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Accuracy of the Atherosclerotic Cardiovascular Risk Equation in a Large Contemporary, Multiethnic Real-World Population

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Abstract

Background—The accuracy of the 2013 American College of Cardiology/American Heart Association (ACC/AHA) risk equation for atherosclerotic cardiovascular disease (ASCVD) events in contemporary and ethnically diverse populations is not well understood.

Objectives—We sought to evaluate the accuracy of the 2013 ACC/AHA risk equation within a large, multiethnic population in clinical care.

Methods—The target population for consideration of cholesterol-lowering therapy in a large, integrated health care delivery system population was identified in 2008 and followed through 2013. The main analyses excluded those with known ASCVD, diabetes mellitus, low-density lipoprotein cholesterol levels <70 or 190 mg/dl, prior statin use, or incomplete 5-year follow-up.

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Patient characteristics were obtained from electronic medical records and ASCVD events were ascertained using validated algorithms for hospitalization databases and death certificates. We compared predicted versus observed 5-year ASCVD risk, overall and by sex and race/ethnicity. We additionally examined predicted versus observed risk in patients with diabetes mellitus.

Results—Among 307,591 eligible adults without diabetes between 40 and 75 years of age, 22,283 were black, 52,917 Asian/Pacific Islander, and 18,745 Hispanic. We observed 2,061 ASCVD events during 1,515,142 person-years. In each 5-year predicted ASCVD risk category, observed 5-year ASCVD risk was substantially lower: 0.20% for predicted risk <2.50%; 0.65% for predicted risk 2.50 to 3.74%; 0.90% for predicted risk 3.75 to 4.99%; and 1.85% for predicted risk 5.00%, with C: 0.74. Similar ASCVD risk overestimation and poor calibration with moderate discrimination (C: 0.68 to 0.74) was observed in sex, racial/ethnic, and socioeconomic status subgroups, and in sensitivity analyses among patients receiving statins for primary prevention. Calibration among 4,242 eligible adults with diabetes was improved, but discrimination was worse (C: 0.64).

Conclusions—In a large, contemporary “real-world” population, the ACC/AHA Pooled Cohort risk equation substantially overestimated actual 5-year risk in adults without diabetes, overall and across sociodemographic subgroups.

Keywords

cardiovascular; diabetes mellitus; prediction; race/ethnicity; risk factor

Introduction

Publication of the 2013 American College of Cardiology (ACC)/American Heart Association (AHA) Pooled Cohort risk equation for estimating atherosclerotic cardiovascular disease ASCVD risk is considered an important step forward, as it estimates risk for both heart disease and stroke, and provides estimates applicable to black/African Americans (1,2).

This equation was developed from several prospective U.S.-based cohorts of enrolled volunteers, primarily conducted in the 1990s, with limited ethnic diversity and age range. Predicted ASCVD risk using the equation was reported to be systematically higher than observed risk in some highly selected cohorts (3,4), but not in others (5). Importantly, however, these studies included persons screened for participation or enrolled in clinical trials, or in much earlier time periods, with limited generalizability to contemporary and diverse populations that are more representative of eligible patients treated in typical clinical practice (6,7). Validation efforts in more contemporary cohorts have further been limited due to inclusion of analyzed participants treated with statin therapy or having a high likelihood of initiating statins during follow-up (4,6,8). Lack of comprehensive surveillance in some studies is another possible reason for overestimation by the Pooled Cohort risk equation due to underascertainment of ASCVD events (3,9).

Another major knowledge gap is the lack of accurate ASCVD risk estimation specific to persons of Asian/Pacific Islander and Hispanic ethnicities, who are currently combined with

the white population in the Pooled Cohort risk equation (10). Furthermore, patterns of risk in more contemporary, community-based populations may be significantly different from the older cohorts used to derive the Pooled Cohort risk equation, which does not reflect the recent treatment era and risk factor levels (11,12). Estimates suggest that nearly half of U.S. adults and up to 65% of European adults would be eligible for statins on the basis of new ACC/AHA cholesterol guidelines using the Pooled Cohort risk equation (13,14). Thus, evaluating the accuracy of ASCVD risk prediction is essential if it is being used as a decision-making tool to determine which persons should receive statin therapy for primary prevention (13,15), and it could have far-reaching impact if applied at a population level.

To address these knowledge gaps, we examined a very large, contemporary, multiethnic, community-based “real-world” population whose clinical characteristics would typically trigger a discussion of initiation of cholesterol-lowering therapy per risk assessment by the Pooled Cohort risk equation (i.e., patients 40 to 75 years of age, without known ASCVD or diabetes, who have low-density lipoprotein cholesterol [LDL-C] levels between 70 and 189 mg/dl) and compared predicted versus observed 5-year risks of ASCVD events, overall and within sex and multiple ethnic subgroups, along with measures of calibration and discrimination. We also repeated the analyses among a cohort of eligible adults with diabetes mellitus.

Methods

Source population

Kaiser Permanente Northern California (KPNC) is a large integrated healthcare delivery system providing comprehensive inpatient and outpatient care to ~4 million ethnically diverse persons who are highly representative of the local and statewide population (16).

Study sample

Using outpatient laboratory databases, we initially identified all members of KPNC between January 1 and December 31, 2008 who were ≥21 years of age and had LDL-C levels from 70 to 189 mg/dl within 5 years before study entry. We used the earliest LDL-C measurement in the year 2008 as the index date or, if their last available LDL-C was prior to 2008, January 1, 2008 was used as the index date. We excluded those who met any of the following criteria: unknown sex or race/ethnicity; prescribed statins or other lipid-lowering therapies within 5 years before the index date; prior hospitalization for acute myocardial infarction, ischemic stroke, or receipt of coronary artery bypass surgery or percutaneous coronary intervention, identified from health plan hospital discharge or billing claims databases using previously validated methods (17,18); <12 months of continuous membership and pharmacy benefit before the index date (to ensure more complete information on clinical characteristics); and <5 years of complete follow-up, except if due to death. On the basis of the requirements of the ASCVD risk calculator, we also excluded patients with missing systolic blood pressure, total cholesterol, or high-density lipoprotein cholesterol (HDL-C) information. We further excluded patients who received statins during follow-up if used for primary prevention of ASCVD (i.e., statin initiated before a documented ASCVD event) on the basis of filled dispensings found in pharmacy databases. The cohort was then stratified

by diabetes mellitus status at index date on the basis of data from a validated regional diabetes registry (20,21).

Prediction of ASCVD risk

We calculated the 10-year ASCVD predicted risk score for cohort members between 40 and 75 years of age, as per the guideline-recommended ASCVD prevention age group (1,13). To directly compare observed versus predicted ASCVD risk at 5-year follow-up, we annualized the 10-year predicted ASCVD risk and categorized the population into 4 groups of estimated 5-year risk: <2.50%; from 2.50% to <3.75%; from 3.75% to <5.00%; and 5.00% or higher, as was previously done (8).

Ascertainment of ASCVD events

Follow-up occurred through December 31, 2013. ASCVD events were defined as acute myocardial infarction, coronary heart disease (CHD) death, or fatal or nonfatal ischemic stroke. Myocardial infarction and ischemic stroke were identified from comprehensive health plan hospital discharge or billing claims databases on the basis of previously validated algorithms (17-19) using International Classification of Diseases, Ninth Edition (ICD-9) primary discharge codes. Coronary death was on the basis of International Classification of Diseases, Tenth Edition (ICD-10) codes (I11, I20–I25) (22) obtained from state death certificate files through 2013, which was the latest available information at the time of analysis.

Covariates

We characterized comorbidity during a 5-year period before the index date on the basis of relevant ICD-9 diagnosis and procedure codes (19,23) from health plan electronic medical records and a regional diabetes registry (20,21). We collected baseline data on age, sex, self-reported race/ethnicity, cigarette smoking status, and body mass index (BMI) from electronic medical records. We ascertained ambulatory measures of baseline total cholesterol, HDL-C, LDL-C, systolic blood pressure, and use of antihypertensive medication within 5 years before the index date from comprehensive health plan laboratory, outpatient visit and pharmacy databases.

Analytic approach

Analyses were conducted using SAS, version 9.3 (Cary, North Carolina). We compared baseline characteristics across predicted ASCVD risk categories using ANOVA for continuous variables and chi-squared tests for categorical variables. We calculated the 5-year incidence of ASCVD events with 95% confidence limits using the first hospitalized acute myocardial infarction, first hospitalized ischemic stroke, or coronary death observed during follow-up. The 5-year expected incidence of ASCVD risk was on the basis of the mean ASCVD predicted risk and associated 95% confidence interval (CI) among patients whose predicted risk fell within each risk category. We then examined the observed and expected 5-year incidence of ASCVD events among nondiabetic patients between 40 and 75 years of age, overall and stratified by sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Asian/Pacific Islander, and Hispanic) and measures of socioeconomic status using U.S.

Census-based residential block-level data (18). We also separately examined the observed and expected 5-year ASCVD incidence among eligible diabetic patients between 40 and 75 years of age.

Accuracy was assessed by evaluating calibration and discrimination. Following the approach used by Cook and Ridker (11), calibration plots were generated comparing observed versus expected risk of ASCVD events within each estimated risk categories. Discrimination was assessed using the C statistic from a logistic regression model evaluating predicted risk categories with observed 5-year ASCVD event risks. Finally, as a sensitivity analysis, we examined the accuracy of the risk equation among eligible adults with and without diabetes who received statin therapy for primary prevention during the follow-up period.

Results

Study cohort and baseline characteristics

We identified 307,591 eligible adults aged 40 to 75 years who did not have diabetes, prior ASCVD, prior receipt of lipid-lowering therapy, and who had complete 5-year follow-up (Figure 1). In addition, we separately identified 4,242 diabetic patients who did not have known ASCVD, prior lipid-lowering therapy, or any other exclusion criteria (Figure 1).

Among eligible adults without diabetes, mean age was 54.8 years and 61.6% were women, with 22,283 being black/African American, 52,917 being Asian/Pacific Islander, and 18,745 being Hispanic. Nearly one-third were former or current smokers, 28% were obese and 33% were on medication for hypertension (Table 1).

Fifty-seven percent of patients were in the lowest (<5%) category of 10-year predicted ASCVD risk, with 12% having predicted risk 5.0% to <7.5%, 8% having predicted risk 7.5% to <10%, and the remaining 23% having predicted risk 10% (Table 1). Patients with higher predicted ASCVD risk were more likely to be older and male, be former or current smokers, have higher systolic blood pressure and BMI, lower HDL-C, and higher LDL-C (Table 1).

Accuracy of ASCVD risk equation by diabetes status

Among eligible patients 40 to 75 years of age without diabetes, 2,061 ASCVD events were observed during 1,515,142 person-years, with 1,464 (0.5%) acute myocardial infarctions, 525 (0.2%) CHD deaths, and 71 (0.02%) ischemic strokes. The cumulative risk of ASCVD events was linear during the entire 5-year follow-up period (Figure 2). Observed 5-year ASCVD incidence was substantially lower than the predicted risk in each category: 0.20% (95% CI: 0.20% to 0.25%) for predicted risk <2.50%; 0.65% (0.55% to 0.70%) for predicted risk 2.50% to <3.75%; 0.90% (0.75% to 1.00%) for predicted risk 3.75% to <5.00%; and 1.85% (1.75% to 1.95%) for predicted risk 5.00% (Central Illustration). Calibration between the predicted versus observed 5-year ASCVD incidence was poor (Figure 4) and the discrimination was moderate (C: 0.74).

Among eligible 40- to 75-year-olds with diabetes, 148 events were observed during 19,196 person-years, with 84 (2%) acute myocardial infarctions, 54 (1.3%) CHD deaths, and 10

(0.2%) ischemic strokes. Observed 5-year ASCVD incidence in each predicted risk category was: 0.10% (0.00% to 0.85%) for predicted risk <2.50%; 2.55% (1.35% to 4.95%) for predicted risk 2.50% to <3.75%; 2.65% (1.30% to 5.30%) for predicted risk 3.75% to <5.00%; and 5.50% (4.60% to 6.50%) for predicted risk ≥5.00% (Central Illustration). Calibration was fair between predicted versus observed 5-year risk of ASCVD events, and discrimination was only modest (C: 0.64) (Figure 4).

Accuracy of ASCVD risk equation by sex, race/ethnicity, and socioeconomic status

Among both nondiabetic men and women, there was systematic overestimation of observed 5-year ASCVD incidence in each predicted risk category, with similarly poor calibration in both sexes (Figures 3 and 4). Discrimination in nondiabetic women (C: 0.72) was better than in men (C: 0.68).

Given that Asian/Pacific islanders and Hispanics are considered under “white or other” in the ASCVD risk equation, we compared the observed versus predicted 5-year ASCVD incidence separately among non-Hispanic whites, non-Hispanic blacks, Asian/Pacific Islanders, and Hispanics. We found systematic overestimation of actual ASCVD risk in each of these ethnic groups (Figure 3) and similarly poor calibration, but with discrimination varying in each group (C: 0.70 to 0.74) (Figure 4). Results were also similar across measures of socioeconomic status (Figure 4).

Assessment of ASCVD risk equation in persons treated with statins for primary prevention

In sensitivity analyses, we separately examined eligible adults who did or did not have diabetes, but received statin therapy for primary prevention during follow-up. We found that in eligible adults without diabetes, there was overestimation of actual 5-year ASCVD incidence in each predicted risk category (Online Figure 1). Observed rates for this population were approximately 6× lower than predicted. In contrast to findings in untreated eligible patients with diabetes, we found that there was systematic overestimation of observed 5-year ASCVD incidence in each predicted risk category among eligible adults with diabetes who received statin therapy for primary prevention (Online Figure 1). Calibration was poor and discrimination was modest in both those with (C: 0.61) and without (C: 0.68) diabetes who received statin therapy for primary prevention (Online Figure 2).

Discussion

In a large, contemporary, “real world” cohort with broad racial/ethnic diversity, we showed that the ACC/AHA Pooled Cohort risk equation substantially overestimated actual 5-year ASCVD risk in each predicted risk category within eligible adults without diabetes (40 to 75 years of age without known ASCVD and with LDL-C 70 to 189 mg/dl) who are a recommended target population for consideration of cholesterol-lowering therapy. Importantly, this overestimation was similar in both men and women, as well as in 4 major ethnic groups, with poor calibration in each subgroup. Discrimination, as measured by the C statistic, was fair to moderate, depending on the patient group. Of interest, we found better

calibration among eligible adults aged 40 to 75 years with diabetes, but worse discrimination.

Since release of the 2013 ACC/AHA cholesterol treatment guidelines, there has been an ongoing debate, especially regarding application of the new Pooled Cohort risk equation for assessing ASCVD risk within and outside the United States. In selected U.S.-based prospective cohorts not used to derive the Pooled Cohort risk equation, such as the MESA (Multi-Ethnic Study of Atherosclerosis) and the REGARDS (REasons for Geographic and Racial Differences in Stroke) studies, the estimated ASCVD risk was higher than observed risk (3,4). Similarly, in a European population 55 years of age or older, the risk equation had poor calibration (15). It has been proposed that results of these and related evaluation efforts are limited due to ~25% of participants taking statins or having a high likelihood of initiating statin during follow-up (6,8). Underascertainment of ASCVD events in these studies has also been suggested as a possible reason for observed overestimation of risk (3,9). There is also concern as to how well the risk equation works in more contemporary patients compared with the older cohorts used to derive the equation (3,11,12). Analyses from the Women's Health Study estimated hypothetical rates if no women were prescribed statins or underwent revascularization and suggested that after accounting for intervention effects of statins and revascularization, as well as hypothetical confounding by indication or underascertainment of events, there would still be a discrepancy in the observed versus predicted ASCVD risk (11). However, because that study enrolled primarily white female nurses between 1992 and 1995, the results are not necessarily generalizable to more diverse, contemporary populations. Similarly, recent analyses from the MESA study share the important limitation of lack of generalizability, as research participants are not likely to accurately represent the general population in clinical practice and during a recent treatment era (4).

Our study addresses many of these challenges. First, we evaluated the accuracy of the Pooled Cohort risk equation in the most contemporary cohort studied to date, with study entry in 2008 and complete follow-up through 2013. Secondly, we excluded patients who had received any statin therapy during the 5 years before or anytime during follow-up, thus minimizing any confounding from statin use when evaluating performance of the risk calculator. Thirdly, as we studied patients receiving care within an integrated healthcare delivery system, we had complete ascertainment of ASCVD events. Fourthly, even after restricting to the target population of nondiabetic adults, 40 to 75 years of age, who had LDL-C between 70 and 189 mg/dl and no known ASCVD, we studied a very large population of 311,827 men and women, which is notably larger and more representative than any prior studies (e.g., 3,433 adults 55 years of age, including diabetics, in the Rotterdam Study (15) and 10,997 from the REGARDS study with a selected subset of 3,333 participants 65 years of age linked to Medicare claims data (8)). Fifthly, we examined 4 major racial/ethnic groups, including Asian/Pacific Islanders and Hispanics, which constitute a major proportion of the U.S. population (24). Present guidelines (1) caution against applying this algorithm to groups that are neither white nor black/African American, and we further demonstrated that the Pooled Cohort risk equation overestimated actual ASCVD risk across all 4 ethnic groups in our study population with variable discrimination. Finally, in contrast to previous cholesterol treatment guidelines (25), the Pooled Cohort risk

equation includes diabetes as part of the scoring criteria, rather than considering it a CHD equivalent, and a recent study showed important differences in predicted risk among those with diabetes (26). We found that calibration was improved, but discrimination was poorer for untreated eligible adults with diabetes; importantly, we showed a wide range of ASCVD risk in these patients, which could inform future studies evaluating different thresholds for initiating statin therapy in patients with diabetes.

Our study also had several limitations. First, we used 5-year versus 10-year follow-up, and it is possible that incidence rates in the first 5 years of follow-up could be less than in the subsequent 5 years. However, we observed a cumulative risk of ASCVD that was linear during the 5-year follow-up (Figure 2), which directly supports extrapolation of our results to 10-year risk. Studying 5-year risk also allowed for a very contemporary estimate of ASCVD risk. Risk score overestimation may have been due to exclusion of those who were started on statins; however, in a sensitivity analysis, there was poor calibration and suboptimal discrimination of the Pooled Cohort risk equation in eligible patients, with or without diabetes, treated with statins for primary prevention during follow-up (Online Figures 1 and 2). Inclusion of death certificate data to help define fatal CHD may have led to some misclassification. Our study population may not be fully generalizable to all parts of the United States or to patients treated in different health care delivery systems; however, approximately one-third of the sample was obese, had known hypertension, and was a current or former smoker. In addition, unlike previous studies, we had a very ethnically diverse sample of patients with uniform access to care, as well as comprehensive ascertainment of clinically recognized ASCVD events, which argues for greater generalizability and validity. Given that most adults with diabetes within our health system were receiving statins for primary prevention, and were therefore not eligible for analysis, the sample we examined is not necessarily fully representative of all patients with diabetes. However, our study sample allowed comprehensive assessment of the observed 5-year ASCVD risk among adults with clinically recognized diabetes across the range of predicted risk, and we required all patients to have the full 5-year follow-up, which is critical to allow enough time to identify all fatal and nonfatal ASCVD events. We are unaware of any evidence that patients with symptoms or signs of possible ASCVD are more or less likely to remain insured and stay or leave our health system. There is a possibility that including those who died, but not those censored from disenrollment, could artificially raise the observed event rates, but given that the absolute risk of death was very low in this population, it is highly unlikely to have had a substantive impact on the results.

Insured patients may have better health habits than patients who are not able to afford insurance or choose not to obtain it. However, if one considers the rationale for risk assessment in the ACC/AHA guideline, this “real-world” population is more likely to represent typical patients in U.S. communities who are seeing a health care provider and who may be considered for preventive therapies, as compared with volunteers enrolled into prospective cohort studies or interventional clinical trials. Furthermore, if significant variation exists in regional population characteristics or outcomes, and if there are systematic differences in cardiovascular risk reduction efforts across health care settings, then it is critical that health care providers use a risk assessment tool that is calibrated to the patient population being seen by those providers.

In sum, as recently recommended (27), we conducted a critical evaluation of the ASCVD Pooled Cohort risk equation from a relevant large, diverse, “real-world” target population, overall and in key understudied subgroups. We found that this risk equation substantially overestimated actual ASCVD risk in adults not treated with statin therapy for primary prevention without diabetes (overall and across all sociodemographic subgroups), and demonstrated suboptimal accuracy in those with or without diabetes. Our study provides evidence to support recalibration of the ASCVD Pooled Cohort risk equation in adults without diabetes, especially given the individual and public health implications of widespread application of this risk calculator. Ongoing research and dialogue in this area remains crucial, and should be encouraged in order to provide more rigorous, valid evidence in contemporary, diverse populations (26-28).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations and Acronyms

ACC	American College of Cardiology
AHA	American Heart Association
ASCVD	atherosclerotic cardiovascular disease
BMI	body mass index
CHD	coronary heart disease
HDL-C	high-density lipoprotein cholesterol
ICD-9	International Classification of Diseases, Ninth Edition
LDL-C	low-density lipoprotein cholesterol

Clinical Perspectives

Competency in Systems-Based Practice

The 2013 ACC/AHA Pooled Cohort risk equation estimates risk for both coronary events and stroke. However, the risk equation substantially overestimates ASCVD risk in adults without diabetes mellitus and has suboptimal accuracy across sociodemographic subgroups and also in adults with diabetes who do not receive statin therapy for primary prevention.

Translational Outlook

More research is needed to develop risk assessment tools that are calibrated to diverse, contemporary populations, especially given the implications of recommending lifelong statin therapy.

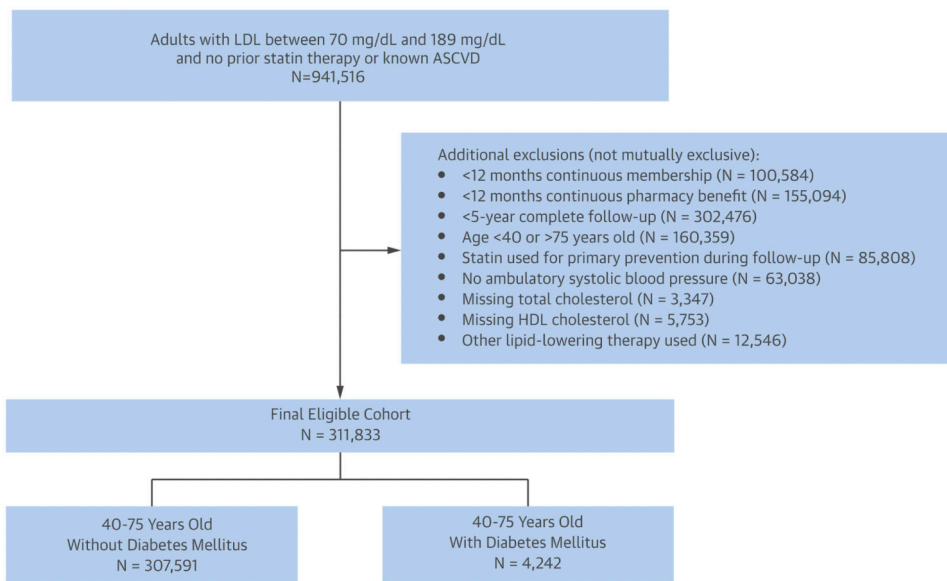


Figure 1. Cohort Assembly

Between January 1, 2008 and December 31, 2008, a cohort of eligible adults, 40 to 75 years of age, with or without diabetes mellitus was identified. ASCVD = atherosclerotic cardiovascular disease; HDL = high-density lipoprotein cholesterol; LDL = low-density lipoprotein

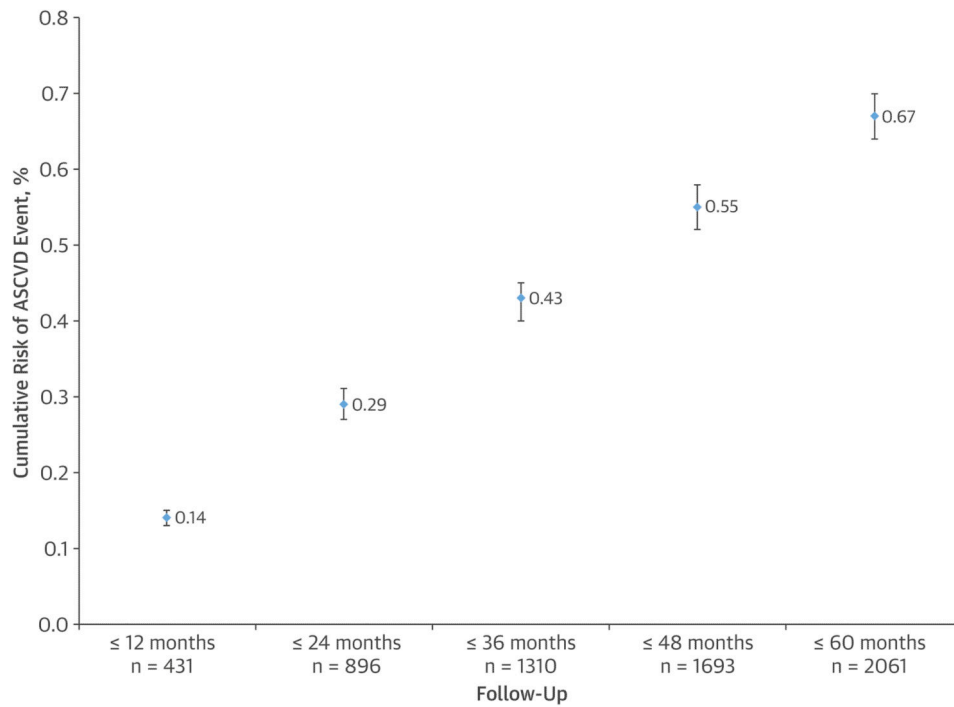


Figure 2. Cumulative Risk of ASCVD Events During 5-Year Follow-Up Off Statin Therapy
N represents the cumulative number of events observed during each follow-up period for calculating the cumulative risk of ASCVD events per year of follow-up among all eligible adults 40 to 75 years of age who did not have diabetes and did not receive statin therapy for primary prevention of ASCVD. ASCVD = atherosclerotic cardiovascular disease.

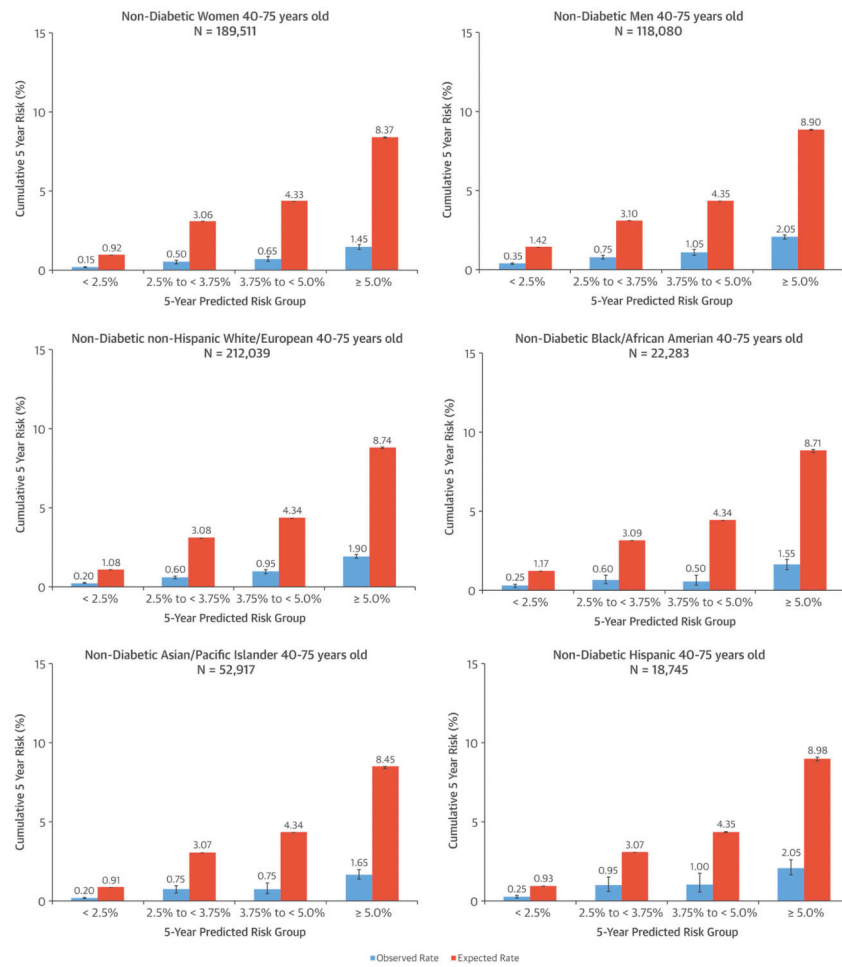
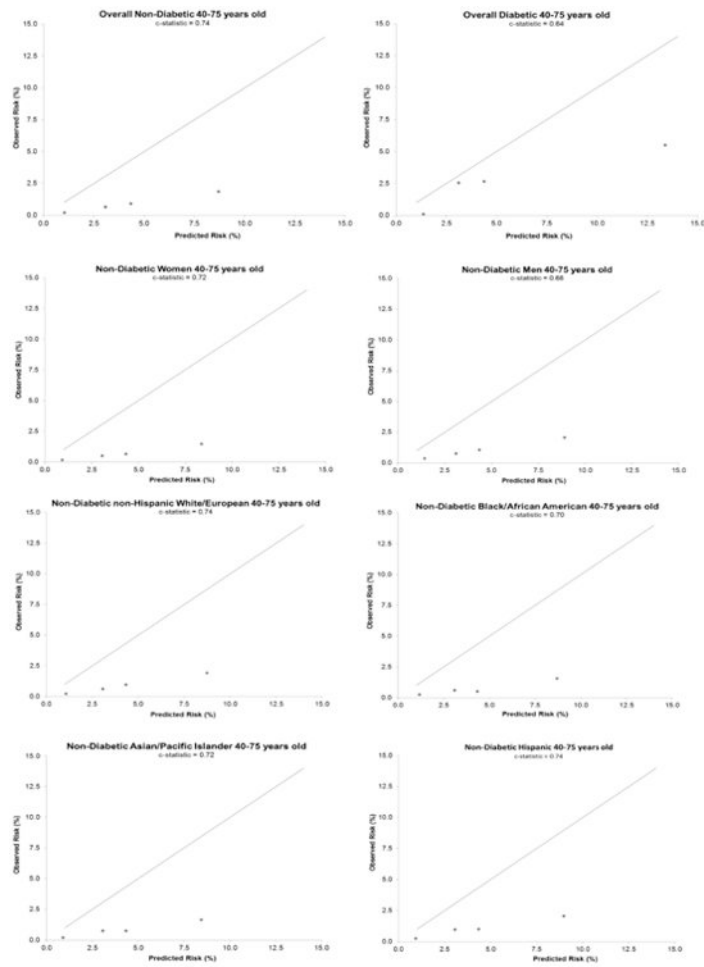


Figure 3. Comparison of Observed Versus Expected ASCVD Risks in Subgroups
 Observed 5-year risks of ASCVD events within each predicted risk category in eligible nondiabetic adults 40 to 75 years of age are shown within sex, racial/ethnic, and socioeconomic status subgroups. ASCVD = atherosclerotic cardiovascular disease.



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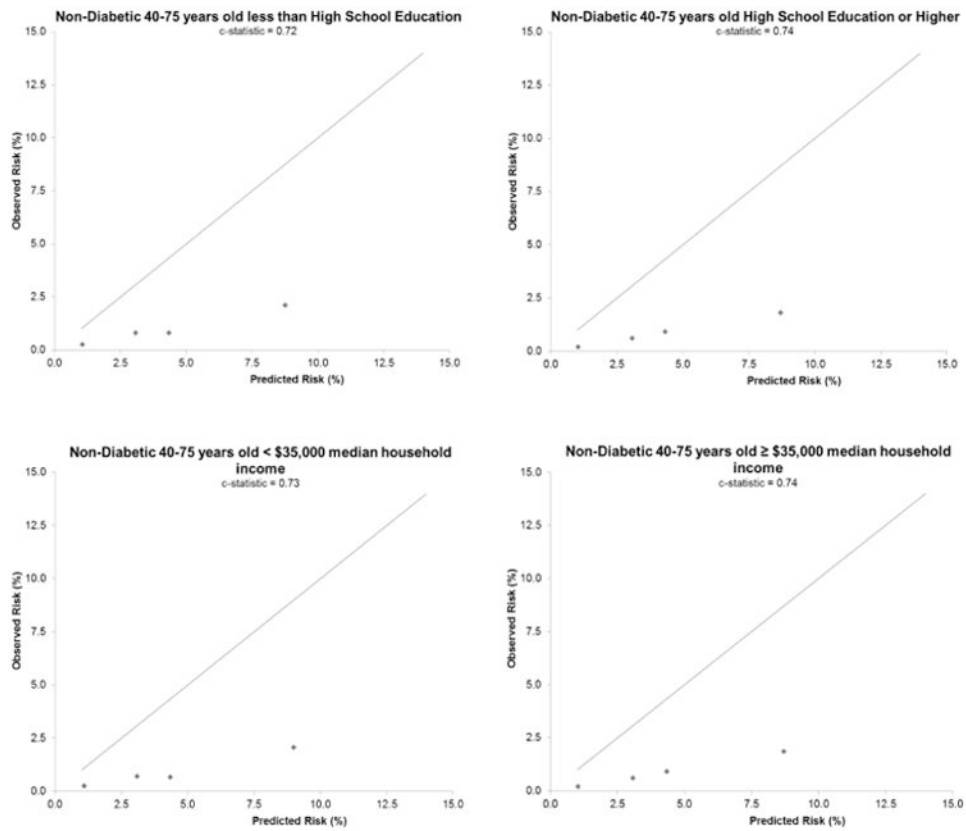
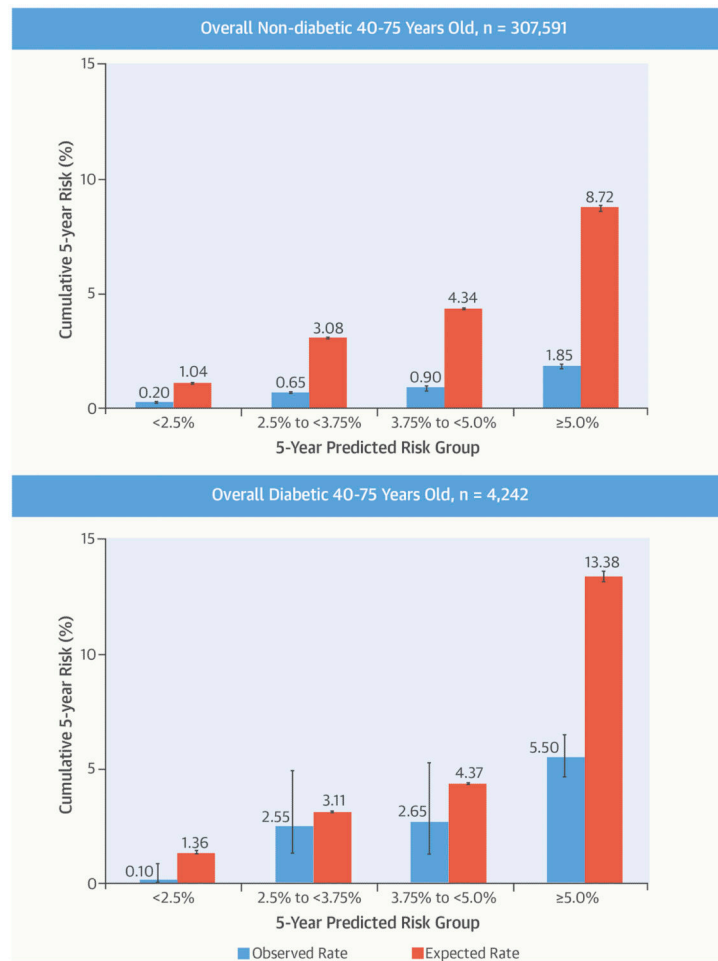


Figure 4. Calibration and Discrimination of ASCVD Risk Equation

Calibration plots and model-based discrimination estimates (C statistic) comparing observed 5-year risk of ASCVD events in each predicted risk category in eligible adults 40 to 75 years of age are shown by diabetes status and in nondiabetic sex, racial/ethnic, and socioeconomic subgroups. ASCVD = atherosclerotic cardiovascular disease.



Central Illustration. Cardiovascular Risk Prediction in Clinical Care: Comparison of Observed Versus Expected ASCVD risks

Observed 5-year risks of ASCVD events within each predicted risk category in eligible adults, 40 to 75 years of age, are shown stratified by diabetes status. ASCVD = atherosclerotic cardiovascular disease.

Table 1
Baseline Characteristics of the Adults 40-75 Years of Age With and Without Diabetes Mellitus, Stratified by Predicted ASCVD Risk Category

No Diabetes Mellitus	10-year Predicted Risk of ASCVD Events				p Value
	Overall N = 307,591	<5.00% N = 175,605	5.00% to <7.50% N = 36,896	7.50% to <10% N = 25,142	
Characteristics					
10-year predicted risk of ASCVD					
Mean ± SD	6.60 ± 7.02	2.08 ± 1.33	6.16 ± 0.72	8.68 ± 0.72	<0.001
Median (IQR)	3.94 (1.56-9.22)	1.81 (0.92-3.08)	6.12 (5.54-6.76)	8.64 (8.05-9.29)	<0.001
Range	0.04-65.64	0.04-5.00	5.00-7.50	7.50-10.00	
Age, yrs, mean ± SD	54.8 ± 9.1	49.8 ± 6.1	56.1 ± 6.8	58.6 ± 7.0	<0.001
Women, n (%)	189,511 (61.6)	134,990 (76.9)	18,745 (50.8)	11,207 (44.6)	<0.001
Race/ethnicity, n (%)					<0.001
White/European (non-Hispanic)	212,039 (68.9)	115,652 (65.9)	26,303 (71.3)	18,067 (71.9)	
Black/African American (non-Hispanic)	22,283 (7.2)	10,164 (5.8)	3,414 (9.3)	2,427 (9.7)	
Asian/Pacific Islander	52,917 (17.2)	36,831 (21.0)	5,099 (13.8)	3,296 (13.1)	
Hispanic	18,745 (6.1)	12,035 (6.9)	1,875 (5.1)	1,222 (4.9)	
Other/unknown	1,607 (0.5)	923 (0.5)	205 (0.6)	130 (0.5)	
Residential block-level socioeconomic status					
Median household income					<0.001
\$35,000	295,497 (96.1)	169,441 (96.5)	35,360 (95.8)	23,984 (95.4)	66,712 (95.4)
<\$35,000	11,772 (3.8)	6,004 (3.4)	1,493 (4.0)	1,118 (4.4)	3,157 (4.5)
Missing	322 (0.1)	160 (0.1)	43 (0.1)	40 (0.2)	79 (0.1)
Highest level of education					<0.001
High school graduate or higher	275,867 (89.7)	157,925 (89.9)	33,073 (89.6)	22,461 (89.3)	62,408 (89.2)
<High school	31,409 (10.2)	17,524 (10.0)	3781 (10.2)	2,641 (10.5)	7,463 (10.7)
Missing	315 (0.1)	156 (0.1)	42 (0.1)	40 (0.2)	77 (0.1)
Tobacco use, n (%)					<0.001
Current	29,537 (9.6)	10,022 (5.7)	5134 (13.9)	3,929 (15.6)	10,452 (14.9)
Former	67,611 (22.0)	19,316 (11.0)	9762 (26.5)	7,964 (31.7)	30,569 (43.7)
Never	210,443 (68.4)	146,267 (83.3)	22,000 (59.6)	13,249 (52.7)	28,927 (41.4)

Characteristics	Overall N = 307,591	10-year Predicted Risk of ASCVD Events				p Value
		<5.00% N = 175,605	5.00% to <7.50% N = 36,896	7.50% to <10% N = 25,142	10% N = 69,948	
Systolic blood pressure, mm Hg, mean ± SD	124.5 ± 15.0	120.2 ± 13.8	126.7 ± 13.5	128.2 ± 13.8	132.8 ± 15.1	<0.001
BMI, kg/m ² , n (%)						<0.001
<18.5	3,604 (1.2)	2,249 (1.3)	337 (0.9)	235 (0.9)	783 (1.1)	
18.5–24.9	107,422 (34.9)	70,931 (40.4)	10,530 (28.5)	6,978 (27.8)	18,983 (27.1)	
25.0–29.9	109,104 (35.5)	57,729 (32.9)	13,773 (37.3)	9,544 (38.0)	28,058 (40.1)	
30.0–39.9	76,401 (24.8)	38,655 (22.0)	10,645 (28.9)	7,325 (29.1)	19,776 (28.3)	
40	8,620 (2.8)	4,845 (2.8)	1,272 (3.4)	846 (3.4)	1,657 (2.4)	
Missing	2,440 (0.8)	1,196 (0.7)	339 (0.9)	214 (0.9)	691 (1.0)	
Antihypertensive medication use, n (%)	101,089 (32.9)	34,085 (19.4)	13,447 (36.4)	10,733 (42.7)	42,824 (61.2)	<0.001
Lipoproteins, mg/dl, mean ± SD						
Total	197.5 ± 29.7	194.6 ± 29.0	201.7 ± 29.7	202.0 ± 30.1	201.0 ± 30.5	<0.001
HDL	55.6 ± 15.4	58.0 ± 15.1	53.4 ± 15.1	52.8 ± 15.2	51.7 ± 15.4	<0.001
LDL	118.1 ± 24.4	115.2 ± 23.9	122.4 ± 24.4	122.6 ± 24.7	121.7 ± 24.4	<0.001
Diabetes Mellitus						
Characteristics	Overall N = 4,242	<5.00% N = 834	5.00% to <7.50% N = 369	7.50% to <10% N = 327	10% N = 2,712	p Value
10-year predicted risk of ASCVD						
Mean ± SD	26.81 ± 26.19	2.05 ± 1.39	6.19 ± 0.72	8.72 ± 0.71	40.23 ± 24.33	<0.001
Median (IQR)	17.36 (5.12–42.58)	1.82 (0.82–3.11)	6.13 (5.56–6.79)	8.67 (8.12–9.32)	34.49 (19.24–57.03)	<0.001
Range	0.00–100.00	0.00–5.00	5.01–7.49	7.51–9.99	10.01–100.00	
Age, yrs, mean ± SD	58.1 ± 9.6	47.6 ± 5.1	51.7 ± 6.1	54.0 ± 6.3	62.7 ± 8.0	<0.001
Women, n (%)	2127 (50.1)	663 (79.5)	229 (62.1)	209 (63.9)	1026 (37.8)	<0.001
Race/ethnicity, n (%)						<0.001
White/European (non-Hispanic)	2,371 (55.9)	390 (46.8)	221 (59.9)	184 (56.3)	1,576 (58.1)	
Black/African American (non-Hispanic)	544 (12.8)	55 (6.6)	32 (8.7)	36 (11.0)	421 (15.5)	
Asian/Pacific Islander	768 (18.1)	253 (30.3)	77 (20.9)	62 (19.0)	376 (13.9)	
Hispanic	529 (12.5)	127 (15.2)	37 (10.0)	42 (12.8)	323 (11.9)	
Other/unknown	30 (0.7)	9 (1.1)	2 (0.5)	3 (0.9)	16 (0.6)	
Residential block-level socioeconomic status						

Characteristics	Overall N = 307,591	10-year Predicted Risk of ASCVD Events			p Value
		<5.00% N = 175,605	5.00% to <7.50% N = 36,896	7.50% to <10% N = 25,142	
Median household income					0.57
\$35,000	3,971 (93.6)	791 (94.8)	349 (94.6)	306 (93.6)	2,525 (93.1)
<\$35,000	268 (6.3)	42 (5.0)	20 (5.4)	21 (6.4)	185 (6.8)
Missing	3 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	2 (0.1)
Highest level of education					0.76
High school graduate or higher	3,534 (83.3)	705 (84.5)	311 (84.3)	275 (84.1)	2,243 (82.7)
<High school	706 (16.6)	128 (15.3)	58 (15.7)	52 (15.9)	468 (17.3)
Missing	2 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.0)
Tobacco use, n (%)					<0.001
Current	481 (11.3)	29 (3.5)	31 (8.4)	46 (14.1)	375 (13.8)
Former	1,227 (28.9)	28 (3.4)	49 (13.3)	69 (21.1)	1,081 (39.9)
Never	2,534 (59.7)	777 (93.2)	289 (78.3)	212 (64.8)	1,256 (46.3)
Systolic blood pressure, mm Hg, mean \pm SD	129.5 \pm 16.6	122.3 \pm 13.7	126.9 \pm 15.5	128.5 \pm 15.0	1,32.3 \pm 16.9
BMI, kg/m ² , n (%)					<0.001
<18.5	50 (1.2)	12 (1.4)	2 (0.5)	2 (0.6)	34 (1.3)
18.5–24.9	716 (16.9)	183 (21.9)	55 (14.9)	42 (12.8)	436 (16.1)
25.0–29.9	1,137 (26.8)	208 (24.9)	84 (22.8)	88 (26.9)	757 (27.9)
30.0–39.9	1,924 (45.4)	325 (39.0)	191 (51.8)	161 (49.2)	1,247 (46.0)
40	389 (9.2)	102 (12.2)	36 (9.8)	32 (9.8)	219 (8.1)
Missing	26 (0.6)	4 (0.5)	1 (0.3)	2 (0.6)	19 (0.7)
Antihypertensive medication use, n (%)	2,924 (68.9)	410 (49.2)	199 (53.9)	191 (58.4)	2,124 (78.3)
Lipoproteins, mg/dl, mean \pm SD					<0.001
Total	175.9 \pm 31.1	174.9 \pm 27.7	178.7 \pm 30.0	180.5 \pm 33.6	175.3 \pm 31.8
HDL	47.9 \pm 13.9	53.7 \pm 14.4	48.6 \pm 13.9	49.5 \pm 14.5	45.8 \pm 13.1
LDL	99.7 \pm 23.4	97.8 \pm 20.9	101.3 \pm 23.5	101.9 \pm 25.6	99.7 \pm 23.8

ASCVD = atherosclerotic cardiovascular disease; BMI = body mass index; HDL = high-density lipoprotein; IQR = interquartile range; LDL = low-density lipoprotein.