



Original Article

Prevalence and Determinant Factors of Metabolic Syndrome in the Azar-Cohort Population

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Abstract

Introduction: Metabolic syndrome (MetS) is a global public health issue with notable regional variations. This study aimed to determine the prevalence and determinant factors of metabolic syndrome in a large population-based cohort in the North-West of Iran.

Methods: This cross-sectional study involved 14,906 adult participants aged 35 to 70 years from the Azar-cohort study. Data on sociodemographic and lifestyle characteristics, and medication history were collected through face-to-face interviews by trained interviewers. Biochemical laboratory tests and medical examinations were conducted. Population of the Shabestar County who met the inclusion criteria and had informed consent were included. MetS was defined by the National Cholesterol Education Program's Adult Treatment Panel III report (ATP III) criteria. To assess the determinant factors we applied logistic regression analysis.

Results: The prevalence of metabolic syndrome was 34%. On average, the MetS group was significantly older and included more women. Waist-to-hip ratio (W/H), was significantly higher in MetS group than in the non-MetS group (0.94 vs. 0.88, $P < 0.001$). In univariate analysis, subjects with very high wealth score index (WSI) quintile had lower odds of MetS compared to the very low quintile (OR=0.79, 95% CI: 0.71-0.88). After adjustment for potential confounding factors, the body mass index (BMI), physical activity level, and smoking status were significantly related to the MetS.

Conclusion: It seems that MetS is relatively high in the Azar-Cohort population, which calls for interventional programs to reduce the burden and future complications. Regarding the non-modifiable factors, it seems vital to tailor interventions to high-risk groups.

Keywords: Risk factors, Epidemiology, Prevalence, Metabolic syndrome, Cardiovascular diseases

Introduction

Metabolic syndrome (MetS) is a multifactorial condition defined by the coexistence of several metabolic abnormalities, including central obesity, hypertension, dyslipidemia, and insulin resistance. These components collectively increase the risk of cardiovascular diseases (CVD), type 2 diabetes mellitus (T2DM), overall mortality, and stroke.^{1,2} The diagnostic criteria for MetS vary slightly among organizations, but many guidelines, including the International Diabetes Federation (IDF), the American Heart Association (AHA), and the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) require the presence of at least three of risk factors for a diagnosis.^{3,4}

Nowadays, the prevention and control of MetS are critical public health priorities due to its rising prevalence globally and strong association with chronic diseases and increased mortality. Early detection and management of MetS can significantly reduce the risk of CVD and T2DM, highlighting the need for effective interventions on lifestyle

modifications and pharmacological treatments.^{5,6}

Worldwide, the prevalence of MetS has been increasing, with recent estimates suggesting that it affects approximately 12.5-39% of the adult population. The highest rates are observed in Eastern Mediterranean Region and Americas and was increased with country's income level, driven by sedentary lifestyles, poor dietary habits, and increasing obesity rates.⁶⁻⁸ In Iran, the prevalence of MetS is alarmingly high, with studies reporting rates ranging from 30% to about 45%, depending on the region and diagnostic criteria used.^{9,10}

Variations in the prevalence of MetS across regions are largely influenced by modifiable behavioral factors such as nutritional practices, physical activity levels, and overall lifestyle behaviors, alongside non-modifiable determinants including demographic attributes and inherited genetic susceptibility. Demographic variables such as age, sex, and ethnicity modulate susceptibility to MetS. Aging is associated with progressive metabolic decline, increased visceral adiposity, and reduced insulin sensitivity, making



older adults particularly vulnerable. Sex-specific differences are evident, with postmenopausal women experiencing hormonal changes that predispose them to central obesity and lipid abnormalities.¹¹ Ethnic disparities reflect both genetic predispositions and environmental exposures; for example, Asian population exhibit higher rates of MetS in women.¹² Socio-behavioral factors play a pivotal role in the development and progression of MetS. Dietary habits, particularly the consumption of energy-dense and nutrient-poor foods, and physical inactivity are strongly associated with increased adiposity and insulin resistance. These patterns are often shaped by cultural norms, food availability, and economic constraints and may vary by region.^{13,14} Tobacco use and excessive alcohol consumption contribute to oxidative stress and dysregulated lipid metabolism, both of which are central to MetS pathophysiology.¹⁵ Socioeconomic status (SES), educational attainment, and employment conditions are critical determinants, with correlating access to nutritious food, healthcare services, and safe environments for physical activity.¹⁶⁻¹⁸ The magnitude of association between individual risk factors and MetS varies across regions, largely influenced by differences in cultural practices and lifestyle behaviors. This highlights the importance of conducting geographically diverse research that incorporates multiple covariates to accurately identify the predominant contributing factors.

Given the significant burden of MetS in Iran and its regional variations, there is a strong rationale to study this condition in a large cohort to investigate its prevalence and associated covariates. Such a study would provide valuable insights into the demographic, lifestyle, cultural, and environmental factors contributing to MetS. This insight enables the development of targeted prevention and intervention strategies to reduce the burden of MetS-related complications in Iran. Therefore, because of increasing burden and geographic variety in distribution of risk factors, in this study we aimed to assess the prevalence and factors affecting the metabolic syndrome in the population of Azar-Cohort in North-West of Iran.

Materials and Methods

Study design and setting

This study used the data obtained from the Azar-cohort study, a subset of the Prospective Epidemiological Research Studies of Iranian adults (PERSIAN).¹⁹ Azar-cohort study was initiated in 2014, enrolling a substantial sample of 15,006 participants. Study population were all adults with the age range of 35 to 70 years, who met the predefined inclusion criteria, provided informed consent, and were permanent residents in Shabestar County in East Azerbaijan province, located in the North West of Iran. It was planned in 4 phases including pilot, enrollment, follow-up, and reassessment. Details about the Azar-cohort study are explained in detail in previous published paper.²⁰ In present study, data of 14906 participants from the pilot phase and enrollment have been used and comparisons were made between two groups of having MetS and non-

metabolic syndrome group (non-MetS).

Inclusion and exclusion criteria

The inclusion criteria in the cohort study were age 35 to 70 years, at least 9 months of permanent residence in Shabestar city, and having at least one Azeri parent. Exclusion criteria were individuals who, despite explaining the benefits of the study were reluctant to participate in the study, and subjects with psychiatric or physical disabilities.²¹

Data collection and measures

The data were collected through face-to-face interviews by trained interviewers. The questionnaire was designed electronically and completed electronically. Based on this questionnaire, data on demographic characteristics, SES, occupation, lifestyle, and medication history were collected. Moreover, biological laboratory tests and medical examinations were conducted. After 12-hour fasting, the following laboratory values were measured and recorded: fasting blood sugar (FBS), triglycerides (TG), and high density lipoprotein cholesterol (HDL-c) using Pars Azmoon Kits.

Body mass index (BMI) is calculated using the standard formula of weight (kg)/height (m²) and was classified as normal (18.5-24.9), overweight (25-29.9), obese (≥ 30). Obesity class I (moderate), II (severe), and III (morbid obesity) were defined as BMI 30-34.9, 35-39.9, and ≥ 40 , respectively. Waist and hip circumferences of subjects are measured according to the USA National Institutes of Health (NIH) guidelines. The daily physical activity was evaluated using a questionnaire, and then the metabolic equivalent (MET) was applied.

MetS was defined by the National Cholesterol Education Program's Adult Treatment Panel III report (ATP III) criteria which includes 5 criteria, and MetS is considered in the presence of 3 or more criteria.⁴ The criteria are as follows: waist circumference ≥ 102 cm in men or ≥ 88 cm in women, blood pressure (≥ 130 mmHg) and/or diastolic (≥ 85 mmHg) or the use of antihypertensive medication, TG ≥ 150 mg/dL (drug treatment for elevated triglycerides is an alternate indicator), HDL cholesterol level less than 40 mg/dL in men or 50 mg/dL in women, and fasting blood sugar ≥ 100 mg/dL or the use of glucose-lowering medication.

Socioeconomic status was evaluated using Wealth Score Index (WSI), calculated by ownership of a variety of durable assets (e.g., dishwasher, car, and television), household conditions (e.g., number of rooms, type of ownership), and education level. The SES was categorized into five WSI quintiles, from the lowest (1st quintile) to the highest (5th quintile).^{19,20}

People who smoked at least one cigarette per day for more than consecutive six months were considered smokers. Those who had ceased smoking at least a year ago were regarded as ex-smokers. Subjects who had never smoked were labeled as non-smokers. Heavy smokers were categorized as smoking more than 20 cigarettes per day, and people who smoked hookah, water pipe, pipe and

chewed nass were categorized as users of other tobacco products.

Statistical analysis

To compare quantitative variables such as age between study groups, t-test was used in the condition of data normality and Mann-Whitney test was used if there was no normal distribution. Chi-square test was used to compare qualitative variables between study groups. Logistic regression test was used to control confounders and predict risk factors of MetS in one unadjusted and two adjusted models (Model 1: adjusted for age, gender, profession, education, and marital status; Model 2: adjusted for age, gender, profession, education, and WSI). Odds ratios (ORs) and the 95% confidence intervals (CIs) were estimated. Interaction terms were evaluated in the multivariable models to assess potential effect modification across demographic subgroups. Model fit indices including AIC (Akaike's information criterion) and BIC (Bayesian information criterion) were also calculated and reported. Statistical significance was set at $P < 0.05$. Data analysis was conducted using SPSS (SPSS Inc., Chicago, IL, version 16).

Results

In total, the data of 14906 subjects was analyzed. The prevalence of MetS was 34.3% in our study population (5114 diagnosed subjects). The MetS prevalence was 26% in men and 41.0% in women. The majority of study population were non-smokers in both groups (Table 1). Mean BMI of non-MetS group and subjects with MetS were 27.5 ± 4.52 kg/m² and 31.5 ± 4.47 kg/m² respectively ($P < 0.001$). Waist-to-hip ratio (W/H) showed significantly higher mean in MetS group than in the non-MetS group (0.94 vs. 0.88, $P < 0.001$).

On average, the MetS group was significantly older and included more women (Table 1). Our univariate analysis revealed that higher educational and profession level were significantly related to lower odds of MetS. Subjects with very high wealth score index (WSI) quintile had lower odds of MetS compared to the very low quintile (OR = 0.79, 95% CI: 0.71-0.88) (Table 2).

Additionally, after adjustment for potential confounding factors, we found that BMI category, physical activity level, and smoking status were significantly related to the MetS (Table 3). People with high level of physical activity showed significantly lower odds of MetS than low MET group (OR = 0.59, 95%CI: 0.35-0.99), although moderate level MET was not related to MetS ($P = 0.52$). The association between MET and MetS was statistically significant (OR = 0.96, 95%CI: 0.95-0.96, $P < 0.001$). Although CVD history, and stroke history were different in univariate analysis between MetS and non-MetS group, the multivariate analysis showed that their association with MetS is non-significant.

For adjusted analysis, comparison of model fit indices showed no substantial difference between Models 1 and 2. Although inclusion of WSI slightly improved the classification accuracy of the model, AIC (Akaike's

information criterion) and BIC (Bayesian information criterion) values did not indicate a substantial improvement in overall model fit.

Discussion

Metabolic Syndrome represents a leading worldwide public health issue which is an interconnected cluster of metabolic conditions including abdominal obesity, hypertension, hyperglycemia, hypertriglyceridemia, and lower HDL-c.^{22,23} The burden of MetS is estimated to be high both in the developing and developed countries, and is still increasing.^{2,23} In light of this variability and the growing burden, we aimed to determine the prevalence and factors affecting the MetS in the population of Azar-Cohort.

Our results showed that the prevalence of MetS in the north-west of Iran (34.3%) is comparable to other regions in Iran and globally. Studies indicate varying rates across Iran from 30 to 45%.^{9,10,24} Globally, MetS prevalence ranges widely, from approximately 20% to 48% in European countries,^{1,25} 29 to 40% in Asian countries,²² to 33-41% in some Middle Eastern nations.²⁶ The age-adjusted prevalence among adults was reported 34.3% in the United States.⁸ The relatively high prevalence of MetS may be linked to urbanization, sedentary behavior, and dietary habits characterized by high fat and sugar intake. These findings emphasize the need for targeted public health interventions to address modifiable risk factors. Further research should explore regional variations to develop localized prevention strategies. On the other hand, in the past decades, Iran has undergone extensive socio-economic changes that can contribute in making obesity, MetS, and its complications a major health problem.

Our findings demonstrate that age is a significant predictor of MetS, with each additional year of age associated with 4.9% higher odds of having MetS (OR = 1.049, 95% CI: 1.04-1.05, $P < 0.001$) in the range of 35 to 70 years. This result is consistent with patterns indicated in other studies showing increasing MetS prevalence with age.^{5,24,27}

Our analysis indicated significantly lower odds of MetS in males compared to females (OR = 0.50, 95% CI: 0.47-0.54, $P < 0.001$), consistent with patterns observed in other studies,^{9,10,24,27} likely due to biological and sociocultural factors influencing metabolic risk.

Our findings revealed significant correlation between occupational status and MetS risk. Housewife/unemployed subjects had significantly higher odds of MetS compared to other groups. This pattern aligns with recent studies showing that unemployed individuals had higher MetS risk than employed counterparts.¹⁸ These variations may reflect differences in physical activity, stress levels, and dietary patterns across occupations.

Our study demonstrated that having higher education was protective against MetS, with university-educated individuals showing the lowest odds compared to illiterate participants (OR = 0.32, 95% CI: 0.28-0.37, $P < 0.001$). Similarly, multiple recent studies reported education level was inversely associated with MetS.^{16,25,28,29} The protective

Table 1. General characteristics of the Azar-Cohort population based on metabolic syndrome status

Variable	Group	No metabolic syndrome N = 9792	Metabolic syndrome N = 5114	P-value
		Number (%)	Number (%)	
Gender	Male	4916(50.2)	1725(33.7)	<0.001**
	Female	4876(49.8)	3389(66.3)	
Profession	Unemployed/housewife	4618(47.2)	3320(64.9)	<0.001**
	Manual worker	2941(30)	970(19.0)	
	Self-employed	1178(12)	426(8.3)	
	Clerical	537(5.5)	196(3.8)	
	Technician	285(2.9)	86(1.7)	
	Professional	233(2.4)	116(2.3)	
Education level	Illiterate (0-1)	1278(13.1)	1210(23.7)	<0.001**
	Primary (2-5)	3776(38.6)	2043(39.9)	
	Secondary (6-12)	3729(38.1)	1553(30.4)	
	Tertiary (> 12)	1009(10.3)	308(6.0)	
Marital status	Unmarried	618(6.3)	474(9.3)	<0.001**
	Married	9174(93.7)	4640(90.7)	
Quintiles of Wealth score index (WSI)	Very low	2159(22.0)	1291(25.2)	<0.001**
	low	1553(15.9)	959(18.8)	
	Moderate	2011(20.5)	1022(20.0)	
	High	2162(22.1)	948(18.5)	
	Very high	1907(19.5)	894(17.5)	
Body Mass Index; BMI (kg/m ²)	Normal (18.5-24.9)	2878(29.4)	235(4.6)	<0.001**
	Overweight (25-29.9)	4371(44.7)	1776(34.7)	
	Obese class I (30-34.9)	1968(20.1)	2082(40.7)	
	Obese Class II (35-39.9)	470(4.8)	794(15.5)	
	Obese class III (≥40)	99(1.0)	227(4.4)	
Physical activity level (MET)	Low	2934(30.0)	2070(40.5)	<0.001**
	Moderate	3180(32.5)	1770(34.6)	
	High	3678(37.6)	1274(24.9)	
Smoking status	Non smoker	7201(73.5)	4145(81.1)	<0.001**
	Ex-smoker	848(8.7)	392(7.7)	
	Smoker	944(9.6)	282(5.5)	
	Heavy smoker (> 20 cigarettes/day)	601(6.1)	214(4.2)	
	Other tobacco products ^a	198(2.0)	81(1.6)	
CVD history	No	9479(96.8)	4697(91.8)	<0.001**
	Yes	313(3.2)	417(8.2)	
Stroke history	No	9726(99.3)	5063(99.0)	0.03**
	Yes	66(0.7)	51(1.0)	
		Mean(SD)	Mean(SD)	
Age (years)		48.23(9.10)	52.31(9.02)	<0.001*
BMI (kg/m ²)		27.5(4.44)	31.5(4.47)	<0.001*
Waist to hip ratio		0.88(0.08)	0.94(0.07)	<0.001*

CVD: Cardiovascular Diseases, MET: Metabolic Equivalent of Task, SD: Standard Deviation, ^a(water pipe, hookah, pipe, chewed nass), *Independent t test, **Chi-square test.

effect likely stems from improved health literacy, healthier lifestyle choices, better nutrition knowledge, higher health awareness, and greater access to preventive healthcare among educated populations.

Our findings showing lower odds of MetS in married people align with some studies but contrast with others that

report varying relationships. For example, one study on men showed higher odds of MetS in divorced than married men.³⁰ Another research indicated that married women are at higher risk of MetS than unmarried women.³¹ Married men may experience better dietary patterns and lower smoking rates, which could be protective against MetS.

Table 2. Logistic regression analysis of general characteristics and metabolic syndrome in the Azar-Cohort population.

Variable	OR	95% CI of OR	P-value
Age	1.049	1.04-1.05	<0.001
Gender			
Male	0.50	0.47-0.54	<0.001
Female	Referent		
Profession			
Unemployed/housewife		Referent	
Manual worker	0.45	0.42-0.50	<0.001
Self-employed	0.50	0.44-0.56	<0.001
Clerical	0.51	0.43-0.60	<0.001
Technician	0.42	0.33-0.54	<0.001
Professional	0.70	0.56-0.88	0.002
Education level			
Illiterate (0-1)		Referent	
Primary (2-5)	0.57	0.52-0.63	<0.001
Secondary (6-12)	0.44	0.39-0.48	<0.001
Tertiary (> 12)	0.32	0.28-0.37	<0.001
Marital status			
Unmarried		Referent	
Married	0.66	0.58-0.75	<0.001
Quintiles of Wealth score index (WSI)			
Very low		Referent	
low	1.04	0.93-1.15	0.495
Moderate	0.85	0.77-0.95	0.002
High	0.74	0.67-0.82	<0.001
Very high	0.79	0.71-0.88	<0.001

OR: Odds Ratio, CI: Confidence Interval.

On the other hand, women may experience weight gain due to reduced physical activity and pregnancy, potentially increasing MetS risk. This underscores the complexity of social determinants in metabolic health.

Our findings indicated that individuals in the “very high” wealth score index (WSI) quintile had lower odds of MetS compared to the “very low” quintile (OR=0.79, 95% CI: 0.71-0.88, $P<0.001$). The low quartile of wealth was not significantly different in terms of MetS compared to very low wealth. Similarly, one study observed that lower-SES group of Kurdish adults in western Iran had higher MetS prevalence.²⁸ In contrast, a few studies showed that higher SES level in some regions can lead to overeating vs. healthy eating.^{16,17} On the other hand, lower SES may be associated with unhealthy diet high in carbohydrate. These disparities suggest that the relationship between wealth and MetS is context-dependent, influenced by dietary habits and culture, urbanization, and healthcare access.^{3,23}

Our findings align with existing evidence that obesity, particularly higher BMI, is strongly associated with MetS. Obesity Class III individuals had the highest odds (OR=24.35, 95% CI: 18.35-32.3, $P<0.001$) than normal BMI group. This finding is consistent with other studies demonstrating that excessive adiposity promotes insulin resistance, dyslipidemia, and hypertension.^{3,6} This finding

should be interpreted with caution as the proportion of subjects in obesity class III was low.

Notably in our unadjusted analysis waist-to-hip ratio (W/H), showed a significantly higher average ratio in MetS group than non-MetS group (0.94 vs. 0.88, $P<0.001$). The W/H ratio is a well-established marker of abdominal obesity and a significant predictor of MetS. This finding aligns with previous research indicating that central obesity, measured by W/H, is strongly associated with insulin resistance, dyslipidemia, and hypertension-key components of MetS.^{3,6,9} The accumulation of visceral fat promotes chronic low-grade inflammation and adipokine dysregulation, contributing to impaired glucose metabolism and endothelial dysfunction.⁶ Studies across different populations, including those in the Asia-Pacific region and the Middle East, have consistently reported a higher prevalence of MetS among individuals with elevated W/H ratios.¹ Furthermore, the International Diabetes Federation (IDF) includes abdominal obesity as a central criterion for MetS diagnosis, underscoring its pathogenic role.³ Interventions targeting visceral fat reduction through lifestyle modifications may thus help mitigate MetS risk.

Higher physical activity levels were protective against MetS. Individuals with high activity levels had significantly lower odds of MetS (OR=0.59, 95% CI: 0.35-0.99, $P=0.04$). According to univariate analysis, for each higher unit of MET the odds of MetS decreased by 4% (95%CI: 0.95-0.96, $P<0.001$). Studies suggest that higher MET-based activity levels inversely correlated with central obesity and dyslipidemia in adults.⁹ Metabolic Equivalent of Task (MET) is a unit used to quantify the energy expenditure of physical activities, where 1 MET represents resting metabolic rate (approximately 3.5 mL O₂/kg/min). Higher MET levels, indicative of greater physical activity, have been consistently associated with a reduced risk of MetS. Although, our multivariate analysis indicated that moderate level MET was not related to MetS ($P=0.52$), which may show that high level activity should be considered a protective modality but not moderate activities. Similarly, studies suggest that regular moderate-to-vigorous physical activity (≥ 3 METs) improves insulin sensitivity, reduces visceral adiposity, and enhances lipid metabolism, thereby mitigating MetS components.^{3,6} These findings underscore the importance of MET-quantified physical activity in MetS prevention.

The relationship between smoking and MetS remains complex, with studies reporting conflicting findings. The Adjusted model analysis revealed that people who use other tobacco products like water pipe, hookah, pipe, and chewed nass were at lower risk of MetS ($P=0.03$) than non-smokers. Our results demonstrated that ex-smokers had higher and smokers had lower MetS odds than non-smokers but these relationships did not remain significant in the multivariate regression analysis. Researchers suggest that smoking may influence MetS through multiple pathways. A cohort study in Northern Iran showed significantly lower MetS in smokers than non-smokers after adjustment for covariates.¹⁰ Conversely, Rus et al.² reported

Table 3. Logistic regression analysis of metabolic syndrome in the Azar-Cohort population.

Variable	Unadjusted	P-value	Model (1)	P-value	Model (2)	P-value
	OR(95%CI)		OR (95%CI)		OR(95%CI)	
BMI (kg/m ²)						
Normal	Referent		Referent		Referent	
Overweight	4.98(4.31-5.76)	<0.001	5.05(4.36- 5.86)	<0.001	5.04(4.35-5.85)	<0.001
Obese class I	12.95(11.19-15.07)	<0.001	12.86(11.04- 14.98)	<0.001	12.83(11.02-14.95)	<0.001
Obese class II	20.68(17.36-24.65)	<0.001	19.56(16.28-23.50)	<0.001	19.52(16.25- 23.46)	<0.001
Obese class III	28.01(21.41-36.82)	<0.001	24.33(18.34-32.27)	<0.001	24.35(18.35- 32.3)	<0.001
Physical activity level (MET)						
Low	Referent		Referent		Referent	
Moderate	0.79(0.73-0.85)	<0.001	0.87(0.58-1.31)	0.51	0.87(0.58-1.31)	0.52
High	0.49(0.45-0.53)	<0.001	0.59(0.35-0.99)	0.04	0.59(0.35- 0.99)	0.04
Smoking status						
No smoker	Referent		Referent		Referent	
Ex-smoker	0.80(0.70-0.91)	<0.001	1.5(0.42-5.58)	0.50	1.54(0.42-5.58)	0.50
Smoker	0.51(0.45-0.59)	<0.001	0.46(0.09-2.31)	0.34	0.46(0.09-2.32)	0.35
Heavy smoker (>20 cigarettes/day)	0.61(0.52-0.72)	<0.001	0.84(0.13-5.15)	0.85	0.84(0.13-5.16)	0.85
Other tobacco ^a	0.71(0.54-0.92)	0.01	0.04(0.002-0.75)	0.03	0.04(0.002-0.75)	0.03
CVD history						
No	Referent		Referent		Referent	
Yes	2.69(2.32-3.13)	<0.001	1.43(0.71-2.90)	0.31	1.43(0.711-2.89)	0.31
Stroke history						
No	Referent		Referent		Referent	
Yes	1.48(1.02-2.14)	0.03	0.82(0.53-1.25)	0.36	0.82(0.53-1.25)	0.36
AIC			15890.08		15891.5	
BIC			16308.58		16317.61	
Correctly classified			72.38		72.41	

BMI: Body Mass Index, OR: Odds Ratio, CI: Confidence Interval, CVD: Cardiovascular Diseases, MET: Metabolic Equivalent of Task, AIC: Akaike's information criterion, BIC: Bayesian information criterion, ^a(water pipe, hookah, pipe, chewed nass).

Model 1: Adjusted for main effect of age, gender, profession, education, marital status, and two-way interaction of these confounders and each variables. Model 2: Adjusted for age, gender, profession, education, WSI, and two-way interaction of these confounders and each variables.

higher frequency of MetS in smokers than non-smokers, however adjustment for covariates was not conducted in their analysis. Similarly, Saki et al.³² indicated higher MetS in smokers than non-smokers but this relationship was non-significant after adjustment. On the other hand, some studies reported no significant association.²⁶ Evidence showed that ex-smokers tend to increase calorie intake and experience weight gain during smoking cessation which results in weight gain and increased insulin resistance.¹⁵ The variability in results may reflect differences in smoking intensity, duration of smoking or cessation, and population characteristics. On the other hand, as people may change their lifestyle after being diagnosed with MetS, longitudinal cohort data can better determine the association.

Our unadjusted analysis showed association between CVD history and MetS. Although this was not significant in the final model, which can be in result of adjusting other covariates ($P=0.31$). However, researchers indicated association which may be due to shared pathophysiological mechanisms. MetS components including central obesity, insulin resistance, dyslipidemia, and hypertension promote endothelial dysfunction, chronic inflammation,

and atherosclerosis, all of which contribute to CVD development.^{3,6} Insulin resistance, a hallmark of MetS, accelerates atherosclerosis by increasing oxidative stress and pro-inflammatory cytokine production.⁴

While our study found only a non-significant trend between stroke history and MetS, other research suggests this relationship may be mediated by hypertension and dyslipidemia, which are common to both conditions.¹ The weaker association for stroke compared to CVD could reflect differences in underlying mechanisms; stroke risk may be more influenced by isolated hypertension or atrial fibrillation rather than the full MetS cluster.

Several strengths of this study include application of validated questionnaires for data collection and adjustment for several confounding factors in the analysis. Moreover, present study reported the findings of large population based data. However, several limitations should be acknowledged. The present study employed a cross-sectional design, wherein certain variables were obtained through self-reporting, rendering the data susceptible to recall bias and response bias. So, the lack of follow-up data restricts our ability to assess causal inference,

temporal relationships or changes in risk factors over time. Longitudinal studies could provide more clear insights about incidence of MetS. It is important to note that not all potential confounding factors could be included, which may influence the interpretation of the findings. Additionally, this study might not be generalizable to all population as the participant's age was limited to 35–70 years.

Conclusion

In this study the prevalence of metabolic syndrome was about 1 in 3 people in the studied population, which is relatively high. Due to the consequences of this syndrome, proper interventional programs are recommended to reduce the burden and future complications. Our results highlight the importance of addressing modifiable risk factors such as obesity, physical inactivity, and low education levels to reduce the prevalence of MetS in the population. Regarding the non-modifiable factors with highest risk, it seems vital to tailor any public health interventions to high-risk groups including older women. The correlation between lower WSI and higher odds of MetS suggests that socioeconomic gradients may influence lifestyle patterns and access to preventive care. These findings advocate for targeted interventions that prioritize health education, promote active lifestyles, and address gender- and age-specific vulnerabilities. Public health strategies should also consider socioeconomic disparities by implementing community-based programs and equitable access to screening and management services, particularly for populations at elevated risk.

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Authors' Contribution

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Competing Interests

The authors declare no conflict of interest.

Ethical Approval

In the main cohort study, written informed consent was gathered from all of the participants. The objectives, stages, and voluntariness of the study were completely explained to the participants. The protocol of this study has been approved by the Ethics Committee of Tabriz

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