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Assessment of 2013 AHA/ACC ASCVD risk scores with behavioral characteristics of an urban cohort in India
Preliminary analysis of Noncommunicable disease Initiatives and Research at AMrita (NIRAM) study

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Abstract

Cardiovascular diseases (CVDs) are the leading cause of death and disability in India. Early and sustained exposure to behavioral risk factors leads to development of CVDs.

The aim of this study was to determine the baseline risk of a "hard CVD event" in subjects attending comprehensive health clinic and assess behavioral characteristics in "at risk" population.

Using WHO STEPwise approach to Surveillance modified questionnaire, prevalence of noncommunicable diseases (NCDs) and risk factors was estimated in this cross-sectional study of 4507 subjects. Baseline cardiovascular risk was determined using Framingham risk score (FRS) and American College of Cardiology (ACC)/American Heart Association (AHA) atherosclerotic cardiovascular disease (ASCVD) algorithms. Modifiable behavior associated with high CVD risk was assessed. Among 40 to 59-year olds, ASCVD risk tool derived both a 10-year and lifetime risk score, which were used to stratify the cohort into 3 risk groups, namely, a high 10-year and high lifetime, a low 10-year and high lifetime, and a low 10-year and low lifetime risks.

Dyslipidemia (30.6%), hypertension (25.5%), diabetes mellitus (20%), and obstructive airway disorders (17.6%) were most prevalent NCDs in our cohort. The ASCVD score stratified 26.1% subjects into high 10-yr and 59.5% into high lifetime risk while FRS classified 17.2% into high 10-year risk. Compared with FRS, the ASCVD risk estimator identified a larger proportion of subjects "at risk" of developing CVD. A high prevalence of alcohol use (38.4%), decreased intake of fruits and vegetables (96.2%) and low physical activity (58%) were observed in "at risk" population. Logistic regression analysis showed that in 40 to 59-year group, regular and occasional drinkers were 8.5- and 3.1-fold more likely to be in high 10-year and high lifetime ASCVD risk category than in low 10-year and low lifetime risk group. Similarly, regular drinkers and occasional drinkers were 2.1 and 1.3 times more likely to be in low 10-year and high lifetime risk than in low 10-year and low lifetime risk category. Subjects with inadequate intake of fruits and vegetables were 1.59 times more likely to be in low 10-year and high lifetime risk than the lower 10-year and lifetime risk group. Obese participants were 2.3-fold more likely to be in low 10-year and high lifetime risk.

Identification of "at risk" subjects from seemingly healthy population will allow sustainable primary prevention strategies to reduce CVD.

Abbreviations: ACC = American College of Cardiology, AHA = American Heart Association, ASCVD = atherosclerotic cardiovascular disease, BMI = body mass index, BP = blood pressure, CHD = coronary heart disease, COPD = chronic obstructive pulmonary disease, CVD = cardiovascular disease, DM = diabetes mellitus, FRS = Framingham risk score, HTN = hypertension, NCD = noncommunicable diseases, OAD = obstructive airway diseases, WHO = World Health Organization.

Keywords: alcohol intake, ASCVD risk, behavioral risk factors, Framingham, India, NCD, WHO STEPS

1. Introduction

Noncommunicable diseases (NCDs) are the leading cause of morbidity and mortality worldwide, accounting for 68% of deaths in 2012.[1] Almost three-quarters of these NCD-associated fatalities have occurred in low- and middle-income countries. In 2010, chronic respiratory diseases (COPD) accounted for about 11.8% of total deaths, followed by cancer (6.7%) and diabetes mellitus (DM) (2.2%).[2] The combination of coronary heart diseases (CHDs) and stroke has resulted in 4.8 million disability-adjusted life years in 2010. In 2012, cardiovascular diseases (CVDs) alone contributed to 26% of the total 5.8 million NCD-related deaths in India.[3] The increasing global burden of NCD and the sociobehavioral risk factors are posing a huge economic challenge for countries like India. National policies and various health organizations are now emphasizing on strategizing primary prevention modalities to tackle the modifiable behavioral risk factors of NCD and thereby reduce the national burden.

In India, the prevalence of some of the common NCD risk factors are alcohol consumption at 30%, tobacco use at 23.6%, unhealthy food habits at 76%, and low level of physical activity at 13.4%.[1] In 2014, Ng et al reported that the prevalence of obesity in India had risen by 22%, almost at par with the USA and China.[4] The national dietary habits are tending toward junk food of low nutritive value with intake of fruits and vegetables below the World Health Organization (WHO) recommendations.[5] The state-wide prevalence of such unhealthy dietary habits in India ranged from 76% to 99%. Similarly, a sedentary lifestyle was significantly associated with DM and obesity, with certain areas in India reporting a prevalence of physical inactivity of more than 50%.[6]

Health policy makers cite Kerala as the first state in India to be in the late stages of health transition.[7] The state has excellent public health policies and a population with high level of literacy. The governmental efforts in human development have resulted in the widely applauded "Kerala model"[8] that places its human development indices at par with developed nations. Unfortunately, the state bears a huge burden of chronic illnesses. The prevalence of DM (16.2%)[9] is almost twice that of the national average (9.2%). Obesity (39.4%) and alcohol consumption (31.1%)[10,11] have also increased in the last 5 years. Over the last decade, the state has witnessed a dramatic change in dietary habits and lifestyle trends. Studies by Krishnan et al[12] and others[13] showed that rise in high-calorie food intake and sedentary behavior accounted for increased prevalence of CVDs. The Epidemiology of Noncommunicable Diseases in Rural Areas (ENDIRA) study exhaustively assessed the prevalence of NCDs and associated risk factors in Kerala, concluding that the incidence of heart attacks and strokes correlate with traditional risk factors like hypercholesterolemia and systemic hypertension (HTN).[14]

The role of early and sustained exposure to major risk factors in the subsequent development of NCDs is well established. Evidence-based approaches suggest that interventions at primary care level are of utmost importance in reducing the NCD burden. These primary prevention programs must largely focus on reducing or eliminating the modifiable lifestyle risk factors contributing to the CVD risk within the population.[15]

An essential aspect of a prevention program is to estimate the baseline and lifetime CVD risk of the population. Various risk calculators are currently available that aid in the identification of people who are at high risk of developing CHDs. The Framingham risk score (FRS), a popular risk scale used to predict 10-year cardiovascular risk,[16] was developed from a cohort consisting mainly of Caucasian population. Recent studies have shown that in other racial population, the risk scores tend to significantly overestimate their absolute coronary risk.[17] A more recent and comprehensive scale put forth by the American Heart Association (AHA) and American College of Cardiology (ACC) is the atherosclerotic cardiovascular disease (ASCVD) risk score.[18] Unlike FRS, the ASCVD risk score algorithm can be applied to other races also and predicts both the 10-year and lifetime ASCVD risk of an individual. In Kerala, very few studies have dealt with the comparison of FRS and ASCVD risk score stratifications and the distribution of cardiovascular risk scores with an emphasis on modifiable risk factors.[19–21] Utilizing the cardiovascular risk scores to identify and stratify the "at risk" population and characterize their modifiable behavior will help to design strategies for primary prevention in low- and middle-income countries.

This study aims to estimate the current NCD burden in the population attending the Amrita comprehensive health clinic, and identify the modifiable risk factors to design better primary preventive strategies. Our objectives include: to characterize the population attending the NCD comprehensive health clinic, to correlate NCD with risk factors, to compare baseline cardiovascular risk estimation by Framingham and ACC/AHA ASCVD scoring, and subgroup evaluation of the individuals at high risk for NCDs.
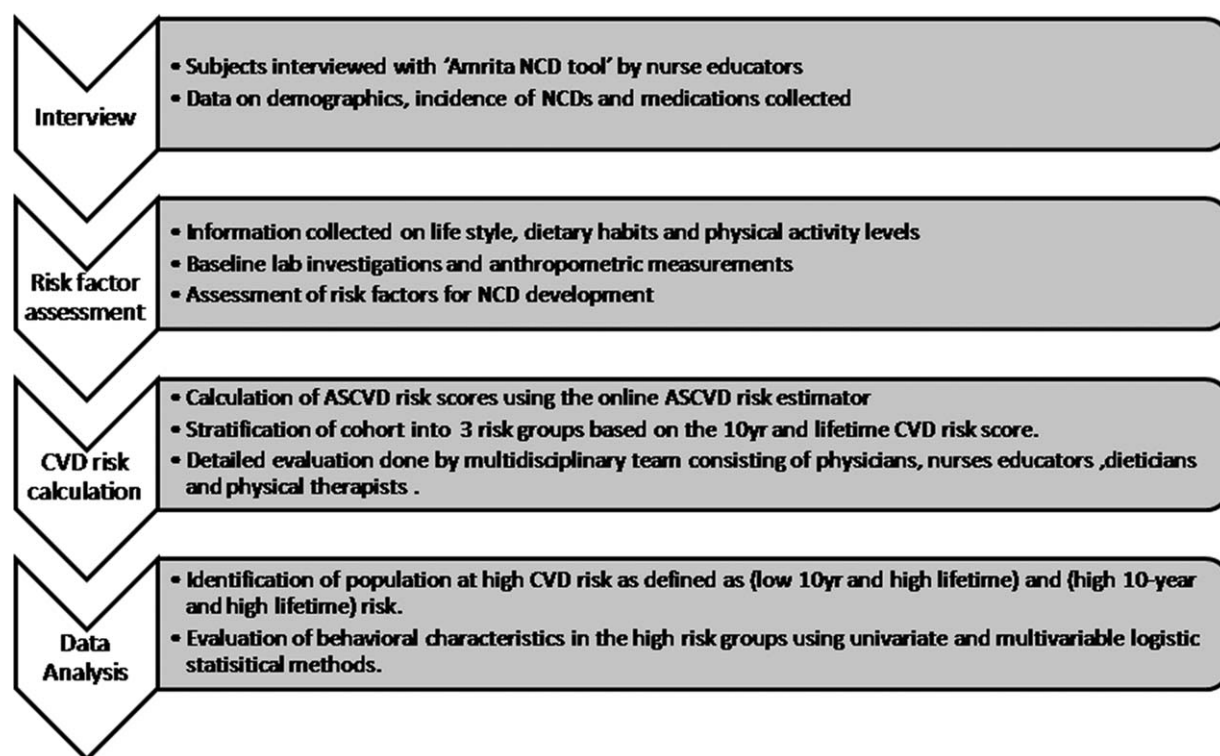
2. Methodology

2.1. Study population and design

NIRAM is an ongoing longitudinal population-based cross-sectional study conducted at the comprehensive health clinic of Amrita Institute of Medical Sciences (AIMS), Kochi. The sample size was determined using nMaster 1.0 based on Thankappan et al.[9] Study cohort consisted of 4507 adults (≥18 years) who visited the clinic from February 2015 to February 2016 and consented to being evaluated and followed via telephone or e-mail. Pregnant women and subjects of foreign descent were excluded.

2.2. Clinical measurements

Study subjects were interviewed by trained nurse educators using "Amrita NCD" surveillance tool. The tool is a modified WHO STEPwise approach to Surveillance (STEPS) questionnaire (STEPS Version 3.0)[22] that included regional and locally relevant variables. Demographics, socioeconomic status, and other questionnaire-specific details including self-reported incidence of NCD and behavioral risk factors were recorded. The questionnaire responses were then populated into a Microsoft Access database. Figure 1 describes the workflow at the clinic.

Information collected for risk factor evaluations included type and frequency of use of alcohol, tobacco use, amount of physical activity including the intensity of physical activity during work, travel, recreation, and sedentary activity. Detailed dietary pattern assessments were made on the basis of information collected on the number of servings of fruits and vegetables/week, type of oil used for cooking, frequency of food consumed away from home, and intake of red meat. Baseline incidence of NCD was evaluated by acquiring history of known HTN, DM, dyslipidemia, coronary artery disease requiring medication and verifying absence of transient ischemic attack/stroke. Screening question-

Figure 1. Work flow methodology at comprehensive health clinic for NCD surveillance, behavioral pattern assessment and CVD risk evaluation. ASCVD = atherosclerotic cardiovascular disease, CVD = cardiovascular disease, NCD = noncommunicable disease.

naire for COPD was also administered. Home medications were also reconciled.

2.3. NCD risk factor definitions

- DM: fasting plasma glucose ≥126 mg/dL, 2-hour postprandial plasma glucose ≥200 mg/dL,[23] HbA1c ≥6.5% or use of antihyperglycemic medications.[23]
- Hypercholesterolemia/ dyslipidemia: total cholesterol ≥240 mg/dL, low-density lipoprotein cholesterol ≥160 mg/dL, or high-density lipoprotein cholesterol <40 mg/dL (for persons with and without DM) or use of a cholesterol-lowering medication.[24]
- HTN: systolic blood pressure (BP) ≥140 mm Hg, diastolic BP ≥90 mm Hg, or use of an antihypertensive medication.[25]
- Obesity: Body mass index (BMI) ≥30 kg/m². The WHO's International Classification of BMI was used for stratifying adults into underweight, normal, overweight, and obesity.[26]
- Self-reported history of CHD and cerebrovascular accident included occurrence of a first hard event of a myocardial infarction or chest pain from angina and physician-informed event of a stroke and a score of more than 0/8 on the QVSFS (verifying stroke questionnaire), respectively.[27]
- Smokers: use of any form of tobacco products in the previous 30 days.
- Based on the frequency of alcohol consumption, participants were grouped into regular drinkers (daily, 5–6 days per week, 3–4 days per week, 2–4 times per week, 1–3 days per week, 1–2 days per week), occasional drinkers (less than once a month, 1–3 days per month, and occasionally) and lifetime abstainers (subjects who have never consumed alcohol in their lifetime).[28,29]
- Inadequate intake of fruits and vegetables: intake of <5 servings of fruit or vegetables/day.[30]

- Food consumed away from home was qualified as regular (eating ≥1/week away from home to eating completely away from home) and occasional consumers (eating <1/week away from home).
- Metabolic equivalent value intervals of 0 to 600, 600 to 3000 and >3000 stratified physical activity into low, moderate, and high levels, respectively.[31]

2.4. Anthropometric and biochemical measurements

Weight (kilograms) and height (meters) were measured using Health o meter, (Sunbeam Products, USA). The BMI of each subject was calculated as per the standard formula, BMI = weight/height². As per the AHA guidelines, seated resting BP was the average of 3 measurements taken using mercury sphygmomanometer after 5 minutes of rest.

Routine biochemical measurements were done after a 10-hour fast. Blood samples were collected for measuring fasting blood sugars with glucose oxidase method, postprandial sugars using Accucheck (Roche Diagnostics, USA) and lipid profile by AU2700plus, Beckman Coulter, USA.

2.5. Cardiovascular risk score stratifications

The 10-year FRS, the 10-year and lifetime ACC/AHA ASCVD risk scores[18] were calculated for each participant. Using the new pooled cohort equations of the ACC/AHA risk scores, the cohort was stratified into 3 groups, namely, 18 to 39 years, 40 to 59 years, and 60 to 79 years. Participants in age groups of 40 to 59 and 60 to 79 years were further stratified as per their 10-year predicted risk for ASCVD events into low-risk (<7.5%) and high-risk (≥7.5%) groups. On the basis of lifetime risk scores, subjects in the age 18 to

Table 1

Baseline sociodemographic characteristics of study cohort.

Sociodemographic details	Total N (%) 4507	Females N (%) 1820 (40.0)	Males N (%) 2687 (59.6)
Age			
18–39	1082 (24)	428 (39.6)	654 (60.4)
40–59	2597 (57.6)	1071 (41.2)	1526 (58.8)
60–79	828 (18.4)	321 (38.8)	507 (51.2)
Education			
Graduates	2569 (57)	1042 (40.6)	1527 (59.4)
Up to higher secondary	1926 (42.7)	771 (40)	1155 (60)
Illiterate	12 (0.3)	7 (58.3)	5 (41.7)
Occupation			
White-collar jobs	2816 (62.5)	612 (21.7)	2204 (78.3)
Manual laborer	99 (2.2)	2 (2)	97 (98)
Homemaker	1029 (22.8)	1019 (99)	10 (1)
Unemployed	563 (12.5)	187 (33.2)	376 (66.8)
Marital status			
Currently married	4168 (92.5)	1660 (39.8)	2508 (60.2)
Divorced	8 (0.2)	5 (62.5)	3 (37.5)
Never married	217 (4.8)	47 (21.7)	170 (78.3)
Widowed	114 (2.5)	108 (94.7)	6 (5.3)

39 and 40 to 59 years were stratified into low (<39%) and high (≥39%) risk subgroups.

In subjects of age group 40 to 59 years, the application of the ASCVD risk calculator estimates both the 10 -year immediate as well as the lifetime CVD risk. Based on these risk scores, the cohort was further classified into 3 subsets, namely, subjects with a high 10-year and a high lifetime CVD risk, subjects with a low 10-year and high lifetime risk, and subjects with a low 10-year and low lifetime risk. We characterized and compared the lifestyle risk profiles of the 3 groups to identify significant behavioral patterns associated with higher CVD risk.

2.6. Statistical analysis

Pearson χ^2 test was used to evaluate significant associations. The risk factors were identified as independent categorical variables with age-stratified ASCVD 10-year and lifetime risk score groups as outcome variable. Multivariate logistic regression was employed to compare the ASCVD categories among the group aged 40 to 59 years with low 10-year and low lifetime as the reference category. $P < 0.05$ was taken as statistically significant.

All statistical tests were performed using SPSS version 17 (IBM, USA). Incomplete and missing data were excluded.

2.7. Ethical review

Ethics approval was obtained for this observational study from the Institutional Ethics Committee (IEC) of Amrita Institute of Medical Sciences and Research Centre.

3. Results

3.1. Socio-demographics

The study cohort demographics are presented in Table 1. Of the total 4507 participants, 60% (2687) were males and 40% (1820) were females, with most of them (58%) aged between 40 and 59 years. Median age of the cohort was 48 years (interquartile range 17 years). Of the study participants, 57% (2569) were college-educated and 93% were married; 87% of the cohort was employed.

3.2. Current NCD burden of the study cohort

Of our cohort, 66.3% had at least one chronic illness at the time of their clinic visit with 13.1% having more than 2 self-reported NCDs (Fig. 2). Age-group-wise distribution of the NCD prevalence indicated that 7.6% of younger adults (18–39 years) had more than 2 chronic illnesses. Differences were also observed in the sex-wise distribution pattern of the cohort, with men having a significant association with one or more NCDs as compared with women (59.7% vs 40.3%; $P = 0.02$).

Among the various NCDs, dyslipidemia was frequently reported, either singly (25.4%) or in combination with other NCDs (30.6%). Self-reported HTN (25.5%), DM (20%), and obstructive airway disorders (OAD) (17.6%) were also highly prevalent in the cohort. Table 2 details the age- and sex-stratified prevalence of the various NCDs in the study population. Among the age group of 18 to 39 years, the prevalence of DM and dyslipidemia were found to be significantly lower in females compared with males.

3.3. Risk factor profiles of the study cohort

A review of behavioral risk factors observed in this cross-sectional population indicated high occurrence of alcohol use
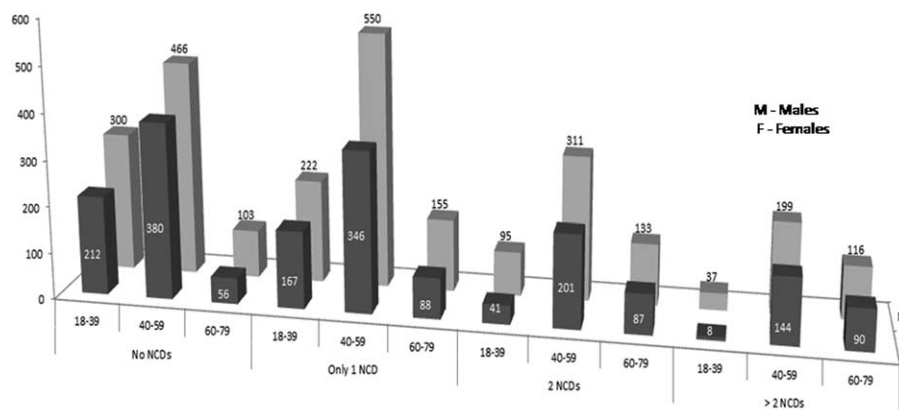
Figure 2. Burden of noncommunicable diseases (NCDs) in study cohort.

Table 2

Prevalence of noncommunicable diseases (NCDs) in the study cohort.

NCD	Total N (%)	Age strata, y	Females N (%)	Males N (%)	Total N (%)	Significance (*P*)
Hypertension	1150 (25.5)	18–39	21 (25.9)	60 (74.1)	81 (7)	0.061
		40–59	220 (33.3)	441 (66.7)	661 (57.5)	
		60–79	156 (38.2)	252 (61.8)	408 (35.5)	
Diabetes	902 (20)	18–39	14 (21.5)	51 (78.5)	65 (7.2)	0.023*
		40–59	205 (37.1)	348 (62.9)	553 (61.3)	
		60–79	91 (32)	193 (68)	284 (31.5)	
Dyslipidemia	1378 (30.6)	18–39	36 (19.7)	147 (80.3)	183 (13.3)	1E-8*
		40–59	320 (37.9)	524 (62.1)	844 (61.2)	
		60–79	163 (46.4)	188 (53.6)	351 (25.5)	
Obstructive airway disorders	795 (17.6)	18–39	98 (44.7)	121 (55.3)	219 (27.5)	0.662
		40–59	174 (41.6)	244 (58.4)	418 (52.6)	
		60–79	64 (40.5)	94 (59.5)	158 (19.9)	

*Indicates a statistical significance of $P < 0.05$.

(38.4%), less than recommended intake of fruits and vegetables (96.2%), and low physical activity (58%) (Supplemental Table 1, http://links.lww.com/MD/B462). The presence of NCDs like HTN, DM, dyslipidemia, and OAD were more common in unemployed male subjects who were older (60–79 years) and without college degree (Supplemental Table 2, http://links.lww.com/MD/B462).

Two major modifiable risk factors identified to be significantly associated with increased prevalence of HTN, DM, and dyslipidemia were BMI (>25) and regular use of alcohol (Table 3). Smoking was significantly associated with OAD. About 25% of subjects who smoked suffered from OAD. Low physical activity significantly correlated with dyslipidemia ($P = 0.005$). Inadequate intake of fruits and vegetables or consumption of meat was not significantly associated with HTN, DM, dyslipidemia, or OAD. Regular consumption of food away from home was associated with HTN and DM in our study group.

3.4. Estimation of cardiovascular risk scores

The baseline 10-year and lifetime risk of developing a hard event, CHD, or stroke was estimated using the 2013 AHA/ACC Pooled Risk Calculator. This calculator is usually used to evaluate the CVD risks of subjects aged between 20 and 79 years. We also evaluated the CVD risk of the cohort using the Framingham Cardiovascular Risk scoring tool. The risk estimates using both algorithms are as shown in Table 4.

Of the 1082 subjects in 18 to 39-year age group, 97% (1052) had a low (<10%) 10-year predicted risk of developing CHD/stroke, while only 4 participants had a high predicted risk (>20%) of CVD, as per their FRS. In the same subcohort, CVD risk assessment by the ASCVD risk calculator identified 61% (657) with a high lifetime predicted risk of developing CHD/stroke.

Similarly, estimating the CVD risks of subjects aged 40 to 59 years using the FRS identified 765 (30%) with moderate risk and

Table 3

Characteristics of risk factors for noncommunicable diseases (NCDs): modifiable risk factors.

Characteristics	Total number (N=4507)	Hypertension	Significance (*P*)	Diabetes	Significance (*P*)	Dyslipidemia	Significance (*P*)	OAD	Significance (*P*)
Anthropometric measurements									
Underweight (BMI <18.5)	43 (1)	4 (9.3)	3.7E-12*	4 (9.3)	0.004*	3 (7)	5.5E-7*	13 (30.2)	0.123
Normal (BMI 18.5–24.9)	1406 (31.2)	286 (20.3)		278 (19.8)		379 (27)		255 (18.1)	
Overweight (BMI 25–30)	2140 (47.5)	553 (25.8)		402 (18.8)		668 (31.2)		362 (16.9)	
Obese (BMI >30)	918 (20.4)	307 (33.4)		218 (23.7)		328 (35.7)		165 918)	
Lifestyle habits									
Smoking	398 (8.8)	109 (27.4)	0.2	90 (22.6)	0.18	129 (32.4)	0.4	97 (24.4)	2.30E-04
Regular use of alcohol	753 (16.7)	250 (33.2)	5.6 E-7*	211 (28)	1.3E-8*	253 (33.6)	0.012	130 (17.3)	0.9
Low physical activity	2615 (58)	624 (23.9)	0.006*	510 (19.5)	0.121	774 (29.6)	0.005*	470 (18)	0.34
Dietary habits									
Less than 5 servings of fruits and/or vegetables	4337 (96.2)	1110 (25.6)	0.3	874 (20.4)	0.13	1327 (30.6)	0.4	759 (17.5)	0.13
Intake of meat	3870 (85.9)	980 (25.3)	0.2	765 (19.8)	0.3	1182 (30.5)	0.9	679 (17.5)	0.683
Regular consumers of food away from home	1509 (33.5)	310 (20.5)	3.70 E-07	268 (17.5)	0.026	436 (28.9)	0.138	274 (18.2)	0.68
Use of saturated oil	2911 (64.6)	766 (26.3)	0.052	595 (20.4)	0.177	903 (29.3)	0.538	520 (17.9)	0.678

BMI=body mass index, OAD=obstructive airway diseases.
*indicates a significance of $P < 0.05$.

Table 4

Age- and sex-stratified distribution of atherosclerotic cardiovascular disease (ASCVD) and Framingham risk scores.

Age, y	Sex	ASCVD risk score				Framingham		
		10-year risk		Lifetime risk				
		<7.5 (Low)	>7.5 (High)	<39 (Low)	≥39 (High)	<10 (Low)	10–20 (Moderate)	>20 (High)
18–39 (n=1082)	Females	0	0	235 (54.9)	193 (45.1)	427 (99.8)	1 (1.2)	0
	Males	0	0	190 (29.1)	464 (70.9)	625 (95.6)	25 (3.8)	4 (0.6)
40–59 (n=2597)	Females	1046 (97.7)	25 (2.3)	284 (26.5)	787 (73.5)	864 (80.7)	174 (16.2)	33 (3.1)
	Males	1037 (68)	489 (32)	288 (18.9)	1238 (81.1)	634 (41.5)	591 (38.7)	301 (19.7)
60–79 (n=828)	Females	151 (47)	170 (53)	0	0	110 (34.3)	132 (41.1)	79 (24.6)
	Males	13 (2.6)	494 (97.4)	0	0	7 (1.4)	135 (26.6)	365 (72)

The 10-year ASCVD risk scores were classified into high risk (≥7.5%) and low risk (≤7.5%). The lifetime ASCVD risk scores were classified into high risk (≥39%) and low risk (<39%). The Framingham risk scores were classified into high risk (≥20%), moderate risk (10–20%), and low risk (≤20%).

334 (12%) with high risk of a future cardiovascular endpoint. In contrast, the ASCVD risk score classification revealed a greater proportion of patients about 20% (514) with a high 10-year predictive risk of developing CHD/stroke. Almost 78% (2025) subjects had a high (>39%) lifetime predicted risk of cardiovascular disease. As per FRS, 54%(444) of the 828 subjects in the 60 to 79 age group had a high 10-year predicted risk of CHD while the ASCVD scoring identified 80% (664) with a high 10-year predicted risk.

Further, subjects in the 40 to 59-year age group were profiled into 3 groups based on their ASCVD risk scores, namely, a low 10-year and low lifetime predicted risk, a low 10-year and high lifetime predicted risk, and a high 10-year and high lifetime predicted risk. Of the 2597 participants in this group, 59% had a low 10-year and high lifetime predicted risk while 19% (500) had a high 10-year and high lifetime predicted ASCVD risk.

Supplemental Table 3 (http://links.lww.com/MD/B462) shows the prevalence pattern of individual risk factors that are part of the ASCVD scoring algorithm. As shown, 70% of smokers were identified to have a high 10-year and high lifetime predicted risk of CVD. The prevalence of other risk factors in this subgroup was similar or even lower than that observed in the low 10-year high lifetime predicted risk subgroup. Not surprisingly, frequency of smoking, DM, HTN, and hypercholesterolemia were much lower in the low 10-year and low lifetime ASCVD risk category.

3.5. Prevalence of modifiable lifestyle CVD risk factors
3.5.1. 40 to 59-year age group.
Results of a comparative evaluation of behavioral risk factors like alcohol intake, dietary habits, and physical activity between the high-risk groups (low 10-year and high lifetime risk, and high 10-year and high lifetime risk) and low-risk (low 10-year and low lifetime risk) are shown in Table 5. Alcohol use had a significant ($P < 0.001$) correlation with increased cardiovascular risk with regular drinkers more likely to have a high lifetime ASCVD score (90.1%) compared with subjects who drink occasionally (81.7%) or are teetotalers (74%). More than 50% each of the regular and occasional alcohol users belonged to the low 10-year but high lifetime category, while 25% of occasional drinkers and about 39% of regular drinkers had a high 10-year, high lifetime risk. Moderate and low physical activities were significant determinants ($P = 0.01$) of high CVD risk.

Meat intake was significantly associated with increased CVD risk ($P = 0.02$), with 29.2% of subjects who consumed meat daily having a high 10-year and high lifetime ASCVD risk compared with those who consumed meat less frequently (bi-weekly or weekly or monthly). The latter were more likely to be categorized

with low 10-year but high lifetime ASCVD risk. Also, subjects consuming food away from home were more likely to be stratified in the high lifetime risk compared with low 10-year and low lifetime risk (79.1% vs 20.9%). Adequate intake of fruits and vegetables and type of oil used for cooking were not significantly associated with a greater lifetime CVD risk.

Further, using a multinomial regression analysis (Table 6), we compared the behavioral risk factors to all the 3 risk categories—high 10-year and high lifetime risk, low 10-year and high lifetime risk, and low 10-year and low lifetime risk. Frequency of alcohol consumption, intake of fruits and vegetables, and BMI emerged as significant predictors of low 10-year and low lifetime ASCVD risk. Compared with the study participants who do not drink alcohol, regular and occasional drinkers were, respectively, 8.5- and 3.1-fold more likely to be in a high 10-year and high lifetime ASCVD risk category than in low 10-year and low lifetime risk group. Similarly, regular drinkers and occasional drinkers were, respectively, 2.1 and 1.3 times more likely to be in low 10-year and high lifetime risk than in low 10-year and low lifetime risk category. Participants having lesser intake of fruits and vegetables compared with adequate consumption of the same were 1.59 times more likely to be in low 10-year and high lifetime risk than in low 10-year and low lifetime risk category. Obese and overweight participants are, respectively, 2.3- and 1.4-fold more likely to be in low 10-year and high lifetime risk than in low 10-year and low lifetime risk category.

3.5.2. 18 to 39-year age group.
Lifetime risk was calculated in this age group and evaluated for associations with high-risk behavior (Supplemental Table 4, http://links.lww.com/MD/B462). Regular alcohol intake, frequent intake of meat, and regular intake of food away from home was significant in the subgroup with high lifetime risk of hard event. Additionally, obesity was associated with high lifetime risk in this group.

3.5.3. 60 to 79-year age group.
Ten-year risk for developing a hard event was calculated in this older age group. Regular alcohol intake and decreased physical activity were associated with high 10-year CVD risk (Supplemental Table 5, http://links.lww.com/MD/B462)

4. Discussion

As per the "WHO Plan of Action for the Prevention and Control of NCDs," interventional approach addressing the 4 modifiable risk factors (tobacco use, poor dietary habits, excess alcohol consumption, and sedentary behavior) can substantially reduce the NCD burden of a society. Our study substantiates this

Table 5

Distribution of behavioral characteristics and risk factors among the atherosclerotic cardiovascular disease (ASCVD) risk classifications in the age group of 40–59 years.

Characteristics	ASCVD risk categories			P
	High 10-y and high lifetime risk (N=500)	Low 10-y and high lifetime risk (N=1525)	Low 10-y and low lifetime risk (N=558)	
BMI				
Underweight (N=18)	2 (11.1)	5 (27.8)	11 (61.1)	1.5E-8*
Normal (N=712)	135 (19)	383 (53.8)	194 (27.2)	
Overweight (N=1326)	258 (19.5)	791 (59.7)	277 (20.9)	
Obese (N=527)	105 (19.9)	346 (65.7)	76 (14.4)	
Alcohol drinking frequency				
Never (N=1608)	190 (11.8)	1000 (62.2)	418 (26)	1.2E-42*
Occasional drinkers (N=512)	130 (25.4)	288 (56.3)	94 (18.4)	
Regular drinkers (N=463)	180 (38.9)	237 (51.2)	46 (9.9)	
Physical activity				
High (N=320)	84 (26.3)	167 (52.2)	69 (21.6)	2.4E-5*
Moderate (N=798)	181 (22.7)	456 (57.1)	161 (20.2)	
Low (N=1465)	235 (16)	902 (61.6)	328 (22.4)	
Intake of fruits and vegetables				
Adequate intake (N=105)	19 (18.1)	56 (53.3)	30 (28.6)	0.2
Less intake (N=2478)	481 (19.4)	1469 (59.3)	528 (21.3)	
Use of oil				
Saturated oil (N=1673)	302 (18.1)	1011 (60.4)	360 (21.5)	0.35
Unsaturated (N=666)	129 (19.4)	381 (57.2)	156 (23.4)	
Meat intake frequency				
Daily (N=236)	69 (29.2)	124 (52.5)	43 (18.2)	0.02*
Bi-weekly (N=333)	72 (21.6)	201 (60.4)	60 (18)	
Weekly (N=728)	146 (20.1)	432 (59.3)	150 (20.6)	
Monthly (N=451)	68 (15.1)	278 (61.6)	105 (23.3)	
Once in a few months (N=502)	89 (17.7)	297 (59.2)	116 (23.1)	
Never (333)	56 (16.8)	193 (58)	84 (25.2)	
Food from outside category				
Never (N=19)	1 (5.3)	15 (78.9)	3 (15.8)	0.001*
Occasional (N=1736)	302 (17.4)	1052 (60.6)	382 (22)	
Regular (N=828)	197 (23.8)	458 (55.3)	173 (20.9)	

χ^2 statistics were employed to test the significance of univariate association between behavioral characteristics and ASCVD risk groups.
BMI=body mass index.
* Indicates a statistical significance of $P < 0.05$.

strategy at the individual and population level. The prevalence data of HTN, DM, dyslipidemia, and obesity in our cohort was similar to several reported studies from Kerala.[10,32] Like elsewhere in the country, rapid urbanization, unhealthy eating habits leading to nutrition transition and decreased physical activity have contributed to the increased prevalence of obesity in our cohort. As observed by Sugathan et al, the prevalence of alcohol consumption in our population was about 40%, a 3-fold

Table 6

Multiple logistic regression comparing behavioural risk factors to ASCVD risk categories of high 10-year and high lifetime, low 10-year and high lifetime & low 10-year and low lifetime.

Characteristics		ASCVD risk categories					
		High 10-y and high lifetime risk			Low 10-y and high lifetime risk		
		Prevalence	OR (95% CI)	P	Prevalence	OR (95% CI)	P
Frequency of alcohol consumption	Regular drinkers (N=463)	38.9%	8.54 (5.91–12.35)	3.2E-30*	51.2%	2.12 (1.51–2.98)	1.9E-5*
	Occasional drinkers (N=521)	25.4%	3.11 (2.26–4.27)	2.66E-12*	56.3%	1.31 (1.01–1.70)	.041*
	Never (N=1608)	11.8%	Referent	NA	62.2%	Referent	NA
Intake of fruit and vegetables	Less intake (N=2478)	19.4%	1.63 (0.884–3.02)	0.117	59.3%	1.59 (1.00–2.5)	0.047*
	Adequate intake (N=105)	18.1%	Referent	NA	53.3%	Referent	NA
BMI	Obese (N=527)	19.9%	2.09 (1.40–3.01)	2.07E-4*	65.7%	2.34 (1.73–3.18)	3.9E-8*
	Overweight (N=1326)	19.5%	1.29 (0.96–1.72)	0.084	59.7%	1.43 (1.15–1.79)	0.001*
	Underweight (N=18)	11.1%	0.389 (0.08–1.87)	0.239	27.8%	0.25 (0.08–0.74)	0.012*
	Normal (N=712)	19%	Referent		53.8%	Referent	NA

Referent category for ASCVD risk: Low 10 year low lifetime ASCVD risk.
ASCVD=atherosclerotic cardiovascular disease, BMI=body mass index, CI=confidence interval, OR=odds ratio.
* Indicates a statistical significance of $P < 0.05$.

increase in the last 2 decades.[32,33] Regular drinking was found to be an important determinant of high "short-term" and "lifetime" risk of CVDs, especially in young- and middle-aged adults. The state of Kerala has the highest record of per capita consumption of liquor in the country at a staggering 8.3 L, compared with the national average of 4 L.[34] It is not surprising that we observed increased frequency of alcohol consumption to be the single most (38%) modifiable risk determinant in our entire cohort. Additionally, most of the drinkers from the state belong to the age group of 21 to 40 years. Therefore, we believe concerted efforts at both state and community levels including policy changes and preventive strategies are necessary to tackle this growing risk behavior.

It was encouraging to note though that the smoking habit had drastically reduced with only 9% of our cohort reporting themselves as current smokers.[10] This could be a consequence of the various antismoking initiatives undertaken at state and national level.[35] We believe that similar efforts may be undertaken at national, local as well as community levels to educate and facilitate the individual as well as "population" as a whole to make favorable and healthy lifestyle choices.

In addition to smoking and alcohol use, a significant risk factor associated with cardiovascular risk is unhealthy dietary habits. Increased intake of meat and saturated oils associated with eating outside the home setting, behaviors commonly linked to the younger age group were prevalent in 60 to 79-year cohort too. It is not clear whether this nutritional shift is part of the societal change or just an observation in our cross-sectional cohort. These observations add to the growing evidence that early and sustained exposure to unhealthy lifestyle habits hugely impacts the future CVD risk of an individual. Additionally, the growing prevalence of these risk factors is predictive of a prospective larger NCD burden.

Further, using the ASCVD risk scoring tool we could better characterize the "at risk" subjects from the apparently asymptomatic cross-sectional population and personalize their risk (short term and long term) for developing CVDs.

Epidemiological evidences suggest that primary prevention program within a health care setting aimed at modifying the "risky" lifestyle factors can significantly reduce the mortality and morbidity associated with NCDs.[36] The key initiative in developing an effective primary prevention program in a resource-limited setting like ours is to first identify the target population most likely to benefit from these interventions. Given the widespread prevalence of heart disease in our state, we prioritized identifying and characterizing the "at risk" population for cardiovascular diseases. Risk stratification using the FRS has been a very common tool used by many clinical practices. However, it has several limitations including bias secondary to Caucasian race.[37] Other scoring systems gaining popularity include the ASCVD 10-year and lifetime CVD risk prediction. The ASCVD algorithm was developed based on United States multiracial community cohorts[18] with the focus on estimation of first hard ASCVD events (defined as the first occurrence of nonfatal myocardial infarction, CHD death, or fatal or nonfatal stroke). Studies have shown that development of atherosclerosis in younger (<50 years) population occurs over a long period and is related to long-term exposure to causal and modifiable risk factors.

As there is no CVD risk calculator specific for Indian population,[21] we evaluated the FRS and ASCVD algorithms in classifying our study cohort into age-associated short-term and lifetime CVD risk. More importantly, we also attempted to identify modifiable lifestyle factors that influence the short-term and lifetime CVD risk.

Application of the ASCVD risk calculator to the 40 to 59-year age group identified 2 distinct subgroups with low short-term (10-year) cardiovascular risk, namely, those with low 10-year and low lifetime predicted risk and low 10-year and high lifetime risk. About 34% (1525) subjects in this age group had low 10-year and high lifetime risk—a group more likely to develop accelerated atherosclerosis in their lifetime. In this subgroup, several modifiable factors like increased alcohol use, unhealthy dietary habits and obesity were identified as major contributors of CVD risk. In the low 10-year and low lifetime risk group the prevalence of all the above risk factors were lower, suggesting the benefit of modifying these for better outcomes in the high-risk group.

The Framingham risk calculator identifies a lower (30/1082— 2.7%) proportion of young adults (18–39 years) to have moderate/high 10-year CVD risk. In the same age group, the ASCVD risk calculator identifies a larger proportion (657/1082 —61%) to be at higher risk of a CHD event in their lifetime. This clearly suggests that application of Framingham risk among this age group lacks precision in identifying the at risk population.[38] On the other hand, the identification of a larger population with high lifetime risk effectively recognizes the target group in younger adults that will be benefitted by interventions.

Improving awareness of our seemingly healthy subjects attending our clinic of their 10-year and lifetime risk of developing a cardiovascular event will empower them to reduce the risk behavior proactively. Behavioral modification like restricting the harmful use of alcohol and smoking, adopting healthier dietary habits, and improving physical activity has the potential to keep an individual at "low-risk" status for lifetime. Based on these findings, we will design individualized behavioral interventions with a higher likelihood of compliance for this "at risk" population. Appropriate evidence-based recommendations of therapeutic interventions will also be ensured for this cohort.

4.1. Limitations

This study cohort comprised white-collared professionals who voluntarily attended our comprehensive health check-up clinic, indicating their high index of health awareness. Such a selection bias in our study sample may result in observations that may not truly reflect the behavioral patterns prevalent among the population in our state. However, our study findings pertaining to behavioral risk factors were similar to previous studies conducted in much larger cohorts by Thankappan et al[33] and Sugathan et al.[33]

The ASCVD pooled cohort risk calculators may not be the most appropriate risk estimator to calculate the CVD risk for an Indian population in a primary care setting. Race and ethnicity are important parameters known to influence the risk algorithm. As the ASCVD risk algorithm was developed from a large, predominantly white and Hispanic cohort, this calculator significantly overestimates the overall CVD risk in non-white and non-Hispanic population. Recent studies from China and Korea have shown that additional correction factor or recalibration of the pooled cohort risk equation is needed to appropriately estimate the short-term and lifetime CVD risk in their population.[39,40] Such population-specific correction factor to the ASCVD risk calculator appropriate for our population is currently lacking and therefore the reported CVD risk scores in this study may be overpredicting the actual risk.

5. Conclusions

In our study population, the ACC/AHA Pooled Cohort Risk Equation was more sensitive than FRS in forecasting the future risk of developing a first hard cardiovascular event and identified modifiable lifestyle habits that associate with increased CVD risk. Clustering and distribution of the major CVD risk determinants is different among the study subjects. Harmful use of alcohol, unhealthy dietary habits, and inadequate physical activity were more commonly associated in subjects with high lifetime CVD risk.

Based on our preliminary findings, we hope to follow this population over the next 10 years and document their development of CVDs and determine the natural history of progression of NCD in the population. We also intend to evaluate the role of intervention in changing the outcome. Additionally, recognizing that the ASCVD AHA score likely overestimates the risk in the Indian population, we hope to contribute to the efforts internationally to recalibrate the score functions for a more accurate estimation.

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