholesterolemia, high low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, and hypertriglyceridemia were 24.1%, 24.8%, 10.0%, and 7.3%, respectively. The standardized prevalence of comorbidities involving at least two of the three conditions was 11.8%. Univariate logistic regression analysis identified gender, age, BMI, waist circumference, hip circumference, heart rate, marital status, and education level as influencing factors ($P<0.05$). After adjusting for these variables plus waist-hip ratio, smoking, and alcohol consumption, multivariate logistic regression analysis revealed that gender, age, marital status, BMI, and heart rate remained significantly associated with comorbidities ($P<0.05$).

Conclusions: The prevalence of dyslipidemia among Kazakhs exceeds that of hypertension and diabetes, with hypercholesterolemia being the predominant lipid abnormality. The combination of dyslipidemia and hypertension is the most common comorbidity pattern. Elderly individuals, males, and those with high BMI should be prioritized for integrated management of the three conditions.

Keywords: Dyslipidemia; Hypertension; Diabetes mellitus; Multiple chronic conditions; Kazakh; Root cause analysis

Introduction

Cardiovascular disease (CVD) represents the leading cause of mortality among Chinese residents [1]. Hypertension, diabetes, and dyslipidemia (collectively known as the “three highs”) constitute major risk factors for CVD [2]. With rapid socioeconomic development in China, the prevalence of these conditions has increased dramatically. National data reveal that between 2002 and 2015, the prevalence of hypercholesterolemia, high low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, and hypertriglyceridemia among Chinese adults rose from 1.6%, 1.3%, 18.8%, and 5.7% to 5.8%, 7.2%, 24.9%, and 15.0%, respectively [3]. The 2018 China Chronic Disease and Risk Factor Surveillance and the 2017 China Diabetes Epidemiology Survey reported that hypertension and diabetes prevalence among Chinese adults aged 18 and older had reached 27.5% and 12.8%, respectively [4,5].

In response to these trends, the State Council issued the “Healthy China Action (2019-2030)” in July 2019, explicitly promoting integrated management of the three conditions to reduce CVD complications and overall mortality risk. The Kazakh population primarily resides in the Tianshan grasslands of northern Xinjiang, including the Ili Kazakh Autonomous Prefecture, Mori Kazakh Autonomous County, and Barkol Kazakh Autonomous County, where they maintain a predominantly nomadic lifestyle. However, large-scale studies examining comorbidities of the three conditions in this ethnic group remain lacking. Dure Town and Tuerhong Township in Fuyun County, Altay Prefecture, are inhabited by over 90% Kazakh residents who preserve traditional Kazakh customs, making them representative of the broader Kazakh population. This study investigates the prevalence and influencing factors of comorbidities among these three conditions in this Kazakh community to provide evidence for integrated management strategies.

Methods

1.1 Study Participants

This cross-sectional study was conducted from March to June 2022 in Dure Town and Tuerhong Township, Fuyun County, Altay Prefecture, Xinjiang—two areas with large, predominantly Kazakh populations. All Kazakh residents aged 18 years and older who participated in the local universal health examination program during this period were eligible. A total of 4,950 individuals were initially identified, and after excluding 115 with incomplete clinical data on blood pressure, lipids, or glucose, 4,835 participants were included in the final analysis. The study protocol was approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (approval number: 220525-06), and all participants provided informed consent.

1.2 Data Collection

Questionnaire Survey: Trained interviewers administered the Xinjiang Universal Health Examination questionnaire to collect information on demographics (name, ethnicity, age, gender, ID number, phone number, marital status, education level, residential address, occupation, and medical insurance type), medical history (hypertension, diabetes, coronary heart disease, dyslipidemia, and tuberculosis), and lifestyle factors (smoking, alcohol consumption, physical activity, living environment, and occupational exposure).

Physical Examination: Height, weight, waist circumference, hip circumference, and blood pressure were measured. BMI was calculated and categorized as underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{--}23.9 \text{ kg/m}^2$), overweight ($24.0\text{--}27.9 \text{ kg/m}^2$), or obese ($\geq 28.0 \text{ kg/m}^2$). Participants were asked to remove shoes and wear light clothing for anthropometric measurements. Blood pressure was measured twice in the right arm after a 5-minute rest, with the participant seated and the sphygmomanometer, cuff, and heart at the same level; the average of the two readings was recorded.

Laboratory Tests: Fasting venous blood samples (5 mL) were collected, centrifuged at 3,000 rpm for 5 minutes, and the serum was stored at -20°C . Samples were transported via cold chain to the Clinical Laboratory Center of the First Affiliated Hospital of Xinjiang Medical University within one month. Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and fasting blood glucose (FBG) were measured using an automated biochemical analyzer (cobas 8000, Roche, Switzerland).

Diagnostic Criteria: Dyslipidemia was defined according to the “Chinese Guidelines for the Management of Dyslipidemia (2023)” [6]: $\text{TC} \geq 6.2 \text{ mmol/L}$ for hypercholesterolemia, $\text{TG} \geq 2.3 \text{ mmol/L}$ for hypertriglyceridemia, $\text{HDL-C} < 1.0 \text{ mmol/L}$ for low HDL-C, or $\text{LDL-C} \geq 4.1 \text{ mmol/L}$ for high LDL-C, or previous diagnosis by a township (community) level or higher hospital. Hypertension was defined as systolic blood pressure $\geq 140 \text{ mmHg}$ and/or diastolic blood pressure $\geq 90 \text{ mmHg}$, or previous diagnosis with medication use within the past two weeks, per the “Chinese Guidelines for the Prevention and Treatment of Hypertension (2018 Revision)” [7]. Diabetes was defined as fasting plasma glucose $\geq 7.0 \text{ mmol/L}$ or previous diagnosis by a township (community) level or higher hospital, according to the “Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 Edition)” [8]. Comorbidity was defined as having two or more of the three conditions. Smoking was defined as having smoked more than 100 cigarettes in one’s lifetime; alcohol consumption was defined as drinking at least once per week.

Quality Control: All staff received standardized training to ensure consistent data collection, physical examination, and blood sample processing. Blood samples were promptly centrifuged, sealed, frozen, transported, and tested to maintain specimen integrity. The Clinical Laboratory Center of the First Affil-

iated Hospital of Xinjiang Medical University operates under the supervision of the Xinjiang Uygur Autonomous Region Clinical Laboratory Center and participates in inter-laboratory quality assessments conducted by the National Health Commission, with satisfactory results ensuring maximal accuracy.

1.3 Statistical Analysis

Data were analyzed using SPSS 26.0 software. Normally distributed continuous variables are presented as mean \pm standard deviation ($\bar{x}\pm s$) and compared using independent samples t-tests. Non-normally distributed continuous variables are expressed as median (interquartile range) [M(P25, P75)] and compared using the Mann-Whitney U test. Categorical variables are reported as frequencies and percentages, with comparisons made using chi-square tests; trend chi-square tests were used for ordinal categorical variables. Multivariate logistic regression analysis was performed to identify factors associated with comorbidities of the three conditions. Statistical significance was set at two-sided $P<0.05$.

Results

2.1 Baseline Characteristics of Participants

The study included 4,835 participants with a mean age of (45.8 ± 12.7) years. The male group comprised 2,331 individuals. Males exhibited significantly higher rates of hypertension, smoking, and alcohol consumption, as well as greater waist circumference, hip circumference, systolic blood pressure, diastolic blood pressure, hemoglobin, creatinine, uric acid, fasting glucose, TC, LDL-C, and TG levels compared to females ($P<0.05$). Conversely, males had lower heart rate and HDL-C levels ($P<0.05$). No significant gender differences were observed in age, marital status, education level, diabetes prevalence, waist-hip ratio, or BMI ($P>0.05$).

2.2 Prevalence of Dyslipidemia, Hypertension, and Diabetes by Participant Characteristics

The crude prevalence rates of dyslipidemia, hypertension, and diabetes among Kazakh residents were 39.6%, 23.0%, and 4.4%, respectively, which after age and gender standardization became 37.9%, 21.1%, and 4.0%. Among dyslipidemic individuals, the crude prevalence rates of hypercholesterolemia, high LDL-C, low HDL-C, and hypertriglyceridemia were 27.1%, 27.9%, 8.8%, and 7.4%, respectively, with standardized rates of 24.1%, 24.8%, 10.0%, and 7.3%.

Males had significantly higher prevalence rates of all types of dyslipidemia and hypertension compared to females ($P<0.05$), while diabetes prevalence did not differ significantly by gender ($P>0.05$). Except for hypertriglyceridemia, the prevalence of all other lipid abnormalities, diabetes, and hypertension increased with age ($P<0.05$). Hypercholesterolemia, high LDL-C, dyslipidemia, and hypertension prevalence decreased with higher education level ($P<0.05$). All three

conditions showed increasing prevalence with higher BMI and waist circumference ($P < 0.05$). Smokers had significantly higher rates of hypercholesterolemia, high LDL-C, low HDL-C, and dyslipidemia compared to non-smokers ($P < 0.05$), while alcohol consumption was not significantly associated with dyslipidemia or diabetes prevalence ($P > 0.05$).

2.3 Comorbidity Patterns and Associated Factors

The crude prevalence rates of dyslipidemia with hypertension, dyslipidemia with diabetes, hypertension with diabetes, and all three conditions together were 9.6%, 1.1%, 1.0%, and 1.0%, respectively. After age and gender standardization, these rates became 8.7%, 0.9%, 1.1%, and 1.0%. The overall standardized prevalence of comorbidities involving at least two of the three conditions was 11.8%.

Univariate logistic regression analysis was performed with comorbidity status (yes=1, no=0) as the dependent variable and the following as independent variables: gender (male=1, female=2), age, education level (primary or below=1, junior/high school or technical secondary school=2, college or above=3), marital status (married=1, unmarried=2), smoking status (non-smoker=0, smoker=1), alcohol consumption (non-drinker=0, drinker=1), BMI ($< 18.5 \text{ kg/m}^2=1$, $18.5\text{--}23.9 \text{ kg/m}^2=2$, $24.0\text{--}27.9 \text{ kg/m}^2=3$, $\geq 28.0 \text{ kg/m}^2=4$), waist circumference, hip circumference, and waist-hip ratio (all as continuous variables). The analysis identified gender, age, BMI, waist circumference, hip circumference, heart rate, marital status, and education level as significant factors ($P < 0.05$).

After adjusting for gender, age, marital status, education level, BMI, waist circumference, hip circumference, waist-hip ratio, heart rate, smoking, and alcohol consumption, multivariate logistic regression analysis revealed that gender, age, marital status, BMI, and heart rate were independently associated with comorbidities ($P < 0.05$).

Discussion

This study found that the standardized prevalence rates of dyslipidemia, hypertension, and diabetes among Kazakhs were 37.9%, 21.1%, and 4.0%, respectively—all lower than the national averages for Chinese adults aged 18 and older (40.4%, 27.5%, and 12.8%) [4,5,9]. Among the three conditions, dyslipidemia was most prevalent, followed by hypertension and then diabetes. This pattern differs from findings in Chinese adults over 45 years reported by Yu et al. [10], where hypertension was most common, followed by dyslipidemia, then diabetes, suggesting a more severe dyslipidemia burden among Kazakhs.

Further analysis of dyslipidemia subtypes revealed that hypercholesterolemia (24.1%) and high LDL-C (24.8%) prevalence among Kazakhs substantially exceeded national levels (6.9% and 8.1%, respectively), while low HDL-C (10.0%)

and hypertriglyceridemia (7.3%) were lower than national figures (20.4% and 13.8%) [11]. These findings indicate that despite an overall lower dyslipidemia prevalence compared to the national average, Kazakhs exhibit particularly high rates of hypercholesterolemia and high LDL-C. Since elevated TC is an independent CVD risk factor [12] and LDL-C levels correlate closely with all-cause and cardiovascular mortality [13], integrating dyslipidemia screening and management into existing hypertension and diabetes management programs is essential.

Among two-condition comorbidities, dyslipidemia with diabetes (0.9%) and hypertension with diabetes (1.1%) occurred at similar rates, both substantially lower than dyslipidemia with hypertension (8.7%). This pattern aligns with national trends [10] and likely reflects the relatively high prevalence of dyslipidemia and hypertension alongside comparatively low diabetes prevalence in this population. Hypertension represents a well-established CVD risk factor incorporated into various atherosclerotic cardiovascular disease (ASCVD) risk scores [14-17]. The coexistence of hypertension and dyslipidemia significantly elevates 10-year ASCVD risk, necessitating more intensive lipid-lowering therapy to achieve lower LDL-C targets [6,12]. Therefore, integrated management should emphasize coordinated lipid-lowering and antihypertensive treatment, with dynamic adjustment of therapeutic goals based on risk stratification to reduce CVD incidence.

Multivariate logistic regression demonstrated that age, gender, BMI, marital status, and heart rate were independently associated with comorbidities, consistent with findings from Yu et al. [10]. Age emerged as an independent risk factor for CVD and its risk factors (hypertension, diabetes, dyslipidemia) [2,4,8,11], underscoring the importance of targeted screening and health education for elderly individuals to enable early lifestyle and pharmacological interventions. A large prospective study using UK Biobank data revealed that young men experienced higher myocardial infarction rates than young women, though this gender gap narrowed with advancing age [18]. This phenomenon may be attributed to the protective effects of endogenous estrogen and its receptors in premenopausal women [19], which diminish after menopause [20]. Consequently, more aggressive interventions may be warranted for men in middle-aged and younger populations.

BMI reflects overall obesity, while waist circumference indicates abdominal adiposity. A meta-analysis demonstrated that both BMI and waist circumference show significant continuous associations with CVD risk, with similar effect sizes [21]. Our univariate analysis identified both measures as associated with comorbidities, but after adjusting for age, gender, and other factors, only BMI remained significant, suggesting that the relationship between waist circumference and comorbidities may be mediated through BMI. Therefore, individuals with elevated BMI should be prioritized for early inclusion in integrated management programs.

This study has several limitations. First, for feasibility reasons, we selected a

typical Kazakh population rather than employing complex sampling across all of Xinjiang, which may limit generalizability. Second, the absence of 2-hour postprandial glucose testing may have missed some individuals with normal fasting glucose but elevated postprandial glucose, potentially underestimating diabetes prevalence. Third, we did not assess lifestyle factors such as diet and physical activity, which warrant investigation in future studies.

In summary, dyslipidemia prevalence exceeds that of hypertension and diabetes among Kazakhs, with hypercholesterolemia being the predominant lipid abnormality. The combination of dyslipidemia and hypertension represents the most common comorbidity pattern. Gender, age, marital status, BMI, and heart rate are independent influencing factors, indicating that elderly individuals, men, and those with high BMI should be prioritized for integrated management of the three conditions.

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Author Contributions: JIN Menglong was responsible for data collection, processing, statistical analysis, figure preparation, and manuscript drafting. QIN Xiaoying, MALIYA Amity, and JIAZINI Nuerbai coordinated participant recruitment and survey implementation. LI Jianxin and CAO Jie conceptualized the study and designed the methodology. LUO Sifu, LIU Cheng, ZHANG Yuchen, GAI Mintao, and LI Yanpeng performed data collection and laboratory testing. LU Xiangfeng contributed to study conceptualization and methodology design. FU Zhenyan supervised the project and revised the final manuscript.

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