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Complete List of Authors:	Sarma, P; Sree Chitra Tirunal Institute for Medical Science and Technology, Achuth Menon Centre for Health Science Studies Sadanandan, Rajeev; Government of Kerala, Department of Health & Family Welfare Thulaseedharan, Jissa Vinoda; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Soman, Biju; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Sciences Studies Srinivasan, Kannan; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Varma, R; Sree Chitra Tirunal Institute for Medical Science and Technology, Achutha Menon Centre for Health Science Studies Nair, Manju; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Pradeepkumar, AS; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Jeemon, Panniyammakal; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Thankappan, KR; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Kutty, Raman; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies
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Prevalence of risk factors of non-communicable diseases in Kerala, India.

Authors: P Sankara Sarma[1], Rajeev Sadanandan[2], Jissa Vinoda Thulaseedharan[1], Biju Soman[1]*, Kannan Srinivasan[1], Ravi Prasad Varma[1], Manju R Nair[1], AS Pradeepkumar[1], Panniyammakal Jeemon[1], Kavumpurathu Raman Thankappan[1], V Raman Kutty[1]

*Corresponding author: Biju Soman, Professor, Achutha Menon Centre for Health Science Studies (AMCHSS), Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Thiruvananthapuram, Kerala, India, PIN695011; bijusoman@sctimst.ac.in, +91 944 786 2736

Affiliations:

1. Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum
2. Department of Health and Family Welfare, Government of Kerala.

P Sankara Sarma, AMCHSS, SCTIMST, Thiruvananthapuram, India
Rajeev Sadanandan, Dept. of Health & Family Welfare, Govt. of Keala, Thiruvananthapuram, India
Jissa Vinoda Thulaseedharan, AMCHSS, SCTIMST, Thiruvananthapuram, India
K Srinivasan, AMCHSS, SCTIMST, Thiruvananthapuram, India
Ravi Prasad Varma, AMCHSS, SCTIMST, Thiruvananthapuram, India
Manju R Nair, AMCHSS, SCTIMST, Thiruvananthapuram, India
AS Pradeep Kumar, AMCHSS, SCTIMST, Thiruvananthapuram, India
Panniyammakal Jeemon, AMCHSS, SCTIMST, Thiruvananthapuram, India
Kavumpurathu Raman Thankappan, AMCHSS, SCTIMST, Thiruvananthapuram, India
V Raman Kutty, AMCHSS, SCTIMST, Thiruvananthapuram, India

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Abstract

Objectives: To estimate the prevalence of non-communicable disease (NCD) risk factors in Kerala using the state representative data.

Design: Community based cross-sectional survey.

Participants: In 2016-17 a representative sample of 12,012 adults of 18-69 years age group were studied.

Main outcome measures: NCD risk factors as stipulated by the World Health Organization's approach to NCD risk factors Surveillance. Parameters studied include physical activity score, anthropometry, blood pressure and fasting blood sugar and spot urine sample to estimate dietary intake of salt.

Results: Mean age was 42.5 years (SD=14.8). Abdominal obesity was prevalent in 72.6% (95% CI 70.7 to 74.5) females and 39.1% (95% CI 36.6 to 41.7) males. Current use of tobacco and alcohol in males were 20.3% (95% CI 18.6 to 22.1) and 28.9% (95% CI 26.5 to 31.4) respectively. The overall prevalence of hypertension and diabetes were 30.4% (95% CI 29.1 to 31.7) and 19.2% (95% CI 18.1 to 20.3) respectively. Hypertension was prevalent in 34.6% (95% CI 32.6 to 36.7) males and 28% (95% CI 26.4 to 29.4) females. Only 12.9% (95% CI 11.3 to 14.7) of persons with hypertension and 15.5% (95% CI 13.5 to 19.8) of the persons with diabetes had their diseases under control. Only 9.7% (95% CI 8.5 to 11.0) males and 5.7% (95% CI 5.0 to 6.6) females were free from any of the NCD risk factors studied.

Conclusion: Only 7.2% of adults in Kerala had none of the NCD risk factors that were studied. The prevalence of hypertension and diabetes in Kerala were found to be higher than the estimates from national surveys like NFHS4, but less than estimates from localised surveys. The higher rates of NCD risk factors and lower rates of disease control calls for concerted primary and secondary prevention strategies to address the future burden of NCDs.

Keywords: Prevalence, NCD risk factors, Kerala, diabetes, hypertension

Strengths and limitations

- The study gives robust rates of NCD risk factors in Kerala that can be compared other studies in India and abroad, as we had used the widely validated WHO STEPS questionnaire and standard pieces of equipment to study a representative sample of adults.
- We took the third reading for blood pressure (BP) only when the difference in systolic BP of the previous two readings was >10 mmHg and that of diastolic BP >6 mmHg which is in deviation to the WHO STEPS guidelines that insist on taking three readings for everyone.
- The biochemical measurements for serum cholesterol and measurements of hip circumference were not done this study due to logistic limitations, but they were not the core features of step 1 and step 2.
- To our knowledge, no other study on NCD risk factors in Kerala in the recent past, including those by the same group of researchers, were done on a statewide representative sample of this scale.

INTRODUCTION

Over two third (67%) of disease burden in India measured by disability-adjusted life years (DALYs) is attributable to Non-communicable diseases (NCDs) and injuries[1]. The India state-level disease burden estimates suggest significant differences between states in the composition of disease burden[1]. Compared to other states in India, the state of Kerala is relatively in an advanced stage of epidemiological transition[2]. Over 90% of premature mortality in Kerala (mortality in the age group of 15-69 years) is attributable to NCDs[2]. Furthermore, nearly a quarter of the total disease burden in DALYs is due to four major NCDs (ischemic heart disease, stroke, chronic obstructive pulmonary diseases and diabetes)[1].

While the disease burden estimates based on modelling of available data are useful in planning resource allocation, strategic investments in prevention and management of NCDs require accurate appraisals of their prevalence and risk factors. Hence we conducted a statewide cross-sectional survey in a representative sample of both urban and rural Kerala. The objective of this paper is to describe the current prevalence of NCD risk factors in Kerala.

METHODS

Study settings

The state of Kerala, in South India, has a population of 33.4 million[3] and an area of 38,863 square kilometres. Nearly half the population is urban. A cross-sectional survey was conducted in all the 14 districts of Kerala, in both rural and urban areas from October 2016 to March 2017.

Sampling

A minimum sample size of 12000 adults was considered to provide separate prevalence estimates in different strata (for example; among male/female and urban/rural residents), of various NCD risk factors with an expected prevalence of 5%, and relative precision of 20%. We also considered a design effect of 1.5 and a response rate of 90% in the sample size estimation.

A multi-stage cluster sampling strategy was adopted to identify a representative sample of eligible participants for the cross-sectional survey (Fig 1). The primary sampling units were a well-defined geographical area administered by the local government institution, i.e. municipal corporations and municipalities in urban areas and Grama Panchayats (GPs) - Grass-root level elected governments in the rural areas. The population of GPs in Kerala are around 20000-40000 whereas those in other states are around 1000-4000. In most districts, data were collected from two urban and three rural sites except in two districts, which had only one urban site each. The survey was conducted in all the municipal corporations (n=6) and randomly selected 20 of 87 municipalities in the urban region. Similarly, three GPs were randomly selected from each district (42 GPs from 14 districts).

Each of the primary sampling units is further divided into wards. In the next stage of sampling, a total 200 of the 390 wards of the municipal corporations and 499 of the 697 wards of the selected municipalities were randomly selected for the survey. All the 724 wards of selected GPs were also selected. In the final stage of sampling, one cluster of nine households was identified from each ward. For the selection of a cluster of households, one household was identified randomly from the available list of all the households in the selected ward and followed by the selection of eight more households with consecutive house numbers.

Study participants

All the individuals between the age group of 18-69 years were eligible to be part of the survey. If there were more than one adult in this age group, KISH method[4] was used to identify one of them from the household. Pregnant women were excluded from physical and biochemical measurements.

Ethical considerations

All participants of the study have given written informed consent. The Institutional Ethics Committee of SCTIMST, Trivandrum formally approved the conduct of the study (SCT/IEC/902/MAY-2016 dated 11/05/2016).

Study measurements

Interview Schedule

A structured interview schedule based on the WHO STEPwise approach to NCD risk factors Surveillance (STEPS) 5, which was validated in Malayalam[6] was used for this survey. Awareness of diabetes and hypertension status was assessed by asking questions about past diagnosis and history of both conditions. Global physical activity questionnaire (GPAQ) was used to assess physical activity levels[7].

Anthropometric measurements

Physical and clinical measurements included height, weight, waist circumference, blood pressure and heart rate. All the measurements were taken in the participant's household, by trained nurses. Height was measured using a SECA 213 stand-alone stadiometer in centimetres. Weight was measured using a portable SECA 803 battery operated electronic

weighing scale in kilograms. Both measurements were taken with the participants wearing no footwear and any heavy objects in their body such as mobile phones, wallets and heavy belts. Additionally, SECA 201 ergonomic retractable tape was used to measure waist circumference. In order to measure waist circumference, the lower palpable margin of the ribs and the upper margin of the iliac crest were identified initially and then marked the midpoints between these margins along the mid-axillary line on both sides were marked. The measurement tape was then wrapped horizontally all around by connecting the marked points on both sides of the participant's body. Height was noted to the nearest 0.5 cm, weight to the nearest 10 gm and waist circumference to the nearest 0.1 cm at the end of the normal expiration.

Measurement of blood pressure and pulse rate

The blood pressure(BP) and pulse rate were measured using standard battery operated automatic BP monitors (OMRON HEM-7120). Before measurement, the participants were seated comfortably in a relaxed upright position for at least five minutes. Appropriate size cuff was used to take two readings of blood pressure and pulse rate three minutes apart.[8] The machine was switched off between the readings, after recording the systolic BP and diastolic BP in mm Hg and the heart rate in beats/minute. If systolic BP readings varied more than 10 mmHg or diastolic BP readings more than six mmHg, between the two initial measurements, then a third reading was taken. The mean of the last two readings of blood pressure was considered as the final BP.

Biochemical measurements

A spot urine sample (20 ml) was collected from each participant for urinary sodium and creatinine estimation. Urinary sodium was assessed using indirect ion-selective electrode

method, and urinary creatinine was measured using the alkaline picrate method in an accredited central laboratory. Modified Kawasaki formulae were used to estimate the 24-hour urinary excretion of sodium chloride.[9] Point of care glucometers (One touch ultra-easy, Johnson & Johnson) were used for capillary blood glucose estimation in the fasting stage. A minimum of eight hours fasting was ensured in all study participants. The blood glucose measurement in mg/dl was noted and recorded.

Administration of questionnaire and recording of study measurements

Computer tablets with custom-made data entry forms, with display both in English and Malayalam (local language), were prepared in Open Data Kit (ODK) software were used for data collection. ODK is a freely available Open Source Software, and we have integrated a utility to run KISH method[4] for selection of participants in the data entry form for the STEPS survey in it. Thirty-four pairs of trained nurses did the field level data collection. They carried the computer tablets, glucometer, weighing machine, stadiometer, measuring tape and the blood pressure monitors into the household. After obtaining signed informed consent from the participants on printed forms, computer tablets with internet facility was used to gather information on questionnaire and measurements, directly on to the computer tablets by the nurses. They also did random blood glucose estimation of the study participants and gave sample bottles for urine collection with instruction on how to collect the early morning samples, which were collected back in the next morning. The data gets automatically sent to the institute server (all tablets had mobile INTERNET facility) that was monitored by the district managers on a daily basis and subsequently by the state project management unit, once a week. The aggregated data was downloaded for analysis using the ODK Briefcase utility.

Quality control

Two senior public health professionals, who were working as Additional Directors of in the state health services, entrusted with the overall supervision and conduct of the survey and related activities. They were helped by 28 (two per district) middle-level district program managers. Residential training sessions with hands-on training on data collection (using computer tablets) and standard procedures for the physical and biochemical measurements were conducted for the 34 pairs of nurses at four places (Thiruvananthapuram, Ernakulam, Thrissur and Kannur) by the same team of investigators to ensure quality and uniform standards. Data collected was checked by the district programme managers for completeness, consistency, and feedback given to data collectors. The district program managers made regular concurrent and consecutive visits to the selected households to ensure quality. The time and location of the survey could be ascertained for the quality check as the geo-location were also captured. Data cleaning was also done centrally, and monthly updates were sent to the field staff to improve the quality of data collection.

Definitions

Hypertension, diabetes and high salt intake

Hypertension was defined systolic BP≥140 mmHg or diastolic BP of ≥90 mmHg or the person currently using antihypertensive medications(self-reported treatment).[10] Diabetes was defined as fasting plasma glucose of ≥126 mg/dl or self-reported treatment for diabetes. Fasting plasma glucose in the range of 100-125 mg/dl was defined as pre-diabetes. Dysglycemia was defined as either diabetes or pre-diabetes. High salt intake was defined as >5 gm excretion of sodium chloride in 24 hours.

Obesity and overweight

Obesity was defined as a body mass index of ≥30 kg/m^2, while overweight was defined as body mass index in the range of 25-29.99 kg/m^2.[11] Waist circumference level of >=90 cm and >=80 cm were used to define abdominal obesity in men and women respectively.[12]

Current smoking and alcohol use

Current Tobacco use was defined as the use of any form of tobacco within the past 30 days[5], and current alcohol use was defined intake of at least one standard drink of alcohol in the past 30 days.[5]

Poor diet

A composite diet score was developed based on weekly per person consumption of fruits and vegetables, and 24-hour dietary salt intake. To calculate the score both fruits and vegetable intake per week were divided into tertiles and then assigned a score of 1, 2 and 3 for tertile 1 to 3.

Similarly, the 24-hour sodium chloride intake was divided into tertiles and then assigned a score of 3, 2 and 1 for tertiles 1-3. All the scores were added together and then generated the total diet score (ranged from 3-9). Poor diet was defined as a dietary score in the first tertile (i.e., high salt intake and low fruits and vegetable intake).

Physical inactivity

For the calculation of physical inactivity, the total time spent in physical activity during a typical week and the intensity of the physical activity assessed using the Global Physical Activity Questionnaire (GPAQ) were taken into account. Physical inactivity was defined as <600

metabolic equivalents (MET) minutes of a combination of moderate and vigorous-intensity physical activity.[7]

Number of NCD risk factors

Tobacco use, alcohol use, obesity, abdominal obesity, hypertension, dysglycemia, poor diet, and physical inactivity were counted in the calculation of the number of risk factors. The proportion of individuals with zero, any one, two, and three or more risk factors were estimated.

Statistical analyses

Sampling weights were derived based on the probabilities of selection at various stages of sample selection. The inverse of the product of probabilities of sample selection at different stages was used in sample weighting. Sampling weights were then normalised to the total sample size.

Means and standard errors for quantitative variables and percentages for categorical variables were used to summarise data. Cluster correction was applied as variance inflation while estimating standard errors and 95% confidence intervals. Statistical analyses were done using the software IBM SPSS Statistics for Window version 21 (Armonk, NY, USA: IBM Corp.) and STATA Statistical Software: Release 14. (College Station, TX: Stata Corp LP.)

RESULTS

Socio-demographic characteristics

In total 12,012 adults in the age group of 18-69 years participated in the survey with a response rate of 93.8%. Nearly half (49.3%) of the participants were urban residents with more females(63%) than males (Table 1). Mean age was 42.5 years (SD=14.8). Less than a quarter

(24.3%) had education below primary school level. Only about a third (36.5%) was in the income group of below poverty line. Nearly three fourth (73.5%) were married. One of 20 participants (4.7%) was unemployed.

Body mass index, waist circumference and obesity

The mean BMI was 23.6 kg/m^2 (SE=0.09) and 24.5 kg/m^2 (SE=0.08) in males and females, respectively (Table 2). Similarly, the averages of waist circumference were 86.4 cm and 86.1 cm in males and females, respectively. More females (31.7%) were overweight compared to males (28.4%)(Table 3). Obesity was twice as high in females (10.8%) compared to males (5.2%). Abdominal obesity was 72.6% among females and 39.1% among males.

Behavioural risk factors

Both tobacco and alcohol use was negligible among women. However, the current use of tobacco and alcohol among males were 20.3% (95% CI 8.6 to 22.1) and 28.9% (95% CI 26.5 to 31.4) respectively (Table 3). Physical inactivity was prevalent in 23.7% (95% CI 21.8 to 25.7) and 20.8% (95% CI 19 to 22.7) of males and females, respectively. More than three fourth of the study population (78.3%; 95% CI 76.2 to 80.1) reported consumption of <3 servings of vegetables per day. Similarly, 84.8% (95% CI 82.7 to 86.7) males and 86.5% (95% CI 84.7 to 88.1) females reported consumption of <2 servings of fruits per day. Salt consumption >5gm per day was reported by 82% (95% CI 80.5 to 83.3) females and 51.3% (95% CI 49 to 53.5) males.

Prevalence of hypertension and diabetes

The average systolic BP of males was 129.4 (SE=0.4) and females 125.0 mmHg (SE=0.3) (Table 2). Similarly, the average diastolic BP was 82.5 (SE=0.3) in males and 79.7 mmHg

(SE=0.2) in females. Prevalence of hypertension in males was 34.6% (95% CI 32.6. to 36.7) and 28% (95% CI 26.4 to 29.4) in females (Table 3). Average fasting plasma glucose was 108.9 (SE=0.8) in males and 108.4 (SE=0.7) in females (Table 2). One out of five adults had Type 2 Diabetes Mellitus: 19.8% (95% CI 18.2 to 21.6) in males and 18.8% (95% CI 17.5 to 20.2) in females. Additionally, 36% (95% CI 33.7 to 38.4) of males and 35% (95% CI 32.8 to 37.0) of females were in the pre-diabetes stage. Two of five adults (40%; 95% CI 38.6 to 41.3%) had either diabetes or hypertension. Only 12.9% (95% CI 11.3 to 14.7) of persons with hypertension and 15.5% (95% CI 13.5 to 19.8) of the persons with diabetes had their diseases under control.

Poor diet

On average 40.8% of participants had poor diet score (Table 3), which was higher for women(47.6%) compared to men(29.4%).

Clustering of NCD risk factors

Only 9.7% (95% CI 8.5 to 11.0) of males and 5.7% (95% CI 5.0 to 6.6) of the females population were free of any of the eight NCD risk factors studied (Figure 2). Risk factors in isolation were less frequent (22.7% in males and 21.7%) as compared to co-existence with other risk factors (67.3% in males and 72.3% in females). Three or more risk factors were present in 39.8% of males and 42.5% of females. Further, four or more NCD risk factors were present in 19% of males and 17.3% of the females.

DISCUSSION

This study found that almost all adults (92.8%) of 18-64 year age group in Kerala have at least one NCD risk factors and multiple risk factors were present in the majority.

Hypertension and diabetes are present in 30.4% and 19.2% of adults in Kerala. Overweight prevalence was as high as 30.4%, and twice that much (60.2%) had abdominal obesity, which was more significant (72.6%) among woman. Moreover, dysglycemia (diabetes and pre-diabetes together) was found to be present among 54.5% of adult population.

The prevalence of hypertension found in the study for Kerala is higher than the other NHFS-4(2015-16) figures(16.3%) for Kerala and other states. However, the prevalence of hypertension and diabetes are found to be comparable with the rates for Thiruvananthapuram in 2010 by Thankappan *et al.* (28.8%)[5] but less than the rate by Sathish *et al.* (43.2%).[13] The hypertension prevalence of adults in Kerala of 18-64 years is similar to the rates of urbanites of higher age group (30-64 years) in Tamil Nadu (28.5%).[14] Hypertension rate in Kerala is similar to the estimates of the meta-analysis by Anchala *et al.* for the urban south India (31.8%).[15]

Prevalence of diabetes in Kerala is higher than the diabetic rate of urbanites in Delhi (18.1%).[16] Prevalence of dysglycemia(diabetes and pre-diabetes together), in more than half (54.5%) of the adult population poses a challenge to the existing health care system, to maintain the diseases at the current level and to manage their complications. The increasing behavioural risk factors[13] even among the tribal communities,[17] and higher conversion rate of pre-diabetes to diabetes Indians[18] could be the reason for this much increase in diabetes.

Hypertension or diabetes, present in over 40% of the adult population are significant contributors to cardiovascular disease mortality. Clustering of multiple risk factors, a finding reported by other studies from India[19] increases the risk of developing a major NCD condition or event in the near future. NCD risk factors are identified to be associated with the social

disparity in India[20] and other Asian countries[21] as in the western populations.[22,23] The control rate for hypertension found in this study (12.8%) is low compared to the rates from Iran (49.1%),[24] the United States of America (48%)[25] and even from China (18%).[26] The control rate for diabetes is also low in this study (15.5%) compared to the improving rates of control found in the western countries; they could achieve 20% control even among people with hypertension and diabetes.[27]

Mounting evidence on the reduction in NCD risk factors with concerted public health action in other countries[28,29] gives a positive impetus to the current strategy for NCD risk reduction efforts in Kerala. Hence, the policy action to address the future NCD burden should focus not only on single risk factors but also on several of them simultaneously at the population level. The cumulative effect of acting on multiple risk factors may reduce the total risk substantially and thus avert several future NCD events.

Providing drug therapy and counselling to individuals who are at high risk of a cardiovascular event in the next ten years has been considered as a WHO 'best buy' policy option.[30] However, minimal implementation evidence is available from low and middle-income countries on the usefulness of such strategies in reducing the burden of NCDs.[31] Given the double burden of higher prevalence and poor rates of control of hypertension and diabetes in Kerala, which contradicts the success stories of implementation research in cardiovascular risk factors in Kerala,[32-34] the evaluation of 'best buy' interventions for cardiovascular risk reduction at the population level should be a priority for the state. Researchers should set up longitudinal or cohort studies for surveillance of NCD risk factors in Kerala so that positive strategies that

are scalable to the national level with minimum additional resources could be developed and tested in Kerala.

Strengthening the primary care in Kerala and providing universal access to anti-hypertensive and anti-diabetic medicines to all eligible patients should be a high priority for the Government of Kerala to limit the future burden of NCDs.

The high prevalence of NCD risk factors in Kerala calls for urgent policy action for primary and secondary prevention. It is high time to initiate building up of longitudinal or cohort studies to capture the rate of change of NCD risk factors in the state.

Strengths and limitations of the study

This is a large statewide study on NCD risk factors in Kerala, done by trained nurses using standard equipment, validated research tools and modern utilities like computer tablets. The use of the WHO STEPS framework for the questionnaire enables comparison of studies done within India and abroad.[5] Use of mobile data entry platforms, as we did in this study, are proven to improve the quality and timeliness of STEPS surveys.[5,35] We had taken the third reading of BP only when the difference in systolic BP of the earlier two readings[8] was >10 mmHg and that of diastolic BP >6 mmHg (third reading was taken in 18.2% of subjects), which is in deviation to the WHO STEPS guidelines[5] that insists on taking three readings for everyone. This is a limitation of this study. The biochemical measurements for serum cholesterol and measurements of hip circumference could not be done in this study due to logistic limitations, but they were not the core features of step 1 and step 2.[36] To our knowledge, no other published study on NCD risk factors in Kerala in the recent past,

including those by the same group of researchers, were done on a statewide representative sample. The study is timely as the results could be used for Universal Health Coverage initiative in Kerala, wherein all the peripheral hospitals are being converted to Family Health Centres.

CONCLUSION

About 40% of adult population in Kerala have either hypertension or diabetes, and the disease control rates were meagre (12.9% and 15.5% respectively). The presence of an NCD risk factor in the adult population is near universal and clustering of risk factors is very common. The high prevalence of NCDs and their risk factors in Kerala calls for urgent policy action for secondary prevention and primary prevention.

Table 1. General characteristics of the study population

Variables	Male (N=4472)	Female (N=7537)	Total (N=12,012)*
Age in years, mean (SD)	42.42(15.38)	42.58(14.45)	42.52 (14.8)
Age groups, n (%)			
18-44	2263(50.60)	4114(54.58)	6380(53.11)
45-69	2209(49.40)	3423(45.42)	5632(46.89)
Residence			
Rural	2305(51.54)	3782(50.18)	6087(50.67)
Urban	2167(48.46)	3755(49.82)	5925(49.33)
Education			
Up to primary school	1002(22.41)	1914(25.39)	2916(24.28)
Secondary to High school	2281(51.01)	3645(48.36)	5928(49.35)
>high school	1189(26.59)	1978(26.24)	3168(26.37)
Social groups			
Below poverty line	1633(36.52)	2796(37.10)	4431(36.89)
Above poverty line	2730(61.05)	4555(60.44)	7286(60.66)
Others	109(2.44)	186(2.47)	295(2.46)
Marital status			
Never married	1140(25.49)	954(12.66)	2095(17.44)
Married	3242(72.50)	5579(74.02)	8823(73.45)
Others	90(2.01)	1004(13.32)	1094(9.11)
Occupation			
Officers and professionals	688(15.38)	536(7.11)	1224(10.19)
Self-employed	1286(28.76)	262(3.48)	1549(12.90)
Skilled labourer	703(15.72)	86(1.14)	789(6.57)
Unskilled labourer	490(10.96)	232(3.08)	723(6.02)
Unemployed	413(9.24)	161(2.14)	574(4.78)
Students	617(13.80)	773(10.26)	1390(11.57)
Others	275(6.15)	275(72.80)	5763(47.98)

*3 participants were trans-genders

Table 2: Mean levels of risk factors (weighted means) in the study population

	Male (N=4472)			Female (N= 7537)			Total (N= 12012)		
Variables	n	mean	SE	N	mean	SE	n	mean	SE
Body mass index in kg/m^2	4392	23.63	0.09	7477	24.48	0.08	11872	24.17	0.06
Waist circumference in cm	4407	86.37	0.28	7481	86.13	0.25	11891	86.22	0.21
Systolic blood pressure in mmHg	4407	129.41	0.37	7481	124.99	0.32	11891	126.63	0.26
Diastolic blood pressure in mmHg	4407	82.57	0.26	7481	79.69	0.18	11891	80.76	0.16
Plasma glucose in mg/dl	4299	108.87	0.82	7300	108.39	0.68	11602	108.57	0.58
Salt consumption in grams/day	4299	5.33	0.04	7300	7.49	0.05	11599	6.68	0.45

SE=Standard error, cm=centi meters, kg=kilo gram, mmHg=milli meters of mercury, mg/dl=milli gram/deciliter, SE adjusted for 1387 clusters.

Table 3: Prevalence of NCD risk factors in the study population

Variables	Male (N=4472) Weighted percentage and 95% CI	Female (N=7537) Weighted percentage and 95% CI	Total (N=12012) Weighted percentage and 95% CI
Current tobacco use	20.3 (18.6-22.1)	0.6 (0.4-0.9)	7.9 (7.3-8.7)
Current alcohol use	28.9 (26.5-31.4)	0.2 (0.1-0.4)	8.7 (7.9-9.6)
Physical inactivity (less than 600 met minutes per week)	23.7 (21.8-25.7)	20.8 (19.0-22.8)	21.9 (20.5-23.5)
<3 servings of vegetables per day	79.2 (76.7-81.5)	77.7 (75.5-79.8)	78.3 (76.2-80.1)
<2 servings of fruits per day	83.8 (81.5-85.8)	85.3 (83.4-87.0)	84.7 (83.0-86.3)
>=5 grams per day of salt consumption	51.3 (49.0-53.5)	82.0 (80.5-83.4)	70.6 (69.2-72.0)
Poor Diet score	29.4 (27.0-32.0)	47.6 (44.9-50.4)	40.8 (38.5-43.1)
Overweight	28.2(26.3-30.3)	31.6 (30.0-33.3)	30.4 (29.1-31.7)
Obesity	5.5 (4.6-6.5)	10.9 (9.9-12.0)	8.9 (8.1-9.7)
Abdominal obesity	39.1 (36.6-41.7)	72.6 (70.7-74.5)	60.2 (58.5-61.8)
Hypertension	34.6 (32.6-36.7)	27.9 (26.4-29.4)	30.4 (29.1-31.7)
Diabetes	19.8(18.2-21.6)	18.8 (17.5-20.2)	19.2 (18.1-20.3)
Pre-diabetes	36.1 (33.8-38.4)	34.9 (32.8-37.0)	35.3 (33.6-37.1)

Figure legends

Figure 1: Study sample selection flow-chart

Figure 2. Clustering of NCD risk factors in the study population

A. Contributorship statement

Sankara Sarma contributed to the design, data analysis, data interpretation and reviewing the manuscript; Rajeev Sadanandan contributed to the concept, data interpretation and reviewing the manuscript; Jissa Vinoda Thulaseedharan contributed to the design, data analysis, drafting and reviewing the manuscript; Biju Soman contributed to the design, data acquisition, data analysis, data interpretation, drafting and reviewing the manuscript; K Srinivasan contributed to the design, data interpretation and reviewing the manuscript; Ravi Prasad Varma contributed to the design, data analysis, data interpretation and reviewing the manuscript, Manju R Nair contributed to the design, data analysis, data interpretation and reviewing the manuscript; AS Pradeepkumar contributed to the design, data acquisition, data analysis, data interpretation and reviewing the manuscript; Panniyammakal Jeemon contributed to the data analysis and data interpretation, drafting and reviewing the manuscript; KR Thankappan contributed to the concept, data acquisition, data interpretation and reviewing the manuscript; V Raman Kutty contributed to the concept, data interpretation and reviewing the manuscript

B. Competing interest

We declare that there were no competing interests.

C. Data Sharing statement

This is the first paper from the research work. We are still working on the data, and the data will be made available soon. Meanwhile, we shall share the data on request for legitimate use.

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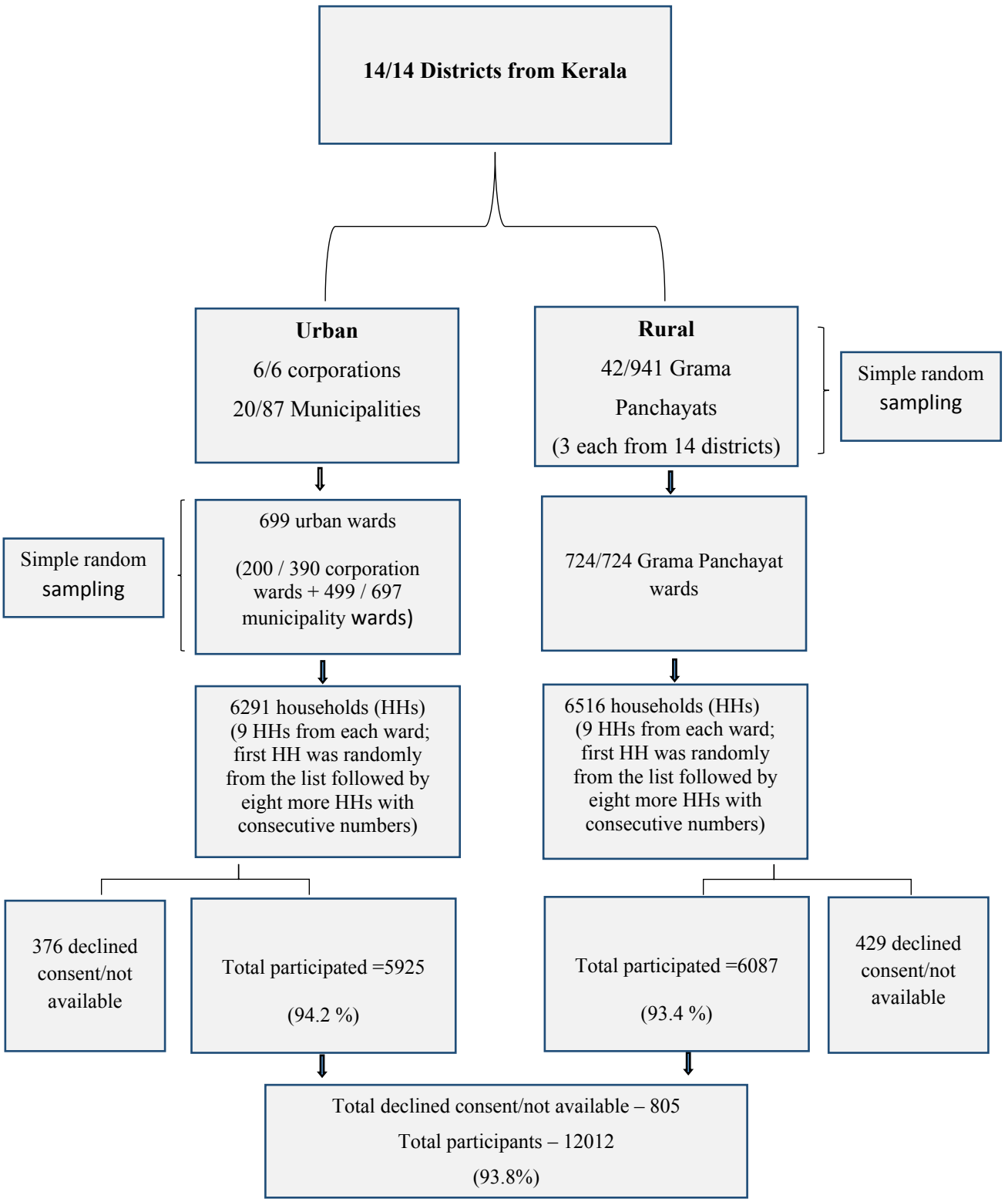

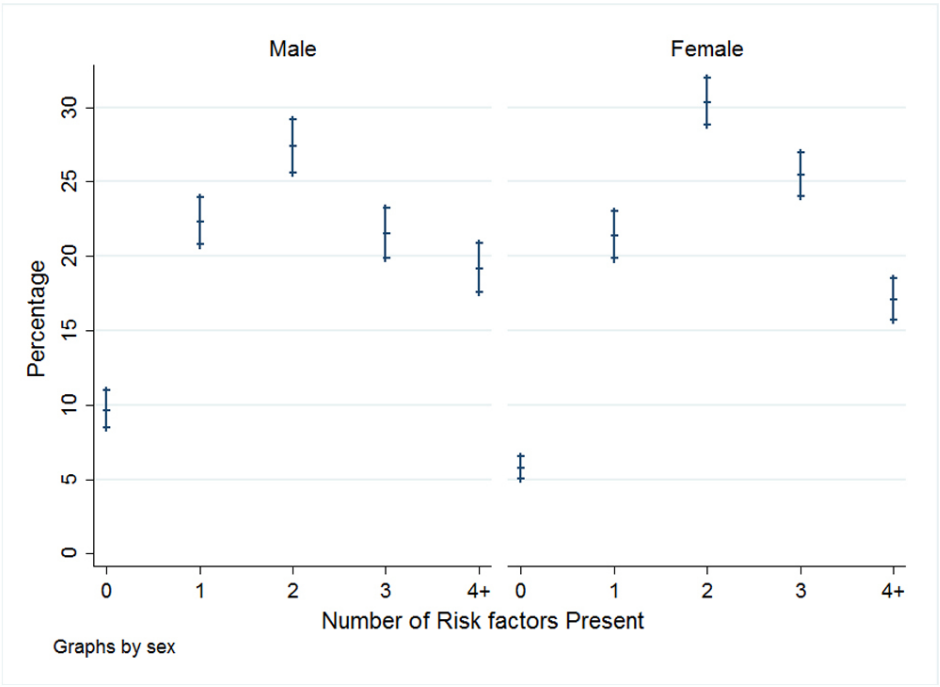

Figure 2. Clustering of NCD risk factors in the study population

90x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	*9*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			12-14

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12, Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	12
Outcome data	15*	Report numbers of outcome events or summary measures	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	12-14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence of risk factors of non-communicable diseases in Kerala, India; results of a cross-sectional study

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Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Cardiovascular medicine, Health policy
Keywords:	Prevalence, NCD risk factors, Kerala, Diabetes, Hypertension < CARDIOLOGY

Prevalence of risk factors of non-communicable diseases in Kerala, India; results of a cross-sectional study

Authors: P Sankara Sarma[1], Rajeev Sadanandan[2], Jissa Vinoda Thulaseedharan[1], Biju Soman[1]*, Kannan Srinivasan[1], Ravi Prasad Varma[1], Manju R Nair[1], AS Pradeepkumar[1], Panniyammakal Jeemon[1], Kavumpurathu Raman Thankappan[1], V Raman Kutty[1]

*Corresponding author: Biju Soman, Professor, Achutha Menon Centre for Health Science Studies (AMCHSS), Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Thiruvananthapuram, Kerala, India, PIN695011; bijusoman@sctimst.ac.in, +91 944 786 2736

Affiliations:
1. Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum
2. Department of Health and Family Welfare, Government of Kerala.

P Sankara Sarma, AMCHSS, SCTIMST, Thiruvananthapuram, India
Rajeev Sadanandan, Dept. of Health & Family Welfare, Govt. of Keala, Thiruvananthapuram, India
Jissa Vinoda Thulaseedharan, AMCHSS, SCTIMST, Thiruvananthapuram, India
K Srinivasan, AMCHSS, SCTIMST, Thiruvananthapuram, India
Ravi Prasad Varma, AMCHSS, SCTIMST, Thiruvananthapuram, India
Manju R Nair, AMCHSS, SCTIMST, Thiruvananthapuram, India
AS Pradeep Kumar, AMCHSS, SCTIMST, Thiruvananthapuram, India
Panniyammakal Jeemon, AMCHSS, SCTIMST, Thiruvananthapuram, India
Kavumpurathu Raman Thankappan, AMCHSS, SCTIMST, Thiruvananthapuram, India
V Raman Kutty, AMCHSS, SCTIMST, Thiruvananthapuram, India

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Number of words: 3964

Abstract

Objectives: To estimate the prevalence of non-communicable disease (NCD) risk factors in Kerala.

Design: Community based cross-sectional survey.

Participants: In 2016-17 a multi-stage cluster sample of 12,012 (18-69 years) participants from all 14 districts in Kerala were studied.

Main outcome measures: NCD risk factors as stipulated by the World Health Organization's approach to NCD risk factors Surveillance. Parameters studied include physical activity score, anthropometry, blood pressure, and fasting blood glucose and spot urine sample to estimate dietary intake of salt.

Results: Mean age was 42.5 years (SD=14.8). Abdominal obesity was more in women (72.6%; 95%CI 70.7-74.5) compared to men (39.1%; 95%CI 36.6-41.7) and more in urbanites (67.4%; 95%CI 65.0-69.7) compared to rural-folk (58.6%; 95%CI 56.6-60.5). Current use of tobacco and alcohol in males were 20.3% (95% CI 18.6-22.1) and 28.9% (95% CI 26.5 to 31.4), respectively. The estimated mean salt intake(6.7 g/day) is lower than other reported figures in India. overall prevalence of raised blood pressure(BP) and raised fasting blood glucose(FBG) 30.4% (95% CI 29.1 to 31.7) and 19.2% (95% CI 18.1 to 20.3) respectively. Raised BP was more in men (34.6%, 95%CI 32.6-36.7) compared to women (28%; 95%CI 26.4-29.4) and not different between urbanites (33.1%; 95%CI 31.3-34.9) and rural-folk (29.8%; 95%CI 28.3-31.3). Only 12.4% of hypertensives and 15.3% of diabetics were found to keep their diseases under control. Only 13.8% of urbanites and 18.4% of rural-folk were free of the seven NCD risk factors studied.

Conclusion: Majority of the participants have more than one NCD risk factors. It was striking to note that there is no rural-urban difference in BP for FBG readings in Kerala. The higher rates of NCD risk factors and lower rates of disease control calls for concerted primary and secondary prevention strategies to address the future burden of NCDs.

Keywords: Prevalence, NCD risk factors, Kerala, diabetes, hypertension

Strengths and limitations

- The study gives robust rates of NCD risk factors in Kerala that can be compared other studies in India and abroad, as we had used the widely validated WHO STEPS questionnaire and standard pieces of equipment to study a representative sample of adults.
- We took the third reading for blood pressure (BP) only when the difference in systolic BP of the previous two readings was >10 mmHg and that of diastolic BP >6 mmHg which is in deviation to the WHO STEPS guidelines that insist on taking three readings for everyone.
- The biochemical measurements for serum cholesterol and measurements of hip circumference were not done this study due to logistic limitations, but they were not the core features of step 1 and step 2.
- To our knowledge, no other study on NCD risk factors in Kerala in the recent past, including those by the same group of researchers, were done on a statewide cross-sectional study.

INTRODUCTION

Over two third (67%) of disease burden in India measured by disability-adjusted life years (DALYs) is attributable to Non-communicable diseases (NCDs) and injuries[1]. The India state-level disease burden estimates suggest significant differences between states in the composition of disease burden[1]. Compared to other states in India, the state of Kerala is relatively in an advanced stage of epidemiological transition[2]. Over 90% of premature mortality in Kerala (mortality in the age group of 15-69 years) is attributable to NCDs[2]. Furthermore, nearly a quarter of the total disease burden in DALYs is due to four major NCDs (ischemic heart disease, stroke, chronic obstructive pulmonary diseases, and diabetes)[1]. The rising proportion of elders (12.6%[3]) and the fast adoption of sedentary lifestyles in Kerala might have contributed to this much increase in non-communicable diseases.[3] Community-level interventions to bring down NCD risk factors are being undertaken by the state government which is a definite indication of the gravity of the situation as mentioned in the government order (GO(Rt)No.609/2016/H&FWD Dated 24/02/2016 by Govt. of Kerala).

While the disease burden estimates based on modelling of available data are useful in planning resource allocation, strategic investments in prevention and management of NCDs require accurate appraisals of their prevalence and risk factors. Hence we conducted a cross-sectional survey in Kerala's 14 districts using a multi-stage cluster sampling strategy to identify a representative sample of eligible participants. The objective of this paper is to describe the current prevalence of NCD risk factors in Kerala.

METHODS

Study settings

The state of Kerala, in South India, has a population of 33.4 million[4] and an area of 38,863 square kilometres. Nearly half the population is urban. A cross-sectional survey was conducted in all the 14 districts of Kerala, in both rural and urban areas from October 2016 to March 2017.

Sampling

A minimum sample size of 12000 adults was considered to provide separate prevalence estimates in different strata (for example; among male/female and urban/rural residents), of various NCD risk factors with an expected prevalence of 5%(based on the physical inactivity rate of men in rural area (4.7%) in our previous study) [5], and relative precision of 20%. We also considered a design effect of 1.5 and a response rate of 90% in the sample size estimation. A multi-stage cluster sampling strategy was adopted to identify a representative sample of eligible participants for the cross-sectional survey (Fig 1). The primary sampling units were a well-defined geographical area administered by the local government institution, i.e., municipal corporations and municipalities in urban areas and Grama Panchayats (GPs) - Grass-root level elected governments in the rural areas. The population of GPs in Kerala is around 20000-40000, whereas those in other states are around 1000-4000. In most districts, data were collected from two urban and three rural sites except in two districts, which had only one urban site each. The survey was conducted in all the municipal corporations (n=6) and randomly selected 20 of 87 municipalities in the urban region. Similarly, three GPs were randomly selected from each district (42 GPs from 14 districts).

Each of the primary sampling units is further divided into wards. In the next stage of sampling, a total 200 of the 390 wards of the municipal corporations and 499 of the 697 wards of the selected municipalities were randomly selected for the survey. All the 724 wards of selected GPs were also selected. In the final stage of sampling, one cluster of nine households were identified from each ward. For the selection of a cluster of households, one household was identified randomly from the available list of all the households in the selected ward and followed by the selection of eight more households with consecutive house numbers.

Study participants

All the individuals between the age group of 18-69 years were eligible to be part of the survey. If there were more than one adult in this age group, KISH method[6] was used to identify one of them from the household. Pregnant women were excluded from physical and biochemical measurements.

Ethical considerations

All participants of the study have given written informed consent. The Institutional Ethics Committee of SCTIMST, Trivandrum formally approved the conduct of the study (SCT/IEC/902/MAY-2016 dated 11/05/2016).

Patient and public involvement

No patients or public were directly involved in the study. The thank the project team, comprising two senior consultants, 28 district-level managers, 68 nurses and two office staff for their untiring efforts. Authors thank the Department of Health Services, Government of Kerala for patronising the survey, allowing the district level project staff to use their facilities and above all for the field level facilitative supervision. We also thank the DDRC SRL

Diagnostics Pvt. Ltd for their support. Finally, we thank all the people of Kerala, particularly the study participants for their wholehearted support for the statewide survey. We shall be disseminating the study results to the public in due course.

Study measurements

Interview Schedule

A structured interview schedule based on the WHO STEPwise approach to NCD risk factors Surveillance (STEPS)[7], which was validated in Malayalam[5] was used for this survey. Awareness of diabetes and hypertension status was assessed by asking questions about past diagnosis and history of both conditions. Global physical activity questionnaire (GPAQ) was used to assess physical activity levels[8].

Anthropometric measurements

Physical and clinical measurements included height, weight, waist circumference, blood pressure, and heart rate. All the measurements were taken in the participant's household by trained nurses. Height was measured using a SECA 213 stand-alone stadiometer in centimetres. Weight was measured using a portable SECA 803 battery operated electronic weighing scale in kilograms. Both measurements were taken with the participants wearing no footwear and any heavy objects in their body, such as mobile phones, wallets, and heavy belts. Additionally, SECA 201 ergonomic retractable tape was used to measure waist circumference. In order to measure waist circumference, the lower palpable margin of the ribs and the upper margin of the iliac crest were identified initially and then marked the midpoints between these margins along the mid-axillary line on both sides. The measurement tape was then wrapped horizontally all around by connecting the marked points on both sides of the participant's

body. Height was noted to the nearest 0.5 cm, weight to the nearest 10 gm and waist circumference to the nearest 0.1 cm at the end of the normal expiration.

Measurement of blood pressure and pulse rate

The blood pressure(BP) and pulse rate were measured using standard battery operated automatic BP monitors (OMRON HEM-7120). Before measurement, the participants were seated comfortably in a relaxed upright position for at least five minutes. Appropriate size cuff was used to take two readings of blood pressure and pulse rate three minutes apart.[9] The machine was switched off between the readings, after recording the systolic BP and diastolic BP in mm Hg and the heart rate in beats/minute. If systolic BP readings varied more than ten mmHg or diastolic BP readings more than six mmHg, between the two initial measurements, then a third reading was taken. The mean of the last two readings of blood pressure was considered as the final BP.

Biochemical measurements

Sample bottles were given to the participants on the survey day, and they were instructed to collect 20 ml of the second voiding urine sample (after first voiding in the morning and before breakfast) on the day of the blood sample collection for glucose estimation. Urinary sodium was assessed using indirect ion-selective electrode method in an accredited central laboratory. Modified Kawasaki formulae were used to estimate the 24-hour urinary intake of sodium,[10] and it was multiplied by 2.54 to estimate daily salt (sodium chloride) intake as advocated by Johnson et al.[11,12] Point of care glucometers (One touch ultra-easy, Johnson & Johnson) were used for capillary blood glucose estimation in the fasting stage. A minimum of eight hours of

fasting was ensured in all study participants. The blood glucose measurement in mg/dl was noted and recorded.

Administration of questionnaire and recording of study measurements

Computer tablets with custom-made data entry forms, with display both in English and Malayalam (local language), were prepared in Open Data Kit (ODK) software were used for data collection. ODK is a freely available Open Source Software, and we have integrated a utility to run KISH method[6] for selection of participants in the data entry form for the STEPS survey in it. Thirty-four pairs of trained nurses did the field level data collection. They carried the computer tablets, glucometer, weighing machine, stadiometer, measuring tape, and the blood pressure monitors into the household. After obtaining signed informed consent from the participants on printed forms, the survey team (nurses) used computer tablets with internet facility to gather information on questionnaire and measurements. They also did random blood glucose estimation of the study participants and gave sample bottles for urine collection with instruction on how to collect the early morning samples, which were collected back in the next morning. The data gets automatically sent to the institute server (all tablets had mobile internet facility) that was monitored by the district managers daily and subsequently by the state project management unit, once a week. The aggregated data was downloaded for analysis using the ODK Briefcase utility.

Quality control

Two senior public health professionals, with vast experience in the conduct of state-level programs, were entrusted with the field level supervision and monitoring. They were helped by 28 (two per district) middle-level district program managers. Residential training sessions

with hands-on training on data collection (using computer tablets) and standard procedures for the physical and biochemical measurements were conducted for the 34 pairs of nurses at four places (Thiruvananthapuram, Ernakulam, Thrissur, and Kannur) by the same team of investigators to ensure quality and uniform standards. Data collected was checked by the district program managers for completeness, consistency, and feedback given to data collectors. The district program managers made regular concurrent and consecutive visits to the selected households to ensure quality. The time and location of the survey could be ascertained for the quality check as the geo-location were also captured. Data cleaning was also done centrally, and monthly updates were sent to the field staff to improve the quality of data collection.

Definitions

Raised BP, raised FBG and daily salt intake

Raised blood pressure(BP) was defined systolic BP≥140 mmHg or diastolic BP ≥90 mmHg or the person currently using antihypertensive medications(self-reported treatment).[13] Raised fasting blood glucose(FBG) was defined as FBG of ≥126 mg/dl or self-reported treatment for diabetes. FBG in the range of 100-125 mg/dl was defined as pre-diabetes.

Current smoking and alcohol use

Current Tobacco use was defined as the use of any form of tobacco within the past 30 days[7], and current alcohol use was defined intake of at least one standard drink of alcohol in the past 30 days.[7]

Fruits and Vegetable intake

The mean servings of Fruits and Vegetables per day as advocated by WHO.[7]

Daily salt intake

The Kawasaki Formula was used to estimate urinary excretion of sodium from the spot urine sample and it was multiplied by 2.54 to get daily salt (sodium chloride) intake.

Physical inactivity

For the calculation of physical inactivity, the total time spent in physical activity during a typical week and the intensity of the physical activity assessed using the Global Physical Activity Questionnaire (GPAQ) were taken into account. Physical inactivity was defined as <600 metabolic equivalents (MET) minutes of a combination of moderate and vigorous-intensity physical activity.[8]

Obesity and overweight

Obesity was defined as a body mass index of ≥30 kg/m^2, while overweight was defined as body mass index in the range of 25-29.99 kg/m^2.[14] Waist circumference level of >=90 cm and >=80 cm were used to define abdominal obesity in men and women respectively.[15]

Number of NCD risk factors

Seven risk factors (tobacco use, alcohol use, obesity, abdominal obesity, raised BP, raised blood glucose, and physical inactivity) were counted in the calculation of the number of risk factors. The proportion of individuals with zero, any one, two, and three or more risk factors were estimated.

Statistical analyses

Sampling weights were derived based on the probabilities of selection at various stages of sample selection. The inverse of the product of probabilities of sample selection at different

stages was used in sample weighting. Sampling weights were then normalized to the total sample size.

Weighted means and 95% confidence intervals (95% CI) for quantitative variables and percentages and 95% CI for categorical variables were used to summarise data. Cluster correction was applied as variance inflation while estimating 95% CI. Statistical analyses were done using the software IBM SPSS Statistics for Window version 21 (Armonk, NY, USA: IBM Corp.) and STATA Statistical Software: Release 14. (College Station, TX: Stata Corp LP.)

RESULTS

Socio-demographic characteristics

In total, 12,012 adults in the age group of 18-69 years participated in the survey with a response rate of 93.8%. Nearly half (49.3%) of the participants were urban residents with more females(63%) than males (Table 1). Mean age was 42.5 years (SD=14.8). The majority (75.7%) have studied up to primary school level or above, and only a third (36.5%) were designated as poor, earning an income below the poverty line. Nearly three fourth (73.5%) were married. One of 20 participants (4.7%) was unemployed.

Behavioural risk factors

The use of tobacco and alcohol was low in women. However, the current use of tobacco and alcohol among males were 20.3% (95% CI 18.6 to 22.1) and 28.9% (95% CI 26.5 to 31.4) respectively (Table 2). Physical inactivity was prevalent in 23.7% (95% CI 21.8 to 25.7) and 20.8% (95% CI 19.0 to 22.7) of males and females, respectively. The mean consumption of fruits was only one serving per day among men, women, urbanites and rural people, and the

intake of vegetables was two servings per day across these subgroups. (Table 2) There were no significant differences in the rates of alcohol, tobacco, and physical inactivity nor in the consumption of fruits and vegetables among urban or rural people. (Table. 2) The mean salt intake among the participants was 6.7 gm/day (95%CI 6.6-6.8). There was no rural-urban difference, but females had significantly higher salt intake (7.5 gm/day; 95%CI 7.4-7.6) compared to males (5.3gm/day; 95%CI 5.2-5.4). (Table 2)

Prevalence of raised BP and raised FBG

The weighted means systolic BP were 129.4 mmHg (95%CI 128.7-130.4) among men and 125.0 mmHg (95%CI 124.4-125.6) among women. (Table 3). Similarly, the average diastolic BP was 82.6 mmHg (95%CI 82.1-83.1) in men and 79.7 mmHg (95%CI 79.3-80.0) in women. Prevalence of raised BP was 34.6% (95% CI 32.6-36.7) in men and 28% (95% CI 26.4 to 29.4) in women (Table 3). There was no rural-urban difference in systolic or diastolic BP readings. Average FBG was 108.6 mg/dl, and there was no male-female nor rural-urban difference for this parameter. (Table 3) Raised FBG values were seen in 19.8% (95% CI 18.2-21.6) of men and 18.8% (95% CI 17.5-20.2) of women, and there was no rural-urban difference. Additionally, 36% of men and 35% of women were in the pre-diabetes stage. There were no rural-urban difference in the rates of raised BP, raised FBG, and two of five adults (40%; 95%CI 38.6-41.3%) had either raised BP or raised FBG.

Among those with a history of hypertension, only 12.3% (95%CI 10.9-14.0) had their BP values under control (meaning systolic BP<140 mmHg or diastolic BP <90 mmHg). The control rate

in men (7.9%; 95%CI 6.4-9.7) was less than the control rate in women (15.6%; 95%CI 13.5-18.0); similarly, the control rates among rural residents (11.5%; 95%CI 9.8-13.5) were less than the urban counterparts. (15.9% (95% CI 13.6-18.4).

Among those hypertensives who claimed to be under treatment, 34.1% had their BP under control (28.6% in males, 36.8% in females, 37.4% in urban residents and 33.2% in rural residents); though the male-female or rural-urban differences were not statistically significant.

Among those with a history of diabetes, 15.3% (95%CI 13.1-17.8) had their BS under control (meaning fasting plasma glucose of <126 mg/dl) and among those who claimed to be under treatment, 31.1% (95%CI 31.1(27.1-35.4) had their BS under control. There was no significant male-female difference, but the urbanites were found to have better control(17.0%; 95%CI 13.9-20.6) compared to rural dwellers(14.9%; 95%CI 12.3-17.9).

Body mass index, waist circumference, and obesity

The mean BMI was 24.2 kg/m^2 (95%CI 24.1-24.4) with statistically significant rise for women and urbanites, though the magnitude of the difference is negligible (Table 3). The weighted mean waist circumference significantly higher for urbanites (88.2 cm; 95%CI 87.6-88.8) compared to rural people(85.8 cm; 95%CI 85.3-86.3)(Table 3. More urbanites were overweight(33.1%) compared to rural-folk (29.8%), and obesity was more among women(10.9%) compared to men (5.5%) (Table 3). Abdominal obesity was higher for women(72.6%) compared to men(39.1%) and urbanites(67.4%) compared to rural-folk(58.6%)(Table 3).

Clustering of NCD risk factors

Only 9.7% (95%CI 8.5-11.0) of men and 5.7% (95% CI 5.0 to 6.6) of women were free of any of the seven NCD risk factors(Tobacco use, alcohol use, obesity, abdominal obesity, raised BP, raised blood glucose, and physical inactivity) studied (Figure 2). Proportion with an isolated risk factor (35.3%) was less frequent than those with multiple risk factors (47.1%), and this trend was true for men(27.8% vs 41.8%), women(38.5% vs 45%), rural(35.9% vs 45.7%) and urban (32.7% vs 53.5%) Three or more risk factors were present in 20.9%% and four or more NCD risk factors were present in 6.5% of the participants.

DISCUSSION

This study found that the majority of adults (82.4%) of 18-64 year age group in Kerala have at least one NCD risk factors, and multiple risk factors were present in 47.1%. Raised BP and raised FBG were present in 30.4% and 19.2% of adults in Kerala. Overweight prevalence was as high as 30.4%, and twice that much (60.2%) had abdominal obesity, which was more significant (72.6%) among woman. Moreover, dysglycemia (raised FBG and pre-diabetes together) was found to be present among 54.5% of the adult population.

The prevalence of hypertension was found to be comparable with the rates for Thiruvananthapuram in 2010 by Thankappan *et al.* (28.8%)[5] but less than the rate by Sathish *et al.* (43.2%).[16] The hypertension prevalence of adults in Kerala of 18-64 years is similar to the rates of urbanites of higher age group (30-64 years) in Tamil Nadu (28.5%).[17] Hypertension rate in Kerala is similar to the estimates of the meta-analysis by Anchala *et al.* for the urban south India (31.8%).[18]

Prevalence of raised FBG in Kerala is higher than the diabetic rate in urban Delhi (18.1%).[19] Prevalence of dysglycemia in more than half (54.5%) of the adult population poses a challenge to the existing health care system, to maintain the diseases at the current level and to manage their complications. The increasing behavioural risk factors[16] even among the tribal communities,[20] and higher conversion rate of pre-diabetes to diabetes Indians[21] could be the reason for this much increase in raised FBG.

There could be underreporting of some of the behavioural risk factors, especially alcohol intake as much public debate is going on in the state since 2015 on curtailing the availability of liquor in the state.[22] The weighted mean salt intake in this study(6.7 g/day) is lower compared to the estimate for Delhi, Haryana, and Andhra Pradesh, reported by Johnson *et al*[23] in 2017. The low levels could be partially due to methodological differences, as we have not inflated the values for non-urinary losses of salt as done by Johnson *et al.*[11] Further the mean salt intake was found to be more in women in Kerala (Table 3) compared to studies elsewhere.[11,23,24] There are methodological controversies regarding use of spot urine for the estimation 24 hour sodium excretion[25] (using Kawasaki formulae) and the apparently low intake of salt in Kerala(compared to other states) needs further research as this hard evidence for salt intake could be the first indication of reversal of NCD risk factors in Kerala!

Raised BP or raised FBG, present in over 40% of the adult population are significant contributors to cardiovascular disease mortality. Clustering of multiple risk factors, a finding reported by other studies from India[26] increases the risk of developing a major NCD condition or event shortly. NCD risk factors are identified to be associated with the social disparity in India[27] and other Asian countries[28] as in the western populations.[29,30] The proportion of

known hypertensives with normal BP found in this study (12.3%) is low compared to the rates from Iran (49.1%),[31] the United States of America (48%)[32] and even from China (18%).[33] Similarly, the proportion diabetic with normal FBG values is also low in this study (15.3%) compared to the improving rates of control found in the western countries; they could achieve 20% control even among people with hypertension and diabetes.[34]

Mounting evidence on the reduction in NCD risk factors with concerted public health action in other countries[35,36] gives a positive impetus to the current strategy for NCD risk reduction efforts in Kerala. Hence, the policy action to address the future NCD burden should focus not only on single risk factors but also on several of them simultaneously at the population level. The cumulative effect of acting on multiple risk factors may reduce the total risk substantially and thus avert several future NCD events.

In addition to primary care, provision of drugs and lifestyle counselling highrisk individuals is necessary to address the rising burden of cardiovascular events.[37] However, we do not have enough evidence on the feasibility of such an approach in middle-income countries.[38] Moreover, in Kerala, despite the high literacy rate and the success stories of implementation research in cardiovascular risk factors[39-41], we have the situation of higher prevalence and poor control of hypertension and diabetes. Further in-depth research using qualitative methods might help us to understand the stumbling blocks in implementation research

Strengthening the primary care in Kerala and providing universal access to anti-hypertensive and anti-diabetic medicines to all eligible patients should be a high priority for the Government of Kerala to limit the future burden of NCDs.

The high prevalence of NCD risk factors in Kerala calls for urgent policy action for primary and secondary prevention.

Strengths and limitations of the study

This was a large statewide study on NCD risk factors in Kerala, done by trained nurses using standard equipment, validated research tools and modern utilities like computer tablets. The use of the WHO STEPS framework for the questionnaire enables the comparison of studies done within India and abroad.[7] Use of mobile data entry platforms, as we did in this study, are proven to improve the quality and timeliness of STEPS surveys.[7,42] We had taken the third reading of BP only when the difference in systolic BP of the earlier two readings[9] was >10 mmHg and that of diastolic BP >6 mmHg (third reading was taken in 18.2% of subjects), which is in deviation to the WHO STEPS guidelines[7] that insists on taking three readings for everyone. We record this as a limitation of this study. Serum cholesterol and hip circumference measurement were not done in this study due to logistic limitations, but they were not the core features of STEP 1 and STEP 2.[43] To our knowledge, no other published study on NCD risk factors in Kerala in the recent past, including those by the same group of researchers, were done on a statewide scale. The study is timely as the results could be used for Universal Health Coverage initiative in Kerala, wherein all the peripheral hospitals are being converted to Family Health Centres.

CONCLUSION

About 40% of the adult population in Kerala have either raised BP or raised FBG, and the overall control rates for these conditions were as low as 12.3% and 15.3% respectively. Majority of the adult population (83.4%) had an NCD risk factor and clustering of risk factors is very common. The high prevalence of NCDs and their risk factors in Kerala calls for urgent policy action for prevention at all levels.

Table 1. General characteristics of the study population

Variables	Male (N=4472)	Female (N=7537)	Total (N=12,012)*
Age in years, mean (SD)	42.42(15.38)	42.58(14.45)	42.52 (14.8)
Age groups, n (%)			
18-44	2263(50.60)	4114(54.58)	6380(53.11)
45-69	2209(49.40)	3423(45.42)	5632(46.89)
Residence			
Rural	2305(51.54)	3782(50.18)	6087(50.67)
Urban	2167(48.46)	3755(49.82)	5925(49.33)
Education			
Up to primary school	1002(22.41)	1914(25.39)	2916(24.28)
Secondary to High school	2281(51.01)	3645(48.36)	5928(49.35)
>high school	1189(26.59)	1978(26.24)	3168(26.37)
Social groups			
Below poverty line	1633(36.52)	2796(37.10)	4431(36.89)
Above poverty line	2730(61.05)	4555(60.44)	7286(60.66)
Others	109(2.44)	186(2.47)	295(2.46)
Marital status			
Never married	1140(25.49)	954(12.66)	2095(17.44)
Married	3242(72.50)	5579(74.02)	8823(73.45)
Others	90(2.01)	1004(13.32)	1094(9.11)
Occupation			
Officers and professionals	688(15.38)	536(7.11)	1224(10.19)
Self-employed	1286(28.76)	262(3.48)	1549(12.90)
Skilled labourer	703(15.72)	86(1.14)	789(6.57)
Unskilled labourer	490(10.96)	232(3.08)	723(6.02)
Unemployed	413(9.24)	161(2.14)	574(4.78)
Students	617(13.80)	773(10.26)	1390(11.57)
Others	275(6.15)	275(72.80)	5763(47.98)

*3 participants were trans-genders

Table.2: Prevalence of NCD risk factors in the study population

Variables	Weighted percentage and 95% CI		Weighted percentage and 95% CI by sex				Weighted percentage and 95% CI by area of residence			
	Total (N=12012)		Male (N=4472)		Female (N=7537)		Urban (N=6087)		Rural (N= 5925)	
Current tobacco use	7.9	(7.2-8.7)	20.3	(18.6-22.1)	0.6	(0.4-0.9)	7.2	(6.0-8.6)	8.1	(7.2-9.0)
Current alcohol use	8.7	(7.9-9.6)	28.9	(26.5-31.4)	0.2	(0.1-0.4)	8.9	(7.6-10.3)	8.7	(7.7-9.7)
Physical inactivity (< 600 MET* minutes per week)	21.9	(20.4-23.5)	23.7	(21.8-25.7)	20.8	(19.0-22.8)	23	(20.8-25.3)	21.7	(20.0-23.5)
Overweight	30.4	(29.1-31.7)	28.2	(26.2-30.3)	31.6	(30.0-33.3)	33.5	(31.5-35.4)	29.7	(28.2-31.2)
Obesity	8.9	(8.1-9.7)	5.5	(4.6-6.5)	10.9	(9.9-12.0)	11.2	(9.9-12.7)	8.4	(7.5-9.3)
Abdominal obesity	60.2	(58.5-61.8)	39.1	(36.6-41.7)	72.6	(70.7-74.5)	67.4	(65.0-69.7)	58.6	(56.6-60.5)
Raised blood pressure†	30.4	(29.1-31.7)	34.6	(32.6-36.7)	27.9	(26.4-29.4)	33.1	(31.3-34.9)	29.8	(28.3-31.3)
Raised FBG‡	19.2	(18.1-20.3)	19.8	(18.2-21.6)	18.8	(17.4-20.2)	19.8	(18.1-21.6)	19	(17.7-21.4)
Pre-diabetes	35.3	(33.6-37.1)	36.1	(33.7-38.4)	34.9	(32.8-37.0)	31.7	(29.6-33.9)	36.1	(34.0-38.2)

*MET = metabolic equivalents

†Numerator includes people with raised blood pressure and those who were under treatment (self-reported) for hypertension.

‡ FBG = fasting blood glucose; numerator includes people with raised fasting blood glucose values and those who were under treatment (self-reported) for diabetes.

All estimates and 95% CI were adjusted for 1387 clusters

Table.3: Mean levels of risk factors (weighted means) in the study population

Variables	Weighted mean and 95% CI Total (N= 12012)		Weighted mean and 95% CI by sex Male (N=4472)		Female (N= 7537)		Weighted mean and 95% CI by area of residence Urban (N=6087)		Rural (N= 5925)	
Systolic BP in mmHg	126.6	(126.1-127.1)	129.4	(128.6-130.1)	125	(124.3-125.6)	126.6	(125.8-127.2)	126.6	(126.0-127.2)
Diastolic BP in mmHg	80.8	(80.4-81.1)	82.6	(82.0-83.1)	79.7	(79.3-80.0)	80.9	(80.5-81.4)	80.7	(80.3-81.1)
FBG in mg/dl	108.6	(107.4-109.7)	108.9	(107.2-110.5)	108.4	(107.0-109.7)	108.4	(106.4-110.3)	108.6	(107.3-109.9)
Fruit intake (servings/day)	1.1	(1.0-1.1)	1.1	(1.0-1.2)	1	(0.9-1.0)	1	(0.9-1.0)	1.1	(1.0-1.1)
Vegetable intake (servings /day)	2	(1.9-2.1)	2	(1.8-2.0)	2	(1.9-2.1)	1.9	(1.7-2.0)	2	(1.9-2.1)
Mean vegetable and fruit intake (servings/day)	1.5	(1.4-1.6)	1.5	(1.4-1.6)	1.5	(1.4-1.6)	1.4	(1.3-1.5)	1.6	(1.5-1.6)
Salt (sodium chloride) intake, (g/day)	6.7	(6.6-6.8)	5.3	(5.2-5.4)	7.5	(7.4-7.6)	6.6	(6.4-6.7)	6.7	(6.6-6.8)
Body mass index in kg/m^2	24.2	(24.1-24.4)	23.6	(23.5-24.0)	24.5	(24.3-24.7)	24.9	(24.7-25.1)	24.1	(23.9-24.2)
Waist circumference in cm	86.2	(85.8-86.6)	86.4	(85.5-86.9)	86.1	(85.6-86.6)	88.2	(87.6-88.8)	85.8	(85.3-86.3)

CI= Confidence Interval, BP = blood pressure, FBG =fasting blood glucose, cm= centimeters, kg= Kilogram, mmHg= millimeters of mercury, mg/dl = milligram/deciliter, g/day = gram per day; All estimates and 95% CIs are adjusted for 1387 clusters

Figure legends

Figure 1: Study sample selection flow-chart

Figure 2. Clustering of NCD risk factors in the study population

A. Contributorship statement

Sankara Sarma contributed to the design, data analysis, data interpretation and reviewing the manuscript; Rajeev Sadanandan contributed to the concept, data interpretation and reviewing the manuscript; Jissa Vinoda Thulaseedharan contributed to the design, data analysis, drafting and reviewing the manuscript; Biju Soman contributed to the design, data acquisition, data analysis, data interpretation, drafting and reviewing the manuscript; K Srinivasan contributed to the design, data interpretation and reviewing the manuscript; Ravi Prasad Varma contributed to the design, data analysis, data interpretation and reviewing the manuscript, Manju R Nair contributed to the design, data analysis, data interpretation and reviewing the manuscript; AS Pradeepkumar contributed to the design, data acquisition, data analysis, data interpretation and reviewing the manuscript; Panniyammakal Jeemon contributed to the data analysis and data interpretation, drafting and reviewing the manuscript; KR Thankappan contributed to the concept, data acquisition, data interpretation and reviewing the manuscript; V Raman Kutty contributed to the concept, data interpretation and reviewing the manuscript.

B. Competing interest

We declare that there were no competing interests.

C. Data Sharing statement

This is the first paper from the research work. We are still working on the data, and the data will be made available soon. Meanwhile, we shall share the data on request for legitimate use.

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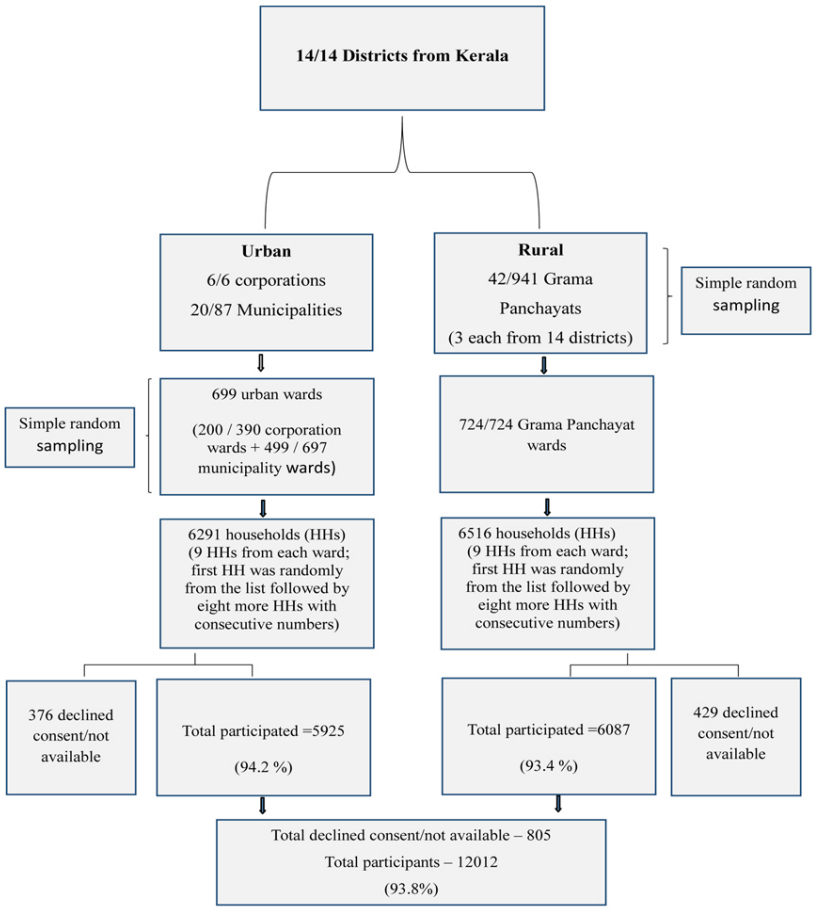

Figure 1: Study sample selection flow-chart

90x90mm (300 x 300 DPI)

Figure 2. Clustering of NCD risk factors in the study population

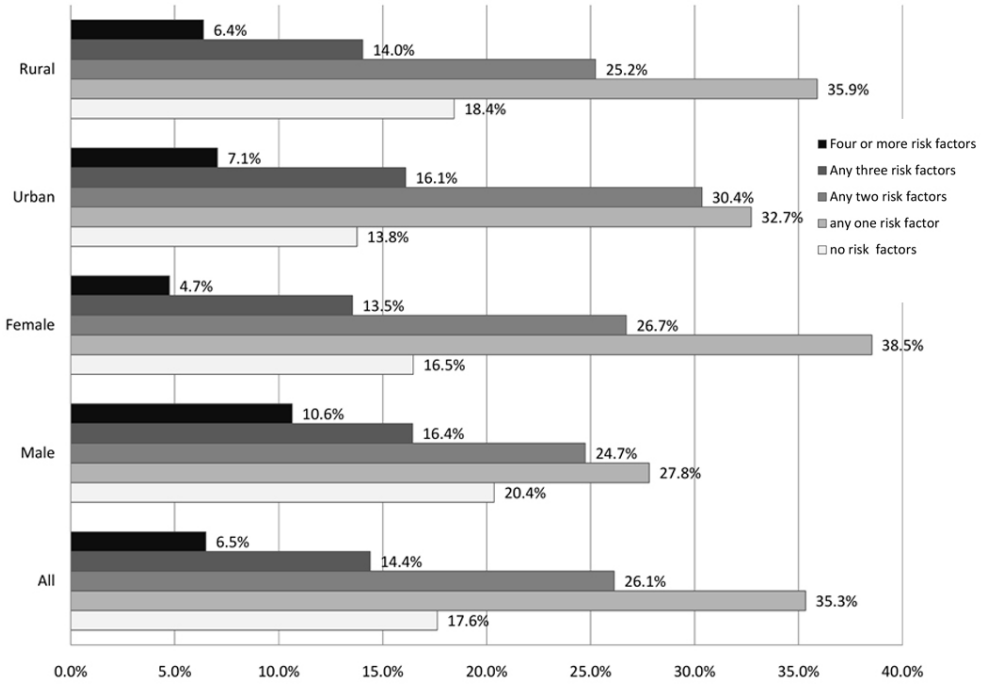

Figure 2: Clustering of NCD risk factors in the study population

90x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	*9*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			12-14

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12, Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	12
Outcome data	15*	Report numbers of outcome events or summary measures	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	12-14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	17,18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Complete List of Authors:	Sarma, P; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Sadanandan, Rajeev; Government of Kerala, Department of Health & Family Welfare Thulaseedharan, Jissa Vinoda; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Soman, Biju; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Sciences Studies Srinivasan, Kannan; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Varma, R; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Nair, Manju; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Pradeepkumar, AS; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Jeemon, Panniyammakal; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Thankappan, KR; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies Kutty, Raman; Sree Chitra Tirunal Institute for Medical Sciences and Technology, Achutha Menon Centre for Health Science Studies
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Cardiovascular medicine, Health policy
Keywords:	Prevalence, NCD risk factors, Kerala, Diabetes, Hypertension < CARDIOLOGY

Prevalence of risk factors of non-communicable diseases in Kerala, India; results of a cross-sectional study

Authors: P Sankara Sarma[1], Rajeev Sadanandan[2], Jissa Vinoda Thulaseedharan[1], Biju Soman[1]*, Kannan Srinivasan[1], Ravi Prasad Varma[1], Manju R Nair[1], AS Pradeepkumar[1], Panniyammakal Jeemon[1], Kavumpurathu Raman Thankappan[1], V Raman Kutty[1]

*Corresponding author: Biju Soman, Professor, Achutha Menon Centre for Health Science Studies (AMCHSS), Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Trivandrum, Kerala, India, PIN695011; bijusoman@sctimst.ac.in, +919447862736

Affiliations:
1. Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum
2. Department of Health and Family Welfare, Government of Kerala.

P Sankara Sarma, AMCHSS, SCTIMST, Trivandrum, India
Rajeev Sadanandan, Dept. of Health & Family Welfare, Govt. of Kerala, Thiruvananthapuram, India
Jissa Vinoda Thulaseedharan, AMCHSS, SCTIMST, Trivandrum, India
K Srinivasan, AMCHSS, SCTIMST, Trivandrum, India
Ravi Prasad Varma, AMCHSS, SCTIMST, Trivandrum, India
Manju R Nair, AMCHSS, SCTIMST, Trivandrum, India
AS Pradeep Kumar, AMCHSS, SCTIMST, Trivandrum, India
Panniyammakal Jeemon, AMCHSS, SCTIMST, Trivandrum, India
Kavumpurathu Raman Thankappan, AMCHSS, SCTIMST, Trivandrum, India
V Raman Kutty, AMCHSS, SCTIMST, Trivandrum, India

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Number of words: 3951

Abstract

Objectives: To estimate the prevalence of non-communicable disease (NCD) risk factors in Kerala.

Design: A community based cross-sectional survey.

Participants: In 2016-17 a multi-stage cluster sample of 12,012 (18-69 years) participants from all 14 districts in Kerala were studied.

Main outcome measures: NCD risk factors as stipulated in the World Health Organization's approach to NCD risk factors Surveillance were studied. Parameters studied included physical activity score, anthropometry, blood pressure, and fasting blood glucose and morning urine sample to estimate dietary intake of salt.

Results: Mean age was 42.5 years (SD=14.8). Abdominal obesity was more in women (72.6%; 95%CI 70.7-74.5) compared to men (39.1%; CI 36.6-41.7), and more in urban (67.4%; CI 65.0-69.7) compared to rural residents (58.6%; CI 56.6-60.5). Current use of tobacco and alcohol in men were 20.3% (CI 18.6-22.1) and 28.9% (CI 26.5-31.4), respectively. The estimated mean salt intake (6.7 g/day) was lower than other reported figures in India. The overall prevalence of raised blood pressure (BP) was 30.4% (CI 29.1-31.7) and raised fasting blood glucose (FBG) was 19.2% (95% CI 18.1 - 20.3). Raised BP was more in men (34.6%, CI 32.6-36.7) compared to women (28%; CI 26.4-29.4) but not different among urban (33.1%; CI 31.3-34.9) and rural (29.8%; CI 28.3-31.3) residents. Only 12.4% of hypertensives and 15.3% of diabetics were found to have these conditions under control. Only 13.8% of urban and 18.4% of rural residents did not have any of the seven NCD risk factors studied.

Conclusion: Majority of the participants had more than one NCD risk factor. There was no rural-urban difference in raised BP or raised FBG prevalence in Kerala. The higher rates of NCD risk factors and lower rates of hypertension and diabetes control call for concerted primary and secondary prevention strategies to address the future burden of NCDs.

Keywords: Prevalence, NCD risk factors, Kerala, diabetes, hypertension

Strengths and limitations

- The study gives robust rates of NCD risk factors in Kerala that can be compared with other studies in India and abroad, as we had used the widely validated WHO STEPS questionnaire, standard equipment and methods to study a representative sample of adults.
- We took the third reading for blood pressure (BP) only when the difference in systolic BP of the previous two readings was >10 mmHg, and that of diastolic BP was >6 mmHg which is a deviation from the WHO STEPS guidelines that insist on taking three readings for everyone.
- The biochemical measurements for serum cholesterol and measurements of hip circumference were not done in this study due to logistic limitations, but they were not the core features of WHO STEPS 1 & 2.
- To our knowledge, no other study on NCD risk factors in Kerala in the recent past, including those by the same group of researchers, was done on a state-wide cross-sectional sample.

INTRODUCTION

Over two-thirds (67%) of disease burden in India, measured by disability-adjusted life years (DALYs), is attributable to Non-communicable diseases (NCDs) and injuries.[1] The India state-level disease burden estimates suggest significant differences among states in the composition of disease burden.[1] Compared to other states in India, the state of Kerala is relatively in an advanced stage of epidemiological transition[2]. For example over 90% of premature mortality in Kerala (mortality in the age group of 15-69 years) could be attributed to NCDs.[2] Nearly a quarter of the total disease burden in DALYs is due to four major NCDs (ischemic heart disease, stroke, chronic obstructive pulmonary diseases, and diabetes).[1] The increasing proportion of elders (12.6%[3]) and the adoption of sedentary lifestyles in Kerala might have contributed to the increase in non-communicable diseases.[3] Considering the gravity of the challenge, the state government has taken up community-based interventions to reduce NCD risk factors. (GO(Rt)No.609/2016/H&FWD Dated 24/02/2016 by Govt. of Kerala).

While the estimates of disease burden based on modelling of routine health data are useful in planning resource allocation, strategic investments in prevention and management of NCDs require accurate assessment of their prevalence and risk factors. Hence, we conducted a state-wide cross-sectional survey to estimate the current prevalence of NCD risk factors in Kerala.

METHODS

Study settings

The state of Kerala, in South India, has a population of 33.4 million[4] and an area of 38,863 square kilometres. Nearly half the population is urban. A cross-sectional survey was conducted in all the 14 districts of Kerala, in both rural and urban areas from October 2016 to March 2017.

Sampling

To provide separate prevalence estimates for different strata (for example; among male/female and urban/rural residence), of various NCD risk factors with an expected prevalence of 5% (based on the physical inactivity rate of men in rural area as 4.7%[5] in our previous study), and relative precision of 20% a sample size of 12000 adults was arrived at. We also considered a design effect of 1.5 and a response rate of 90% in the sample size estimation.

A multi-stage cluster sampling strategy was adopted to identify a representative sample of eligible participants for the cross-sectional survey (Fig 1). The primary sampling strata were a defined geographical area administered by one of the local government institutions, i.e., municipal corporations and municipalities in urban areas and Grama Panchayats (GPs) in rural areas, which are the lowest tier of administrative units. The population of GPs in Kerala ranges from 20000 to 40000. Data were collected from two urban and three rural sites in 12 out of the 14 districts; the single urban site (these have only one urban site each) and three rural sites were selected from the other two districts. We surveyed all the municipal corporations (n=6) and a random sample of 20 of 87 municipalities in the urban region. We randomly selected three GPs from each district (the number of GPs per district ranges from 23 to 94, and the total number of GPs is 941).

Each of the primary sampling strata is further divided into wards. We selected 200 out of 390 wards in the municipal corporations, and 499 out of 697 wards of the selected municipalities for the survey. All the 724 wards of selected GPs were also selected. (Fig 1) In the final stage of

sampling, we identified a cluster of nine households from each ward. For the selection of a cluster of households, one household was identified randomly from the available list of all the households in the selected ward, followed by the selection of eight more households with consecutive house numbers.

Study participants

All the individuals between the age group of 18-69 years were eligible to be part of the survey. If there were more than one adult in this age group, KISH method[6] was used to identify one of them from the household. We excluded pregnant women from physical and biochemical measurements.

Ethical considerations

All participants of the study have given written informed consent. The Institutional Ethics Committee of SCTIMST, Trivandrum formally approved the conduct of the study (SCT/IEC/902/MAY-2016 dated 11/05/2016).

Patient and public involvement

No patients or public were directly involved in the study. We plan to disseminate the study results to the policymakers and the public.

Study measurements

Interview Schedule

We used a structured interview schedule based on the WHO STEPS strategy to NCD risk factors Surveillance (STEPS)[7], and Thankappan *et al.*[5] had already validated the tool in Malayalam.

Awareness of diabetes and hypertension status was assessed by asking questions about past diagnosis and history of those conditions. Global physical activity questionnaire (GPAQ) was used to assess physical activity levels.[8]

Anthropometric measurements

Physical and clinical measurements included height, weight, waist circumference, blood pressure, and heart rate. Trained nurses took all the measurements at the homes of the participants, ensuring convenience and privacy of the participants. Height was measured using a SECA 213 stand-alone stadiometer in centimetres. Weight was measured using a portable SECA 803 battery-operated electronic weighing scale in kilograms. Participants were asked to remove footwear and avoid holding any heavy objects in their bodies, such as mobile phones, wallets, and heavy belts while taking the measurements.

SECA 201 ergonomic retractable tape was used to measure waist circumference, using the following protocol; firstly the nurses identified and marked the lower palpable margin of the ribs and the upper margin of the iliac crest, and then they marked the midpoints between these margins along the mid-axillary line on both sides. The measurement tape was then wrapped horizontally all around by connecting the marked points on both sides of the participant's body. Similarly, the nurses documented the height to the nearest 0.5 cm, weight to the nearest 10 gm and waist circumference to the nearest 0.1 cm at the end of the normal expiration.

Measurement of blood pressure and pulse rate

The blood pressure (BP) and pulse rate were measured using standard battery-operated automatic BP monitors (OMRON HEM-7120). Before measurement, the participants were seated comfortably in a relaxed upright position for at least five minutes. Appropriate size cuff was used to take two readings of blood pressure and pulse rate three minutes apart.[9] The machine

was switched off between the readings, after recording the systolic BP and diastolic BP in mm Hg and heart rate in beats/minute. If systolic BP readings varied more than ten mmHg or diastolic BP readings varied more than six mmHg, between the two initial measurements, then a third reading was taken. We estimated the final BP by taking the mean of the last two readings.

Biochemical measurements

Nurses gave sample bottles to the participants on the survey day, and they were instructed to collect 20 ml of the second voiding urine sample (after first voiding in the morning and before breakfast) on the day of the blood sample collection for glucose estimation. Urinary sodium was assessed using indirect ion-selective electrode method in an accredited central laboratory. Modified Kawasaki formulae were used to estimate the 24-hour urinary intake of sodium,[10] and it was multiplied by 2.54 to estimate daily salt (sodium chloride) intake as advocated by Johnson et al.[11,12] Capillary blood glucose estimation was done using point of care glucometers (One-touch ultra-easy, Johnson & Johnson) in the fasting stage. We ensured a minimum of eight hours of fasting of the participants before taking samples and recorded the glucose measurements in mg/dl.

Administration of questionnaire and recording of study measurements

Open Data Kit (ODK) software was used to develop custom-made data entry forms, with display both in English and Malayalam (local language), and we used handheld computer tablets for data collection. ODK is a freely available Open Source Software, and we have integrated a utility to run KISH method[6] for selection of participants in the data entry form for the STEPS survey in it. Thirty-four pairs of trained nurses did the field level data collection. They carried the computer tablets, glucometer, weighing machine, stadiometer, measuring tape, and the blood pressure

monitors to the house of the interviewee. After obtaining signed informed consent from the participants on printed forms, the survey team (nurses) used computer tablets with internet facility to gather information and record measurements. They also did random blood glucose estimation of the study participants and gave sample bottles for urine collection with instruction on how to collect the morning samples, which were collected back in the next morning. The data get sent automatically to the institute server via the internet. The process was monitored daily by the district managers and subsequently by the state project management unit, once a week. We used the *ODK Briefcase* utility to download the aggregated data.

Quality control

Two senior public health professionals, with vast experience in the conduct of state-level programs, were entrusted with the field level supervision and monitoring. They were helped by 28 (two per district) middle-level district programme managers. Residential training sessions with hands-on training on data collection (using computer tablets) and standard procedures for the physical and biochemical measurements were conducted for the 34 pairs of nurses at four places (Thiruvananthapuram, Ernakulam, Thrissur, and Kannur) by the same team of investigators to ensure quality and uniform standards. Data collected were checked by the district programme managers for completeness, consistency, and they gave daily feedback to the data collectors. The district programme managers made regular concurrent and consecutive visits to selected households to ensure quality. The ODK utility helped in quality check as we recorded the geo-location and time of the data collection in each household. In addition to the district level monitoring, we monitored the data collection centrally and sent monthly updates to district programme managers and field staff on any incomplete records, missing data or any inconsistencies.

Definitions

Raised BP, raised FBG and daily salt intake

We defined raised blood pressure (BP) as systolic BP≥140 mmHg or diastolic BP ≥90 mmHg or the person currently using antihypertensive medication (self-reported treatment).[13] Similarly, we defined raised fasting blood glucose (FBG) as FBG of ≥126 mg/dl or self-reported treatment for diabetes, pre-diabetes as FBG in the range of 100-125 mg/dl and dysglycemia as those with raised FBG values or pre-diabetes.

Current smoking and alcohol use

We defined current tobacco use as the use of any form of tobacco within the past 30 days[7], and current alcohol use as the intake of at least one standard drink of alcohol in the past 30 days.[7]

Fruits and Vegetable intake

The mean servings of Fruits and Vegetables per day as advocated by WHO.[7]

Daily salt intake

We used the Kawasaki Formula to estimate urinary excretion of sodium from the morning urine sample and multiplied the estimate by 2.54 to get daily salt (sodium chloride) intake.

Physical inactivity

We used the Global Physical Activity Questionnaire (GPAQ) to estimate the total time spent in physical activity and the intensity of the physical activity during a typical week to calculate the physical inactivity. We defined physical inactivity as a combined score of <600 metabolic equivalents (MET) minutes of moderate and vigorous-intensity physical activity in a typical week.[8]

Obesity and overweight

We defined obesity[14] if the body mass index was ≥30 kg/m^2, overweight[14] if the body mass index was in the range of 25-29.99 kg/m^2, and abdominal obesity[15] if the waist circumference was >=90 cm and >=80 cm in men and women respectively.

Clustering of NCD risk factors in participants

Out of the prominent NCD risk factors identified from the previous studies[5], we studied only seven (tobacco use, alcohol use, obesity, abdominal obesity, raised BP, raised blood glucose, and physical inactivity) in this survey, due to logistic limitations. We analysed the pattern of multi-morbidity by estimating the proportions of individuals with no risk factors, anyone risk factor, two risk factors, three risk factors and more than three risk factors.

Statistical analyses

We derived sampling weights based on the probabilities of selection at various stages of sample selection and used the inverse of the product of probabilities of sample selection at different stages in sample weighting. Then we normalised the sampling weights to the total sample size.

We used weighted means with 95% confidence intervals (95%CI) to summarise quantitative variables and percentages with 95%CI to summarise categorical variables and applied variance inflation for cluster correction while estimating 95%CI. We used IBM SPSS Statistics software for Windows version 21 (Armonk, NY, USA: IBM Corp.) and STATA Statistical Software: Release 14. (College Station, TX: Stata Corp LP.) for analysis.

RESULTS

Socio-demographic characteristics

In total, 12,012 adults in the age group of 18-69 years participated in the survey with a response rate of 93.8%. Nearly half (49.3%) of the participants were urban residents, and 63% were

women (Table 1). Mean age was 42.5 years (SD=14.8). The majority (75.7%) have studied up to primary school level or above, and only a third (36.9%) were designated as economically weak, belonging to the Below Poverty Line (BPL) category. Nearly three fourth (73.5%) were married. One of 20 participants (4.8%) was unemployed.

Behavioural risk factors

The rates of use of tobacco and alcohol were low in women. However, the current use of tobacco and alcohol among men were 20.3% (95%CI 18.6-22.1) and 28.9% (95%CI 26.5-31.4) respectively (Table 2). Physical inactivity was reported in 23.7% (95%CI 21.8-25.7) and 20.8% (95%CI 19.0-22.8) of men and women, respectively. The average consumption of fruits was only one serving per day among men, women, urban and rural residents, and the intake of vegetables was two servings per day across these subgroups (Table 3). There were no significant differences in the rates of alcohol consumption, tobacco use, physical inactivity, and consumption of fruits and vegetables between urban and rural residents (Table 2 & 3). The mean salt intake among the participants was 6.7 gm/day (95%CI 6.6-6.8). Table 3 shows that there was no rural-urban difference, but women had significantly higher salt intake (7.5 gm/day) compared to men (5.3gm/day).

Prevalence of raised BP and raised FBG

The weighted means systolic BP were 129.4 mmHg (95%CI 128.6-130.1) among men and 125.0 mmHg (95%CI 124.3-125.6) among women (Table 3). Similarly, the average diastolic BP was 82.6 mmHg (95%CI 82.1-83.1) in men and 79.7 mmHg (95%CI 79.3-80.0) in women. Prevalence of raised BP was 34.6% (95% CI 32.6-36.7) in men and 27.9% (95% CI 26.4 to 29.4) in women (Table 2). There was no rural-urban difference in systolic or diastolic BP. Mean FBG

was 108.6 mg/dl, and there were no men-women or rural-urban difference for this parameter (Table 3). One in five, 19.8% (95%CI 18.2-21.6) of men and 18.8% (95%CI 17.4-20.2) of women, had raised FBG values, and there was no rural-urban difference (Table 2). Additionally, 36% of men and 35% of women were in the pre-diabetes stage. No rural-urban differences were present in the rates of raised BP, raised FBG, and two in five adults (40%; 95%CI 38.6-41.3%) had either raised BP or raised FBG.

Among those with a history of hypertension, only 12.3% (95%CI 10.9-14.0) had their BP values under control (systolic BP<140 mmHg and diastolic BP <90 mmHg). The control rate in men (7.9%; 95%CI 6.4-9.7) was less than the control rate in women (15.6%; 95%CI 13.5-18.0); similarly, the control rates among rural residents (11.5%; 95%CI 9.8-13.5) were less than the urban counterparts (15.9%; 95%CI 13.6-18.4).

Among those hypertensives who claimed to be under treatment, 34.1% had their BP under control (28.6% in men, 36.8% in women, 37.4% in urban residents and 33.2% in rural residents); the men-women or rural-urban differences were not statistically significant.

Among those with a history of diabetes, 15.3% (95%CI 13.1-17.8) had their Blood Sugar under control (fasting plasma glucose <126 mg/dl) and among those who claimed to be under treatment, 31.1% (95%CI 27.1-35.4) had their Blood Sugar under control. There was no significant men-women difference, but the urban residents were found to have better control (17.0%; 95%CI 13.9-20.6) compared to rural residents (14.9%; 95%CI 12.3-17.9).

Body mass index, waist circumference, and obesity

The mean BMI was 24.2 kg/m^2 (95%CI 24.1-24.4) with statistically significant higher BMI for women and urban residents, though the magnitude of the difference was negligible (Table 3).

The weighted mean waist circumference (Table 3) was significantly higher for urban residents (88.2 cm; 95%CI 87.6-88.8) compared to rural residents (85.8 cm; 95%CI 85.3-86.3). Overweight was higher among urban residents (33.5%) and women (31.6%) compared to rural residents (29.7%), and men (28.2%) respectively (Table 2). Similarly, abdominal obesity was higher for women (72.6%) and urban residents (67.4%) compared to men (39.1%) and rural residents (58.6%) respectively (Table 2).

Clustering of NCD risk factors

Only 20.4% (95%CI 18.5-22.3) of men and 16.5% (95%CI 14.9-18.1) of women were free of any of the seven NCD risk factors studied, tobacco use, alcohol use, obesity, abdominal obesity, raised BP, raised blood glucose, or physical inactivity (Figure 2). Proportion with an isolated risk factor (35.3%) was less frequent than those with multiple risk factors (47.1%), and this trend was same for all categories like men (27.8% *vs* 41.8%), women(38.5% *vs* 45%), rural residents (35.9% *vs* 45.7%) and urban residents (32.7% *vs* 53.5%). Three or more risk factors were present in 20.9%, and four or more NCD risk factors were present in 6.4% of the participants.

DISCUSSION

This study found that most adults (82.4%) of 18-64 years age group in our sample had at least one of the NCD risk factors, and multiple risk factors were present in 47.1%. Raised BP and raised FBG were present in 30.4% and 19.2% of adults in Kerala. Overweight prevalence was as high as 30.4%, and 60.2% had abdominal obesity, which was significantly higher for the woman. Moreover, dysglycemia (raised FBG and pre-diabetes together) was found to be present among 54.5% of the adult population.

The prevalence of hypertension was found to be comparable with the rates for Thiruvananthapuram in 2010 by Thankappan *et al.* (28.8%)[5] but less than the rate by Sathish *et al.* (43.2%).[16] The hypertension prevalence of adults in Kerala of 18-64 years was similar to the rates of urban residents of higher age group (30-64 years) in Tamil Nadu (28.5%).[17] Hypertension prevalence in Kerala was similar to the estimates of the meta-analysis by Anchala *et al.* for the urban south India (31.8%).[18]

Prevalence of raised FBG in Kerala was higher than the diabetes prevalence in urban Delhi (18.1%).[19] Prevalence of dysglycemia in more than half (54.5%) of the adult population poses a challenge to the existing health care system, to maintain the diseases at the current level and to manage their complications. The increasing behavioural risk factors[16] even among the tribal communities,[20] and higher conversion rate of pre-diabetes to diabetes among Indians[21] could be the reason for this much increase in raised FBG.

There could be underreporting of some of the behavioural risk factors, especially alcohol intake as much public debate is going on in the state since 2015 on curtailing the availability of liquor in the state.[22] The weighted mean salt intake in this study (6.7 g/day) was lower compared to the estimate for Delhi, Haryana, and Andhra Pradesh, reported by Johnson *et al*[23] in 2017. The low levels could be partially due to methodological differences, as we have not inflated the values for non-urinary losses of salt as done by Johnson *et al*.[11] Further the mean salt intake was found to be more in women in Kerala (Table 3) compared to studies elsewhere.[11,23,24] There are methodological controversies regarding use of spot urine for the estimation of 24 hour sodium excretion[25] (using Kawasaki formulae) and the apparently low intake of salt in Kerala (compared to other states) needs further research as this hard evidence for salt intake could be the first

indication of reversal of NCD risk factors in Kerala. However, more evidence is needed to substantiate such explanations.

Raised BP or raised FBG, present in over 40% of the adult population are significant contributors to cardiovascular disease mortality. Clustering of multiple risk factors, a finding reported by other studies from India[26] increases the risk of developing a significant NCD condition or event shortly. NCD risk factors are identified to be associated with the social disparity in India[27] and other Asian countries[28] as in the western population.[29,30] The proportion of known hypertensives with normal BP found in this study (12.3%) was low compared to the rates from Iran (49.1%),[31] the United States of America (48%)[32] and China (18%).[33] Similarly, the proportion diabetic with FBG values within normal limits was also low in this study (15.3%) compared with the improved rates of control found in the western countries; they could achieve 20% control among people with hypertension and diabetes.[34]

Mounting evidence on the reduction in NCD risk factors with concerted public health action in other countries[35,36] gives a positive impetus to the current strategy for NCD risk reduction efforts in Kerala. Hence, the policy action to address the future NCD burden should focus not only on single risk factors but also on several of them simultaneously at the population level. The cumulative effect of acting on multiple risk factors may reduce the total risk substantially and thus avert several future NCD events.

In addition to primary care, provision of drugs and lifestyle counselling for high-risk individuals is necessary to address the rising burden of cardiovascular events.[37] However, we do not have enough evidence on the feasibility of such an approach in middle-income countries.[38] Moreover, in Kerala, despite the high literacy rate and the success stories of implementation research in cardiovascular risk factors,[39-41] we have the situation of higher prevalence and poor

control of hypertension and diabetes. Further in-depth research using qualitative methods might help us to understand these dilemmas.

Strengthening the primary care in Kerala, with a focus on addressing NCD risk factors and providing universal access to anti-hypertensive and anti-diabetic medicines to all eligible patients should be a high priority for the Government of Kerala to limit the future burden of NCDs. The study is timely as the results could be used for Universal Health Coverage initiative in Kerala, wherein the government is upgrading many peripheral hospitals to Family Health Centres, with additional inputs in staff and facilities. The high prevalence of NCD risk factors in Kerala calls for urgent policy action for primary and secondary prevention.

Strengths and limitations of the study

We did a sizeable state-wide study on NCD risk factors in Kerala, using trained nurses, standard equipment, validated research tools and modern utilities like handheld computer tablets. The use of the WHO STEPS framework for the questionnaire enables the comparison of studies done within India and abroad.[7] Use of mobile data entry platforms, as we did in this study, are proven to improve the quality and timeliness of STEPS surveys.[7,42] We had taken the third reading of BP only when the difference in systolic BP of the earlier two readings[9] was >10 mmHg and that of diastolic BP >6 mmHg (we did third reading in only 18.2% of participants), which is a deviation to the WHO STEPS guidelines[7] that insists on taking three readings for everyone. We state this as a limitation of the study. We could not do serum cholesterol and hip circumference measurements due to logistic limitations, but they are not the core features of the first two phases of STEPS guidelines.[43] To our knowledge, no other published study on NCD

risk factors in Kerala in the recent past, including those by the same group of researchers, were done on a state-wide scale.

CONCLUSION

About 40% of the adult population in Kerala had either raised BP or raised FBG, and the overall control rates for these conditions were as low as 12.3% and 15.3% respectively. Majority of the adult population (83.4%) had at least one NCD risk factor, and clustering of risk factors was very common. The high prevalence of NCDs and their risk factors in Kerala calls for urgent policy action for prevention at all levels.

Table 1. General characteristics of the study population

Variables	Male (N=4472)	Female (N=7537)	Total (N=12,012)*
Age in years, mean (SD)	42.42(15.38)	42.58(14.45)	42.52 (14.8)
Age groups, n (%)			
18-44	2263(50.60)	4114(54.58)	6380(53.11)
45-69	2209(49.40)	3423(45.42)	5632(46.89)
Residence			
Rural	2305(51.54)	3782(50.18)	6087(50.67)
Urban	2167(48.46)	3755(49.82)	5925(49.33)
Education			
Up to primary school	1002(22.41)	1914(25.39)	2916(24.28)
Secondary to High school	2281(51.01)	3645(48.36)	5928(49.35)
>high school	1189(26.59)	1978(26.24)	3168(26.37)
Social groups			
Below poverty line	1633(36.52)	2796(37.10)	4431(36.89)
Above poverty line	2730(61.05)	4555(60.44)	7286(60.66)
Others	109(2.44)	186(2.47)	295(2.46)
Marital status			
Never married	1140(25.49)	954(12.66)	2095(17.44)
Married	3242(72.50)	5579(74.02)	8823(73.45)
Others	90(2.01)	1004(13.32)	1094(9.11)
Occupation			
Officers and professionals	688(15.38)	536(7.11)	1224(10.19)
Self-employed	1286(28.76)	262(3.48)	1549(12.90)
Skilled labourer	703(15.72)	86(1.14)	789(6.57)
Unskilled labourer	490(10.96)	232(3.08)	723(6.02)
Unemployed	413(9.24)	161(2.14)	574(4.78)
Students	617(13.80)	773(10.26)	1390(11.57)
Others	275(6.15)	275(72.80)	5763(47.98)

*3 participants were trans-genders

Table.2: Prevalence of NCD risk factors in the study population

Variables	Weighted percentage and 95% CI	Weighted percentage and 95% CI by sex		Weighted percentage and 95% CI by area of residence	
	Total (N=12012)	Male (N=4472)	Female (N=7537)	Urban (N=6087)	Rural (N= 5925)
Current tobacco use	7.9 (7.2-8.7)	20.3 (18.6-22.1)	0.6 (0.4-0.9)	7.2 (6.0-8.6)	8.1 (7.2-9.0)
Current alcohol use	8.7 (7.9-9.6)	28.9 (26.5-31.4)	0.2 (0.1-0.4)	8.9 (7.6-10.3)	8.7 (7.7-9.7)
Physical inactivity (< 600 MET* minutes per week)	21.9 (20.4-23.5)	23.7 (21.8-25.7)	20.8 (19.0-22.8)	23 (20.8-25.3)	21.7 (20.0-23.5)
Overweight	30.4 (29.1-31.7)	28.2 (26.2-30.3)	31.6 (30.0-33.3)	33.5 (31.5-35.4)	29.7 (28.2-31.2)
Obesity	8.9 (8.1-9.7)	5.5 (4.6-6.5)	10.9 (9.9-12.0)	11.2 (9.9-12.7)	8.4 (7.5-9.3)
Abdominal obesity	60.2 (58.5-61.8)	39.1 (36.6-41.7)	72.6 (70.7-74.5)	67.4 (65.0-69.7)	58.6 (56.6-60.5)
Raised blood pressure†	30.4 (29.1-31.7)	34.6 (32.6-36.7)	27.9 (26.4-29.4)	33.1 (31.3-34.9)	29.8 (28.3-31.3)
Raised FBG‡	19.2 (18.1-20.3)	19.8 (18.2-21.6)	18.8 (17.4-20.2)	19.8 (18.1-21.6)	19 (17.7-21.4)
Pre-diabetes	35.3 (33.6-37.1)	36.1 (33.7-38.4)	34.9 (32.8-37.0)	31.7 (29.6-33.9)	36.1 (34.0-38.2)

*MET = metabolic equivalents

†Numerator includes people with raised blood pressure and those who were under treatment (self-reported) for hypertension.

‡ FBG = fasting blood glucose; numerator includes people with raised fasting blood glucose values and those who were under treatment (self-reported) for diabetes.

All estimates and 95% CI were adjusted for 1387 clusters

Table.3: Mean levels of risk factors (weighted means) in the study population

Variables	Weighted mean and 95% CI Total (N= 12012)		Weighted mean and 95% CI by sex Male (N=4472)		Female (N= 7537)		Weighted mean and 95% CI by area of residence Urban (N=6087)		Rural (N= 5925)	
Systolic BP in mmHg	126.6	(126.1-127.1)	129.4	(128.6-130.1)	125	(124.3-125.6)	126.6	(125.8-127.2)	126.6	(126.0-127.2)
Diastolic BP in mmHg	80.8	(80.4-81.1)	82.6	(82.0-83.1)	79.7	(79.3-80.0)	80.9	(80.5-81.4)	80.7	(80.3-81.1)
FBG in mg/dl	108.6	(107.4-109.7)	108.9	(107.2-110.5)	108.4	(107.0-109.7)	108.4	(106.4-110.3)	108.6	(107.3-109.9)
Fruit intake (servings/day)	1.1	(1.0-1.1)	1.1	(1.0-1.2)	1	(0.9-1.0)	1	(0.9-1.0)	1.1	(1.0-1.1)
Vegetable intake (servings /day)	2	(1.9-2.1)	2	(1.8-2.0)	2	(1.9-2.1)	1.9	(1.7-2.0)	2	(1.9-2.1)
Mean vegetable and fruit intake (servings/day)	1.5	(1.4-1.6)	1.5	(1.4-1.6)	1.5	(1.4-1.6)	1.4	(1.3-1.5)	1.6	(1.5-1.6)
Salt (sodium chloride) intake, (g/day)	6.7	(6.6-6.8)	5.3	(5.2-5.4)	7.5	(7.4-7.6)	6.6	(6.4-6.7)	6.7	(6.6-6.8)
Body mass index in kg/m^2	24.2	(24.1-24.4)	23.6	(23.5-24.0)	24.5	(24.3-24.7)	24.9	(24.7-25.1)	24.1	(23.9-24.2)
Waist circumference in cm	86.2	(85.8-86.6)	86.4	(85.5-86.9)	86.1	(85.6-86.6)	88.2	(87.6-88.8)	85.8	(85.3-86.3)

CI= Confidence Interval, BP = blood pressure, FBG =fasting blood glucose, cm= centimetres, kg= Kilogram, mmHg= millimetres of mercury, mg/dl = milligram/decilitre, g/day = gram per day; All estimates and 95% CIs are adjusted for 1387 clusters

Figure legends

Figure 1: Study sample selection flow-chart

Figure 2. Clustering of NCD risk factors in the study population

A. Contributorship statement

Sankara Sarma contributed to the design, data analysis, data interpretation and reviewing the manuscript; Rajeev Sadanandan contributed to the concept, data interpretation and reviewing the manuscript; Jissa Vinoda Thulaseedharan contributed to the design, data analysis, drafting and reviewing the manuscript; Biju Soman contributed to the design, data acquisition, data analysis, data interpretation, drafting and reviewing the manuscript; K Srinivasan contributed to the design, data interpretation and reviewing the manuscript; Ravi Prasad Varma contributed to the design, data analysis, data interpretation and reviewing the manuscript, Manju R Nair contributed to the design, data analysis, data interpretation and reviewing the manuscript; AS Pradeepkumar contributed to the design, data acquisition, data analysis, data interpretation and reviewing the manuscript; Panniyammakal Jeemon contributed to the data analysis and data interpretation, drafting and reviewing the manuscript; KR Thankappan contributed to the concept, data acquisition, data interpretation and reviewing the manuscript; V Raman Kutty contributed to the concept, data interpretation and reviewing the manuscript.

B. Competing interest

We declare that there were no competing interests.

C. Data Sharing statement

This article is the first paper from the research work. We are still working on the data, and the data will be made available soon. Meanwhile, we shall share the data on request for legitimate use.

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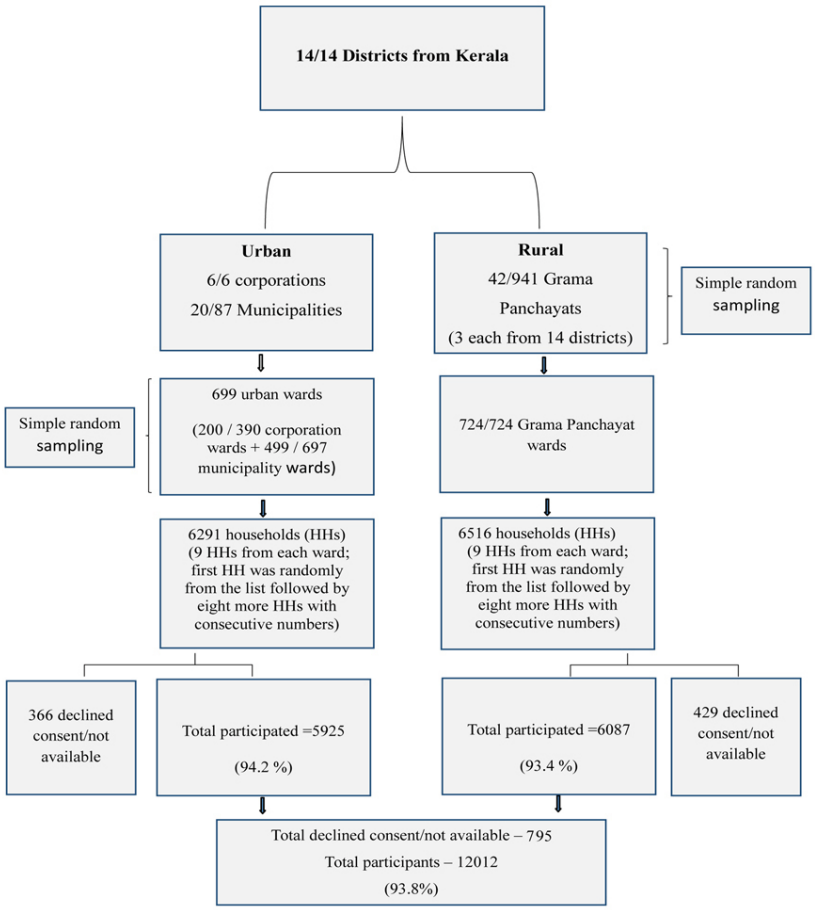

Figure 1: Study sample selection flow-chart

90x90mm (300 x 300 DPI)

Figure 2. Clustering of NCD risk factors in the study population

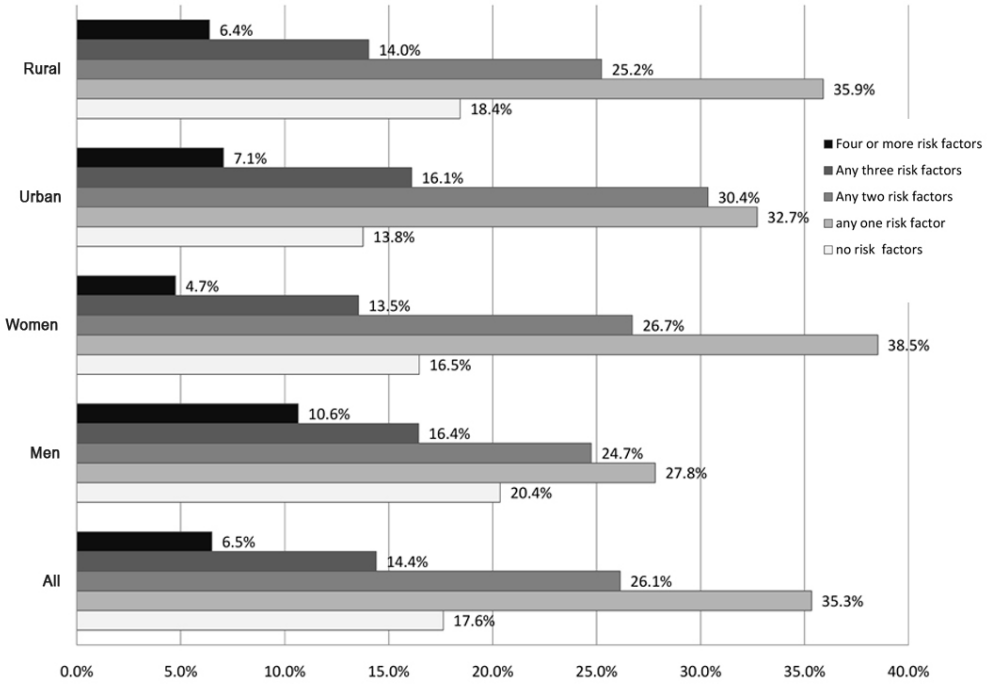

Figure 2: Clustering of NCD risk factors in the study population

90x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	*9*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	11
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11
		(*e*) Describe any sensitivity analyses	11
Results			12-14

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12, Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	12
Outcome data	15*	Report numbers of outcome events or summary measures	12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	12-14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	17,18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Cuschieri S. The STROBE guidelines. *Saudi J Anaesth* 2019;**13**:S31–4. doi:10.4103/sja.SJA_543_18