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Original Article

Overweight, the major determinant of metabolic syndrome among industrial workers in Kerala, India: Results of a cross-sectional study

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ABSTRACT

Aim: To determine the prevalence and associated risk factors of metabolic syndrome (MS) among industrial workers in Kerala, India.

Materials and methods: We measured fasting plasma glucose (FPG), triglycerides, high density lipoprotein cholesterol, waist circumference, systolic blood pressure and diastolic blood pressure among 2287 industrial workers (mean age 46 years, men 70%) from selected industries of two southern most Kerala districts using standard protocol in 2009. MS was defined according to international diabetes federation (IDF), Adult Treatment Panel (ATP-III) and American Heart Association(AHA)/National Heart Lung and Blood Institute (NHLBI) criteria (Harmonization). Age-standardized prevalence of MS was assessed for men and women. Multivariable logistic regression models were developed to find the associated factors of MS.

Results: Age-standardized prevalence of MS was 14% (men 14%, women 15%), 19% (men 19%, women 21%) and 27% (men 30%, women 21%) as per IDF, ATP-III and Harmonization criteria respectively. Overweight adults were nine times (OR 9.41, 95% CI 7.34–12.06), twelve times (OR 11.80 CI 9.38–14.84), and four times (OR 3.56, CI 2.94–4.29) more likely to have MS compared to their counterparts according to IDF, ATP-III and Harmonization criteria respectively. Older adults and current alcohol users were more likely to have MS compared to their counterparts. Women were more likely to have MS as per IDF and ATP-III criteria.

Conclusions: MS prevalence was high among Industrial workers who generally have good access to health care. Overweight and other predictors of MS need to be addressed to reduce MS prevalence in this population.

1. Introduction

The metabolic syndrome (MS) is a constellation of endogenous risk factors that increase the risk of developing both atherosclerotic cardiovascular diseases (ASCVD) and type 2 diabetes mellitus [1]. Various international agencies such as World Health Organization (WHO), International Diabetes Federation (IDF) and the third report of the national cholesterol education program's adult treatment panel (NCEP ATP III) define MS differently. Currently, the most commonly used definitions for MS are ATP III and IDF [2]. ATP III-defines metabolic syndrome as the presence of at least three of the five risk factors (waist circumference, serum triglycerides, serum high density lipoprotein (HDL) cholesterol, blood pressure and fasting glucose level) in an individual [3]. IDF defines MS as the presence of central obesity and any two of the above mentioned four risk factors. Because of the inappropriate cut off for central obesity which underestimates MS, ATP III was modified for Asians with central obesity as waist circumference >=80 cm in women and >=90 cm in men [4].

MS was reported to be significantly associated with diabetes [5] and cardiovascular diseases [6–10]. High level of cardiovascular mortality was reported in many studies among non-resident Indians with MS [11–13]. The INTERHEART study and a study from Spain, reported more than a 2.5-fold risk of acute myocardial infarction among people with MS using either the WHO or IDF definition [14,15].

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MS prevalence among adults aged 18 years and above was reported as 9.3% in rural [16] and 30% in urban India [17] according to harmonization criteria. Another study from South India reported a prevalence of 41% among adults aged 20–75 years in urban Tamil Nadu State [18]. MS prevalence of 36% [19] was reported among university employees in Jordan, 31% among Iranian professional drivers [20], 33% among day time electronics manufacturing workers and 43% among the same group of night time workers in Taiwan [21]. The prevalence in different areas was found to be different and not strictly comparable since the definitions used were different. A crude MS prevalence of 18.5% was reported among urban men industrial workers in Rajasthan state of India [22]. This study reported the crude prevalence of MS using IDF definition using a sample of 651 men who came for the annual medical examination at the occupational health centre.

Kerala state is reported to have the highest prevalence of non-communicable diseases (NCDs) and their risk factors in India [23] and is reported as the most advanced Indian state in epidemiologic transition [24]. A recent study from Kerala reported an age-adjusted MS prevalence of 24%, 29% and 33% in a state representative sample of 5063 general population using ATP III, IDF and Harmonization criteria [25]. However, data on MS prevalence and its correlates among industrial workers who generally have better access to health care compared to the general population in Kerala are limited. The objectives of our study were to assess the MS prevalence and associated risk factors among industrial workers in Kerala, India.

2. Materials and methods

This study was part of a large multi-country study on Community based Interventions for Health (CIH), with an objective to find the effectiveness of culturally adapted community-based interventions on prevalence of three major NCD risk factors: tobacco use, unhealthy diet and physical inactivity in different settings. This was conducted in three places; Kerala in India, Hangzhou city in China and Mexico City in Mexico, in four different settings: health centers, workplace, schools, and community. Detailed methodology [26] and main outcomes of CIH [27] were published earlier.

In this manuscript, we analyzed workplace data from the Kerala state of India. Using a quasi-experimental study design, two major industries were selected from two southern districts of Kerala. The sample size was fixed as 2000 for the industry setting in each country as previously reported in the methodology paper [26]. At least 1000 workers were selected from each of the control and intervention industries making a total of at least 2000 workers in the sample. In this manuscript, we report the baseline prevalence and risk factors of MS in the combined sample of both intervention and control industries.

Using the WHO STEPS approach, we collected data from 2426 workers aged 18–64 years from the two selected industries in Kerala. Age, sex, education, tobacco use and alcohol consumption were collected using interview schedule. We measured fasting plasma glucose (FPG), triglycerides (TG) and high-density lipoprotein (HDL) cholesterol using Cholestech LDX system [28]. Waist circumference, weight, height, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using WHO STEPS protocol [29]. During analysis, data of 139 workers were discarded due to incomplete information. Thus, finally we analyzed data of 2287 (92.7%) workers for the present study.

We used three definitions for metabolic syndrome: International Diabetes Federation (IDF) [30], Third report of the national cholesterol education program's Adult Treatment Panel (ATP III) [31] and American Heart Association(AHA)/National Heart Lung and Blood Institute (NHLBI) criteria (Harmonization) [32]. World Health Organization definition on metabolic syndrome was not used since we did not collect the urinary albumin, an essential component of the WHO criteria, due to limited resources.

MS was defined according to International Diabetes Federation criteria as: central obesity (defined as waist circumference ≥90 cm for men and ≥80 cm for women, plus any two of the following four factors: Raised TG level (≥150 mg/dl or on treatment for lipid abnormality), reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women or on treatment for lipid abnormality), raised blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or on treatment for hypertension), raised fasting plasma glucose (FPG) (FPG≥100 mg/dl or on treatment for diabetes).

MS was defined according to ATP III criteria as central obesity: waist circumference >=90 cm for men and >=80 cm for women and any two of the following four factors: triglycerides >=150 mg/dl, reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality; SBP≥130 or DBP≥85 or on medication for hypertension) and raised fasting plasma glucose (FPG≥100 mg/dl or on medication or diabetes).

MS was defined according to Harmonization criteria as the presence of three or more of the following five risk factors: (1) waist circumference ≥90 cm for men and ≥80 for women, (2) triglycerides ≥150 mg/dl or on treatment for lipid abnormality, (3) reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality, (4) systolic blood pressure (SBP) ≥130 or diastolic blood pressure (DBP) ≥85 or on medication for hypertension and (5) raised fasting plasma glucose (FPG) ≥100 mg/dl) or on medication for diabetes.

Statistical analysis was done using IBM SPSS Statistics for Windows, Version 21.0. (Armonk, NY: IBM Corp. Chicago, IL). Bivariate and multivariate analysis were done to find out the correlates of MS. The minimum statistical significance level was fixed as $p < 0.05$. Using direct standardization method, age standardization was done using World Health Organization (WHO) standard population for 2000–2025 aged 15–64 years [33]. A five-year interval with a total of ten strata was used.

The study was approved by the Institutional Ethics Committee (IEC) of Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum. Written informed consent was obtained from all the participants before the study.

3. Results

3.1. Demographics

Mean age of the sample was 46 years (SD:10). Seventy percent were men. Eighteen percent of the sample had less than high school education and 60% were high school or higher secondary completed and 22% had college education. Current tobacco use was reported by 24% and alcohol consumption by 31%.

3.2. Prevalence of individual risk factors of metabolic syndrome

Prevalence of individual risk factors of metabolic syndrome by sex is presented in Table 1. Raised TG level, raised BP and raised FPG were significantly higher for men than women whereas central obesity was significantly higher for women than men. The most common risk factor of MS was reduced HDL cholesterol (66.7%), followed by high blood pressure (53.3%), elevated triglycerides (34.0%), central obesity (37.7%) and elevated FPG (49.5%). Prevalence of raised TG level among men exceeded double than that of the prevalence among women. Mean and standard deviation (SD) of anthropometric and biochemical variables are presented in Table 2. Prevalence of individual risk factors of metabolic syndrome

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Table 1
Prevalence of individual risk factors for metabolic syndrome by sex.

Risk factors	Men (N = 1609) n(%)	Women(N = 678) n(%)	Total(N = 2287) n(%)
Central Obesity[a]*	488(30.3)	374(55.2)	862(37.7)
Raised TG level[b]*	670(41.6)	107(15.8)	777(34.0)
Reduced HDL cholesterol[c]	1065(66.2)	461(68.0)	1526(66.7)
Raised blood pressure[d]*	933(58.0)	287(42.3)	1220(53.3)
Raised FPG[e]*	894(55.6)	237(35.0)	1131(49.5)

*p < 0.05.
[a] Waist circumference ≥90 cm for men and ≥80 for women.
[b] Triglycerides (TG) ≥150 mg/dl or specific treatment for this lipid abnormality.
[c] HDL<40 mg/dl in men and <50 mg/dL in women or specific treatment for this lipid abnormality.
[d] SBP≥130 or DBP≥85 or on medication for hypertension.
[e] Raised fasting plasma glucose (FPG) ≥100 mg/dL or on medication for diabetes.

Table 2
Mean (SD) of continuous variables.

Variables	Mean ± SD	Range
Weight (kg)	63 ± 11	28–158
Height (cm)	162 ± 9	130–190
Waist circumference (cm)	84 ± 10	50–120
Systolic BP (mm Hg)	130 ± 19	53–226
Diastolic BP (mm Hg)	80 ± 11	36–133
Fasting plasma glucose (mg/dl)	112 ± 43	36–459
Triglycerides (mg/dl)	123 ± 74	45–612
HDL cholesterol (mg/dl)	40 ± 12	15–89

SD: Standard Deviation.

by background characteristics is presented in Table 3.

3.3. Prevalence and risk factors of metabolic syndrome

The age standardized prevalence of metabolic syndrome by sex according to different criteria is presented in Table 4. Prevalence of MS based on IDF criteria was 14% (men 14%, women 15%), 19% based on ATP III criteria (men 19%, women 21%) and 26% based on Harmonization criteria (men 30%, women 21%).

Table 4
Crude and age standardized prevalence (per 100) of metabolic syndrome by sex according to different criteria.

Criteria for metabolic syndrome	Men	Women	Total
IDF			
Crude	21.0	24.3	22.0
Standardized	14.9	15.4	14.4
ATP III *			
Crude	26.5	33.9	28.7
Standardized	19.1	21.8	19.4
Harmonization criteria*			
Crude	44.6	33.5	41.3
Standardized	30.2	21.5	26.5

IDF: International Diabetes Federation, ATP: Adult Treatment Panel, MS: Metabolic Syndrome.
*p < 0.05.

Number of MS risk factors present in our sample population for men and women is provided in Table 5. Majority of workers had at least one component of metabolic syndrome. More men were having three or more components of metabolic syndrome than women (44% vs 33%).

Results of multivariable logistic regression analysis according to

Table 3
Prevalence of individual risk factors of metabolic syndrome by background characteristics.

Variables	Total N = 2287	Over weight[a] %	Central Obesity[b] %	Raised blood pressure[c] %	Raised Fasting blood sugar (FBS)[d] %	Raised TG level[e] %	Reduced HDL cholesterol[f] %
Age group (years)		*	*	*	*	*	*
18-34	370	87(23.5)	64(17.3)	84(22.7)	10(2.7)	57(15.4)	224(60.5)
35-44	449	192(42.8)	189(42.1)	199(44.3)	57(12.7)	112(24.9)	292(65.0)
45-54	1011	448(44.3)	401(39.7)	615(60.8)	264(26.1)	428(42.3)	698(69.0)
55-64	457	182(39.8)	208(45.5)	322(70.5)	159(34.8)	180(39.4)	312(68.3)
Sex			*	*	*	*	
Men	1609	620(38.5)	488(30.3)	933(58.0)	386(24.0)	670(41.6)	1065(66.2)
Women	678	289(42.6)	374(55.2)	287(42.3)	104(15.3)	107(15.8)	461(68.0)
Education		*		*	*	*	
<High school (HS) education	402	119(29.6)	141(35.1)	200(49.8)	69(17.2)	96(23.9)	266(66.2)
HS & higher secondary completed	1377	575(41.8)	542(39.4)	766(55.6)	337(24.5)	500(36.3)	915(66.4)
College Education	508	215(42.3)	179(35.2)	254(50.0)	84(16.5)	181(35.6)	345(67.9)
Current Tobacco Use			*			*	
Yes	537	199(37.1)	167(31.1)	297(55.3)	115(21.4)	223(41.5)	351(65.4)
No	1750	710(40.6)	695(39.7)	923(52.7)	375(21.4)	554(31.7)	1175(67.1)
Current Alcohol use		*		*	*	*	*
Yes	712	301(42.3)	255(35.8)	441(61.9)	170(23.9)	330(46.3)	430(60.4)
No	1575	608(38.6)	607(38.5)	779(49.5)	320(20.3)	447(28.4)	1096(69.6)

*p < 0.05.
[a] Body mass index (BMI) ≥25 kg/m^2.
[b] Waist circumference ≥90 cm for men and ≥80 for women.
[c] SBP≥130 or DBP≥85 or on medication for hypertension.
[d] Raised fasting plasma glucose (FPG) ≥100 mg/dL or on medication for diabetes.
[e] Triglycerides ≥150 mg/dl or on treatment for lipid abnormality.
[f] Reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality.

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Table 5
Risk factor clustering of metabolic syndrome in study participants by age and sex.

Sex/Age group	Number of risk factors present			
	0	1	2	3 or more
Men				
18-24	29(32.2)	43(47.8)	13(14.4)	4(4.4)
25-34	30(20.8)	46(31.9)	30(20.8)	25(17.4)
35-44	27(11.0)	67(27.3)	63(25.7)	52(21.2)
45-54	38(4.7)	124(15.4)	231(28.6)	222(27.5)
55-64	20(6.2)	40(12.4)	91(28.2)	81(25.1)
Total	**144(8.9)**	**320(19.9)**	**428(26.6)**	**717(44.6)**
Women				
18-24	18(45.0)	18(45.0)	3(7.5)	1(2.5)
25-34	29(30.2)	36(37.5)	26(27.1)	3(3.1)
35-44	19(9.3)	56(27.5)	75(36.8)	32(15.7)
45-54	11(5.4)	37(18.1)	68(33.3)	59(28.6)
55-64	7(5.2)	17(12.7)	31(23.1)	39(29.1)
Total	**84(12.4)**	**164(24.2)**	**203(29.9)**	**227(33.5)**

various definitions of MS are presented in Table 6. The findings indicated that odds of metabolic syndrome increased with increase in age. MS was higher among women according to two criteria (IDF and ATP III) and higher for men as per Harmonization criteria. Metabolic syndrome was higher among current alcohol users. Overweight was the strongest predictor of MS. Being overweight increased the risk of MS more than thrice according to Harmonization criteria and more than nine times in case of IDF criteria and more than eleven times as per ATP III criteria.

4. Discussion

In this study age adjusted prevalence of MS was estimated using ATP III, IDF and Harmonization criteria and the prevalence was 19%, 14% and 26% respectively, which was lower than the corresponding prevalence figures reported among general population in the state of Kerala [25]. MS prevalence according to ATP III in our study was lower than that of the 25% MS prevalence reported among general population in another part of India [17]. Age adjusted prevalence of MS in our study according to harmonization criteria for Asian Indians was lower than that was reported among general population in urban India [34]. The unadjusted prevalence in our study (22%) was higher than the unadjusted prevalence of 19% among industrial workers in India [22] and was lower than the unadjusted findings in Chennai (26%) and unadjusted prevalence based on a community-based sample from Kerala (35%). In Asia, the prevalence of metabolic syndrome varied from 15% in Philippines to 35% in Pakistan according to IDF definition [35]. In India, comparable studies on prevalence of MS using different definitions are limited. A study from south India [36] reported MS prevalence of 25.8% by IDF and 18.3% using ATP-III definition.

Women, older adults and those with overweight were more likely to have metabolic syndrome similar to the findings from general population in the Indian state of Kerala [25] as well as the findings from urban India [34].

Several studies reported a higher prevalence of metabolic syndrome among women than men [14,17,25]. However in our study women were less likely to have MS compared to men as per the harmonization criteria which was similar to the findings reported from rural India [37] and other parts of the world [38–42]. This high prevalence of MS among men may be associated with the higher proportion of three or more risk factors present among men compared to women (see Table 5).

The contribution of aging population to the growing prevalence of the MS was well-known [43,44]. MS was more prevalent among women as seen in earlier studies [45–48]. This difference was associated with the difference in sexual hormones in men and women [49]. Risk factors of MS were different for men and women. For example, the major risk factor for women was central obesity where as raised triglycerides, blood pressure and fasting blood glucose were the major risk factors among men.

Similar to the findings from a prospective study in Korea [50], the prevalence of MS in our study was higher among alcohol users. However, this needs to be further studied with the level of alcohol consumption which was not captured in this study.

Clustering of metabolic syndrome among overweight individuals was reported from very early times [51]. The prevalence of metabolic syndrome is likely to rise in future since the prevalence of overweight is on the rise. Nearly one third (32%) of adult women and 29% of adult men in the state were overweight or obese [52]. The rise in MS will have major effect on the future CAD prevalence in an ageing society like Kerala because of the association between MS and CAD as reported in the recent study from Kerala [25]. Intervention strategies to reduce over weight should be strengthened for adults in India and particularly in the industrial population

Table 6
Factors associated with metabolic syndrome: Results of multivariable logistic regression analysis.

Variables	Criteria for metabolic syndrome		
	IDF	ATP III criteria	Harmonization criteria
Age group			
18-34	Reference	Reference	Reference
35-44	2.26(1.35–3.79)	2.43(1.55–3.79)	2.57(1.76–3.74)
45-54	3.76(2.34–6.04)	2.56(2.36–5.37)	5.31(3.79–7.46)
55-64	6.50(3.94–10.72)	5.71(3.67–8.90)	7.58(5.24–10.97)
Sex			
Men	Reference	Reference	Reference
Women	1.44(1.09–1.92)	1.94(1.47–2.55)	0.76(0.60–0.96)
Education			
<High School (HS)	Reference	Reference	Reference
HS & higher secondary completed	1.08(0.78–1.49)	1.08(0.80–1.47)	1.45(1.12–1.88)
College Education	0.88(0.60–1.30)	0.88(0.61–1.27)	1.24(0.91–1.69)
Current alcohol use			
No	Reference	Reference	Reference
Yes	1.30(1.00–1.70)	1.52(1.18–1.97)	1.27(1.03–1.58)
Over weight[a]			
No	Reference	Reference	Reference
Yes	9.41(7.34–12.06)	11.80(9.38–14.84)	3.56(2.94–4.29)

IDF: International Diabetes Federation, ATP: Adult Treatment Panel.
[a] Body mass index (BMI) ≥25 kg/m^2.

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in order to reduce MS prevalence. Most industries have better access to health care compared to the general population. This facility should be utilized for the prevention and control of MS in this population.

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Conflicts of interest

None Declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.dsx.2018.07.009.

References

[1] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. American Heart Association; National heart, lung, and blood institute. diagnosis and management of the metabolic syndrome: an american heart association/national heart, lung, and blood institute scientific statement. Circulation 2005;112(17):2735–52.

[2] Kassi E, Pervanidou P, Kaltsas G, Chrousos G. Metabolic syndrome: definitions and controversies. BMC Med 2011;9:48. https://doi.org/10.1186/1741-7015-9-48.

[3] Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). J Am Med Assoc 2001;285(19):2486–97.

[4] Tan CE, Ma S, Wai D, Chew SK, Tai ES. Can we apply the national cholesterol education program adult treatment panel definition of the metabolic syndrome to Asians? Diabetes Care 2004;27(5):1182–6.

[5] Haffner SM, Valdez RA, Hazuda HP, Mitchell BD, Morales PA, Stern MP. Prospective analysis of the insulin-resistance syndrome (syndrome X). Diabetes 1992;41(6):715–22.

[6] Isomaa B, Almgren P, Tuomi T, Forsén B, Lahti K, Nissén M, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683–9.

[7] Fuller JH, Shipley MJ, Rose G, Jarrett RJ, Keen H. Coronary heart disease risk and impaired glucose tolerance: the Whitehall Study. Lancet 1980;1:1373–6.

[8] McNeill AM, Rosamond WD, Girman CJ, Golden SH, Schmidt MI, East HE, et al. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. Diabetes Care 2005;28:385–90.

[9] Hunt KJ, Resendez RG, Williams K, Haffner SM, Stern MP. National cholesterol education program versus world health organization metabolic syndrome in relation to all-cause and cardiovascular mortality in the san Antonio heart study. Circulation 2004;110:1251–7.

[10] Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. J Am Med Assoc 2002;288:2709–16.

[11] Kamath SK, Hussain EA, Amin D, Mortillaro E, West B, Peterson CT, et al. Cardiovascular disease risk factors in 2 distinct ethnic groups: Indian and Pakistani compared with American premenopausal women. Am J Clin Nutr 1999;69:621–31.

[12] McKeigue P, Ferrie J, Pierpoint T, Marmot MG. Association of early-onset coronary heart disease in South Asian men with glucose intolerance and hyperinsulinemia. Circulation 1993;87:152–61.

[13] Enas EA, Garg A, Davidson MA, Nair VM, Huet BA, Yusuf S. Coronary heart disease and its risk factors in first-generation immigrant Asian Indians to the United States of America. Indian Heart J 1996;48:343–53.

[14] Mente A, Yusuf S, Islam S, McQueen MJ, Tanomsup S, Onen CL, Rangarajan S, Gerstein HC, Anand SS. INTERHEART Investigators. Metabolic syndrome and risk of acute myocardial infarction a case-control study of 26,903 subjects from 52 countries. J Am Coll Cardiol 2010;55(21):2390–8. https://doi.org/10.1016/j.jacc.2009.12.053.

[15] Cabré JJ, Martín F, Costa B, Piñol JL, Llor JL, Ortega Y, et al. Metabolic syndrome as a cardiovascular disease risk factor: patients evaluated in primary care. BMC Publ Health 2008;8:251. https://doi.org/10.1186/1471-2458-8-251.

[16] Kamble P, Deshmukh PR, Garg N. Metabolic syndrome in adult population of rural Wardha, central India. Indian J Med Res 2010;132:701–5.

[17] Prabhakaran D, Chaturvedi V, Shah P, Manhapra A, Jeemon P, Shah B, et al. Differences in the prevalence of metabolic syndrome in urban and rural India: a problem of urbanization. Chron Illness 2007;3(1):8–19.

[18] Ramchandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Metabolic syndrome in urban Asian Indian adults - a population study using modified ATP-III criteria. Diabetes Res Clin Pract 2003;60:199–204.

[19] Obeidat BA, Al-Shami EKA, Abdul-Razzak KK, Khader YS. Predictors of metabolic syndrome among employees: a study from Jordan. Food Nutr 2012;3:669–77.

[20] Mohebbi I, Saadat S, Aghassi M, Shekari M, Matinkhah M, Sehat S. Prevalence of metabolic syndrome in Iranian professional drivers: results from a population based study of 12,138 men. PLoS One 2012;7(2):e31790. https://doi.org/10.1371/journal.pone.0031790.

[21] Lin YC, Hsieh IC, Chen PC. Utilizing the metabolic syndrome component count in workers' health surveillance: an example of day-time vs. day-night rotating shift workers. Int J Occup Med Environ Health 2015;28(4):675–88. https://doi.org/10.13075/ijomeh.1896.00335.

[22] Nair CV. Metabolic syndrome: an occupational perspective. Indian J Community Med 2010;35(1):122–4. https://doi.org/10.4103/0970-0218.62569.

[23] Thankappan KR, Shah B, Mathur P, Sarma PS, Srinivas G, Mini GK, et al. Risk factor profile for chronic non-communicable diseases: results of a community-based study in Kerala, India. Indian J Med Res 2010;131:53–63.

[24] India state-level disease burden initiative collaborators. Nations within a nation: variations in epidemiological transition across the states of India, 1990-2016 in the global burden of disease study. Lancet 2017;390(10111):2437–60. https://doi.org/10.1016/S0140-6736(17)32804-0. 2.

[25] Harikrishnan S, Sarma S, Sanjay G, Jeemon P, Krishnan MN, Venugopal K, et al. Prevalence of metabolic syndrome and its risk factors in Kerala, South India: analysis of a community based cross-sectional study. PLoS One 2018;13(3):e0192372. https://doi.org/10.1371/journal.pone.0192372. eCollection 2018.

[26] O'Connor Duffany K, Finegood DT, Matthews D, McKee M, Narayan KMV, Puska P, et al. Community Interventions for Health (CIH): a novel approach to tackling the worldwide epidemic of chronic diseases. CVD Prev. Contr. 2011;6(2):47–56.

[27] Dyson PA, Anthony D, Fenton B, Stevens DE, Champagne B, Li LM, et al. Community Interventions for Health (CIH) collaboration. Successful up-scaled population interventions to reduce risk factors for non-communicable disease in adults: results from the International Community Interventions for Health (CIH) Project in China, India and Mexico. PLoS One 2015;10(4):e0120941. https://doi.org/10.1371/journal.pone.0120941.

[28] Carey M, Markham C, Gaffney P, Boran C, Maher V. Validation of a point of care lipid analyser using a hospital based reference laboratory. Ir J Med Sci 2006;175(4):30–5.

[29] Surveillance of risk factors for non communicable diseases. The WHO STEP wise approach. Non communicable diseases and mental health. Geneva: World Health Organization; 2003. http://www.who.int/ncd_surveillance/steps/riskfactor/en/index.html.

[30] Alberti G, Zimmet P, Shaw J. The IDF consensus worldwide definition of the metabolic syndrome. Obes Metabol 2005;2(3):47–9.

[31] Grundy SM. Definition of metabolic syndrome: report of the national heart, lung, and blood institute/american heart association conference on scientific issues related to definition. Circulation 2004;109(3):433–8.

[32] Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement 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; and international association for the study of obesity. Circulation 2009;120(16):1640–5.

[33] Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. Age standardization of rates: a new WHO standard, vol 31. Geneva: World Health Organization; 2001. p. 1–4.

[34] Deepa M, Farooq S, Datta SM, Deepa R, Mohan V. Prevalence of metabolic syndrome using WHO, ATP-III and IDF definitions in Asian Indians: the Chennai urban rural epidemiology study (CURES-34). Diabetes Metabol. Res. Rev. 2007;23(2):127–34.

[35] Ranasinghe P, Mathangasinghe Y, Jayawardena R, Hills AP, Misra A. Prevalence and trends of metabolic syndrome among adults in the Asia-pacific region: a systematic review. BMC Publ Health 2017;17(1):101. https://doi.org/10.1186/s12889-017-4041-1.

[36] Deedwania PC, Gupta R, Sharma KK, Achari V, Gupta B, Maheshwari A, et al. High prevalence of metabolic syndrome among urban subjects in India: a multisite study. Diabetes, Metab. Syndrome 2014;8(3):156–61. https://doi.org/10.1016/j.dsx.2014.04.033.

[37] Chow CK, Naidu S, Raju K, Raju R, Joshi R, Sullivan D, et al. Significant lipid, adiposity and metabolic abnormalities amongst 4535 Indians from a developing region of rural Andhra Pradesh. Atherosclerosis 2008;196(2):943–52.

[38] Vaughan C, Schoo A, Janus ED, Philpot B, Davis-Lameloise N, Lo SK, et al. The association of levels of physical activity with metabolic syndrome in rural

Australian adults. BMC Publ Health 2009;9:273.
[39] Hao Z, Konta T, Takasaki S, Abiko H, Ishikawa M, Takahashi T, et al. The association between microalbuminuria and metabolic syndrome in the general population in Japan: the Takahata study. Intern Med 2007;46(7):341–6.
[40] Ming J, Xu S, Yang C, Gao B, Wan Y, Xing Y, et al. China national diabetes and metabolic disorders study group. Metabolic syndrome and chronic kidney disease in general Chinese adults: results from the 2007–08 China national diabetes and metabolic disorders study. Clin Chim Acta 2014;430:115–20.
[41] Sobko T, Trindade D, Lao QX, Wong M, Io TK, Wa CK, et al. Men in Macau SAR have higher prevalence in metabolic syndrome and among related metabolic components: a cross-sectional Macau Health Survey. BMC Publ Health 2014;14:1065.
[42] Hydrie MZ, Shera AS, Fawwad A, Basit A, Hussain A. Prevalence of metabolic syndrome in urban Pakistan (Karachi): comparison of newly proposed International Diabetes Federation and modified Adult Treatment Panel III criteria. Metab Syndrome Relat Disord 2009;7(2):119–24.
[43] Veronica G, Esther RR. Metabolic syndrome: early development and aging. J Diabetes Metabol 2011;S2(002). https://doi.org/10.4172/2155-6156.S2-002.
[44] Hildrum B, Mykletun A, Hole T, Midthjell K, Dahl AA. Age-specific prevalence of the metabolic syndrome defined by the international diabetes federation and the national cholesterol education program: the Norwegian HUNT 2 study. BMC Publ Health 2007;7:220.
[45] Beigh SH, Jain S. Prevalence of metabolic syndrome and gender differences. Bioinformation 2012;8(13):613–6. https://doi.org/10.6026/97320630008613.
[46] He Y, Jiang B, Wang J, Feng K, Chang Q, Fan L, et al. Prevalence of the metabolic syndrome and its relation to cardiovascular disease in an elderly Chinese population. J Am Coll Cardiol 2006;47(8):1588–94.
[47] Sidorenkov O, Nilssen O, Brenn T, Martiushov S, Arkhipovsky VL, Grjibovski AM. Prevalence of the metabolic syndrome and its components in Northwest Russia: the Arkhangelsk study. BMC Publ Health 2010;10:23. https://doi.org/10.1186/1471-2458-10-23.
[48] Park HS, Oh SW, Cho SI, Choi WH, Kim YS. The metabolic syndrome and associated lifestyle factors among South Korean adults. Int J Epidemiol 2004;33(2):328–36.
[49] Guarner-Lans V, Rubio-Ruiz ME, Pérez-Torres I, Baños de MacCarthy G. Relation of aging and sex hormones to metabolic syndrome and cardiovascular disease. Exp Gerontol 2011;46(7):517–23. https://doi.org/10.1016/j.exger.2011.02.007.
[50] Baik I, Shin C. Prospective study of alcohol consumption and metabolic syndrome. Am J Clin Nutr 2008;87(5):1455–63.
[51] Reaven GM. Banting lecture. Role of insulin resistance in human disease. Diabetes 1988;37:1595–607.
[52] International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-4), India, 2015-16:Kerala. Mumbai: IIPS. 2017.

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