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Risk factors for cardiovascular disease in rural South India: cohort study

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ABSTRACT

Background and objectives Cardiovascular diseases (CVD) accounted for one-third of the deaths in India. We conducted a cohort study to estimate the incidence of CVD and the association of established risk factors with the incident CVD in a rural population in South India.

Design, setting and participants We conducted a community-based cohort study among 6026 adults aged 25–64 years in five villages in Tiruvallur, Tamil Nadu. We did baseline (2005–2007) and two follow-up surveys in 2008–2009 and 2013–2015. Risk factors studied were tobacco, alcohol, hypertension, self-reported diabetes and central obesity.

Outcome measures Outcome measures were fatal or non-fatal ischaemic heart disease or cerebrovascular event. We estimated HRs for the risk factors and population attributable fraction (PAF).

Results We followed up 5641 (94.4%) subjects, and follow-up duration was 33 371 person years. The overall incidence of cardiovascular event or death was 4.6 per 1000 person years. Current smoking (HR 1.6, 95% CI 1.1 to 2.6) and hypertension (HR 2.2, 95% CI 1.5 to 3.4) were the risk factors among men and accounted for 47% of the PAF. Among women, hypertension (HR 1.8, 95% CI 1.0 to 3.4), self-reported diabetes (HR 4.3, 95% CI 2.2 to 8.1) and central obesity (HR 2.2, 95% CI 1.2 to 4.0) were associated with CVD and accounted for more than half of the PAF.

Conclusions We described the high burden of fatal CVD and identified the role of CVD risk factors such as hypertension, self-reported diabetes, smoking and central obesity. There is an urgent need to implement low-cost interventions such as smoking cessation and treat hypertension and diabetes in primary care settings.

Strengths and limitations of this study

- Our study is one of the few cohort studies on cardiovascular risk factors in a rural population in South India.
- We had a high response rate and uniform tools for data collection for all the visits.
- Behavioural risk factors namely diet and physical activity were not included in any of the surveys.
- Diabetes was self-reported and fasting glucose or glycated hemoglobin (HbA1c) could not be done to confirm diabetes.
- Cardiovascular disease events were recorded based on clinical records or prescription; however, we might have missed the CVD diagnosis for patients who did not have any records or did not report any treatment.

INTRODUCTION

Globally, cardiovascular disease (CVD) are the leading cause of death. Although there was a decline in the CVD mortality between 1990 and 2015 in most of the high-income and middle-income countries, trend was not similar in low-income countries.[1] CVD mortality among the South Asian population (369/100 000) was higher than the global average (286/100 000) in 2015.[1] Since there are many risk factors for CVD, it is challenging for policy-makers and public health planners to achieve progress across all the risk factors. Reduction in cardiovascular mortality would require prioritisation of risk factors in the context of the locally available data. High systolic blood pressure (BP) and smoking were the leading risk factors contributing to disability adjusted life years (DALYs) in 2016.[2] A multisite case-control study with participants from 52 countries established the role of nine risk factors such as smoking, abdominal obesity, self-reported diabetes and hypertension which accounted for 90% of the population attributable risk (PAR) among men and 94% among women.[3]

CVD accounted for 28% of the deaths in India.[4] Ischaemic heart disease was ranked sixth in terms of DALY in 1990; however, it became the leading cause in 2016. Similarly, DALY due to stroke rose from 12th place to 5th place from 1990 to 2016.[4] High systolic BP was the fourth leading risk factor contributing to DALY in India in 2016.[5] Although there is ample data on the burden of risk factors such as hypertension in the Indian population, there are few cohort studies which explored the relationship between the risk factors such as hypertension and CVD among Indians.[6 7]

Tamil Nadu is one of the southern states in India at an advanced level of epidemiological transition. CVDs accounted for 40%

of the deaths among adults over 40 years in 2016. Ischaemic heart disease was the leading cause of years of life lost due to premature mortality in Tamil Nadu in 2016.[4 5] There is ample evidence regarding the high burden of noncommunicable disease (NCD) risk factors in the rural Tamil Nadu; however, there are limited data from longitudinal studies regarding CVD incidence and risk factors.[7] We had earlier reported a high prevalence of obesity, smoking and hypertension in a rural population in Tiruvallur district, Tamil Nadu.[8 9] We conducted a cohort study in the same community to estimate the incidence of CVD and the association of established risk factors with the incident CVD in a rural South India.

METHODS

Study design and setting

Tamil Nadu is one of the southern states in India with good health infrastructure and favourable health indicators. We conducted a community-based cohort study in five villages in district Tiruvallur, Tamil Nadu. All adults aged 25–64 years were considered eligible for the study at the baseline as per WHO STEPwise approach to Surveillance (STEPS) guidelines.[10] We purposely selected the villages considering the access and feasibility of long-term follow-up. We collected data at baseline (2005–2007) and did two follow-up surveys in 2008–2009 and 2013–2015.

Sample size

We surveyed all eligible adults in the age group of 25–64 years at the baseline in the five villages. As we did not calculate the sample size for various risk factors at the baseline, we did power calculation to estimate if the sample size was adequate to analyse CVD outcomes for the risk factors separately among men and women. We used the input data of disease incidence among the individuals exposed to specific risk factors. The sample size was adequate, as the power for smoking, hypertension, self-reported diabetes and current alcohol consumption was 99%, 100%, 58% and 74%, respectively, for men. Similarly, the power was 100% for women for all the three risk factors, namely hypertension, self-reported diabetes and central obesity.

Risk factors

We collected data for risk factors such as age, education, tobacco use, alcohol consumption, self-reported hypertension and self-reported diabetes using a structured questionnaire.

Tobacco use: current smoker was defined as a person who had smoked at least 100 cigarettes over his/her lifetime and continued to smoke at the time of survey daily or occasionally. An ex-smoker was the one who had quit smoking.[11] Current smokeless tobacco use was defined as the daily of occasional use of any form of smokeless tobacco at the time of the survey.

Current alcohol consumption: current consumer was defined as the consumption of alcohol in the previous 12 months. The past consumer was alcohol consumption before the previous 12 months.[12]

Hypertension: we measured the BP in the right arm after sitting for at least 5 min using a digital automatic BP apparatus (Omron MX3) as recommended in WHO STEPS manual.[10] We recorded the average of the two readings taken 5 min apart. The definition of hypertension at baseline survey was systolic BP ≥140 mm Hg or diastolic BP ≥90 mm Hg as per WHO criteria or history of the previously diagnosed disease.[13]

Central obesity: we measured waist circumference (WC) to the nearest 0.1 cm at the narrowest point between the lower end of the rib cage and iliac crest. Field investigators were trained to do WC as per the standard protocol. Privacy was maintained for female respondents while doing WC measurements. Female investigators did the measurements inside the house for female respondents during the door-to-door survey. We defined central obesity as WC ≥90 cm for men and WC ≥80 cm for women.[14]

Outcome measures

Incident CVD was the occurrence of fatal or non-fatal ischaemic heart disease, acute myocardial infarction or cerebrovascular event. We reviewed the clinical records, hospital discharge summaries and prescriptions to establish the diagnosis of ischaemic heart disease or cerebrovascular disease. As the study villages were approximately 30–50 km from a major metropolitan city, Chennai; most patients sought care in the tertiary care facilities in Chennai. The area has a primary healthcare centre, which provides treatment for hypertension and diabetes; however, CVD cases are referred to tertiary care hospitals in Chennai.

We also examined the death certificate, if available. We conducted verbal autopsy using a validated tool for all the deaths in the cohort during follow-up visits.[15] The tool includes questions regarding various symptoms, history of pre-existing diseases, prior treatment history and detailed narrative section. We classified the events and deaths in International Classification of Diseases. We defined CVD according to the ICD codes I20–I25 (ischaemic heart disease) and I60–I69 (cerebrovascular disease).[16] We referred patients with newly detected hypertension to the closest primary health centre for further management. We referred the patients with diagnosed ischaemic heart disease or stroke to the nearest tertiary care health facility.

Statistical analysis

The outcome measure was the first event of CVD or CVD death. The overall incidence of CVD per 1000 person years was computed. Person time defined as the date of the baseline survey to either date of last survey or date of death. Cox proportional hazards regression model was done for each risk factor independently in model 1 and adjusted for baseline age as a continuous variable in model 2. In model 3, we included all the risk factors in addition to age as a continuous variable and interactions.

We calculated HRs with 95% CI, and p values for each of the risk factors.

We computed population attributable fraction (PAF) with 95% CIs for various risk factors individually and cumulatively based on the adjusted HR.[17] PAF is the fraction of disease risk which can be potentially eliminated from the population if the risk factor is removed. All analyses were performed using Stata, V.13.0.[18]

Patient and public involvement

We did the surveys in the field practice area of our institution in Tiruvallur district. While doing surveys for various infectious diseases, community members informed the field staff about many deaths due to heart attacks and lack of adequate health facilities to seek treatment. We discussed with the community regarding their willingness to participate in the research involving repeat surveys for cardiovascular risk factors and received positive feedback. We counselled the patients with hypertension, diabetes and CVD for lifestyle modification and treatment during the surveys. We shared the information about the high burden of untreated hypertension and other risk factors with the community members and local health authorities after completing the surveys. Government of Tamil Nadu has strengthened the rural public sector health facilities catering to the study population in terms of services and drugs for hypertension and diabetes over the past decade.

RESULTS

At baseline, we surveyed 6026 (90.8%) subjects among 6639 eligible adults aged 25–64 years in the study villages. The reasons for non-response were absence after three visits (597 (9.0%)), pregnancy (6 (0.09%)), refusal (3 (0.05%)) and physically handicapped (7 (0.1%)) We excluded 48 subjects who reported CVD at the baseline and followed up the remaining study participants. Among 5978 subjects in the cohort, we followed up 5641 (94.4%) subjects during two follow-up visits. The primary reason for loss to follow-up was migration from the study villages. Total follow-up duration was 33 371 person years, and the median duration of follow-up was 7 years. There was a total of 96 deaths (79 ischaemic heart disease and 17 cerebrovascular disease) and 58 events (46 ischaemic heart disease and 12 cerebrovascular disease) due to CVD. The overall incidence of CVD event or death was 4.6 per 1000 person years. Among them, the incidence of CVD death was 2.9 per 1000 person years, and CVD event was 1.7 per 1000 person years. Overall incidence was higher among men as compared with women (7.2 vs 2.7 per 1000 person years).

We surveyed 2570 men and 3071 women at the baseline. The baseline characteristics of the participants with and without CVD are presented in tables 1 and 2. Overall, 66.6% of the study participants were below 45 years. Among men, 36.6% had ≤5 years of school education, 34.9% were smokers, 28.6% were alcohol user and 20.2% were centrally obese. Among women, 66.5% had ≤5 years of school education, 59.2% did not engage in any paid work, 43% were smokeless tobacco users and 26.4% were centrally obese. Hypertension was prevalent in one-fifth (21.6%) of the men and women, and 4.0% had self-reported diabetes (tables 1 and 2).

We estimated the unadjusted HR for education, occupation, smoking, current alcohol consumption, hypertension, self-reported diabetes and central obesity among men. Lack of school education or less than 6 years of school education and farmer/manual labour were associated with CVD; however, it was not significant after adjusting for age. Current smoking was associated with a 1.6-fold increased risk of CVD after adjusting for all other risk factors. Current alcohol consumption was associated with 1.7-fold increased risk in model 2; however, HR (1.3, 95% CI 0.9 to 2.0) was not significant after adjusting for other risk factors. There was a twofold increased risk of the disease due to hypertension in model 3 (HR 2.2, 95% CI 1.5 to 3.4). Self-reported diabetes and central obesity were not significantly associated with the outcome after adjusting for age. We also examined the interaction effect of central obesity and hypertension/diabetes for CVD. The interaction effect was not statistically significant. Among men, hypertension (24.0%) and smoking (23.4%) had high PAF (table 3).

We estimated the unadjusted HR for education, occupation, smokeless tobacco use, hypertension, self-reported diabetes and central obesity among women. The level of education and lack of paid work were not associated with CVD. The HR for hypertension was 1.8 (95% CI 1.0 to 3.4) after adjusting for all risk factors. The HR adjusted for age and all other risk factors for self-reported diabetes and obesity was 4.3 (95% CI 2.2 to 8.1) and 2.2 (95% CI 1.2 to 4.0), respectively. Similar to men, there was no interaction effect of central obesity and hypertension/diabetes for CVD. The major risk factors accounted for 69% of the disease (table 4).

DISCUSSION

We examined the role of various cardiovascular risk factors in a rural cohort in South India. Our study had a high response rate, uniform tools for data collection in all the visits and the same team of interviewers throughout the study, which ensured high quality of data and good rapport with the community. Although there are sufficient data regarding the high NCD risk factor burden in South India, there are only two longitudinal studies from urban India which documented the role of established risk factors such as hypertension in causing CVD.[6 7] Our research is unique as it documented the CVD incidence and role of risk factors in the context of epidemiological transition in the rural population in the previous decade.

One of the critical observation was that nearly two-thirds of the CVD events were fatal in the study population. A multisite prospective urban rural epidemiology (PURE) cohort study reported high fatality among patients with CVD in low-income (six times) and middle income

Table 1 Person years of follow-up and proportion with and without cardiovascular disease (CVD) in the risk factors categories among men, Tiruvallur, India

Risk factors	Follow-up duration (total—14 510 person years)	CVD (n=104)		No CVD (n=2466)	
		n	%	n	%
Age group (years)					
25–34	5288.5	12	11.5	905	36.7
35–44	4545.5	26	25.0	769	31.2
45–54	3259.0	34	32.7	547	22.2
55–64	1417.0	32	30.8	245	9.9
Education					
Not attended school	1785.0	22	21.2	299	12.1
1–5 years of school education	3407.5	35	33.7	585	23.7
6–8 years of school education	3269.5	19	18.3	552	22.4
9–12 years of school education and above	6048.0	28	26.9	1030	41.8
Occupation					
Farmer owns land	907.5	14	13.5	134	5.4
Labourer	8140.5	61	58.7	1393	56.5
Salaried employee/self-employed	5462.0	29	27.9	939	38.1
Smoking					
Non-smoker	9589.0	48	46.2	1624	65.9
Current smoker	4921.0	56	53.8	842	34.1
Alcohol consumption					
No	10 471.5	62	59.6	1774	71.9
Yes	4038.5	42	40.4	692	28.1
Hypertension					
Present	3051.0	47	45.2	509	20.6
Absent	11 459.0	57	54.8	1957	79.4
Diabetes (self-reported)					
Present	552.5	9	8.7	95	3.9
Absent	13 957.5	95	91.3	2371	96.1
Central obesity					
Obese	2924.0	26	25.0	493	20.0
Normal	11 586.0	78	75.0	1973	80.0

(three times) countries as compared with high-income countries.[19] High fatality in the context of the scarce resource as observed in our study setting might be due to a combination of lack of control of the risk factors and lack of access to timely emergency care. A global monitoring framework has been adopted to monitor the implementation of interventions for NCD, including CVD. The primary outcome indicator is a 25% relative reduction in the premature mortality from NCD (CVDs, cancer, diabetes or chronic respiratory diseases).[20] A multipronged strategy with a combination of community-based interventions targeting the risk behaviours and health systems strengthening might improve the treatment coverage and reduce the CVD burden in India. Our study reinforced the importance of modifiable risk factors in the context of high CVD burden in India. In a subgroup analysis of a case-control INTERHEART study, among South Asians, four risk factors namely hypertension (19.3%), self-reported diabetes (11.8%), smoking (37.5%) and central obesity (37.7%) were associated with high PAR for myocardial infarction.[21] We observed a similar pattern for hypertension and smoking. Central obesity and self-reported diabetes were related to high PAR only among women in our cohort. We can nearly prevent half of the CVD by reducing the burden of these modifiable risk factors in the study population.

Hypertension emerged as one of the significant risk factors for CVD in the rural population in South India. Mumbai cohort study demonstrated that hypertension nearly doubled the risk of circulatory system deaths in

Table 2 Person years of follow-up and proportion with and without cardiovascular disease (CVD) in the risk factors categories among women, Tiruvallur, India

Risk factors	Follow-up duration (total—18861 person years)	CVD (n=50)		No CVD (n=1057)	
		n	%	n	%
Age group					
25–34	6606.0	4	8.0	1057	35.0
35–44	6001.0	9	18.0	965	31.9
45–54	3889.5	14	28.0	609	20.2
55–64	2364.5	23	46.0	390	12.9
Education					
Not attended school	6422.0	23	46.0	1038	34.4
1–5 years of school education	6096.5	15	30.0	965	31.9
6–8 years of school education	3362.5	6	12.0	537	17.8
9–12 years of school education and above	2980.0	6	12.0	481	15.9
Occupation					
Employed	7751.5	13	26.0	1239	41.0
No paid work	11109.5	37	74.0	1782	59.0
Smokeless tobacco use					
Present	2765.5	10	20.0	464	15.4
Absent	16095.5	40	80.0	2557	84.6
Hypertension					
Present	3738.5	28	56.0	606	20.1
Absent	15122.5	22	44.0	2415	79.9
Diabetes (self-reported)					
Present	747.5	15	30.0	119	3.9
Absent	18113.5	35	70.0	2902	96.1
Central obesity					
Obese	4869.0	28	56.0	784	26.0
Normal	13992.0	22	44.0	2237	74.0

an urban community.[6] A cohort study from Chennai—a large metropolitan in Tamil Nadu—reported that an increase of 20 mm Hg systolic BP was associated with a relative risk of 2.45 and 1.74 for stroke and cardiac mortality, respectively.[7]

Our study reiterates the importance of hypertension management and control for the urban and for the rural populations. Combination of high prevalence (21.4%) and poor control (6.6%) in the study population was already reported in 2006.[9] Poor hypertension control might have been one of the primary reason for cardiovascular events in our cohort. Hypertension is a high priority risk factor in the context of India, which is home to 200 million adults with raised BP among nearly a billion adults with elevated BP globally. Mean systolic BP of South Asian population, including India, showed an upward trend over the past decades, unlike high-income western countries.[22] The rising trend is contrary to the goal of 25% relative reduction of raised BP by 2025.[20] There is ample evidence regarding the efficacy of BP control in reducing CVD mortality. A global perspective studies collaboration involving a million participants estimated a 50% reduction in coronary heart disease (CHD) mortality for 20 mm Hg decline in the systolic BP across 40–69 years of age.[23] The treatment of raised BP with low-cost affordable drugs is one of the cost-effective intervention for low-resource settings and should be scaled up rapidly to reduce CVD mortality.[24]

Smoking was one of the main risk factors for CVD among men in our study. A pooled analysis of 40 cohort studies from the Asia Pacific region concluded that smoking was a risk factor for CHD and stroke. The risk of CHD was 1.6-fold and haemorrhagic stroke 1.2-fold among smokers as compared with non-smokers, risk being higher among the population from Australia/New Zealand as compared with Asians.[25] Among South Asians in INTERHEART case-control study, smoking was associated with nearly 2.5-fold increased odds of myocardial infarction.[21] Given the available evidence, smoking should continue to be a priority area for public health interventions to reduce the

Table 3 Cardiovascular disease risk factors and population attributable fraction (PAF) for various risk factors among men, Tiruvallur, India

Factors	HR (95% CI) Unadjusted	HR (95% CI) Age adjusted	HR (95% CI) All adjusted	PAF(95% CI) (%)
Age group				
25–34	1			
35–44	2.519 (1.3 to 5.0)			
45–54	4.576 (2.4 to 8.8)			
55–64	9.871 (5.1 to 19.2)			
Education				
Not attended school	2.656 (1.5 to 4.6)	1.407 (0.8 to 2.5)	1.257 (0.7 to 2.3)	
5 years of schooling	2.211 (1.3 to 3.6)	1.384 (0.8 to 2.3)	1.281 (0.7 to 2.2)	
8 years of schooling	1.255 (0.7 to 2.2)	1.014 (0.6 to 1.8)	0.897 (0.5 to 1.6)	
12 years of schooling and above	1			
Occupation				
Farmer owns land	2.894 (1.5 to 5.5)	1.465 (0.8 to 2.8)	1.652 (0.9 to 3.2)	0.0 (0.0 to 23.1)
Labourer	1.407 (0.9 to 2.2)	0.932 (0.6 to 1.5)	0.833 (0.5 to 1.4)	
Salaried employee/self employed	1			
Smoking				
Non-smoker	1			
Current smoker	2.266 (1.5 to 3.3)	1.718 (1.2 to 2.5)	1.672 (1.1 to 2.6)	23.4 (4.3 to 38.6)
Alcohol consumption				
No	1			
Yes	1.755 (1.2 to 2.6)	1.686 (1.1 to 2.5)	1.300 (0.9 to 2.0)	9.7 (0.0 to 23.9)
Hypertension				
Absent	1			
Present	3.092 (2.1 to 4.6)	2.249 (1.5 to 3.3)	2.272 (1.5 to 3.4)	24.2 (9.6 to 36.4)
Diabetes (self-reported)				
Absent	1			
Present	2.383 (1.2 to 4.7)	1.296 (0.6 to 2.6)	1.243 (0.6 to 2.6)	2.0 (0.0 to 7.9)
Central obesity				
Normal	1			
Obese	1.316 (0.8 to 2.1)	1.164 (0.7 to 1.8)	1.009 (0.6 to 1.7)	1.3 (0 to 13.3)
Cumulative PAF				45.4 (12.6 to 66.0)

CVD burden among men. Although there was a decline in the age-standardised prevalence of smoking among men 15–69 years from 27% (1998) to 24% (2010) over a decade in India, there was an increase in the smoking prevalence among men 15–29 years during this period and proportion who quit smoking was low.[26] Combination of policy interventions such as high taxation and access to smoking cessation services might increase the smoking cessation rates in the future.

Central obesity is the more crucial anthropometric measure for myocardial infarction as compared with body mass index, more so among South Asians.[3 21] There is ample evidence of the high prevalence of central obesity and diabetes among the South Indian population. In rural Tamil Nadu, the prevalence of central obesity and diabetes was 22.1% and 7.8%, respectively.[27 28] Besides, a case-control study from Bangalore, South India, documented the association of central obesity and diabetes with acute myocardial infarction in South Indians.[29] Our study reiterated the importance of central obesity and diabetes for CVD, especially among women in a longitudinal cohort.

The study had several limitations. We did purposive sampling for selection of villages from the institution's field practice area considering access and travel time to reach the villages, which could cause selection bias. The

Table 4 Cardiovascular disease risk factors and population attributable fraction (PAF) for various risk factors among women, Tiruvallur, India

Factors	HR (95% CI) Unadjusted	HR (95% CI) Age adjusted	HR (95% CI) All adjusted	PAF (95% CI) (%)
Age group				
25–34	1			
35–44	2.476 (0.8 to 8.0)			
45–54	5.949 (2.0 to 18.1)			
55–64	15.838 (5.5 to 45.8)			
Education				
Not attended school	1.772 (0.7 to 4.4)	0.565 (0.2 to 1.5)	0.873 (0.3 to 2.2)	
5 years of schooling	1.222 (0.5 to 3.1)	0.645 (0.2 to 1.7)	0.859 (0.3 to 2.2)	
8 years of schooling	0.887 (0.3 to 2.7)	0.642 (0.2 to 2.0)	0.712 (0.3 to 2.2)	
12 years of schooling and above	1			
Occupation				
Employed	1			
No paid work	1.991 (1.1 to 3.7)	2.037 (1.1 to 3.8)	1.684 (0.9 to 3.2)	33.5 (0.0 to 60.1)
Smokeless tobacco use				
Present	1			
Absent	1.447 (0.7 to 2.9)	0.756 (0.4 to 1.5)	1.060 (0.5 to 2.2)	0.0 (0.0 to 12.4)
Hypertension				
Absent	1			
Present	5.097 (2.9 to 8.9)	2.587 (1.4 to 4.7)	1.815 (1.0 to 3.4)	27.1 (0.0 to 48.4)
Diabetes (self-reported)				
Absent	1			
Present	10.268 (5.6 to 18.8)	5.877 (3.2 to 10.9)	4.262 (2.2 to 8.1)	23.1 (8.6 to 36.0)
Central obesity				
Normal	1			
Obese	3.651 (2.1 to 6.4)	3.204 (1.8 to 5.6)	2.225 (1.2 to 4.0)	28.6 (4.0 to 46.8)
Cumulative PAF				68.8 (40.5 to 83.7)

study population was similar to the rural population of the district as per age distribution, sex ratio and literacy.[30] The diabetes was self-reported and fasting glucose or HbA1c could not be done to confirm diabetes. Therefore, we might have underestimated the burden of diabetes in the population. We did not collect data regarding diet, physical inactivity and serum cholesterol and cannot comment regarding the role of these risk factors. BP was measured twice only during one visit, which could have led to an overestimation of the burden of hypertension. CVD events were recorded based on clinical records or prescription; however, we might have missed the CVD diagnosis for patients who did not have any records or did not report any treatment.

Indian states are at varying levels of the epidemiological transition and therefore have a variable burden of NCDs. Tamil Nadu is already in the advanced stage of epidemiological transition with the high burden of NCD risk factors in the urban and in the rural areas.[5]

We observed the high burden of fatal CVD and confirmed the role of established risk factors such as hypertension, diabetes, smoking and central obesity for CVD. The findings indicate the need for a shift in the policy and programme to address NCD control while sustaining the gains made in infectious disease control. Although there have been efforts to improve NCD care in the state in the past few years, there should be a sustained investment for the implementation of low-cost interventions such as smoking cessation and treatment of risk factors in the primary care. Health systems need to be strengthened to achieve high coverage of treatment of hypertension and diabetes in the rural population to reduce the CVD morbidity and mortality.

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Contributors PK designed the study, supervised fieldwork, planned data analysis and wrote the first draft of the paper. SRR, RV and BK supervised data collection for quality, analysed the data and revised the manuscript. ER and KK designed the data collection tools, managed data and gave critical comments in finalising the manuscript. VT and MDG conceptualised the study and gave critical comments in finalising the manuscript. All authors approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Institutional Ethics Committee of ICMR-National Institute of Epidemiology, Chennai, approved the study. Written consent was obtained from all participants.

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