Contents lists available at ScienceDirect

American Journal of Preventive Cardiology

Original Research

Socioeconomic status, cardiovascular risk profile, and premature coronary heart disease

Safi U. Khan [a,g], Ryan T. Nguyen [b], Zulqarnain Javed [d,e], Maninder Singh [c], Javier Valero-Elizondo [e,f], Miguel Cainzos-Achirica [a,e,f], Khurram Nasir [a,e,f,*]

[a] Department of Cardiovascular Medicine, Houston Methodist DeBakey Heart and Vascular Center, Houston, TX, USA
[b] Department of Medicine, Houston Methodist, Houston, TX, USA
[c] Guthrie Health System/Robert Packer Hospital, Sayre, PA, USA
[d] Division of Health Equity and Disparities Research, USA
[e] Center for Outcomes Research, Houston Methodist, Houston, TX, USA
[f] Department of Cardiovascular Medicine, Cardiovascular Prevention and Wellness, 6550 Fannin St, Suite 1801, Houston 77030, USA
[g] Methodist DeBakey Heart and Vascular Center, Houston, TX, USA

ARTICLE INFO

ABSTRACT

Background: The combined influence of traditional cardiovascular risk factors and socioeconomic status (SES) on premature CHD (<65 years) remains understudied.
Methods: We used the National Health Interview Survey (NHIS) database (2012-2018) to examine the association of sociodemographic (income, education, insurance status) and cardiovascular risk profile (CRF: ranging from optimal (0–1 risk CV factor) to poor (≥4 risk CV factors)) with CHD in young (18- 44 years) and middle-aged (45–64 years) adults.
Results: Among the 168,969 included adults (young: 46.6%), the prevalence of CHD was 3%, translating to 6.4 million young and middle-aged adults. Adults with low family income, lesser education and no insurance were more likely to have CHD. While majority of young adults (65%) had optimal CRF profile and only 4% had poor CRF profile, 26% of middle-aged adults carried poor CRF profile. When examined by income status, education, and insurance status, odds of CHD were increased with worsening CRF profile. In multivariate regressions, low income participants who had a poor CRF (reference: optimal CRF) had higher odds of CHD in both young (aOR: 9.12 [95% CI, 6.16–13.50]) and middle-aged adults (aOR: 8.22 [95% CI, 6.12–11.05]). Within participants with a high school education or lower, those with a poor CRF profile (reference: optimal CRF) had increased odds of CHD in young (aOR: 10.35 [95% CI, 6.66–16.11]) and middle-aged adults (aOR: 10.40 [95% CI, 7.91–13.66]). In the uninsured, those with a poor CRF profile (reference: optimal CRF) had an 8-9 fold increased odds of CHD in young (aOR: 7.65 [95% CI, 4.26–13.73]) and middle-aged adults (aOR: 9.34 [95% CI, 5.90–14.79]).
Conclusions: In this national survey, individuals with poor CRF profile had higher odds of premature CHD than those with optimal profile, and burden of CHD increased with worsening of CRF profile.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of mortality and morbidity worldwide [1] and in the United States (US). Coronary heart disease (CHD) constitutes 42.6% of all CVD in the US [2]. While gains in CV survival has slowed down overall [3], a concerning increase in CVD mortality has been witnessed among adults <65 years of age since 2011 [4,5]. Along with increasing prevalence of traditional cardiovascular risk factors which are known to influence the pathogenesis and development of CHD at all ages, low socioeconomic status (SES) has been linked with increased risk of developing premature CHD [6]. Yet the impact of SES factors such as income, education, and insurance status on the onset of premature CHD remains understudied.

In high income countries, SES is inversely associated with CVD and

CV risk factors [7]. When further examined in the US on a county level, CHD mortality was higher in low-income counties than those with higher income [8]. A deeper understanding of the link between SES and cardiovascular risk factors on the genesis of CHD is critical in identifying optimal medical, social, and economic interventions that can mitigate the rising burden of premature CHD, particularly among vulnerable groups [9]. Therefore, we used a nationally-representative data for US adults <65 years to assess sociodemographic determinants of CHD in this age group, the association between traditional cardiovascular risk factors and prevalence of CHD, and the relationship between SES and traditional risk factors and their implications for CHD burden.

2. Methods

2.1. Setting

We utilized the National Health Interview Survey (NHIS) database, which is an annual cross-sectional survey conducted by the National Center for Health Statistics/Center for Disease Control and Prevention [10]. The NHIS uses complex, multistage probability sampling incorporating stratification, clustering, and oversampling, to adequately provide estimates of the non-institutionalized US population. The NHIS questionnaire has four core sections: Household Composition, Family Core, Sample Child Core, and Adult Sample Core. The Household Composition file collects general information about individuals living under the same household, and the Family Core collects sociodemographic characteristics per family, including, but not limited to, general health indicators, physical limitations, injuries and insurance coverage [11]. From each family, one child and one adult (Sample Child and Adult Core files, respectively) are selected randomly for a more in-depth questionnaire, such as barriers to care, healthcare-related financial issues, health behaviors and disease-related information. This study used the Sample Adult questionnaire as its base, further supplemented with information from the Household and Family files. This study was exempt from formal institutional review board given the deidentified and public availability nature of data [12].

2.2. Study design and population

We conducted a cross-sectional analysis using NHIS data for 2012–2018. Our study population was restricted to adults ages 18 to 64 years, and further stratified to young (18–44 years) and middle-aged (45-64 years) groups, to study differences between these age groups.

2.3. Assessment of sociodemographic characteristics and comorbidities

We included various sociodemographic variables such as race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic Asian or Hispanic), education level (≥some college or ≤high school), insurance status (insured or uninsured), and geographic region (Northeast, Midwest, South, or West). We considered family income as a measure of SES; family income was defined in function of it as a percentage of the federal poverty limit and was categorized as high- (≥400%), middle- (200% to <400%) or low- (<200%) income status. Comorbidities were ascertained (also self-reported), and included chronic obstructive pulmonary disease, emphysema, asthma, gastrointestinal ulcer, arthritis (including arthritis, gout, fibromyalgia, rheumatoid arthritis and systemic lupus erythematosus), cancer (any), any kind of liver condition or "weak/failing" kidneys. Number of prevalent comorbidities were summed for each individual and stratified into 0, 1 and ≥ 2.

2.4. Ascertainment of Cardiovascular Risk Factors (CRF) and definition of CRF profile

Traditional risk factors included hypertension, diabetes mellitus, high cholesterol, smoking, obesity, and insufficient physical activity.

Ascertainment of disease states was done based on following survey questions: (1) hypertension: "*Have you ever been told by a doctor or other health professional that you have hypertension, also called high blood pressure?*"; (2) diabetes: "*Has a doctor or other health professional EVER told you that you had diabetes or high blood sugar?*" and (3) high cholesterol: "*Have you EVER been told by a doctor or other health professional that you had high cholesterol?*".

Smoking was ascertained as an individual being either former or current smoker, and obesity (defined as a body mass index ≥30 kg/m^2) was calculated based on self-reported height and weight. Insufficient physical activity was defined as not meeting the current physical activity guidelines (i.e. not participating in moderate-intensity aerobic physical activity for > 150 min per week, or vigorous-intensity aerobic physical activity for > 75 min per week, or a total combination of ≥ 150 minutes per week of moderate/vigorous-intensity aerobic physical activity) [13].

We defined 3 mutually-exclusive cardiovascular risk factor (CRF) profiles. Based on the absence/presence of the sum of the previously described CRF, individuals were assigned a "Poor" (≥4), "Average" (2–3), or "Optimal" (0–1) CRF profile.

2.4.1. Ascertainment of prevalent CHD

Presence or absence of CHD was ascertained based on individual responses to the survey question: "Have you ever been told by a doctor or other health professional that you had coronary heart disease, or angina, also called angina pectoris, or a heart attack (also called myocardial infarction)?" [14].

2.5. Statistical analyses

We evaluated the distribution of various traditional risk factors (both individually and as CRF profiles) and sociodemographic characteristics among non-elderly adults and compared them between those with and without CHD. We used survey-specific Rao-Scott Chi square test to compare categorical variables. We also performed survey-specific logistic regression analysis to assess the relationship between traditional cardiovascular risk factors, both individually and as CRF profiles, and CHD. Unadjusted and adjusted (a) odds ratios (OR) and 95% confidence intervals (CI) are reported. Variables included in the regression models included age, sex, race/ethnicity, education, insurance status, geographical region and comorbidities. All analyses were performed using Stata® 16 (StataCorp, College Station, TX), and addressed the complex design of the NHIS.

3. Results

3.1. Study participants

Between 2012 and 2018, 6,186 individuals with CHD were surveyed (weighted n = 6,401,333). Of these, 950 (weighted n = 1,107,818) were young- and 5,236 (weighted n = 5,293,515) were middle-aged adults. In young and middle-aged US adults, more men than women had CHD (Table 1). Overall, Non-Hispanic (NH) White adults, participants having low family income, and lesser education were more likely to have CHD.

3.2. Traditional risk factors and risk factor profiles by CHD status

In both young- and middle-aged adults, insufficient physical activity (42.0% and 51.7%, respectively), and smoking (30.4% and 42.1%, respectively) were the most frequently reported traditional risk factors (Table 2). The prevalence of obesity (29.4% and 37.2%), hypertension (11.8% and 38.8%), high cholesterol (9.5% and 35.9%), and diabetes (2.7% and 12.7%) varied in both young and middle-aged cohorts, respectively. Among young adults, participants with CHD were more likely to have hypertension (45.7% vs. 11.5%), diabetes mellitus (15.9% vs. 2.5%), obesity (48.0% vs. 29.3%), hypercholesterolemia (38.0% vs. 9.3%), and insufficient physical activity (60.0% vs 41.8%) than those

Table 1

General characteristics among young and middle-aged adults with and without CHD, from the national health interview survey, 2012–18.

	18 – 44 years of age (Young)			45–64 years of age (Middle-Aged)		
	No CHD	CHD	*P* value	No CHD	CHD	*P* value
Sample (N)	92280	950		70442	5236	
Weighted sample, (weighted %)	111,688,757 (99.0)	1,107,818 (1.0)		77,571,339 (93.6)	5,293,515 (6.4)	
Sex, n (weighted %)			0.003			<0.001
Male	42,408 (49.5)	478 (56.1)		31,909 (47.5)	3,052 (61.7)	
Female	49,872 (50.5)	472 (43.9)		38,533 (52.5)	2,184 (38.3)	
Race/Ethnicity, n (weighted %)			0.002			<0.001
Non-Hispanic White	52,248 (58.5)	496 (57.0)		47,447 (69.6)	3,568 (71.9)	
Non-Hispanic Black	12,740 (13.8)	148 (15.8)		9,767 (11.8)	866 (14.2)	
Non-Hispanic Asian	6,687 (6.9)	36 (3.4)		3,425 (5.5)	138 (3.1)	
Hispanic	19,278 (20.9)	247 (23.9)		8,907 (13.1)	557 (10.9)	
Family Income, n (weighted %)			<0.001			<0.001
High-Income	26,485 (34.8)	152 (18.5)		29,506 (50.6)	1,255 (30.8)	
Middle-Income	24,942 (29.7)	215 (29.0)		16,846 (25.7)	1,192 (26.5)	
Low-Income	35,809 (35.5)	546 (52.6)		18,735 (23.7)	2,503 (42.7)	
Education, n (weighted %)			<0.001			<0.001
Some College or Higher	60,618 (64.8)	475 (49.9)		43,812 (63.6)	2,565 (50.8)	
HS/GED or Less than HS	31,406 (35.2)	475 (50.1)		26,322 (36.4)	2,648 (49.2)	
Insurance Status, n (weighted %)			0.03			0.08
Insured	74,219 (82.2)	726 (78.4)		61,290 (88.7)	4,669 (89.6)	
Uninsured	17,553 (17.8)	222 (21.6)		8,890 (11.3)	546 (10.4)	
Region, n (weighted %)			0.07			<0.001
Northeast	13,728 (16.4)	132 (13.4)		12,289 (19.2)	816 (16.3)	
Midwest	20,127 (22.7)	208 (25.2)		15,024 (21.8)	1,165 (24.3)	
South	32,834 (36.3)	375 (39.9)		25,145 (36.5)	2,241 (42.9)	
West	25,591 (24.7)	235 (21.6)		17,984 (22.5)	1,014 (16.5)	
Comorbidities, n (weighted %)			<0.001			<0.001
0	69,538 (76.0)	415 (45.9)		37,169 (54.5)	1,369 (27.9)	
1	18,385 (19.7)	275 (29.9)		21,545 (30.3)	1,575 (30.9)	
≥ 2	4,357 (4.3)	260 (24.1)		11,728 (15.3)	2,292 (41.1)	

Abbreviations: CHD, coronary heart disease; GED, General Equivalency Diploma; HS, high school.

Table 2

Individual cardiovascular risk factors and risk factor profile among young and middle-aged adults with and without CHD, from the national health interview survey, 2012–18.

	18 – 44 years of age (Young)			45-64 years of age (Middle-Aged)		
	No CHD	CHD	p value	No CHD	CHD	p value
Sample (N)	92,280	950		70,442	5,236	
Weighted sample, (weighted %)	111,688,757 (99.0)	1,107,818 (1.0)		77,571,339 (93.6)	5,293,515 (6.4)	
Hypertension, n (weighted %)	11,112 (11.5)	444 (45.7)	<0.001	26,408 (36.4)	3,911 (73.7)	<0.001
Diabetes Mellitus, n (weighted %)	2,452 (2.5)	139 (15.9)	<0.001	8,035 (11.3)	1,733 (34.3)	<0.001
High Cholesterol, n (weighted %)	8,514 (9.3)	340 (38.0)	<0.001	23,315 (33.6)	3,548 (68.8)	<0.001
Smoke (Former/Current), n (weighted %)	29,344 (30.1)	485 (51.3)	<0.001	30,265 (40.8)	3,316 (62.5)	<0.001
Obesity, n (weighted %)	27,223 (29.3)	442 (48.0)	<0.001	25,869 (36.4)	2,612 (49.0)	<0.001
Insufficient Physical Activity, n (weighted %)	37,784 (41.8)	556 (60.0)	<0.001	35,612 (50.8)	3,452 (65.3)	<0.001
CRF Profile, n (weighted %)			<0.001			<0.001
Optimal	57,466 (65.1)	240 (27.0)		24,965 (38.4)	366 (8.4)	
Average	28,985 (31.5)	428 (47.3)		30,644 (45.2)	1,933 (39.4)	
Poor	3,205 (3.4)	220 (25.7)		11,560 (16.4)	2,601 (52.2)	

Abbreviations: CHD, coronary heart disease; CRF, Cardiovascular Risk Factor.

without CHD (Table 2). Similar findings were noted in middle-aged individuals.

Participants without CHD were more likely to have optimal or average CRF profile, and those with CHD had greater number of participants with poor CRF profile. Among individuals with CHD, 25.7% of young adults had a poor CRF profile vs. 74.3% having either optimal or average CRF profile. This proportion shifted to more unfavorable profiles in middle-aged adults, where 52.2% had a poor CRF profile vs. 47.8% having optimal or average CRF profiles.

The majority of young adults had an optimal (64.8%) CRF profile, with only 3.6% having a poor CRF profile. In contrast, middle-aged adults were more normally distributed, with the highest proportion having an average (44.8%) profile, and 18.6% having a poor CRF profile. Individuals with an average or poor CRF profiles had 2-fold and 7-fold higher odds of CHD, respectively, when compared to those with optimal CRF in both cohorts (Table S1).

3.3. Interplay between cardiovascular risk profile, income status and CHD

There was an increase in the burden of CHD prevalence with worsening income status and CRF profile (Fig. 1).Young and Middle-Aged adults with Low Income and Poor CRF profile had higher CHD prevalence rates compared to other similar aged adults coming from higher income and CRF profile brackets. Findings from multivariate regression are presented in Tables 3, 4 and 5. Among middle/high income group, poor CRF (reference: optimal CRF) was associated with 9 to 12 fold

higher odds of CHD, respectively in middle aged (aOR, 8.92 [95% CI, 7.47–10.65]) and young (aOR, 11.90 [95% CI, 8.02–17.65]) adults, after full adjustment for covariates (Table 3). Similarly, in the low income group, participants with poor CRF had higher odds of CHD in both young (aOR: 9.12 [95% CI, 6.16–13.50]), and middle-aged adults (aOR: 8.22 [95% CI, 6.12–11.05]) when compared to those with optimal CRF profiles. In both middle/high and low income groups and across age groups, individuals with average CRF profiles had a 2-3 fold increased odds of CHD compared to those with optimal CRF profile.
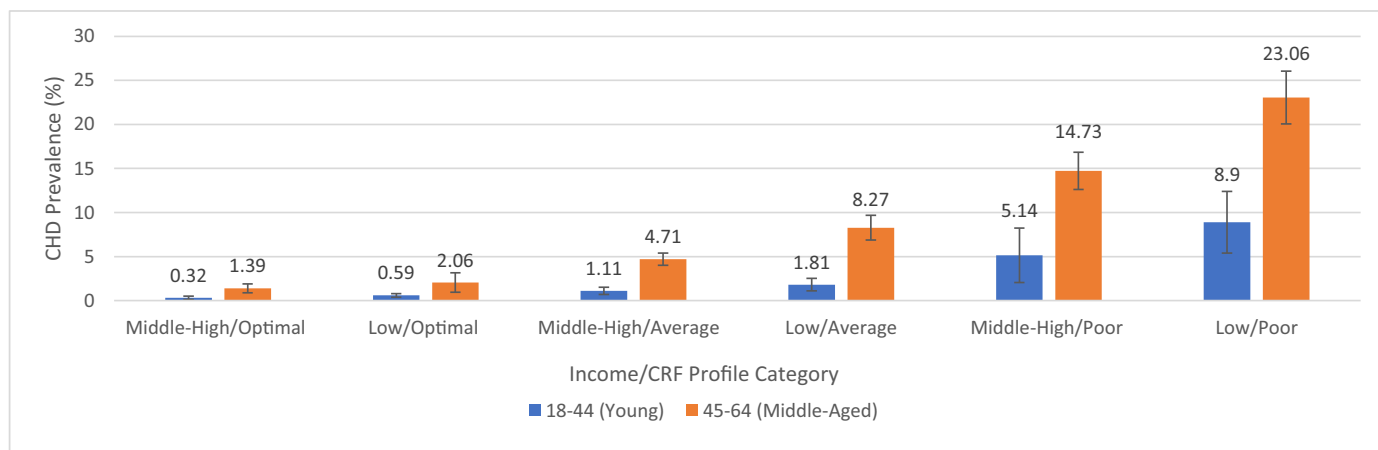
(A) Prevalence of Coronary Heart Disease by CRF and Family Income
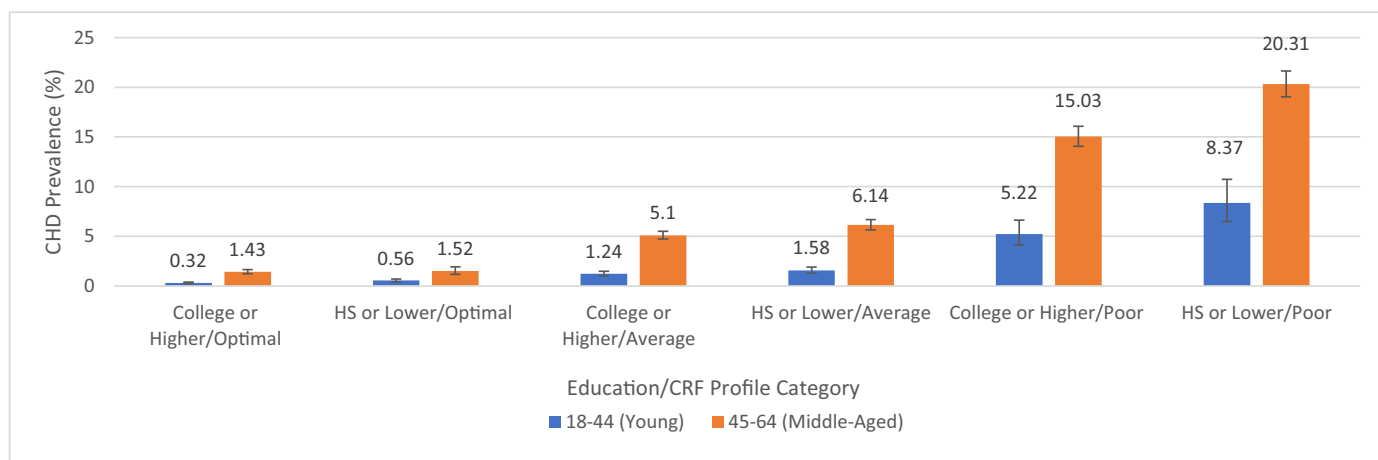
(B) Prevalence of Coronary Heart Disease by CRF and Education Status
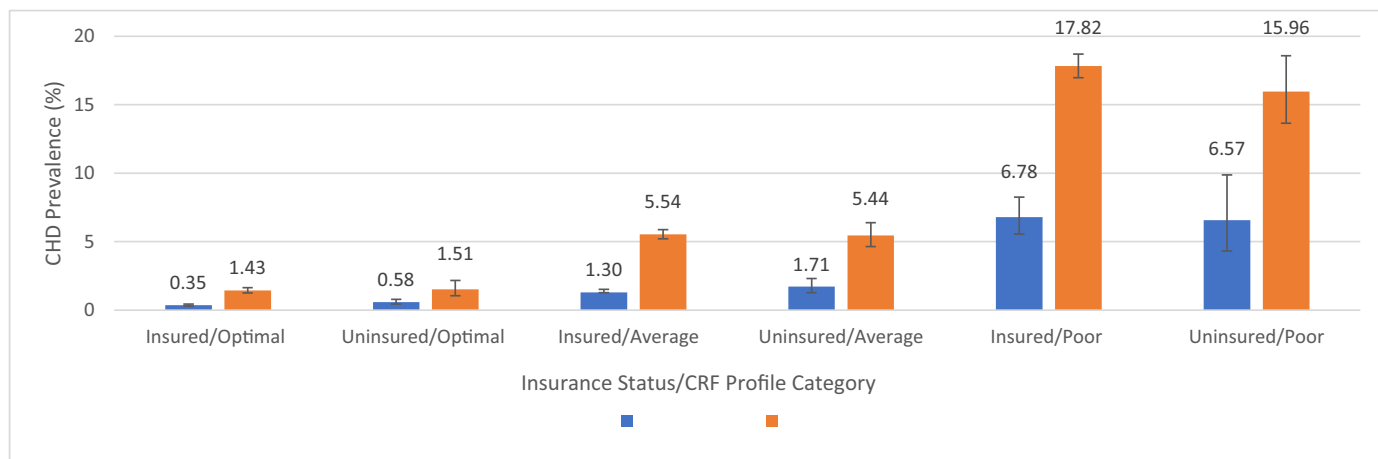

Fig. 1. Prevalence of Coronary Heart Disease by Cardiovascular Risk Factor Profile (CRF) and Family Income (A), Educational Status (B), Insurance Status (C) Among Young and Middle-aged Adults, from the National Health Interview Survey, 2012-18.

Table 3

Predictors of history of CHD among young and middle-aged adults, stratified by age and income groups, from the national health interview survey, 2012–18.

Odds for Reporting CHD				
	Middle/High-Income		**Low Income**	
	18-44 years of age (Young)	45-64 years of age (Middle-Aged)	18-44 years of age (Young)	45-64 years of age (Middle-Aged)
	aOR (95% CI), p-value	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*
CRF Profile				
Optimal	Reference	Reference	Reference	Reference
Average	2.94 (2.19, 3.96), *p* < 0.001	2.98 (2.49, 3.56), *p* < 0.001	2.45 (1.79, 3.36), *p* < 0.001	3.20 (2.39, 4.29), *p* < 0.001
Poor	11.90 (8.02, 17.65), *p* < 0.001	8.92 (7.47, 10.65), *p* < 0.001	9.12 (6.16, 13.50), *p* < 0.001	8.22 (6.12, 11.05), *p* < 0.001

Abbreviations: CHD, coronary heart disease; aOR, adjusted Odds Ratios; CI, confidence interval; HS, high school; GED, General Equivalency Diploma. Model adjusted for sex, race/ethnicity, education, insurance status, geographical region and comorbidities.

Table 4

Predictors of history of CHD among young and middle-aged adults, stratified by age and education groups, from the national health interview survey, 2012–18.

Odds for Reporting CHD				
	College/Higher Education		**Highschool or Lower**	
	18–44 years of age (Young)	45–64 years of age (Middle-Aged)	18–44 years of age (Young)	45–64 years of age (Middle-Aged)
	aOR (95% CI), p-value	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*
CRF Profile				
Optimal	Reference	Reference	Reference	Reference
Average	3.08 (2.33, 4.08), *p* < 0.001	2.99 (2.49, 3.59), *p* < 0.001	2.27 (1.61, 3.19), *p* < 0.001	3.38 (2.55, 4.47), *p* < 0.001
Poor	10.08 (7.01, 14.47), *p* < 0.001	7.76 (6.47, 9.30), *p* < 0.001	10.35 (6.66, 16.11), *p* < 0.001	10.40 (7.91, 13.66), *p* < 0.001

Abbreviations: CHD, coronary heart disease; aOR, adjusted Odds Ratios; CI, confidence interval; HS, high school; GED, General Equivalency Diploma. Model adjusted for sex, race/ethnicity, insurance status, geographical region and comorbidities.

3.4. Interplay between cardiovascular risk profile, education status and CHD

Among those receiving a college/high school education or higher, poor CRF profile (reference: optimal CRF) was associated with an 8-10 fold higher odds of CHD in middle-aged (aOR, 7.76 [95% CI, 6.47–9.30)] and young (aOR, 10.08 [95% CI, 7.01–14.47]) adults, respectively, after full adjustment for covariates (Table 4). Among individuals receiving a high school education or lower, those with a poor CRF profile (reference: optimal CRF) had a 10 fold increased odds of CHD in middle-aged (aOR, 10.40 [95% CI, 7.91–13.66] and young (aOR, 10.35 [6.66–16.11]) adults, respectively. In both college/higher education and high school or lower education and across all age groups, individuals with an average CRF profile had a 2–3 fold increased odds of CHD compared to those with optimal CRF profile (Table 4).

Table 5

Predictors of history of CHD among young and middle-aged adults, stratified by age and insurance groups, from the national health interview survey, 2012–18.

Odds for Reporting CHD				
	Insured		Uninsured	
	18–44 years of age (Young)	45–64 years of age (Middle-Aged)	18–44 years of age (Young)	45–64 years of age (Middle-Aged)
	aOR (95% CI), p-value	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*	*aOR (95% CI), p-value*
CRF Profile				
Optimal	Reference	Reference	Reference	Reference
Average	2.86 (2.21, 3.71), *p* < 0.001	3.04 (2.59, 3.58), *p* < 0.001	2.20 (1.41, 3.44), *p* < 0.001	3.29 (2.11, 5.13), *p* < 0.001
Poor	11.37 (8.22, 15.72), *p* < 0.001	8.59 (7.33, 10.08), *p* < 0.001	7.65 (4.26, 13.73), *p* < 0.001	9.34 (5.90, 14.79), *p* < 0.001

Abbreviations: CHD, coronary heart disease; aOR, adjusted Odds Ratios; CI, confidence interval; HS, high school; GED, General Equivalency Diploma. Model adjusted for age, sex, race/ethnicity, education, geographical region, and comorbidities.

3.5. Interplay between cardiovascular risk profile, insurance status and CHD

Among the insured, poor CRF profile (reference: optimal CRF) was associated with a 9–11 fold higher odds of CHD in middle-aged (aOR, 8.59 [95% CI, 7.33–10.08]) and young (aOR 11.37, [95% CI, 8.22–15.72] adults, respectively, after full adjustments for covariates (Table 5). Among the individuals who are uninsured, those with a poor CRF profile had an 8-9 fold increased odds of CHD in young (aOR 7.65 [95% CI, 4.26–13.73]) and middle-aged (aOR, 9.34 [95% CI, 5.90–14.79]) adults, respectively, compared to uninsured individuals with an optimal CRF profile. In both insured and insured across all age groups, individuals with an average CRF profile had a 2–3 fold increased odds of CHD compared to those with an optimal CRF profile (Table 5).

3.5.1. Traditional risk factors, cardiovascular risk profile, and CHD

In multivariable-adjusted analyses, all traditional risk factors were independently associated with higher odds of CHD among both cohorts, except association of obesity was attenuated after adjusting for covariates (Table S2). Similarly, multivariable analysis showed that participants with average CRF profile had two times, and those with poor profile had 7 times higher odds of CHD compared to those with optimal CRF in both cohorts (Table S1).

4. Discussion

In this nationally-representative study of young and middle-aged US adults, one in thirty individuals had CHD, translating to ~6.4 million individuals in the US annually. Traditional risk factors were independently associated with increased risk of CHD. Young and middle-aged adults with poor CRF profile had 7-8 times higher odds of having CHD when compared to those with optimal CRF profile. Furthermore, participants from lower income strata, lesser education and with no insurance had higher prevalence of CHD. The association between CRF profiles and CHD was consistently seen across strata of SES (income, education, and insurance status). Further, this association was robust to adjustment for covariates.

Similar to previous studies, traditional risk factors such as hypertension, diabetes, and high cholesterol levels were identified as independent predictors of CHD in our study [7,15,16]. Prior reports have also shown an association between CRF profile and CHD [17]. On the same account, a significant relationship between favorable CRF profile and lower medical expenditure and healthcare utilization amongst

individuals without CHD has been documented [18]. Our data reveals that a poor CRF profile leads to higher CHD risk, further validating prior studies. While efforts are aimed towards mitigating traditional cardiovascular risk factors in hopes of reducing the burden of CHD, such an approach does not account for upstream factors of low SES such as lack of insurance, poverty, and education [9,19].

In general, among notable components of SES showing an association with CV disease, income level, employment status, educational attainment, insurance status, and environmental factors have shown to carry most importance [15,20,21]. Despite the mentioned individual components of SES, family income has been considered a key surrogate of SES for the purpose of public health research [15,16,22]. Our study showed an increased CHD prevalence among those coming from low income and poor CRF backgrounds (Fig. 1) which suggest an association between suboptimal upstream SES factors (particularly low income levels) and CHD. However, in our multivariate regression model involving upstream SES factors (income, education, insurance status), the CRF profile, a more downstream risk factor, had a more influential impact on overall CHD risk. The association between CRF and CHD was seen consistently across SES strata, without substantial variation in the observed effect size. Despite these findings, other studies continue to highlight an effect of upstream SES factors on CVD. In a study involving participants from the US and Finland, individuals in the low-income group had higher risk of non-fatal myocardial infarction and cardiac mortality even after multivariate adjustment [21]. Another study showed that each $10,000 increase in median income of a neighborhood lessened the death risk by 10% [23]. A more recent analysis of the national database showed a higher comorbidity burden and poorer cardiovascular outcomes in patients having low SES and admitted with acute myocardial infarction [16]. Although our study showed a marginal effect of upstream SES factors, the results from other studies and ours suggest that the effect of these factors might be impacting CVD indirectly via increased prevalence of cardiovascular risk factors which is shown to have a strong association with overall CVD outcomes.

Hamad et al. summarized the potential pathways linking the effects of low SES with development of CHD [9]. One main postulated mechanism is that limited economic and educational opportunities contribute to increased risk of CHD through decreased access to education, nutrition, or resources for physical activity (i.e. safe neighborhoods)[9, 24–28]. Poverty and lack of education also influence the decision-making bandwidth regarding healthier lifestyle behaviors [28, 29]. Therefore, a low SES could lead to the buildup of a poor CRF profile by depriving access to health care [3,9,30]. This is important to note because a poor CRF profile is linked with a higher probability of developing CHD in the younger population [31]. Interestingly when further stratified, our study revealed that middle-aged adults had higher proportions of poor CRF profiles and subsequently increased risk of CHD compared to young adults. This is likely due to the fact that aging individuals have more exposure to developing traditional risk factors. Our report underscores the importance of considering SES and CRF as a composite target in halting the development of premature CHD, especially in a vulnerable population such as the young and middle-aged adults.

Our study involved subjective self-reported data which revealed an association primarily between CRF profile and CHD. Upstream factors of SES (income, education, insurance status) had a marginal effect on this association. Similarly, in a study involving more objective measures derived from the MESA databank, Christine et al investigated the effects of neighborhood foreclosures on cardiometabolic risk factors and determined that greater exposure to neighborhood foreclosures had mixed associations with cardiometabolic risk factors over time [32]. In contrast, Foster et al highlighted that a combination of lifestyle factors was associated with increased hazard ratios for both cardiovascular disease mortality and CVD incidence in socioeconomic deprived populations from the UK Biobank [33]. Overall, the findings from these two large scale studies and our own study suggest a mixed degree of influence of SES on cardiovascular risk factors and disease that warrants further investigations.

The American College of Cardiology/American Heart Association (ACC/AHA) – 2019 guidelines for primary prevention of cardiovascular disease emphasizes socioeconomic inequalities as a strong social determinant of cardiovascular disease [34]. These guidelines recommend a tailored approach which take into account an individual's SES for primary and secondary prevention of CHD. However, the ACC/AHA standard risk assessment tools, such as the pooled cohort equation, do not account for SES which may underestimate the predicted CHD risk in individuals from disadvantaged communities [9,35]. In view of large proportion of young and middle-aged individuals residing in no insurance and low income brackets, public health targets and professional guidelines must incorporate the socioeconomic variables for slowing the epidemic of premature CHD.

4.1. Study limitations

We report several limitations of this study. First, our reported prevalence of CHD might seem small, but our results correspond to national prevalence cited by the AHA [2]. This is primarily due to studying adults < 65 years of age. When expanding our study population to all adults, CHD prevalence equals 6.3%, as compared to 6.7% as per the AHA [2]. Second, the analysis did not account for the effect of a family history of premature CHD, other lifestyle factors such as dietary habits, or the prevalence of coronary artery anomalies as the underlying reason for CHD, due to inherent limitations of NHIS database. Third, due to the nature of the NHIS dataset, it was not possible to ascertain how the diagnosis of CHD was established, or whether it was clinical or sub-clinical CHD. Fourth, we examined the prevalence of CHD as opposed to the incidence of CHD in this NHIS dataset. Finally, while including all possible confounders in multivariate analysis, due to the cross-sectional nature of the dataset, the possibility of residual confounding remains present. Our findings highlight potential limitations of existing solitary markers of SES (income, education, insurance status) in studying their effects on clinical outcomes, and call for the need to develop additional comprehensive polysocial indices to help capture the true extent of social disadvantage [36]. While our manuscript examined SES factors in young and middle-aged adult populations, additional studies should consider stratifying by gender and ethnicity to further examine these disparities.

5. Conclusions

Amongst a nationally representative sample of ~6.4 million young and middle-aged US adults per year, besides traditional CHD risk factors, individuals with CHD reported a significantly higher proportion of socio-economic disadvantages such as low education levels, low family income or being under-insured. A poor CRF profile was a strong independent predictor of CHD in both young and middle-aged individuals. Public health goals and treatment strategies should address the combined impact of socioeconomic dynamics and CRF to halt the rising burden of premature CHD.

CRediT authorship contribution statement

Safi U. Khan: Writing – original draft, Writing – review & editing, Formal analysis. **Ryan T. Nguyen:** Writing – original draft, Writing – review & editing, Visualization. **Zulqarnain Javed:** Writing – review & editing, Formal analysis, Investigation, Visualization. **Maninder Singh:** Writing – original draft. **Javier Valero-Elizondo:** Formal analysis, Investigation, Writing – review & editing. **Miguel Cainzos-Achirica:** Formal analysis, Writing – review & editing. **Khurram Nasir:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2022.100368.

References

[1] Mensah GA, Roth GA, Fuster V. The global burden of cardiovascular diseases and risk factors: 2020 and beyond. J Am Coll Cardiol 2019;74(20). https://doi.org/10.1016/j.jacc.2019.10.009.

[2] Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, Djousse L, Elkind MSV, Ferguson JF, Fornage M, Khan SS, Kissela BM, Knutson KL, Kwan TW, Lackland DT, Heard DG. Heart disease and stroke statistics–2020 update: a report from the American heart association. Circulation 2020. https://doi.org/10.1161/CIR.0000000000000757.

[3] Wilmot KA, O'Flaherty M, Capewell S, Ford ES, Vaccarino V. Coronary heart disease mortality declines in the United States from 1979 through 2011: evidence for stagnation in young adults, especially women. Circulation 2015;132:997–1002.

[4] Michos ED, Choi AD. Coronary artery disease in young adults: a hard lesson but a good teacher. J Am Coll Cardiol 2019;74:1879–82.

[5] Collet JP, Zeitouni M, Procopi N, Hulot JS, Silvain J, Kerneis M, Thomas D, Lattuca B, Barthelemy O, Lavie-Badie Y, Esteve JB, Payot L, Brugier D, Lopes I, Diallo A, Vicaut E, Montalescot G. Long-term evolution of premature coronary artery disease. J Am Coll Cardiol 2019;74:1868–78.

[6] Karlamangla AS, Merkin SS, Crimmins EM, Seeman TE. Socioeconomic and ethnic disparities in cardiovascular risk in the United States, 2001–2006. Ann Epidemiol 2010;20(8):617–28. https://doi.org/10.1016/j.annepidem.2010.05.003.

[7] de Mestral C, Stringhini S. Socioeconomic status and cardiovascular disease: an update. Curr Cardiol Rep 2017;19:115.

[8] Dwyer-Lindgren L, Bertozzi-Villa A, Stubbs RW, Morozoff C, Kutz MJ, Huynh C, Barber RM, Shackelford KA, Mackenbach JP, van Lenthe FJ, Flaxman AD, Naghavi M, Mokdad AH, Murray CJL. US County-level trends in mortality rates for major causes of death, 1980–2014. JAMA 2016;316:2385–401.

[9] Hamad R, Penko J, Kazi DS, Coxson P, Guzman D, Wei PC, Mason A, Wang EA, Goldman L, Fiscella K, Bibbins-Domingo K. Association of low socioeconomic status with premature coronary heart disease in US adults. JAMA Cardiol 2020.

[10] National Center for Health Statistics. Available at: https://www.cdc.gov/nchs/nhis/about_nhis.htm. Accessed at July 20, 2020.

[11] NHIS Data, Questionnaires and related documentation. Available at https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm. Accessed at 4th June, 2020.

[12] IRB Exemption. Available at http://www.hhs.gov/ohrp/regulations-and-policy/decision-trees/-c2. Accessed at 4th June, 2020.

[13] American Heart Association recommendations for physical activity in adults and kids. www.heart.org. (n.d.). Retrieved September 29, 2021, from https://www.heart.org/en/healthy-living/fitness/fitness-basics/aha-recs-for-physical-activity-in-adults.

[14] Hastings KG, Boothroyd DB, Kapphahn K, Hu J, Rehkopf DH, Cullen MR, Palaniappan L. Socioeconomic differences in the epidemiologic transition from heart disease to cancer as the leading cause of death in the United States, 2003 to 2015: an observational study. Ann Intern Med 2018;169:836–44.

[15] Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, Quyyumi AA, Taylor HA, Gulati M, Harold JG, Mieres JH, Ferdinand KC, Mensah GA, Sperling LS. Socioeconomic status and cardiovascular outcomes: challenges and interventions. Circulation 2018;137:2166–78.

[16] Matetic A, Bharadwaj A, Mohamed MO, Chugh Y, Chugh S, Minissian M, Amin A, Van Spall H, Fischman DL, Savage M, Volgman AS, Mamas MA. Socioeconomic status and differences in the management and outcomes of 6.6 million US patients with acute myocardial infarction. Am J Cardiol 2020.

[17] Michos ED, Santos RD, Narla V, Pandey S, Meneghelo R, Carvalho JA, Budoff MJ, Blumenthal RS, Nasir K. Favorable cardiovascular risk factor profile is associated with reduced prevalence of coronary artery calcification and inflammation in asymptomatic nondiabetic white men. Prev Cardiol 2008;11:189–94.

[18] Valero-Elizondo J, Salami JA, Ogunmoroti O, Osondu CU, Aneni EC, Malik R, Spatz ES, Rana JS, Virani SS, Blankstein R, Blaha MJ, Veledar E, Nasir K. Favorable cardiovascular risk profile is associated with lower healthcare costs and resource utilization: the 2012 medical expenditure panel survey. Circul Cardiovasc Qual Outcomes 2016;9:143–53.

[19] Williams DR, Costa MV, Odunlami AO, Mohammed SA. Moving upstream: how interventions that address the social determinants of health can improve health and reduce disparities. J Public Health Manag Pract JPHMP 2008;14(Suppl): S8–17.

[20] Mosquera PA, San Sebastian M, Waenerlund AK, Ivarsson A, Weinehall L, Gustafsson PE. Income-related inequalities in cardiovascular disease from mid-life to old age in a Northern Swedish cohort: A decomposition analysis. Soc Sci Med 2016;149:135–44.

[21] Kucharska-Newton AM, Harald K, Rosamond WD, Rose KM, Rea TD, Salomaa V. Socioeconomic indicators and the risk of acute coronary heart disease events: comparison of population-based data from the United States and Finland. Ann Epidemiol 2011;21:572–9.

[22] Daly MC, Duncan GJ, McDonough P, Williams DR. Optimal indicators of socioeconomic status for health research. Am J Public Health 2002;92:1151–7.

[23] Gerber Y, Weston SA, Killian JM, Therneau TM, Jacobsen SJ, Roger VL. Neighborhood income and individual education: effect on survival after myocardial infarction. Mayo Clin Proc 2008;83:663–9.

[24] Adler NE, Ostrove JM. Socioeconomic status and health: what we know and what we don't. Ann NY Acad Sci 1999;896:3–15.

[25] Ludwig J, Sanbonmatsu L, Gennetian L, Adam E, Duncan GJ, Katz LF, Kessler RC, Kling JR, Lindau ST, Whitaker RC, McDade TW. Neighborhoods, obesity, and diabetes–a randomized social experiment. N Engl J Med 2011;365:1509–19.

[26] White JS, Hamad R, Li X, Basu S, Ohlsson H, Sundquist J, Sundquist K. Long-term effects of neighbourhood deprivation on diabetes risk: quasi-experimental evidence from a refugee dispersal policy in Sweden. Lancet Diabetes Endocrinol 2016;4: 517–24.

[27] Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. Correlates of physical activity: why are some people physically active and others not? Lancet (London, England) 2012;380:258–71.

[28] Mani A, Mullainathan S, Shafir E, Zhao J. Poverty impedes cognitive function. Science 2013;341:976–80.

[29] Schilbach F, Schofield H, Mullainathan S. The psychological lives of the poor. Am Econ Rev 2016;106:435–40.

[30] Galobardes B, Lynch JW, Davey Smith G. Childhood socioeconomic circumstances and cause-specific mortality in adulthood: systematic review and interpretation. Epidemiol Rev 2004;26:7–21.

[31] Zeitouni M, Clare RM, Chiswell K, Abdulrahim J, Shah N, Pagidipati NP, Shah SH, Roe MT, Patel MR, Schuyler Jones W. Risk factor burden and long-term prognosis of patients with premature coronary artery disease. J Am Heart Assoc 2020;9(24). https://doi.org/10.1161/JAHA.120.017712.

[32] Christine PJ, Moore K, Crawford ND, Barrientos-Gutierrez T, Sánchez BN, Seeman T, Diez Roux AV. Exposure to neighborhood foreclosures and changes in cardiometabolic health: results From MESA. Am J Epidemiol 2017;185(2):106–14. https://doi.org/10.1093/aje/kww186. Jan 15Epub 2016 Dec 16. PMID: 27986705; PMCID: PMC5253973.

[33] Foster HME, Celis-Morales CA, Nicholl BI, Petermann-Rocha F, Pell JP, Gill JMR, O'Donnell CA, Mair FS. The effect of socioeconomic deprivation on the association between an extended measurement of unhealthy lifestyle factors and health outcomes: a prospective analysis of the UK Biobank cohort. Lancet Public Health 2018;3(12):e576–85. https://doi.org/10.1016/S2468-2667(18)30200-7. DecEpub 2018 Nov 20. PMID: 30467019.

[34] Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, Himmelfarb CD, Khera A, Lloyd-Jones D, McEvoy JW, Michos ED, Miedema MD, Muñoz D, Smith SC, Virani SS, Williams KA, Yeboah J, Ziaeian B. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. Circulation 2019;140:e596–646.

[35] Dalton JE, Perzynski AT, Zidar DA, Rothberg MB, Coulton CJ, Milinovich AT, Einstadter D, Karichu JK, Dawson NV. Accuracy of cardiovascular risk prediction varies by neighborhood socioeconomic position: a retrospective cohort study. Ann Intern Med 2017;167:456–64.

[36] Javed Z, Valero-Elizondo J, Dudum R, Khan SU, Dubey P, Hyder AA, Xu J, Bilal U, Kash BA, Cainzos-Achirica M, Nasir K. Development and validation of a polysocial risk score for atherosclerotic cardiovascular disease. Am J Prev Cardiol 2021;8: 100251. https://doi.org/10.1016/j.ajpc.2021.100251. Aug 30PMID: 34553187; PMCID: PMC8441152.