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Risk factor profile for chronic non-communicable diseases: Results of a community-based study in Kerala, India

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***Background & objectives*: Kerala State is a harbinger of what will happen in future to the rest of India in chronic non-communicable diseases (NCD). We assessed: (*i*) the burden of NCD risk factors; (*ii*) estimated the relations of behavioural risk factors to socio-demographic correlates, anthropometric risk factors with behavioural risk factors; (*iii*) evaluated if socio-demographic, behavioural and anthropometric risk factors predicted biochemical risk factors; and (*iv*) estimated awareness, treatment and adequacy of control of hypertension and diabetes, in Kerala state.**

***Methods*: A total of 7449 individuals (51% women) stratified by age group, sex and place of residence were selected and information on behavioural risk factors; tobacco use, diet, physical activity, alcohol use, measured anthropometry, blood pressure was collected. Fasting blood samples were analysed for blood glucose, total cholesterol, high density lipoprotein cholesterol and triglycerides in a sample subset. Using multiple logistic regression models the associations between socio-demographic and anthropometric variables with biochemical risk factors were estimated.**

***Results*: The burden of NCD risk factors was high in our sample. Prevalence of behavioural and each of the biochemical risk factors increased with age, adjusting for other factors including sex and the place of residence. The odds ratios relating anthropometric variables to biochemical variables were modest, suggesting that anthropometric variables may not be useful surrogates for biochemical risk factors for population screening purposes.**

***Interpretation & conclusions*: In this large study of community-based sample in Kerala, high burden of NCD risk factors was observed, comparable to that in the United States. These data may serve to propel multisectoral efforts to lower the community burden of NCD risk factors in India in general, and in Kerala, in particular.**

Key words Anthropometry - biochemical risk factors - Kerala - non-communicable diseases - WHO STEPs

Heart disease, stroke, cancer and other chronic non communicable diseases (NCDs) contributed to 35 of the 58 million deaths (60.3%) in the world in 2005[1]. Eighty per cent of these deaths occurred in low and middle income countries. In India, NCDs were responsible for 53 per cent of deaths and 44 per cent of disability adjusted life years lost[2]. India is experiencing a rapid health transition. Within India, the State of Kerala, well known for health at low cost[3], is the most advanced State in this transition, and a harbinger of what will happen to the rest of India in the future.

NCDs have common risk factors such as tobacco use, unhealthy diet, physical inactivity and excess adiposity. Policies and programmes focusing on reducing the burden of these common risk factors are likely to make a substantial impact on mitigating the mortality and morbidity due to NCDs[4]. The World Health Organization (WHO) has recommended surveillance of common risk factors with the "STEPwise" approach, which uses standardized instruments and protocols for collecting, analyzing and monitoring trends for risk factors within and across countries[5]. Thus, STEPS approach focuses on the collection of data on key risk factors of major NCDs at regular intervals in order to design community-based interventions targeted at the reduction of these risk factors and monitoring the results of such interventions. STEPS includes the following sequential phases: collection of information on socio-demographic variables, and behavioural risk factors, *i.e.*, tobacco use, alcohol use, physical inactivity, diet and related factors using a questionnaire (STEP 1); obtaining clinical measurements such as weight, height, waist circumference, and blood pressure using standardized protocols and instruments (STEP 2); acquiring biochemical measurements such as serum total cholesterol, high density lipoprotein (HDL) cholesterol, blood glucose and triglycerides using fasting blood samples (STEP 3). All these three steps have core, expanded, and optional elements. Depending on the need of a specific country/province and the availability of resources, data collection may be limited only to the core items or extended to gather additional data from the list of expanded and optional items.

A few countries such as Indonesia[6] and Vietnam[7] have reported risk factors for NCDs using the WHO STEPS methodology. These studies did not include the STEP 3 component, which is expensive and logistically difficult to implement in low-resource settings. Moreover, most of the information on major risk factors can possibly be obtained using STEPs 1 and 2, and it was thought that a large proportion of the biochemical risk factors could be predicted. Therefore, the real need for STEP 3 data collection needs to be evaluated in community-based settings in developing countries.

The present study was undertaken to: (*i*) assess the burden of NCD risk factors (STEPS1-3) in a community-based setting in Kerala which is likely to provide a window into the prevalence of NCD risk factors in the future in other parts of India; (*ii*) estimate the relations of behavioural risk factors to socio-demographic correlates (both STEP1), the associations of anthropometric risk factors (STEP 2) with behavioural risk factors (STEP 1); (*iii*) evaluate if socio-demographic, behavioural (STEP1) and anthropometric risk factors (STEP 2) can predict biochemical (STEP 3) risk factors; and (*iv*) estimate awareness, treatment and adequacy of control of hypertension and diabetes.

Material & Methods

This study was part of a multi-site study in India co-ordinated by the Indian Council of Medical Research (ICMR) New Delhi, aimed as a feasibility exercise for setting up national level NCD risk factor surveillance mechanisms. In the process information on risk factors was also collected. Thiruvananthapuram district in Kerala State was selected for the present study keeping in mind the feasibility of continuous monitoring by the State Health Department and by the Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), the institution undertaking this research. This district had a human development index score of 0.773 (the same as average for the State in 2005), a life expectancy at birth of 75.2 yr (compared to the State average of 74.6 yr), and a literacy rate of 89.4 per cent (compared to the State average of 90.9%)[8]. These data demonstrate that Thiruvananthapuram district is quite representative of the State of Kerala, and a study of NCD risk factors in this district may mirror that for the entire State.

Sample size: The sample size calculated using the means of the risk factors aimed to include approximately 250 individuals in each age and sex group between ages 15 and 64 yr (stratified into 10 yr intervals). A total of 7449 individuals (51% women) stratified by age group, sex and place of residence (using three sampling frames representing the rural, urban and slum communities) were included. Kish method[9] was used to select one individual from each household.

Rural sample: One of the 19 community development blocks (CDB) of Thiruvananthapuram district with a total population of 1,84,560 in the latest census of 2001 was selected randomly[10]. The CDB was further divided into six village *Panchayats*, which are the local administrative units. One of these *Panchayats* was selected randomly of the six eligible. The selected *Panchayat* was again divided into 15 geographic areas known as 'wards'. Eight out of the 15 wards of the *Panchayat* were randomly selected in order to get a total sample size of 2510 individuals (52.7% women) in the age group of 15-64 yr.

Urban sample: An urban sample was selected from the capital city (Thiruvananthapuram city) within the district. There were 81 wards in the city. For the convenience of the district administration for continuous monitoring, one of the wards was selected randomly and two adjacent wards were added to complete the required sample size. The total population in the three selected wards was 26,047 according to the 2001 census[10]. From these three wards, 2475 individuals (50.3% women) were selected stratified by age and sex groups similar to the rural sample selection process.

Slum sample: For selecting the slum sample, all 37 slums in Trivandrum Corporation were enlisted based on data available in Urban slums in Kerala from the Town Planning Department[11]. The total slum population in Trivandrum City Corporation was 29, 681. The largest four slums were targeted according to population size, and 2464 individuals (50.2% women) stratified by age and sex groups were selected similar to the sampling scheme used for the rural and urban areas.

Sample for biochemical examination: Because biochemical analysis is expensive and logistically challenging in resource-poor settings, it was restricted to a subsample of 1500 individuals (500 each in rural, urban and slum areas stratified by age and sex groups) selected through systematic random sampling by the co-ordinating center (ICMR, New Delhi). Blood samples (5ml) were collected from 1462 eligible individuals (54% women).

Data collection (STEP 1): The protocol developed by the WHO STEPS program[5] was adopted. Information on socio-demographic variables and behavioural NCD risk factors (tobacco use, alcohol use, physical activity and diet) was collected using a pre-tested and structured interview schedule (STEP 1) in the local language (translated and back-translated).

Clinical measurements (STEP 2): Height, weight, waist circumference, and blood pressure were measured using standardized instruments and protocols (STEP 2). For blood pressure measurement, electronic equipment (OMRON -4, Omron Corporation, Kyoto, Japan) was used that has been recommended by the WHO for community-based studies[9]. Two blood pressure measurements were obtained initially in a seated position, and if there was a difference of more than 10 mm of Hg either in systolic or diastolic blood pressure between the initial readings, a third measurement was obtained and average of two or more readings was taken.

Biochemical measurements (STEP 3): Blood samples were drawn on individuals after 10-12 h fasting. Laboratory measurements of blood glucose and lipids were made using standard automated procedures (Cobas Mira Plus-Roche, USA) and commercially available kits (Randox Laboratories Ltd, UK). Plasma glucose was estimated using the GOD-PAP (Glucose oxidase/peroxidase- phenol-4-amenophenazone) method[12]. Serum total cholesterol was determined by an enzymatic endpoint method using the CHOD-PAP (Cholesterol oxidase/peroxidase- 4- phenol- aminoantipyrine) method[13]. Serum triglycerides were estimated by GPO-PAP (Glycerol-3-phosphate oxidase/peroxidase-4-chlorophenol and 4-aminophenazone) method[14]. For the determination of HDL cholesterol, low-density lipoproteins and the chylomicron fraction from the serum samples were first precipitated out. The clear supernatant was then analyzed for cholesterol using the method described above. External quality control of these biochemical investigations was performed by sending 10 per cent of the samples to a standardized core laboratory at the All India Institute of Medical Sciences (AIIMS), New Delhi. A comparison of results with the core laboratory for this subsample yielded an inter-laboratory coefficient of variation <5 per cent.

STEPs 1 and 2 of the study were completed in 2005 and STEP 3 in 2006. The study protocol was approved by the Ethical Review Board of Sree Chitra Tirunal Institute for Medial Science and Technology, Thiruvananthapuram. Informed written consent was obtained from all the participants.

Statistical methods: Considering the unequal distribution of age, sex and residence in the population, appropriate sampling weights were used for all data analyses. Data were analyzed using SPSS version 11.5. Mean values of continuous variables such as body mass index (BMI), waist circumference, blood pressure, and biochemical variables were determined.

Multivariable logistic regression models were constructed relating the clinical risk factors, *i.e.*, STEP 2 variables (dependent variables modeled individually; hypertension, overweight, and abdominal obesity) to the STEP 1 variables (independent variables modeled simultaneously; demographic variables and behavioural risk factors). Similar analyses were performed relating the biochemical risk factors, *i.e.*, STEP 3 variables (dependent variables modeled individually; diabetes, hypercholesterolaemia, low HDL and hypertriglyceridaemia) to the STEP 1 variables (independent variables modeled simultaneously). To gain additional insights into whether the clinical risk factors could predict presence of biochemical risk factors, we also evaluated regression models in which STEP 3 variables (dependent variables) were regressed on the STEP 2 variables (independent variables), forcing in place of residence in the models.

Definitions used: Any form of tobacco use or alcohol use was considered as an NCD risk factor. Individuals who consumed less than five servings of fruits and vegetables were considered as the 'at risk' group[15]. Overweight was defined as BMI of more than or equal to 25 kg /m^2 and obesity as ≥30 kg/m^2 [16]. Abdominal obesity was defined as a waist circumference of ≥90 cm in men and ≥85 cm in women[11]. Hypertension was defined as a systolic blood pressure of ≥140 mm of Hg, or a diastolic blood pressure of ≥90 mm of Hg or the use of blood pressure-lowering medications for hypertension[17]. Individuals with a fasting plasma glucose of ≥126 mg /dl or on medications for high blood sugar were considered to have diabetes mellitus[18]. A suboptimal serum cholesterol level was defined as total cholesterol ≥200 mg/dl, low HDL cholesterol was indicated by a value of < 40 mg/dl in men or <50 mg/dl in women, whereas hypertriglyceridaemia was defined as a serum triglyceride value ≥150 mg/dl[19]. Physical activity was classified into three groups: (1) inactive when the individual was inactive at work, transport and leisure time, (2) vigorous when the individual had vigorous activity at work, transport or leisure time, and (3) all other individuals were classified as having moderate activity.

Results

The study sample characteristics, data on socio-demographic variables and behavioural risk factors are presented in Tables I and II. The individuals living in the slums were characterized by a higher prevalence of tobacco use and alcohol intake and a lower dietary consumption of fruits and vegetables, but physical inactivity was less frequent. Urban residence was associated with higher education, and physical inactivity.

The prevalences of major NCD risk factors (according to sex and residence) are shown in Table III, whereas the mean values of BMI, waist circumference, blood pressure (systolic and diastolic), fasting biochemical values (total cholesterol, HDL cholesterol, triglycerides, and blood glucose) are presented in Table IV. In each of the three residential areas, tobacco use and alcohol intake were very infrequent in women. Women also had a higher prevalence of overweight, abdominal obesity and diabetes mellitus compared to men within each of the regions. Prevalences of hypertension, hypertriglyceridaemia and HDL levels were lower in women compared to men within each residential area. Comparing prevalences within each sex but across regions, the prevalence of diabetes was higher ($P<0.05$) but that of overweight and obesity

Table I. Study sample characteristics: Socio-demographic characteristics

Variables		Sample, N (%)			Total
		Urban	Rural	Slum	
Age (yr)	15-24	491 (19.8)	501 (20.0)	498 (20.2)	1490 (20.0)
	25-34	499 (20.2)	539 (21.5)	494 (20.0)	1532 (20.6)
	35-44	498 (20.1)	493 (19.6)	497 (20.2)	1488 (20.0)
	45-54	494 (20.0)	497 (19.8)	492 (20.0)	1483 (19.9)
	55-64	493 (19.9)	480 (19.1)	483 (19.6)	1456 (19.5)
Sex	Males	1229 (49.7)	1186 (47.3)	1227 (49.8)	3642 (48.9)
	Females	1246 (50.3)	1324 (52.7)	1237 (50.2)	3807 (51.1)
Education					
	<10 yr of schooling	698 (28.2)	1070 (42.6)	1420 (57.6)	3188 (42.8)
	≥10 yr of schooling	1777 (71.8)	1440 (57.4)	1044 (42.4)	4261 (57.2)
Occupation	Clerical	517 (20.9)	246 (9.8)	218 (8.8)	981 (13.2)
	Skilled/Unskilled	443 (17.9)	751 (29.9)	931 (37.8)	2125 (28.5)
	Housewives	879 (35.5)	1030 (41.1)	866 (35.1)	2775 (37.3)
	Unemployed	636 (25.7)	483 (19.2)	449 (18.2)	1568 (21.0)
Total		2475	2510	2464	7449

Table II. Study sample characteristics: Behavioural characteristics

Variables	Sample, N (%)			Total
	Urban	Rural	Slum	
Tobacco use				
Non users	1915 (77.4)	1901 (75.7)	1545 (62.7)	5361 (72.0)
Users	560 (22.6)	609 (24.3)	919 (37.3)	2088 (28.0)
Alcohol use				
Non Users	2148 (86.8)	2257 (89.9)	1894 (76.9)	6299 (84.6)
Users	327 (13.2)	253 (10.1)	570 (23.1)	1150 (15.4)
Diet habits				
<5 servings of fruits and vegetables	940 (38.0)	1012 (40.3)	1549 (62.9)	3501 (47.0)
≥5 servings of fruits and vegetables	1535 (62.0)	1498 (59.7)	915 (37.1)	3948 (53.0)
Physical activity				
Inactive	236 (9.5)	159 (6.3)	110 (4.5)	505 (6.8)
Moderate	1956 (79.0)	1782 (71.0)	1439 (58.4)	5177 (69.5)
Vigorous	283 (11.4)	569 (22.7)	915 (37.1)	1767 (23.7)
Total	2475	2510	2464	7449

lower ($P<0.05$) in the rural areas, compared to urban and slum areas. Dyslipidaemia was more frequent in urban areas.

Multivariable analyses evaluating inter-relations of STEP 1, 2 and 3 risk factors: Results of multiple logistic regression analyses are shown in Tables V-VII. The prevalence of behavioural and each of the biochemical risk factors increased with age, adjusting for other factors including sex and the place of residence (Tables V and VI). There were important sex-related differences in these adjusted analyses, paralleling some of the unadjusted observations. Women had higher odds of overweight, obesity and hypercholesterolaemia but lower odds of having hypertension, low HDL or hypertriglyceridaemia, adjusting for other socio-demographic characteristics. Sex was not associated with diabetes mellitus. Compared to urban residence, rural residence was associated with higher odds of diabetes, but lower odds of overweight, abdominal obesity, hypercholesterolaemia or having low HDL levels (Tables V and VI).

Tobacco use was associated with a lower prevalence of anthropometric risk factors and hypertension, but was not associated with biochemical risk factors. Alcohol intake was associated with higher odds of overweight, abdominal obesity, hypertension and hypertriglyceridaemia but was associated with lower odds of diabetes mellitus. Physical inactivity was associated with higher odds of overweight, abdominal obesity and hypertension, but was not associated with any of the biochemical risk factors.

In analyses relating biochemical risk factors to anthropometric ones (Table VII), overweight and abdominal obesity were associated with higher odds of hypertriglyceridaemia and low HDL. Presence of hypertension (a STEP 2 factor) was associated with higher odds of each of the biochemical risk factors (STEP 3 factors).

Awareness, treatment and control of NCD risk factors: Awareness, treatment and adequacy of control of hypertension and diabetes are shown in Table VIII. Overall, only a third of individuals with hypertension were aware of their condition, and only a quarter was treated. Only a third of the treated people with hypertension had their blood pressure adequately controlled, and a quarter of these individuals (24.4%) had severe hypertension (not included in Table VIII). Regardless of the place of residence, women with hypertension were more likely to be aware of the condition, more likely to be treated, and less likely to have a severe degree of hypertension compared to men with the condition. In contrast, over two-thirds of people with diabetes were aware of their condition and a similar proportion was treated with hypoglycaemic agents. Whereas a majority of individuals who were aware of their diabetes were treated, only a fifth was adequately controlled. Women were more likely to be aware of diabetes and more likely to be treated than men, although their control rates were much lower.

Discussion

There are not many comprehensive studies done in developing countries on NCD risk factors using WHO STEPS. The prevalence of smoking among men in the present study (42%) was comparable to that of a recent survey in the State (40%)[20] but was lower than that of Indonesia (54%)[6] and Vietnam (58%)[7]. The prevalence of overweight (men – 23.9%, women – 37.5%) in our

Table III. Prevalence of risk factors in urban, rural, slum and the total population by sex

	Urban			Rural			Slum			Total			Total#
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	
Behavioural risk factors													
Tobacco users, %	43.0	2.6	22.6*	45.2	5.5	24.3*	62.6	12.2	37.3*	50.3	6.7	28.0*	21.9
Alcohol users, %	26.5	0.1	13.2*	20.9	0.4	10.1*	45.4	1.0	23.1*	31.1	0.5	15.4*	11.1
Dietary habits, <5 servings of fruits and vegetables, %	36.5	39.4	38.0	35.1	45.0	40.3*	56.9	68.8	62.9*	42.9	50.9	47.0*	39.7
Physical inactivity, %	10.4	8.7	9.5*	4.7	7.8	6.3*	4.1	4.9	4.5*	6.4	7.1	6.8*	6.9
Anthropometric measurement risk categories													
Overweight, %	27.9	44.8	36.3*	13.7	27.4	20.9*	29.7	41.0	35.3*	23.9	37.5	30.8*	24.9
Abdominal obesity, %	30.0	53.7	41.9*	17.8	48.4	33.9*	29.7	54.9	42.4*	25.9	52.2	39.4*	33.9
Hypertension, %	36.2	33.6	34.9	34.4	30.8	32.5	31.0	30.3	30.6	33.9	31.6	32.7*	28.8
Biochemical risk categories													
Diabetic mellitus, %	12.3	17.1	14.8	19.0	22.0	20.6	11.4	14.5	13.1	14.3	17.8	16.2	14.8
Hypercholesterolaemia, %	59.1	62.9	61.0	45.9	64.8	56.0*	48.8	57.2	53.6	51.4	61.5	56.8*	54.1
Low HDL cholesterol, %	57.4	34.3	45.6*	42.9	22.3	31.9*	51.2	33.3	41.1*	50.5	29.9	39.5*	36.9
Hypertriglyceridaemia, %	30.2	13.9	21.9*	22.1	15.9	18.8	18.5	15.9	17.0	23.8	15.3	19.2*	19.0

**P*<0.05 (comparing men and women); Overweight: BMI ≥ 25 kg/m² & non pregnant; Abdominal obesity: ≥ 90 cm in men and ≥85 cm in women.
Hypertension: SBP ≥140 mm Hg or DBP ≥ 90 mm Hg or on medication for hypertension; Diabetes mellitus: Fasting blood glucose ≥126 mg/dl or on medication for diabetes; Hypercholesterolemia: Elevated cholesterol ≥200 mg/dl; Low HDL Cholesterol: <40 mg/dl for males and <50 mg/dl for females; Hypertriglyceridaemia: ≥150 mg/dl; #For weighted samples

Table IV. Mean values of NCD risk factors (continuous variables) by sex and place of residence

Variables	Urban			Rural			Slum			Total		
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Body mass index (kg/m²)	22.5±4.0	24.2±4.3	23.4±4.2*	20.9±3.5	22.3±4.2	21.7±3.9*	22.7±3.9	24.0±4.5	23.4±4.2*	21.5±3.7	23.0±4.3	22.2±4.1*
Waist circumference (cm)	83.7±11.5	85.8±11.1	84.8±11.4*	79.4±10.4	84.4±11.0	82.0±11.0*	83.0±11.4	86.3±12.4	84.7±11.8*	80.9±11.0	84.9±11.1	82.9±11.2*
Systolic BP (mm Hg)	130.2±17.1	126.4±19.0	128.2±18.2*	129.5±17.0	125.9±17.5	127.6±17.3*	128.7±18.3	123.4±19.0	125.9±18.5*	129.7±17.0	126.1±18.0	127.8±17.6*
Diastolic BP (mm Hg)	79.2±11.7	78.8±10.7	79.0±11.2	78.7±11.5	79.0±10.5	78.8±11.0	78.3±12.6	78.3±11.4	78.3±11.8	78.8±11.6	78.9±10.5	78.9±11.1
Blood glucose (mg/dl)	84.9±24.4	98.1±47.9	91.7±39.0*	98.5±39.3	111.4±48.2	105.3±44.6*	94.9±51.8	102.4±49.4	98.8±44.7	93.9±35.5	106.9±48.5	100.6±43.2*
Total cholesterol (mg/dl)	209.7±42.5	208.3±36.9	209.0±39.7	191.4±38.6	210.5±39.5	201.3±40.2*	196.6±52.1	202.2±52.5	199.5±46.2	197.6±40.9	209.7±38.6	203.9±40.2*
HDL cholesterol (mg/dl)	38.7±9.9	44.8±9.8	41.9±10.3*	41.1±8.0	48.4±11.1	44.9±10.4*	39.9±12.7	43.6±12.0	41.8±11.0*	40.3±8.8	47.1±10.8	43.9±10.5*
Triglycerides (mg/dl)	135.6±78.2	94.3±52.1	114.9±69.0*	112.6±67.3	101.1±55.4	106.6±61.6*	108.4±76.6	92.9±61.8	100.3±61.4*	120.4±71.9	98.8±54.4	109.2±64.3*

**P*<0.05 (comparing men and women)
Values are mean ± SD

Table V. Results of multiple logistic regression analysis relating STEP 2 variables with STEP 1 variables

STEP 1	Physical measurements (STEP 2)					
	Overweight		Abdominal obesity		Hypertension	
	Prevalence, %	OR (95% CI)	Prevalence %	OR (95% CI)	Prevalence, %	OR (95% CI)
Socio-demographic characteristics						
Age (yr)						
15-24	9.4	Referent	12.1	Referent	11.4	Referent
25-34	24.8	3.41 (2.81-4.14)*	33.0	3.95 (3.31-4.72)*	19.1	1.88 (1.57-2.26)*
35-44	34.2	5.62 (4.64-6.81)*	45.0	7.77 (6.49-9.30)*	33.1	4.02 (3.36-4.80)*
45-54	32.5	5.20 (4.25-6.37)*	47.0	8.85 (7.32-10.70)*	44.0	6.41 (5.34-7.71)*
55-64	30.3	4.45 (3.55-5.57)*	48.2	8.78 (7.12-10.84)*	60.7	12.51 (10.19-15.57)*
Sex						
Males	18.1	Referent	20.0	Referent	30.9	Referent
Females	31.3	1.71 (1.49-1.96)*	47.8	3.03 (2.66-3.46)*	26.8	0.67 (0.59-0.77)*
Area						
Urban	34.8	Referent	39.5	Referent	30.0	Referent
Rural	19.7	0.47 (0.41-0.52)*	31.0	0.71 (0.64-0.80)*	28.2	1.00 (0.89-1.12)
Slum	33.3	1.12 (0.48-2.64)	39.3	1.24 (0.52-2.95)	25.9	0.90 (0.36-2.26)
Behavioural risk factors						
Tobacco use						
Non users	26.9	Referent	38.5	Referent	27.7	Referent
Users	17.6	0.65 (0.54-0.78)*	19.6	0.50 (0.42-0.60)*	32.7	0.75 (0.64-0.88)*
Alcohol use						
Non users	25.4	Referent	35.7	Referent	28.2	Referent
Users	20.8	1.26 (1.01-1.56)*	23.6	1.49 (1.20-1.84)*	33.7	1.23 (1.01-1.48)*
Physical activity						
Inactive	33.8	2.51 (1.94-3.25)*	46.6	2.79 (2.18-3.57)*	34.0	1.64 (1.28-2.09)*
Moderate activity	27.5	1.80 (1.50-2.16)*	38.2	1.79 (1.51-2.13)*	29.8	1.47 (1.26-1.71)*
Vigorous activity	12.3	Referent	16.0	Referent	23.3	Referent

OR= odds ratio.
*$P<0.05$

study however, was much higher than urban Indonesia (men – 13.3%, women – 23.7%)[6] or Vietnam (men – 3%, women – 4%)[7].

Our results showed a high burden of NCD risk factors in Kerala. In terms of behavioural risk factors (STEP 1), a fifth of the sample used tobacco products, and a tenth consumed alcohol, and two-fifths consumed a diet low in fruit and vegetable content (relative to some dietary guidelines), but physical inactivity was uncommon. The prevalence of smoking in men (42%) was double that observed in the United States (21%)[21], whereas that in women was quite low, consistent with cultural differences. The prevalences of a diet low in fruits and vegetables (40%) and physical inactivity (7%) were considerably lower than in the United States where the prevalence of these behavioural habits are 60-70 per cent and 11-23 per cent, respectively (range of estimates for different ethnicities)[22].

In terms of anthropometric risk factors (STEP 2), the prevalence of overweight (25%) and abdominal obesity (34%) was high, using thresholds applied in developed countries that are very conservative for South-Asian populations who are likely to have lower cut-points for these conditions. Overall, the prevalence of excess adiposity was lower than in the United States, where over 60 per cent of adults were reported to be overweight and between 40 per cent (men) to 60 per cent (women) with abdominal obesity[23].

High blood pressure was observed in nearly 30 per cent of individuals evaluated, comparable to recent estimates in the United States[24]. The prevalence of diabetes mellitus was 50 per cent higher than estimates for the condition in the United States[25]. We observed a suboptimal cholesterol level in over half of the sample, and overall the mean serum cholesterol levels in our sample was comparable to that in the United States[26]. Mean levels of HDL cholesterol and triglycerides were lower than in the United States[26,27]. Consistent with the comparison of the mean levels, the prevalences of low HDL cholesterol was higher

Table VI. Results of multiple logistic regression analysis relating STEP 3 variables with STEP 1 variables

STEP 1 Variable	Bio-chemical results (STEP 3 Variables)							
	Diabetes mellitus		Hypercholesterolaemia		Low HDL cholesterol		Hypertriglyceridaemia	
	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)
Socio-demographic characteristics								
Age (yr)								
15-24	2.9	Referent	29.8	Referent	36.2	Referent	9.8	Referent
25-34	4.1	1.53 (0.69-3.40)	49.9	2.38 (1.75-3.23)*	35.3	1.01 (0.73-1.38)	18.3	2.06 (1.33-3.19)*
35-44	15.0	6.46 (3.27-12.75)*	64.4	4.39 (3.18-6.08)*	43.1	1.40 (1.02-1.93)*	25.9	3.21 (2.09-4.94)*
45-54	31.4	17.79 (9.13-34.66)*	73.1	6.78 (4.70-9.78)*	34.0	0.89 (0.63-1.28)	21.6	2.50 (1.57-3.98)*
55-64	42.3	30.23 (15.06-60.71)*	71.2	6.02 (3.95-9.20)*	34.0	0.93 (0.61-1.40)	24.4	2.94 (1.76-4.92)*
Sex								
Males	13.4	Referent	48.1	Referent	48.9	Referent	24.9	Referent
Females	16.0	0.87 (0.60-1.26)	59.6	1.64 (1.26-2.13)*	25.9	0.33 (0.25-0.42)*	13.5	0.49 (0.35-0.67)*
Area								
Urban	11.3	Referent	58.9	Referent	44.9	Referent	20.9	Referent
Rural	16.6	1.88 (1.31-2.70)*	51.7	0.74 (0.58-0.94)*	32.7	0.56 (0.44-0.71)*	18.0	0.84 (0.63-1.11)
Slum	16.7	1.08 (0.54-21.77)	50.0	0.63 (0.10-3.87)	40.0	0.92 (0.15-5.45)	16.7	0.63 (0.05-7.12)
Behavioural risk factors								
Tobacco use								
Non users	15.1	Referent	54.5	Referent	34.9	Referent	17.3	Referent
Users	13.5	0.71 (0.45-1.14)	52.3	0.90 (0.64-1.25)	44.7	0.90 (0.65-1.24)	25.4	0.85 (0.58-1.23)
Alcohol use								
Non users	15.5	Referent	54.0	Referent	36.1	Referent	17.5	Referent
Users	7.8	0.37 (0.17-0.77)*	53.9	1.11 (0.73-1.68)	44.0	0.79 (0.53-1.19)	33.3	1.57 (1.01-2.44)*
Physical activity								
Inactive	16.9	1.34 (0.63-2.86)	57.3	1.24 (0.73-2.11)	38.2	1.15 (0.68-1.94)	21.1	1.19 (0.64-2.21)
Moderate activity	15.6	1.54 (0.97-2.42)	55.4	1.04 (0.77-1.39)	35.0	0.96 (0.72-1.28)	17.6	0.93 (0.66-1.30)
Vigorous activity	11.4	Referent	48.5	Referent	43.1	Referent	23.1	Referent

OR= odds ratio.
*$P<0.05$

Table VII. Results of multiple logistic regression analysis relating STEP 3 variables with STEP 2 variables

STEP 2 Variables	STEP 3 Variables							
	Diabetes mellitus		Hypercholesterolaemia		Low HDL Cholesterol		Hypertriglyceridaemia	
	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)	Prevalence, %	OR (95% CI)
Overweight								
No	11.9	Referent	49.5	Referent	34.4	Referent	14.2	Referent
Yes	24.2	1.16 (0.79-1.70)	68.9	1.22 (0.89-1.68)	44.9	1.47 (1.08-2.01)*	34.3	2.45 (1.72-3.50)*
Abdominal obesity								
No	9.0	Referent	46.0	Referent	35.6	Referent	14.4	Referent
Yes	26.2	2.82 (1.95-4.06)*	70.0	2.29 (1.72-3.03)*	39.5	0.88 (0.66-1.17)	28.2	1.25 (0.89-1.77)
Hypertension								
No	9.6	Referent	50.2	Referent	34.2	Referent	15.3	Referent
Yes	26.8	2.79 (2.05-3.80)*	63.0	1.39 (1.09-1.76)*	43.2	1.41 (1.11-1.79)*	27.5	1.72 (1.29-2.20)*
Area of residence								
Urban	11.3	Referent	58.9	Referent	44.9	Referent	20.9	Referent
Rural	16.6	1.74 (1.23-2.46)*	51.7	0.77 (0.61-0.97)*	32.7	0.60 (0.48-0.76)*	18.0	0.94 (0.70-1.25)
Slum	16.7	0.83 (0.04-15.09)	50.0	0.62 (0.10-3.65)	40.0	0.92 (0.16-5.28)	16.7	0.63 (0.05-7.25)

OR= odds ratio.
*$P<0.05$

but the prevalence of high triglyceride levels lower than in the United States[26,27].

The prevalence of all NCD risk factors increased with age. Interesting sex-related differences emerged in adjusted analyses. As noted above, women had a very low prevalence of alcohol intake or tobacco use, suggesting potentially beneficial influences of social mores. Although women had a higher prevalence of overweight and abdominal obesity, they had a lower prevalence of hypertension and dyslipidaemia and a similar prevalence of diabetes (compared to men). One potential explanation for this observation may be that women may be relatively more protected against the effects of excess adiposity. An alternative explanation may lie in the use of a lower threshold for abdominal obesity in women (which may increase prevalence of the condition). The place of residence influenced the prevalence of NCD risk factors. Rural residence was associated with 30-50 per cent lower odds of being overweight or having abdominal obesity, which translated into lower odds of dyslipidaemia in these areas. Yet, odds of having diabetes was 88 per cent higher compared to urban residence.

Physical inactivity was associated with greater prevalence of overweight, abdominal obesity and hypertension, but was not related to prevalence of diabetes and dyslipidaemia. Smoking was associated with a lower prevalence of overweight, abdominal obesity and hypertension, but was unrelated to prevalence of diabetes and dyslipidaemia. Alcohol intake was associated with greater odds of overweight, abdominal obesity, and hypertriglyceridaemia. It was associated with a greater odds of high blood pressure, consistent with epidemiological evidence for a blood pressure raising effect of alcohol[28]. It was also associated with a lower prevalence of diabetes mellitus, again consistent with the results of a meta-analysis[29].

In analyses relating STEP 3 variables to STEP 2 variables in an attempt to understand causal pathways, indices of excess adiposity were associated with diabetes mellitus and dyslipidaemia. Presence of high blood pressure was associated with greater odds of having dyslipidaemia and diabetes, confirming the well established clustering of NCD risk factors.

Overall, these observations suggest that though presence of overweight or obesity is a marker of greater metabolic and NCD risk factor burden, the relations among behavioural, anthropometric and biochemical

Table VIII. Awareness, treatment, and adequacy of control of hypertension and diabetes (%)

Area	Hypertension				Diabetes			
	All hypertensive			Treated hypertensive	All diabetes			Treated diabetes
	Aware[a]	Treated[b]	Controlled[c]	Controlled[d]	Aware[e]	Treated[f]	Controlled[g]	Controlled[h]
Urban								
Males	36.2	26.5	6.7	25.4	89.7	86.2	58.6	68.0
Females	41.3	34.6	11.7	33.8	88.1	85.7	28.6	33.3
Total	38.7	30.4	9.1	30.0	88.7	85.9	40.8	47.5
Rural								
Males	27.9	20.3	6.9	33.7	59.1	56.8	25.0	44.0
Females	43.4	29.7	8.8	29.8	67.2	65.5	8.6	13.1
Total	35.7	25.0	7.8	31.4	63.7	61.8	15.7	25.3
Slum								
Males	24.2	15.3	4.7	31.0	70.8	54.2	8.3	15.3
Females	48.3	34.7	13.1	37.7	65.0	60.0	10.0	16.6
Total	36.2	24.9	8.9	35.6	67.2	57.8	9.4	16.2
Total								
Males	29.8	21.0	6.2	29.3	71.1	64.9	30.9	47.6
Females	44.2	32.9	11.1	33.8	72.9	70.0	15.0	21.4
Total	36.9	26.9	8.6	32.1	72.2	67.9	21.5	31.6

[a], Who have reported the history of hypertension; [b], Who are under treatment for hypertension; [c, d], Who have SBP<140 and DBP<90; [e], Who have reported history of diabetes; [f], Who are under treatment for diabetes; [g, h], Who have blood glucose level <126 mg/dl

risk factors is complex. While excess adiposity is associated with greater biochemical risk, some factors associated with overweight or abdominal obesity (female sex, or urban residence, for example) do not always translate into a greater burden of dyslipidaemia, hypertension or diabetes mellitus. The odds ratio noted for relating STEP 2 variables to STEP 3 variables were modest, suggesting that STEP 2 factors may not be useful surrogates for biochemical risk factors for population screening purposes[30].

Low levels of awareness of high blood pressure, paralleled by low rates of treatment and control was observed. In comparison, awareness of diabetes was high, being comparable to that in the United States[25], but control rates were uniformly low. These observations emphasize the importance of public health education and physician education as complementary strategies to combat the increasing burden of NCD risk factors.

In conclusion, in this community-based study in Kerala, a high burden of NCD risk factors was observed being comparable to that in the United States in some instances. Some interesting patterns of association of socio-demographic and behavioural risk factors with biochemical risk factors were seen, overall characterized by a concordance in the prevalence of overweight or abdominal obesity and biochemical risk factors. These data may serve to propel multisectoral efforts to lower the community burden of NCD risk factors in India in general, and in Kerala, in particular.

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