

BMJ Open Prevalence of risk factors for coronary artery disease in an urban Indian population

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ABSTRACT

Objective: The objective of this study was to assess the prevalence of risk factors for coronary artery disease (CAD) in government employees across India.

Methods: The study population consisted of government employees in different parts of India (n=10 642 men and n=1966 women; age 20–60 years) and comprised various ethnic groups living in different environmental conditions. Recruitment was carried out in 20 cities across 14 states, and in one union territory. All selected individuals were subjected to a detailed questionnaire, medical examinations and anthropometric measurements. Blood samples were collected for blood glucose and serum lipid profile estimation, and resting ECG was recorded. Results were analysed using appropriate statistical tools.

Results: The study revealed that 4.6% of the study population had a family history of premature CAD. The overall prevalence of diabetes was 16% (5.6% diagnosed during the study and the remaining 10.4% already on medication). Hypertension was present in 21% of subjects. The prevalence of dyslipidemia was significantly high, with 45.6% of study subjects having a high total cholesterol/high density lipoprotein ratio. Overall, 78.6% subjects had two or more risk factors for CAD.

Conclusions: The present study demonstrates a high prevalence of CAD risk factors in the Indian urban population. Therefore, there is an immediate need to initiate measures to raise awareness of these risk factors so that individuals at high risk for future CAD can be managed.

INTRODUCTION

Coronary artery disease (CAD) is one of the most common causes of mortality and morbidity in both developed and developing countries. It is a leading cause of death in India, and its contribution to mortality is rising; the number of deaths due to CAD in 1985 is expected to have doubled by 2015.¹ According to reports from the National Commission on Macroeconomics and Health, 62 million people in India will have CAD by

Strengths and limitations of this study

- Our study is the first of its type to investigate people of diverse ethnicities and age groups living in various cities in different parts of India.
- Qualified doctors took histories and clinically examined all subjects, while all biochemical investigations were conducted using similar kits and evaluation techniques.
- A limitation of this study was that only 14 500 of approximately 26 000 employees gave informed consent, and only data from 12 608 of these participants were analysed.
- The limited resources allocated to phase I meant we could only study conventional coronary risk factors.

2015, with 23 million of these below 40 years of age.² The prevalence of classic cardiovascular risk factors such as hypertension, dyslipidemia, obesity and diabetes, varies widely between different countries, and shows some important secular trends. The conventional risk factors for CAD can be divided into non-modifiable and modifiable risk factors. The former include age, sex and family history, while the latter include diabetes mellitus (DM), smoking, dyslipidemia, hypertension and obesity. There is increasing incidence indicating that Asian Indians are at increased risk of CAD, which cannot be attributed to the common risk factors. Recently, a number of newer cardiovascular risk factors have been identified, which are of great interest as more than 60% of CAD in native Indians remains unexplained by conventional risk factors. Comparative studies on newer risk factors show that Indians have higher C-reactive protein, plasminogen activator inhibitor (PAI-1) and homocysteine levels.³

The incidence of CAD is likely to increase further because of rapid urbanisation and its accompanying lifestyle changes, including changes in diet, physical inactivity, drug and

alcohol intake, as well as an increase in the prevalence of DM.^{4 5} The prevalence of risk factors in a population determines the future burden on healthcare services and the loss of an individual's productive years. Risk factors constitute a health risk for the individual and impose an overall burden on the economy. There are no large scale studies of adequate sample size to evaluate the prevalence of risk factors, risk factor patterns and electrocardiographic changes in Indian populations. The present study was thus planned to evaluate the future risk of CAD in a national organisation. As the organisation has offices across the entire country (figure 1), the study population included subjects from various ethnic groups, living in various environments and consuming different diets. To the best of our knowledge the present study is the first of its kind conducted across India.

MATERIALS AND METHODS

Patient population and study design

All subjects were civilian government employees working in various parts of the country. Subjects of both sexes and aged from 20 to 60 years were enrolled after written informed consent was obtained. Recruitment was carried in 20 cities across 14 states and in one union territory in India, namely: Delhi (Delhi), Karnataka (Bangalore, Mysore), Andhra Pradesh (Hyderabad, Vishakhapatnam), Maharashtra (Pune, Ambernath, Ahmednagar), Uttar Pradesh (Agra, Kanpur), Rajasthan (Jodhpur), Himachal Pradesh (Manali), Chandigarh, Uttarakhand (Dehradun, Mussourie), Orissa (Chandipur), Assam (Tejpur), Jammu and Kashmir (Leh), Madhya Pradesh (Gwalior), Tamil Nadu (Chennai) and Kerala (Kochi). Recruitment began in 2009 and phase 1 evaluation was completed in 2012. The sample size calculation was not performed as it was an open study where voluntary participation of all employees was encouraged.

Inclusion and exclusion criteria

To be included, a subject had to be: (a) a civilian government employee working in any area of the country; (b) apparently healthy; (c) aged 20–60 years; and (d) either male or female. A subject was excluded if they were known to have CAD.

Assessment process

Participants were asked to visit the health centre of their employment organisation at 8:00 am after an overnight fast. They were asked to continue their medication, if any, as usual. A detailed questionnaire was administered by medical personnel before clinical measurements and blood collection. The questionnaire recorded information on demographic data, socio-economic details and marital status. Information on several lifestyle factors was also recorded, including tobacco, alcohol and caffeine consumption, physical activity, family history, disease history, medication use, and family history of premature CAD in first degree relatives (age <55 years in men and

<65 years in women). In women, further data regarding reproductive and obstetric history, oral contraception and hormonal replacement therapy were collected.

Anthropometric and clinical examination including blood pressure (BP) measurement was carried out for each subject. Body weight and height were measured with participants standing without shoes in light clothes. Bodyweight was measured in kilograms to the nearest 0.1 kg using a digital scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a height gauge. Body mass index (BMI), defined as weight in kg/(height in metres)² was also calculated.

BP and heart rate were measured on the left arm, with an appropriately sized cuff, after at least 10 min of rest in the seated position, using an automated BP instrument. The average of the last two measurements was used for analysis. The subjects diagnosed as having high BP for the first time were recalled the next day for BP monitoring before they were diagnosed as hypertensive. Resting ECG was also obtained as part of the evaluation.

Blood samples were collected in the fasting state and 2 h after 75 g of oral glucose administration. Biochemical evaluation of blood samples included complete blood count, fasting plasma glucose (FPG), post-prandial plasma glucose (PPPG), lipid profile, and liver and kidney function tests. The clinical chemistry tests were performed on fresh blood samples using automatic analysers on the same day. Subjects whose FPG was ≥ 126 mg/dL and/or PPPG ≥ 200 mg/dL were diagnosed as new cases of DM. Other subjects with a past history of DM and/or taking medication for DM were also considered to have diabetes.

When lipid profiles were being calculated, a total cholesterol/high density lipoprotein (HDL) cholesterol value of ≥ 4.5 was considered abnormal. Known cases of dyslipidemia and/or those on medication for dyslipidemia were considered to have the dyslipidemia risk factor. Table 1 summarises the definitions for the different risk factors in the study.

The strength of the study was that each participant had personal contact with at least one of the project team doctors. Each questionnaire was scrutinised by a doctor. This added value to the data as in most epidemiological studies paramedics usually collect the data.

Statistical analysis

The final data were recorded on a predesigned performa and managed in Microsoft Access. Data analysis was performed using SPSS V.20.0. The values of various parameters are presented as means \pm SD, in absolute numbers and as percentages. Data for men and women were compared using the t test. Correlation statistics between various risk factors were also computed. The minimum significance level was set at 0.05.

Ethics approval

The study was approved by the Institutional Ethics Committee of the Institute of Nuclear Medicine and Allied Sciences (INMAS), Delhi.

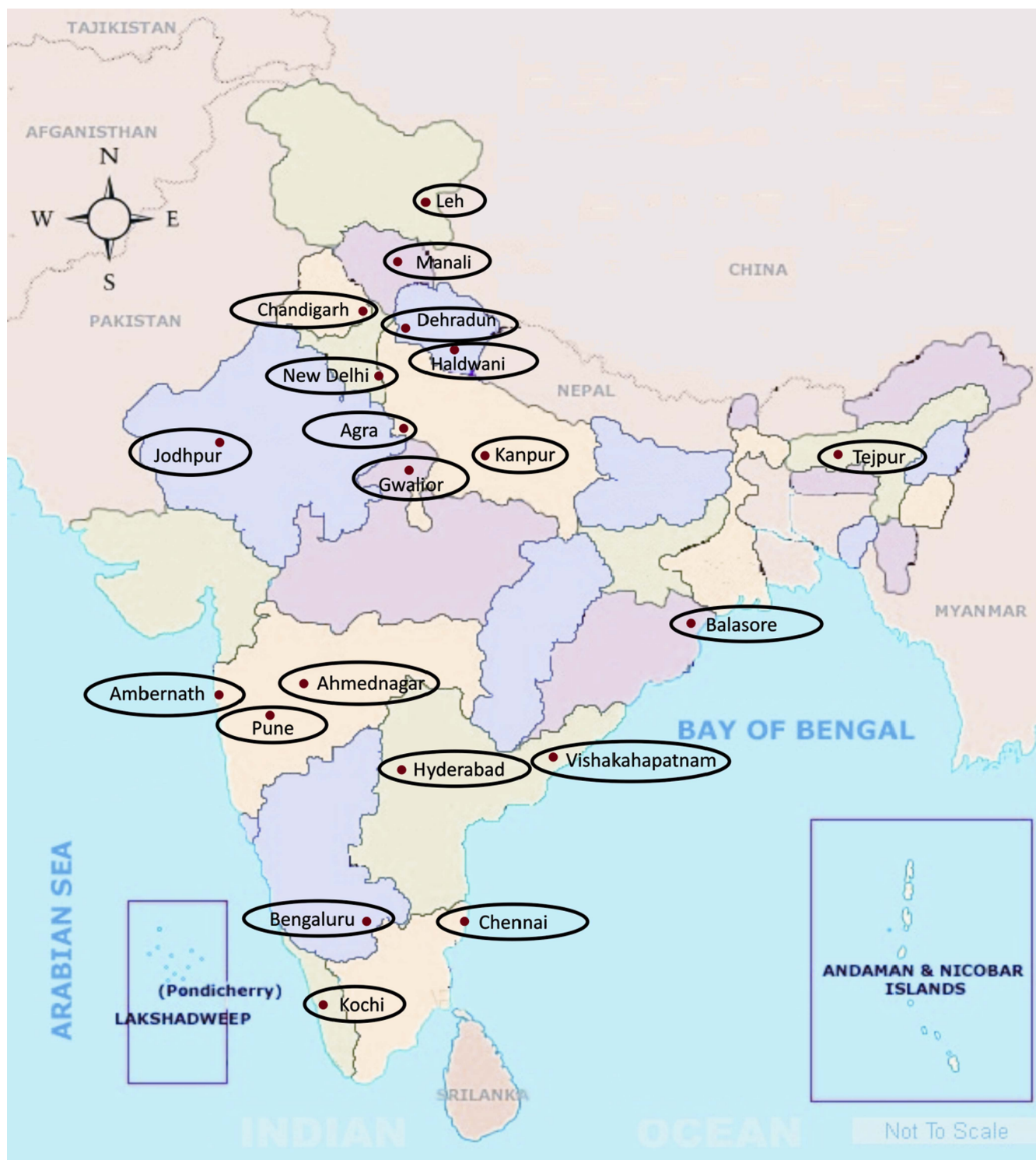


Figure 1 Locations in India where the study was carried out.

RESULTS

A total of 14 500 subjects were evaluated in the study. After informed consent was obtained, exclusion criteria were applied, and clinical and biochemical assessment was carried out, complete data for 12 608 subjects (10 642 men and 1966 women) were available for final analysis. The mean age of men was 44.34 ± 10.63 years, while their median age was 47.00 years. The mean age

of women was 42.47 ± 10.34 years, while their median age was 44.00 years. Baseline characteristics are shown in [table 2](#).

The different parameters considered for calculating the risk factors and their results are given in [table 3](#).

A family history of premature CAD was present in 4.6% of the study population: 4.4% of men and 6% of women had a first degree relative with a history of CAD

Table 1 Definitions for the different risk factors in the study

Risk factor	Definition
Hypertension	Systolic BP \geq 140 mm Hg and/or diastolic BP \geq 90 mm Hg during the visit and/or presence of anti-hypertensive drug treatment; considered known if the subject was aware of this condition
Diabetes mellitus	FPG \geq 126 mg/dL and/or PPPG \geq 200 mg/dL at the time of investigation and/or presence of anti-diabetic drug treatment; considered known if the subject was aware of this condition
Obesity	BMI \geq 30 kg/m ²
Overweight	BMI \geq 25 kg/m ²
Hypercholesterolaemia	Total blood cholesterol \geq 200 mg/dL
Decreased HDL cholesterol	\leq 40 mg/dL
Adverse total cholesterol/HDL ratio (dyslipidemia)	\geq 4.5
Age	>45 years in men and >55 years in women
Sex	Male sex
Family history of CAD	Premature CAD in first degree relatives (<55 years in men and <65 years in women)
Risk factors for CAD	Age, sex, family history, diabetes mellitus, smoking, dyslipidemia, hypertension and obesity

BMI, body mass index; CAD, coronary artery disease; FPG, fasting plasma glucose; HDL, high density lipoprotein; PPPG, post-prandial plasma glucose.

($p < 0.05$). The prevalence of smoking was significantly higher in men (13.8%) than in women (0.1%) ($p < 0.001$).

Of the 12 608 study subjects, 6002 (47.6%) had a BMI \geq 25 kg/m²: 4910 (46.1%) men and 1092 (55.5%) women were overweight or obese ($p < 0.001$). On further analysis it was observed that 39.46% of men and 38.6% of women were overweight (BMI 25–30 kg/m²) ($p < 0.001$). The mean BMI of the overweight men and women was 26.93 \pm 1.31 and 27.35 \pm 1.44, respectively. Obesity (BMI \geq 30 kg/m²) was present in 6.6% of men with a mean BMI of 32.78 \pm 4 and in 16.7% of women with a mean BMI of 33.41 \pm 3.74 ($p < 0.05$).

The overall prevalence of diabetes was 16% in the study population, with no significant difference between men (16.6%) and women (12.7%). These 16% comprised 5.6% who were diagnosed during the study and

10.4% who had known DM and were already on medication.

Hypertension was identified in 2383 (22.4%) of the 10 642 men and in 264 (13.4%) of the 1966 women ($p < 0.001$). The overall prevalence of hypertension was 21% among study subjects. Of these subjects, only 4.76% were aware of they had the condition and were on medication, with a further 16.22% identified during the study.

The prevalence of dyslipidemia in the study population was significantly high, with 45.6% of study subjects having a high total cholesterol/HDL cholesterol ratio: 48.27% of men and 31.4% women were found to have dyslipidemia ($p < 0.001$). The prevalence of hypercholesterolaemia in the study population was 31.3%, with no significant difference between men (32%) and women (27.6%). When a cut-off value of 40 mg/dL was used,

Table 2 Baseline characteristics of the study population (n=12 608)

Parameters	Men (n=10 642)	Women (n=1966)	p Value
Age, years	44.34 \pm 10.63	42.47 \pm 10.34	0.000
Height, cm	166.92 \pm 6.89	154.74 \pm 6.34	0.000
Weight, kg	69.36 \pm 10.69	62.24 \pm 11.30	0.001
BMI	24.89 \pm 3.58	26.02 \pm 4.69	0.001
Systolic BP, mm Hg	127.35 \pm 16.12	120.05 \pm 15.25	0.000
Diastolic BP, mm Hg	81.08 \pm 10.04	77.05 \pm 9.60	0.000
FPG, mg/dL	95.91 \pm 31.08	93.48 \pm 32.10	0.01
PPPG, mg/dL	135.44 \pm 56.31	131.86 \pm 54.47	0.01
Total cholesterol, mg/dL	186.11 \pm 40.56	181.69 \pm 36.62	0.001
HDL, mg/dL	42.46 \pm 11.55	46.54 \pm 11.36	0.001

Values are mean \pm SD.

BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; HDL, high density lipoprotein; PPPG, post-prandial plasma glucose.

Table 3 Percentage (%) of risk factors in the study population (n=12 608)

Parameters	Total (n=12 608)	Men (n=10 642)	Women (n=1966)	p Value
Family history of CAD	580 (4.6%)	460 (4.4%)	120 (6%)	<0.05
Smoking	1471 (11.6%)	1469 (13.8%)	2 (0.1%)	<0.001
BMI >25 kg/m ²	6002 (47.6%)	4910 (46.1%)	1092 (55.5%)	
Mean±SD		27.8±3.59	29.17±3.66	<0.001
BMI 25–30 kg/m ²	4959 (39.3%)	4200 (39.46%)	759 (38.6%)	
Mean±SD		26.93±1.31	27.35±1.44	<0.001
BMI ≥30 kg/m ²	1029 (8.2%)	700 (6.6%)	329 (16.7%)	
Mean±SD		32.78±4.00	33.41±3.74	<0.05
Diabetes mellitus	2016 (16%)	1766 (16.6%)	250 (12.7%)	NS
Hypertension	2647 (21%)	2383 (22.4%)	264 (13.4%)	<0.001
Dyslipidemia	5755 (45.6%)	5137 (48.27%)	618 (31.4%)	<0.001

Values are n (%) unless otherwise indicated.

BMI, body mass index; CAD, coronary artery disease.

37.7% of men were found to have low HDL and similarly, when a cut-off value of <50 mg/dL was used, 76% of women were found to have low HDL.

The study population was divided into four groups according to age. Subjects aged 20–30 years (n=1885), 30–40 years (n=2724), 40–50 years (n=3604) and 50–60 years (n=4395) were categorised as group I, group II, group III and group IV, respectively.

The mean level of total cholesterol in these age groups was: group I, 174.2 mg/dL; group II, 182.5 mg/dL; group III, 188.2 mg/dL; and group IV, 189.7 mg/dL. Levels were significantly higher in group II as compared with group I (p<0.05). A significant difference was found when we compared group III with group II (p<0.05). However, there was no significant difference when groups III and IV were compared. The mean HDL cholesterol levels in these age groups were: group I, 43.79 mg/dL; group II, 42.53 mg/dL; group III, 42.80 mg/dL; and group IV, 43.37 mg/dL. No significant difference was seen in the levels of HDL cholesterol among these age groups.

A total of 9909 (78.6%) subjects had two or more risk factors for CAD: 9251 (86.9%) men had two or more risk factors compared with 658 (33.46%) women. The most prevalent risk factor in men was dyslipidemia (present in 48.27% of men), followed by a BMI >25

(present in 46.1% of men). In women, a BMI >25 was the most prevalent factor (present in 55.5% of women), followed by dyslipidemia in 31.45%.

HDL correlated negatively with FPG, PPPG and BMI. BMI had a positive correlation with systolic and diastolic BP, FPG and PPPG, and total cholesterol. Total cholesterol had a positive correlation with systolic and diastolic BP, FPG and PPPG, and BMI (table 4).

DISCUSSION

This study investigated the prevalence of risk factors for CAD in a national organisation employing people in different regions of India. Participants were of both sexes and aged 20–60 years. It was found that approximately half of the study population had dyslipidemia (45.6%) and approximately half had a BMI >25 kg/m² (47.6%). About one fifth of the study population was hypertensive (21%) and one sixth had DM (16%). Two or more CAD risk factors were identified in 78.6% of participants, which indicates that there is a large population who will develop CAD in the near future.

The present results can be compared with the findings in 739 subjects (451 men and 288 women) of the Jaipur Heart Watch-5 study by Gupta *et al.*⁶ That study found that 46.2% of men and 50.7% of women were

Table 4 Correlations among risk factors by Pearson correlation (two-tailed) (n=12 608)

Parameters	Systolic BP	Diastolic BP	FPG	PPPG	Serum total cholesterol	Serum HDL	BMI
Systolic BP	1	0.715*	0.149*	0.136*	0.086*	−0.011	0.190*
Diastolic BP	0.715*	1	0.119*	0.107*	0.114*	−0.011	0.216*
FPG	0.149*	0.119*	1	0.821*	0.095*	−0.054*	0.099*
PPPG	0.136*	0.107*	0.821*	1	0.092*	−0.042*	0.117*
Serum total cholesterol	0.086*	0.114*	0.095*	0.092*	1	0.000	0.063*
Serum HDL cholesterol	−0.011	−0.011	−0.054*	−0.042*	0.000	1	−0.068*
BMI	0.190*	0.216*	0.099*	0.117*	0.063*	−0.068*	1

*Correlation is significant at the 0.01 level (two-tailed).

BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; HDL, high density lipoprotein; PPPG, post-prandial plasma glucose.

overweight or obese. The prevalence of hypertension was 39.5% in men and 24.6% in women, diabetes was present in 15.5% of men and in 10.85% of women, and 33% of men and 32.7% of women had high cholesterol levels.

Similar results were found by a study by Prabhakaran *et al*⁷ among men working in an industry in northern India. A high serum total cholesterol/HDL ratio was found in 62% of the population, overweight in 47%, hypertension in 30% and diabetes in 15%. Prabhakaran *et al* also showed that 47% of their subjects had at least two CAD risk factors, compared with 78.6% with two or more CAD risk factors in the present study.

Another study in 2008 by Mohan and Deepa showed the following prevalences of major risk factors for cardiovascular disease: diabetes 11.9%, hypertension 25.4%, dyslipidemia 40.2%, hypertriglyceridaemia 28.3%, overweight (BMI ≥ 23 kg/m²) 60.2% and metabolic syndrome 34.1%.⁸

Various other studies have also shown similar trends in the Indian population.^{9–15} An increasing prevalence of impaired glucose tolerance and diabetes in urban residents of Chennai was reported by Ramchandran *et al*.¹⁶ In 2002, Gupta *et al* showed that smoking and low physical activity levels were widespread in 20–39-year-old urban adults.¹⁷ Another important independent risk factor for CAD is a family history of CAD, as reported by Goel *et al* in 2003.¹⁸

Our study has clearly shown that among the middle class Indian population, there is a high prevalence of obesity, hypertension, dyslipidemia and diabetes, which are all modifiable CAD risk factors. The study has shown a direct correlation between increased BMI and dyslipidemia, diabetes and hypertension. CAD has a multifactorial aetiology, with many of the risk factors being influenced by lifestyle. Rapid change in dietary habits coupled with decreased physical activity in India as consequence of urbanisation may partly explain the increase in CAD. India is experiencing an epidemiological transition with high rates of urbanisation.^{19–22} This has led to economic improvement, the consequences of which are increased fast food consumption and tobacco usage, and decreased physical activity. With the introduction of an era of refined foods, sugar and hydrogenated oils, the traditional high complex carbohydrate, high fibre and low fat diet has been replaced by a diet rich in fats and simple sugars low in dietary fibre.²³ One of the effects of this transition is a shift in the disease spectrum from communicable to non-communicable diseases, particularly CAD and diabetes.^{24–26} More importantly, CAD is affecting young Indians who comprise the productive workforce. The incidence of CAD in young Indians is 12–16%, which is higher than in other ethnic groups worldwide. Lack of awareness of the preventable risk factors and ignorance of the disease are also important factors responsible for the increasing rate of CAD among Indians.^{27–32} In the present study, of the 21% of hypertensive study subjects, only 4.76% were aware they had

condition and were on medication, while the remaining 16.22% were identified during the study. Similarly, of the 16% of the study population who had diabetes, 5.6% were diagnosed during the study. This shows that awareness and control of hypertension and diabetes was poor in the study population, indicating low detection and poor management of major CAD risk factors.

Prevention and control of the risk factors for CAD can reduce the rate of CAD. This requires changes in the individual as well as at the community level. Modifying risk factors such as smoking, increased levels of body fat, consuming too much fat and salt, and a sedentary lifestyle together with the use of accessible and affordable preventive medicines, can lower the risk of CAD. Television and other media can be utilised to create awareness among the general population. Local resident welfare associations and religious groups can also be encouraged to promote a healthy lifestyle and exercise among the community.

CONCLUSION

The present study demonstrates a high prevalence of CAD risk factors in the Indian population, as the study population was representative of the national population, and reflects the rising trend in CAD in urban India. The incidence of CAD is likely to increase further because of rapid urbanisation and its accompanying lifestyle changes. Therefore, there is an immediate need to raise awareness among the general population about these risk factors, promote the correct diet and physical activity, and at the same time develop guidelines for screening and preventive therapeutic programmes to identify and manage individuals at high risk for future CAD.

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Contributors TS: principal investigator; RSK: co-principal investigator of the study, medical evaluation and manuscript writing; RW, PC, MC and RA: medical evaluation of the study subjects and data compilation; YKS: statistical evaluation and analysis of the study population; JSe: dietary evaluation and data compilation; JSu, KB, SS, NR, TC, MS and SKS: laboratory sample analysis.

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Competing interests None.

Ethics approval The Institutional Ethics Committee of the Institute of Nuclear Medicine and Allied Sciences approved this study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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