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Prevalence and correlates of metabolic syndrome among rural women in Mysore, India

Karl Krupp [a, b, *], Prajakta Adsul [c], Meredith L. Wilcox [d, e], Vijaya Srinivas [b], Elizabeth Frank [f], Arun Srinivas [g], Purnima Madhivanan [a, b, h, i]

[a] Department of Health Promotion Sciences, Mel & Enid Zuckerman College of Public Health, University of Arizona, Tucson, USA
[b] Public Health Research Institute of India, Mysore, India
[c] National Cancer Institute, National Institutes for Health, USA
[d] Midwest Biomedical Research/Center for Metabolic and Cardiovascular Health, Addison, IL, USA
[e] MB Clinical Research, Boca Raton, FL, USA
[f] Biochem Laboratories, Mysore, India
[g] Department of Cardiology, Apollo Hospital, Mysore, India
[h] Division of Infectious Diseases, College of Medicine, University of Arizona, Tucson, USA
[i] Department of Family & Community Medicine, College of Medicine, University of Arizona, Tucson, USA

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ABSTRACT

Aims: Metabolic Syndrome (MetS) is a strong predictor of Coronary Heart Disease (CHD). Studies in urban India have found about one-third of Indians suffer from MetS. Less is known about the prevalence of MetS in rural areas, where 70% of the population reside. This study examined the prevalence of Metabolic Syndrome in a population of rural women in India.

Methods: Data were gathered in a community-based study of 500 rural and tribal women residing in the Mysore district, between the age of 30–59 years. The study used the WHO STEPS approach, in which information on demographics and behavioral risk factors were collected. Along with anthropometric measurements, blood pressure, blood glucose, lipids were measured. A harmonized definition of MetS recommended by International Diabetes Federation Task Force on Epidemiology and Prevention was used in this study.

Results: Three out of five study participants were found to have MetS (47.1%, $n = 223$). Of those, 56.5% met 3 of the 5 criteria, 32.2% met 4 criteria, and 11.2% met all 5 criteria. Among the entire sample, low HDL was the most prevalent criterion (88.4%), followed by elevated glucose (57.9%), elevated triglycerides (49.3%), elevated BP (41.5%), and increased waist circumference (15.3%). In this sample, women with METS were generally older ($p < 0.001$), housewives ($p = 0.001$), that consumed salty highly processed foods ($p = 0.020$) and had low physical activity ($p = 0.015$).

Conclusions: This study showed a high prevalence of MetS in rural women. There is a compelling need for interventions aimed at reducing CHD risk factors in this population.

1. Introduction

The term “metabolic syndrome” (MetS) was first used in the 1970's to describe a constellation of abnormal physical and chemical processes like impaired glucose metabolism, hyperinsulinemia; and elevated triglycerides (TG), glucose, and cholesterol, on progression of cardiovascular disease.[1] MetS has been widely accepted as a simple and inexpensive tool for identifying patients at high-risk for coronary heart disease (CHD).[2] At least four international organizations including the World Health Organization (WHO) have recommended clinical criteria for diagnosis of the syndrome.[3] While there are significant differences, definitions share criteria for glucose intolerance, abnormal lipid levels, obesity, and elevated blood pressure.[4] The pathophysiology of MetS is still not well understood,[5] but research has confirmed that CHD incidence and mortality, and all-cause mortality, are elevated in individuals with

Note: All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

* corresponding author. Department of Health Promotion Sciences, Mel & Enid Zuckerman College of Public Health, University of Arizona, 1295 N. Martin Avenue, P.O. Box 245209, Tucson, AZ, 85724-5209, USA.
E-mail address: kkrupp@email.arizona.edu (K. Krupp).

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the MetS, even in the absence of baseline cardiovascular disease (CVD) and diabetes.[6,7]

In India, the prevalence and correlates of MetS have mainly been studied among urban populations.[8–13] Research suggests that about one-third of Indians living in cities suffer from MetS with rates among females (range: 2.6%–65.9%) higher than those found in males (range: 8.4%–39.9%). Much less is known about MetS in India's rural populations, where 70% of the population resides.[14] The few available studies show wide variations in MetS prevalence. A study in rural West Bengal for example, found 10.7% of the males and 20.3% of the females had MetS.[15] Research in Maharashtra showed that men had a higher MetS prevalence (17.6%) than women (16.8%)[16]; a study in rural Andhra Pradesh found 28.6% of men and 20.4% of women had MetS[17] and a cross-sectional survey in Kerala found rural women had higher prevalence than men (28% vs 20%) of MetS.[18]

Identifying the correlates and modifiable risk factors of MetS is a key ingredient in designing effective interventions. Previous studies have shown that female gender,[19] higher socioeconomic class,[19,20] sedentary lifestyle,[19] smoking,[21] alcohol consumption,[22] healthy diet,[23] and educational level[19] were correlated with MetS. Certain genetic factors also appear to predispose Indians to elevated levels of MetS. Studies found that hyperglycemia, hypertension, and hypertriglyceridemia occurred at lower levels of body mass index (BMI) and waist circumference among Bangladeshis, Pakistanis, and Asian Indians, suggesting the need for adjusted cutoff points for MetS components among South Asians.[24–26] In 2005, the International Diabetes Federation (IDF) also introduced an ethnicity-specific definition of MetS to improve its utility as a predictive tool for CVD risk.[27]

The purpose of the present analysis is to examine the prevalence of MetS and its correlates among a sample of women living in rural Mysore, India. We have used a modified consensus definition of MetS among South Asians recommended by International Diabetes Federation Task Force on Epidemiology and Prevention.[28]

2. Methods

2.1. Study population

Data for this study were gathered in a community based cross-sectional study of rural and tribal women, between the ages of 30–59 years, residing in the Hunsur *Taluk* of Mysore District, Karnataka (population, 2,994,744; 50% female; 86% belonging to Hindu religion). About 59% of the district's population resides in rural villages. Rural women have an estimated annual per capita income of Indian Rupees (INR) 16,086 and a literacy rate of 63% which was low compared to the all-India annual per capita income of INR 38,005 and literacy rate of 74%. The Hunsur *taluka* has population of 50,865 of which 25,435 are females as per report released by Census India 2011.[29] Based on the national census, we estimated that 33% of the females belong in the eligible age group of 30–59 years. This helped determine a sampling frame of 8394 females between the ages of 30–59 years. Using this information, we estimated a sample size for a prevalence study with a finite population correction as follows: At a precision level of 5%, confidence interval of 95%, an unknown prevalence at 50% for a population 8,400, the estimated sample size was 368. With 20% oversampling for missing data the final sample size was determined to be 450.

2.2. Study setting and duration

The study was conducted between January and August 2016, with a follow-up period until December 2017. Twenty-five villages were chosen as community sites for the implementation of the project based on two criteria[1]: accessibility by road (within the Hunsur taluk), and[2] availability of a community center or a primary healthcare center with toilet facilities and access to running water. Complete data were available for 473 women and included in the analysis for this paper. A detailed recruitment plan is described elsewhere.[30]

2.3. Ethical review

The protocol for the study was reviewed and approved by the Institutional Review Boards of Public Health Research Institute of India and Florida International University. Informed consent was obtained from all women participating in the study before data collection.

2.4. Survey

The study used the World Health Organization's STEPS approach, which entails a stepwise collection of the risk factor data. In Step 1, information on demographics and behavioral risk factors (tobacco use, alcohol consumption, fruit and vegetable intake, physical inactivity, as well as history of raised blood pressure and diabetes) was collected through self-report using an interviewer-administered questionnaire in Kannada. Physical measurements of height and weight were recorded to calculate BMI, waist circumference and blood pressure were also recorded in Step 2, and Step 3 consisted of biochemical measurements of blood glucose and total cholesterol levels.[31]

2.5. Anthropometry

The following anthropometric measures were taken three times and the mean was recorded: height (centimeters [cm]), weight (kilogram [kg]) and waist circumference (cm). Height was measured using a stadiometer without shoes. Weight was measured on a calibrated digital scale to the nearest 100 g. Waist circumference was measured using a measuring tape at the midpoint between the lower border of the rib cage and upper border of the iliac crest. Blood pressure (BP) was measured using an electronic manometer and cuff, and an average systolic and diastolic blood pressure reading was determined after three consecutive readings.

2.6. Biochemical analysis

Blood for biochemical analysis was obtained from the participants in two different vacutainers – one 3 ml tube with EDTA for testing the HbA1c and second plain 5 ml tube for testing serum lipids. The samples were collected in the community and stored in an icebox for same day transportation to the laboratory for analysis within 24 h. Serum was tested for the concentration of triglycerides (TG), total cholesterol (TC), low-density lipoproteins (LDL), high-density lipoproteins (HDL).

2.7. Primary outcome

The primary outcome of this study was the presence of metabolic syndrome (MetS) as defined by the harmonized definition of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society modified for inclusion of Glycated HemoglobinA1c in Adults, which has been found to enhance detection of hyperglycemia for the diagnosis of MetS.[28,32] Women in this study that met at least three of the following criteria were classified as having MetS:

a) Increased waist circumference (≥80 cm)
b) Elevated triglycerides (TG) (≥150 mg per deciliter [mg/dL])
c) Low high-density lipoprotein cholesterol (HDL) levels (<50 mg/dL)
d) Elevated blood pressure (≥130/85 mmHg) or on drug treatment for hypertension
e) Elevated glucose (HbA1c ≥ 5.7%) or drug treatment for diabetes mellitus.

2.8. Explanatory variables

Twenty explanatory variables with potential to influence the presence of MetS were selected on the basis of a review of the literature: age; education; religion; caste; marital status; work status; annual household income; household size; current use of tobacco products; current use of smokeless tobacco products; alcohol use; frequency of adding salt or having pickles when eating; frequency of adding salt or salty seasoning when cooking or preparing food; frequency of consuming processed food high in salt; type of oil or fat used for meal preparation; consumption of sweetened beverages; consumption of meal products; level of physical activity; sedentary behavior; and history of heart attack or chest pain from heart disease or stroke.

2.9. Statistical analyses

Data were presented as frequencies and percentages for categorical variables, and as mean (standard deviation [SD]) and median (first quartile [Q1], third quartile [Q3]) for continuous variables. Differences in socio-demographics, health behaviors, and medical history by MetS were assessed using chi-squared (χ^2) tests and analysis of variance (ANOVA) for categorical and continuous variables, respectively. Logistic regression analyses were conducted to identify variables associated with MetS. Variables found to be conservatively associated with MetS using χ^2 test or ANOVA ($p < 0.20$) or those of clinical importance were selected *a priori* to be included in the model. Variables were excluded from the model if there was little variation in response (i.e. if ≥ 90% of the sample fell into a single response category); or if variables were highly correlated. Correlation and multicollinearity were assessed using Pearson's correlation coefficients (r) and variance inflation factors (VIFs) respectively (Montgomery et al, 2001). All analyses used a two-tailed significance level of $\alpha \leq 0.05$ and were performed using Statistical Package for the Social Sciences (SPSS) version 26 (SPSS Inc., Chicago, IL).

3. Results

3.1. Characteristics of the study sample

The mean age of the women was 41.2 years and almost all reported their religion as Hindu (Table 1). The majority had no formal education and were married, and self-employed. In India, caste is used as a proxy measure for socioeconomic status within the community and approximately, 67% reported themselves as belonging to the lower caste. The mean household size was 3.1 persons. The median annual household income was $1490 USD (IQR = $776.93–2330.79 USD).

Few women currently smoked tobacco products daily (2.1%), however one-third currently used smokeless tobacco products

Table 1
Sociodemographic characteristics of the study population from Rural Mysore, India.

Characteristic	n (%)
Age in years	
Mean (SD)	41.2 (8.452)
Median (Q1, Q3)	40.0 (34.0–47.0)
Highest level of education	
No formal education	271 (57.3)
Primary school or less	125 (26.4)
Secondary school or higher	77 (16.3)
Religion	
Hindu	467 (98.7)
Other (Muslim and Christian)	6 (1.3)
Marital status	
Married	366 (77.5)
Never married	2 (0.4)
Other (widowed, separated)	104 (22.0)
Work status	
Self employed	320 (67.7)
Housewife	114 (24.1)
Other (government employee, nongovernment/private employee)	39 (8.2)
Annual household income (USD)	
< $1500	231 (50.3)
≥ $1500	228 (49.7)
Household size	
Mean (SD)	3.1 (1.532)
Median (Q1, Q3)	3.0 (2.0, 4.0)

SD = standard deviation; Q1 = first quartile; Q3 = third quartile; USD= United States dollar.
Highest level of education: *Primary school or less* includes less than primary school ($n = 73$) and primary school completed ($n = 52$). *Secondary school or higher* includes secondary school completed ($n = 28$), high school completed ($n = 35$), college/university completed ($n = 13$), and post graduate degree ($n = 1$).
Religion: *Other* includes Muslim ($n = 5$) and Christian ($n = 1$).
Marital status: *Other* includes widowed ($n = 84$) and separated ($n = 20$).
Work status: *Other* includes government employee ($n = 29$), nongovernment/private employee ($n = 8$), retired ($n = 1$), and unemployed but able to work ($n = 1$).
Annual household income: 1 USD = 67.06 Indian Rupees (INR).

Table 2
Factors associated with metabolic syndrome among rural women in Mysore, India.

Characteristic	Metabolic syndrome		*p*-value
	Yes	No	
	n (%)	n (%)	
	($n = 271$)	($n = 200$)	
Socio-demographics			
Mean age in years (SD)	42.7 (8.35)	38.7 (8.00)	*< 0.001*
Highest level of education			
No formal education	181 (62.2)	88 (48.9)	*0.006*
Primary school or less	63 (21.6)	62 (34.4)	
Secondary school or higher	47 (16.2)	30 (16.7)	
Caste			
Lower	271 (99.3)	174 (97.8)	0.219
Higher	2 (0.7)	4 (2.2)	
Marital status			
Married	225 (77.6)	140 (77.8)	0.378
Never married	2 (0.7)	0 (0.0)	
Other	63 (21.7)	40 (22.2)	
Work status			
Self employed	183 (62.9)	135 (75.0)	*0.024*
Housewife	80 (27.5)	34 (18.9)	
Other	28 (9.6)	11 (6.1)	
Annual household income (USD)			
< $1500	144 (50.7)	86 (49.7)	0.837
≥ $1500	140 (49.3)	87 (50.3)	
Mean household size (SD)	3.23 (1.637)	2.93 (1.331)	*0.038*
Health behaviors			
Currently smoke tobacco products			
Yes	6 (2.1)	4 (2.2)	0.911
No	284 (97.9)	176 (97.8)	
Currently use smokeless tobacco products			
Yes, daily	103 (35.6)	70 (38.9)	0.286
Yes, but not daily	19 (6.6)	6 (3.3)	
No	167 (57.8)	104 (57.8)	
Ever consumed alcohol			
Yes	35 (12.0)	12 (6.7)	0.059
No	256 (88.0)	168 (93.3)	
Frequency of adding salt or having pickles when eating			
Never/rarely	90 (31.0)	59 (32.8)	0.880
Sometimes	8 (2.8)	4 (2.2)	
Often/always	192 (66.2)	117 (65.0)	
Frequency of adding salt or salty seasoning when cooking or preparing food			
Never	35 (12.0)	27 (15.0)	0.133
Less than daily	12 (4.1)	14 (7.8)	
Daily	244 (83.8)	139 (77.2)	
Frequency of consuming processed food high in salt			
Never	184 (63.2)	107 (57.8)	0.151
Less than weekly	53 (18.2)	29 (16.1)	
Weekly	54 (18.6)	47 (26.1)	
Sweetened beverages consumption (cups/day)	2.17 (1.425)	2.10 (1.263)	0.602
Frequency of meat product consumption (days/week)	1.28 (1.128)	1.22 (1.463)	0.656
Level of physical activity			
Inactive/low	26 (9.2)	10 (5.7)	*0.023*
Active	0 (0.0)	3 (1.7)	
Highly active	258 (90.8)	163 (92.6)	
Sedentary time in a typical day (minutes)	152.0 (92.211)	140.9 (82.969)	0.188
Medical history			
History of heart attack or chest pain from heart disease or stroke			
Yes	31 (10.7)	24 (13.4)	0.374
No	259 (89.3)	155 (86.6)	

SD = standard deviation; USD= United States dollar.
Metabolic syndrome is defined as meeting as least three of the following criteria[1]: increased waist circumference [≥80 cm (cm)][2]; elevated triglycerides [≥150 mg per deciliter (mg/dL)][3]; low high-density lipoprotein cholesterol (HDL) levels [<50 mg/dL][4]; elevated blood pressure [≥130/85 mmHg] or on drug treatment for hypertension[5]; elevated glucose [estimated average glucose level ≥100 mg/dL] or on drug treatment for diabetes mellitus.
Highest level of education: *Primary school or less* includes less than primary school ($n = 73$) and primary school completed ($n = 52$). *Secondary school or higher* includes secondary school completed ($n = 28$), high school completed ($n = 35$), college/university completed ($n = 13$), and post graduate degree ($n = 1$).
Religion: *Other* includes Muslim ($n = 5$) and Christian ($n = 1$).
Caste: *Lower* includes scheduled tribe ($n = 242$), scheduled caste ($n = 80$), and other backward castes ($n = 125$). *Higher* includes general castes ($n = 6$).
Marital status: *Other* includes widowed ($n = 84$) and separated ($n = 20$).
Work status: *Other* includes government employee ($n = 29$), nongovernment/private employee ($n = 8$), retired ($n = 1$), and unemployed but able to work ($n = 1$).
Annual household income: 1 USD = 67.06 Indian Rupees (INR).

daily (37.2%). One out of ten reported ever consuming alcohol (9.9%). The majority of women frequently added salt or had pickles while eating (65.7%) and added salt or salty seasoning daily when cooking or preparing foods (81.4%). One out of five women consumed processed food high in salt at least weekly (21.6%). Vegetable oil was the most common type of oil or fat used for meal preparation among almost all women (99.8%). Women reported drinking an average of 2.1 (SD = 1.36) sweetened beverages per day, and consuming meat products on an average of 1.3 (SD = 1.24) days per week. Although most women were highly active (91.6%), women were sedentary on an average of 147.8 (SD = 88.7) minutes per day. One out of ten women reported having had a heart attack or chest pain from heart disease or a stroke (11.7%).

A majority (58%) of sampled responders lacked knowledge about modifiable risk factors. A significant percentage (70%) of participants failed to identify diabetes as a risk factor and only 67.7% of participants correctly identified smoking cigarettes as a modifiable risk factor for heart disease.

3.2. Prevalence of MetS

Nearly one in every two women had MetS (47.1%, $n = 223$). Of those with MetS, 56.5% met 3 of the 5 criteria, 32.2% met 4 criteria, and 11.2% met all 5 criteria. Among the entire sample, low HDL was the most prevalent criterion (88.4%), followed by elevated glucose (57.9%), elevated triglycerides (49.3%), elevated BP (41.5%), and increased waist circumference (15.3%).

3.2.1. Characteristics of women with MetS

Women with MetS were older than those without MetS ($p < 0.001$) (Table 2). A greater proportion of women with MetS were housewives ($p = 0.001$) and were inactive ($p = 0.015$). Women with MetS also tended to reside in households of greater size ($p = 0.057$). Although nonsignificant, a greater proportion of women with MetS reported consuming additional salt or salty seasoning when cooking or preparing food on a daily basis ($p = 0.070$), while a lower proportion of women with MetS reported consuming processed foods high in salt on a weekly basis ($p = 0.020$).

3.2.2. Variable selection for logistic regression model

The following factors met the study's criterion for inclusion in the logistic regression model: age; highest level of education; work status; household size; frequency of adding salt or salty seasoning when cooking or preparing food; frequency of consuming processed food high in salt; and sweetened beverage consumption. The following factors were excluded from the logistic regression model because at least 90% of the reported response fell into a single response category: religion; current use of tobacco products; alcohol use; type of oil or fat used for meal preparation; and level of physical activity. Additionally, the following factors were excluded because they were not conservatively associated with MetS ($p > 0.20$): caste; marital status; annual household income; current use of smokeless tobacco products; frequency of adding salt or pickles when eating; consumption of meal products; and history of heart attack or chest pain from heart disease or stroke.

3.3. Factors associated with MetS

Results of the logistic regression analysis are presented in Table 3. Age and work status were the only significant determinants of MetS in the adjusted model. Odds of MetS increased by 7% with every one-year increase in age (adjusted odds ratio [AOR] = 1.070; 95%CI: 1.049, 1.108; $p < 0.001$). Being a housewife or other kinds of employment had increased odds (AOR: 2.261 and 3.031 respectively) as compared to being self-employed.

4. Discussion

In the present study, almost one out of two women living in rural Mysore had MetS (47.1%, $n = 223$). Among the entire sample, low HDL was the most prevalent criterion (88.4%), followed by elevated glucose (57.9%), elevated triglycerides (49.3%), elevated BP (41.5%), and increased waist circumference (15.3%). In this sample, older women and women who were self-employed or housewives had higher odds of having MetS.

Our findings show a striking increase in MetS over previous studies in rural populations that found a MetS prevalence ranging from 16.8% to 28.6% among women. This finding is consistent with projections that cardiovascular disease is increasing and is

Table 3
Odds of having metabolic syndrome among rural women in Mysore, India.

Characteristic	Unadjusted model			Adjusted model		
	OR	95% CI	*p*-value	AOR	95% CI	*p*-value
Age (in years)	1.062	(1.036, 1.088)	*< 0.001*	1.050	(1.023, 1.078)	*< 0.001*
Highest level of education						
No formal education	1.313	(0.777, 2.217)	0.309	0.980	(0.558, 1.721)	0.943
Primary school or less	0.649	(0.364, 1.155)	0.141	0.619	(0.339, 1.131)	0.119
Secondary school or higher	Ref.	–	–	Ref.	–	–
Household size	1.155	(1.007, 1.325)	*0.040*	1.072	(0.933, 1.232)	0.329
Frequency of adding salt/salty seasoning when cooking/preparing food						
Never	Ref.	–	–	Ref.	–	–
Less than daily	0.661	(0.263, 1.659)	0.378	0.819	(0.290, 2.311)	0.706
Daily	1.354	(0.786, 2.332)	0.274	1.362	(0.765, 2.426)	0.293
Frequency of consuming processed food high in salt						
Never	Ref.	–	–	Ref.	–	–
Less than weekly	1.033	(0.619, 1.725)	0.901	1.174	(0.661, 2.085)	0.584
Weekly	0.649	(0.410, 1.028)	0.065	0.697	(0.427, 1.136)	0.148
Sedentary time in a typical day (minutes)	1.001	(0.999, 1.004)	0.189	1.001	(0.998, 1.003)	0.525

OR = odds ratio; AOR = adjusted odds ratio; CI = confidence interval.
Metabolic syndrome is defined as meeting as least three of the following criteria[1]: increased waist circumference [≥80 cm (cm)][2]; elevated triglycerides [≥150 mg per deciliter (mg/dL)][3]; low high-density lipoprotein cholesterol (HDL) levels [<50 mg/dL][4]; elevated blood pressure [≥130/85 mmHg] or on drug treatment for hypertension[5]; elevated glucose [estimated average glucose level ≥100 mg/dL] or on drug treatment for diabetes mellitus.
Highest level of education: *Primary school or less* includes less than primary school ($n = 73$) and primary school completed ($n = 52$). *Secondary school or higher* includes secondary school completed ($n = 28$), high school completed ($n = 35$), college/university completed ($n = 13$), and post graduate degree ($n = 1$).

projected to reach 13.5% among the rural elderly (60–69 years old) based on the rising prevalence of risk factors.[33] A recent study in 45 rural villages in Andhra Pradesh, reported that cardiovascular disease already accounted for about a third of all deaths.[34] Based on our findings, it seems likely that those trends are continuing and perhaps accelerating. Another study in and around Vellore, Tamil Nadu, compared the current prevalence of CVD risk factors with that in the early 1990s among 12,000 rural and urban individuals, found that the rate of diabetes, hypertension, overweight/obesity and alcohol use has increased significantly in both settings, but rural populations showed the worst trends for all risk factors.[35] In the rural areas, there was a trebling of diabetes and overweight/obesity, and a doubling of the prevalence of hypertension. On the positive side, the proportion of male current smokers had reduced by 50% in both settings, but lifetime abstainers to alcohol had decreased in the rural area from 46.8% to 37.5%.

Given India's limited public health resources there is a compelling public health need for health promotion and prevention interventions to reduce the alarming rate of increase in CHD. While the level of knowledge about modifiable risk factors among India's rural populations is largely unknown, a study in the general population study found low knowledge about heart disease and its determinants.[36]

This study has limitations and strengths. Findings might not be generalizable as this was not a population-based probability sample. It is possible that only a small percentage of eligible women may have actually attended the screening clinic. It is possible that more of those with pre-existing diseases like diabetes or hypertension may have attended the clinic leading to the possible high prevalence of MetS. There is a potential for information bias as women were self-reporting several behavioral risk factor information which might be over or under reported due to recall and social desirability bias. On the other hand, the strengths of this study include having a large community-based sample of women, standardized laboratory testing and using tested and validated WHO STEPs instruments for evaluation of the risk factor information.

In conclusion, there is an alarming rise in the prevalence of MetS in rural areas that will eventually be reflected in increasing morbidity and mortality from heart disease. There is an urgent need to target interventions to rural women who appear to have the highest prevalence of cardiovascular risk factor. In this population, prevention strategies should target knowledge and management of serum cholesterol and high blood pressure, which are both treatable and represent the most common preventable risk factors in this population.

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Conflict of interest

All authors have none to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ihj.2020.09.015.

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