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Using Body Mass Index Data in the Electronic Health Record to Calculate Cardiovascular Risk

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Abstract

Background—Multivariable cardiovascular disease (CVD) risk calculators, such as the Framingham risk equations, can be used to identify populations most likely to benefit from treatments to decrease risk.

Purpose—To determine the proportion of adults within an electronic health record (EHR) for whom Framingham CVD risk scores could be calculated using cholesterol (lab-based) and/or BMI (BMI-based) formulae.

Methods—EHR data were used to identify patients aged 30–74 years with no CVD and at least 2 years continuous enrollment prior to April 1, 2010 and relevant data from the preceding 5-year time frame. Analyses were conducted between 2010 and 2011 to determine the proportion of patients with a lab- or BMI-based risk score, the data missing, and the concordance between scores.

Results—Of 122,270 eligible patients, 59.7% (*n*=73,023) had sufficient data to calculate the lab-based risk score and 84.1% (102,795) the BMI-based risk score. Risk categories were concordant in 78.2% of patients. When risk categories differed, BMI-based risk was almost always in a higher category, with 20.3% having a higher and 1.4% a lower BMI- than lab-based risk score. Concordance between lab- and BMI-based risk was greatest among those at lower estimated risk, including people who were younger, female, without diabetes, not obese, and those not on blood pressure –or lipid-lowering medications

Conclusions—EHR data can be used to classify CVD risk for most adults aged 30–74 years. In the population for the current study, CVD risk scores based on BMI could be used to identify those at low risk for CVD and potentially reduce unnecessary laboratory cholesterol testing.

Trial registration—This study is registered at clinicaltrials.gov NCT01077388.

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Introduction

Cardiovascular disease (CVD) is the leading cause of death and disability in the U.S.[1] Assessment of coronary heart disease (CHD) or CVD risk is recommended by the Expert Panel on Detection and Evaluation and Treatment of High Blood Cholesterol in Adults (ATPIII)[2, 3] and the U.S. Preventive Services Task Force (USPTF)[4] as a means for identifying asymptomatic high-risk individuals who are most likely to benefit from evidence-based interventions to decrease risk. Models that combine CVD risk factors (age, gender, blood pressure [BP], lipid levels, tobacco use, and diabetes) predict future CVD events more accurately than those that consider risk factors in isolation.[5]

The recent adoption of electronic health records (EHRs) allows new opportunities to efficiently collect CVD risk data and identify populations at increased risk for CVD. Persell and colleagues[6] in an academic internal medicine practice, found that EHR data could be reliably used (based on a chart audit) to calculate Framingham 10-year risk of CHD for over 77% of the adult population aged 20–79 years. Lack of laboratory values for cholesterol (total cholesterol and high-density lipoprotein cholesterol (HDL)) was the most common reason for not being able to calculate risk.

Framingham risk calculations were updated in 2008 (D'Agostino et al.) to predict all atherosclerotic CVD (CHD, stroke, peripheral vascular disease, and heart failure).[7] Additionally, they found that BMI could be substituted for cholesterol and HDL when laboratory data are not available without loss of predictive discrimination of the risk score. Gaziano et al.,[8] using a National Health and Nutrition Examination Survey (NHANES) cohort, confirmed these findings, with BMI- and laboratory based – risk scores having similar discrimination in predicting fatal and nonfatal cardiovascular events.

D'Agostino pointed out that an advantage of the BMI model is that it can be used in low-resource settings without access to labs. BMI-based CVD risk scores might have additional benefits in insured health-plan populations, as it could be used to identify people at high or moderate risk for CVD without laboratory values who might benefit from further assessments; and also those at low risk whose risk assessment would not change based on additional laboratory testing.

The goal of the current study was to determine the proportion of patients who had EHR data to calculate CVD risk using either laboratory cholesterol (lab-based) or BMI (BMI-based) data and the concordance between lab- and BMI-based scores when both measures could be computed.

Methods

The current analysis is part of the e-Care for Heart Wellness Study (RC1HL100590-01). A primary aim of the current study is to determine to whether EHRs can be used to efficiently define CVD risk, and identify those who might benefit from an intervention to decrease CVD risk.

The study setting is Group Health Cooperative, an integrated healthcare system that provides coverage to over 670,000 people in Washington, and health care to approximately 375,000 patients that receive health services at 26 Group Health– owned primary care medical centers. The sample includes all adults aged 30–74 years who receive their care at Group Health – owned primary care clinics and had at least 2 years of continuous enrollment prior to April 1, 2010 (the "index date"). Patient exclusions included those without at least one ambulatory visit 2 years prior to the index date and those with a previous diagnosis of CVD (myocardial infarction, angina, surgery for CHD, strokes, transient ischemic attacks,

congestive heart failure, and peripheral vascular disease), as guidelines are different for those with existing CVD.[2, 3]

Cardiovascular risk factor data from the EHR included: age; gender; most recent BP; BMI; total cholesterol; and HDL (up to 5 years prior to the index date); ever diagnosis of hypertension or diabetes; and smoking status based on the most recent indicator. Current use of hypertension- or lipid-lowering medications was defined as having had any prescription filled in the year prior to the index date.

Analysis

Analyses were conducted from April 2010 until September 2011. The lab-based and the BMI-based Framingham global 10-year CVD risk scores[7] were calculated using gender-stratified prediction equations including age, systolic BP, treatment for hypertension, smoking status, diabetes status, and HDL and total cholesterol[9] (lab-based score) or BMI (BMI-based score). Continuous risk scores were used to classify patients into risk categories as recommended by the Adult Treatment Panel III of the National Cholesterol Education Program (ATPIII);[2, 3] low (<10%), moderate (10% 20%), and high (>20%).

The proportion of patients for whom there was sufficient automated EHR to define both risk scores, lab-based scores only, BMI-based score only, or neither score was calculated. Among patients with both scores, agreement between scores was assessed using concordance correlation coefficients.[10] Estimated mean risk score difference overall and by patient characteristics, stratified by gender, was calculated as the lab-based score subtracted from the BMI-based score. Further, a concordance between categoric scores was computed, defined as the proportion for whom the lab-based and BMI-based score resulted in the same categoric risk. All analyses were conducted using Stata/SE version 10.1 statistical software.

Results

A total of 221,128 patients aged 30–74 years were initially identified. Excluded were 46,631 who had not been continuously enrolled during the prior 2 years, 8749 who were enrolled but had not made at least one ambulatory care visit, and 43,478 patients with prior CVD (Appendix A, available online at www.ajpmonline.org). The remaining 122,270 patients constitute the cohort included in the current study.

The EHR contained sufficient data to calculate the lab-based risk score for 59.7% (*n*=73,023) and BMI-based risk score for 88.1% (102,795) of eligible patients. Both scores could be calculated for 58.3% (71,280); BMI-based risk score only for 25.8% (31,515); lab-based risk score only for 1.4% (1,743). The EMR lacked sufficient data to calculate either score for 14.5% (*n*=17,732) of the eligible cohort. The most commonly missing risk factor was cholesterol (37.8%), followed by missing data for either height, weight, or both (11.5%); blood pressure (8.6%); and smoking status (3.6%).

Some risk scores could be calculated from EHR data by patient characteristics (Table 1). Older people, women, and those with diabetes were more likely to have the data necessary to calculate CVD risk scores. For patients with diabetes, 12% lacked cholesterol data for calculating lab-based risk, with BMI-risk available in an additional 7.4% of patients without these, leaving only 4.5% of diabetics without an estimate of CVD risk. For those aged 30–39 years, 66% did not have data for a lab-based score. However, if BMI was used, only 18.8% had insufficient data for calculating risk.

Appendix B (available online at www.ajpmonline.org) is a scatter plot showing the lab-based risk score compared to the BMI-based score among the 71,280 patients for whom both

scores were available. The risk scores have high agreement with a concordance correlation coefficient of 0.867 (95% CI=0.865, 0.868), with BMI-based CVD risk scores tending to be higher than lab-based risk scores. Table 2 shows the distribution of risk categories (low <10%, moderate 10% 20%, and high >20%) and the concordance between lab- and BMI-based risk. The lab-based risk score classified people as 62.9% at low risk, 24.4% at moderate risk, and 12.8% at high risk, with BMI-based scores 52.9%, 25.8%, and 21.6%, respectively, for the same categories.

Risk categories were concordant in 78.2% of patients (55,764/71,280). When risk categories differed, BMI-based risk was almost always in a higher category than the lab-based risk score, with 20.3% (14,495/71,280) having a higher and 1.4% (1,021/71,280) a lower clinic- than lab-based CVD risk score. When risk categories differed, it was almost always by one category. Patients at high risk based on BMI-based score were classified as being at low-risk in only 162 of 71,280 (0.2%) using the lab-risk score and only two BMI-based low-risk patients were reclassified as being at high CVD risk based on lab risk.

Table 3 provides a comparison of risk scores by patient characteristics stratified by gender. Overall, lab-based risk scores on average estimated risk lower than BMI-based scores. The mean difference in risk scores was 2.1% (SD 3.5%) among women, and 4.5% (SD 5.9%) among men. The difference in risk scores was smallest for those with low estimated risk, including people who were younger, female, without diabetes, not obese, and not on BP- or lipid-lowering medications. Risk categories were least congruent for men aged 50–74 years, women aged 60–74 years, and those who were obese, had diabetes, were current smokers, or were on BP- or lipid-lowering medications. Removing those in the cohort currently on lipid-lowering therapy, a variable currently not included in the Framingham CVD equations, improved concordance between BMI and lab-based CVD scores (concordance correlation coefficient 0.891; 95% CI=0.890, 0.893). Table 4 shows the difference between the Group Health and Framingham populations, from which CVD risk scores were derived. Group Health patients were somewhat older, had lower total cholesterol, higher HDL, and lower systolic BP, were much less likely to smoke, and more likely to be currently being treated for hypertension. The D'Agostino paper of 2008 did not provide information on BMI in the Framingham population.

Discussion

In an integrated healthcare system, data commonly available in the EHR could be used to categorize CVD risk in over 85% of the population aged 30–74 years using lab- or BMI-based Framingham global CVD scores. Overall, the correlation between BMI- and lab-based risk was good, particularly among those at low risk for CVD, people who were younger, female, without diabetes, and not on BP- or lipid-lowering medications. When BMI- and lab-based risk categories did not agree, BMI-based risk was almost always higher, meaning that BMI-based risk scores would rarely miss those who were at moderate to high risk for CVD and who might benefit from further testing or treatment.

Among those at low BMI risk, it correctly classified those currently at low lab-based risk over 99% of the time. Thus, laboratory testing could be avoided in this group, as 10-year risk predictions would not change based on this added information. Further, BMI risk could be used to calculate CVD risk in those without laboratory lipid tests resulting in less than 15% of the age-eligible population not having a CVD risk calculation.

Concordance between BMI- and lab-based risk was lower among older people and for those with obesity, diabetes, or on BP- or lipid-lowering medications. However, concordance improved when those on lipid-lowering medications were removed from the cohort,

suggesting that BMI- and lab-based CVD risk might be improved by inclusion of lipid medication use in the risk model. When there was discordance between the two categoric risk measures, BMI-based risk was almost always higher than the lab-based score. Thus, BMI risk would not dissuade one from ordering laboratory cholesterol tests for those who might benefit most by treatments to reduce risk. For those at low risk, BMI-based risk could easily be repeated, and recommendation for laboratory testing updated as age and other risk factors changed.

The USPSTF does not recommend laboratory cholesterol screening for women aged <45 years and men aged <35 years without major CVD risk factors (diabetes, hypertension, tobacco use, family history of premature heart disease, and BMI ≥30).[4] Potential benefits of universal testing include increasing patient self-awareness of their cholesterol, providing an opportunity to enhance motivation for healthy behaviors and detecting familial hypercholesterolemia. However, after performing a systematic review, the USPSTF recommended targeted screening,[11] based on the following: (1) Evidence does not support that knowledge of cholesterol changes behavior[12–15] (2) familial hypercholesterolemia occurs in less than one in 500 people, the majority can be identified by family history, and less than 10% of those unidentified will have a CHD event prior to the age when universal screening is recommended;[16, 17] (3) there is no direct evidence as to the benefits, harms, and value of medication treatments 20–30 years before substantial risk of a CVD event occurs;[18] and (4) all adults should be offered recommendations for a healthy lifestyle regardless of CVD risk. An additional concern is the complex nature of lipid profiles and CVD risk that are often misinterpreted by patients[19] and under- and mis-used by physicians.[20, 21] Point-of-care automated EHR assessments of CVD risk with decision support could potentially lead to more effective and efficient care.

The ATPIII recommends universal screening for adults age ≥20 years at least every 5 years.[2,3] The ATPIV guidelines are expected to be published in 2012 as part of The Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction. This group recently published their guidelines for children and adolescents, and it recommended laboratory lipid screening for all children aged 9–11 years, with initiation of statins recommended for those with persistently high LDL after a trial of lifestyle behavior change.[22]

In contrast, the USPSTF in 2009 concluded there was insufficient evidence to recommend routine lipid screening for children and young adults (aged <20 years).[23] Psaty and Rivara in a commentary published in the *Journal of the American Medical Association* expressed concern as to the lack of direct evidence as to the long-term efficacy and safety of statin treatment in children and that universal lipid screening might “divert attention from other important parts of the expert panel report including the use of diet and physical activity to reduce obesity”.[24] Future use of EHR data could help to better understand the effectiveness of screening and treatment regimens as practiced.

This study has several limitations. The Group Health population had different distributions of risk factors than the Framingham community cohort. The Framingham cohort had a much higher rate of smoking with lower rates of BP treatment and diabetes. Framingham collected risk-factor data between 1968 and 1987, and the Group Health data are from 2005–2010. There have been important temporal changes in the population-level distribution of risk factors and medication use over these time periods, including greater use of lipid-lowering medications that is not included in Framingham and most other CVD risk calculators.[25] The Framingham equations frequently require recalibration when applied to different geographic and racial populations.[26] Some models, such as the QRISK, have found improvement in discrimination (predictive accuracy) when a measure for social deprivation was added.[27]

Regardless of the risk model chosen, recalibration of and addition of new predictors requires CVD outcome data. As population-wide BP and BMI measurements were not available in databases prior to the EHR, follow-up for CVD outcome data is currently insufficient for recalibration of CVD risk for this study cohort. However, prospective EHR data will provide new opportunities to improve and personalize risk assessment.

Additionally, all people in the Group Health population have health insurance, and the concordance between lab-based and BMI-based risk scores may be different in uninsured populations or in other parts of the U.S. Even in an insured population, 15% of patients did not have lab tests or a BMI for calculating risk, and more efforts might be needed to assure comprehensive and equitable provision of risk identification and treatments to minority socioeconomic and ethnic groups. Finally, CVD risk was used rather than CHD risk on which the USPTF and ATPIII guidelines are based. However, the expanded CVD tool addresses the substantial burden of all CVD combined.

Conclusion

Electronic health record data can be used to classify CVD risk for most adults aged 30–74 years. In the population studied, CVD risk scores based on BMI could be used to identify those at low risk for CVD and potentially reduce unnecessary laboratory cholesterol testing. Further studies are needed to see if these findings can be replicated in other settings or improved by further refinements of CVD risk equations and predictive modeling using data increasingly available in EHRs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Risk score data availability in the EHR by patient characteristics

Row %	Neither score *n*=17,732	BMI-based score only *n*=31,515	Lab-based score only *n*=1,743	Both scores *n*=71,280
Total	14.5	25.8	1.4	58.3
Age (years)				
30–39	18.8	46.8	1.2	33.2
40–49	16.4	28.2	1.4	54.0
50–59	13.5	19.6	1.5	65.4
60–74	10.3	14.3	1.6	73.8
Gender				
Male	19.0	21.9	2.3	56.9
Female	11.0	28.8	0.8	59.4
Diabetes				
No	15.3	27.2	1.3	56.3
Yes	4.5	7.4	2.6	85.5

EHR, electronic health record

Table 2

Distribution and comparison of categoric lab-based and BMI-based risk scores (*n*=71,280)

		BMI-based risk		
		Low, <10%	**Moderate, 10% 20%**	**High, >20%**
Lab-based risk		*n*=37,490 (52.9%)	*n*=18,398 (25.8%)	*n*=15,392 (21.6%)
Low, <10%	*n*=44,819 (62.9%)	36,870 51.7%	7,787 10.9%	162 0.2%
Moderate, 10% 20%	*n*=17,374 (24.4%)	618 0.9%	10,210 14.3%	6546 9.2%
High, >20%	*n*=9,087 (12.8%)	2 0.0%	401 0.6%	8684 12.2%

Marginal distribution of each risk score is provided, with proportion in each risk category shown parenthetically. The body of the table shows the joint distribution of the two risk scores, with cell-proportions displayed. Shaded cells highlight where the categoric risk scores are concordant.

Table 3

Comparison of lab-based and BMI-based risk scores by patient characteristics, stratified by gender

	Difference[a] between continuous risk scores, M (SD)		Concordance[b] between categoric risk scores, %	
	Female	Male	Female	Male
Overall	2.1 (3.5)	4.5 (5.9)	83.2	71.6
Age (years)				
30–39	0.3 (0.7)	0.9 (1.6)	99.4	95.5
40–49	0.8 (1.6)	2.0 (3.2)	95.9	79.2
50–59	1.9 (3.0)	4.2 (5.2)	84.0	62.2
60–74	4.0 (4.7)	8.0 (7.0)	65.9	68.2
Diabetes				
No	1.5 (2.3)	3.8 (4.9)	86.3	70.9
Yes	7.8 (6.8)	10.0 (9.1)	51.8	76.5
BMI				
<25	1.2 (2.2)	3.0 (4.5)	90.7	74.6
25–30	1.7 (3.1)	3.8 (5.1)	84.6	72.2
>30	3.1 (4.4)	6.2 (6.9)	75.6	69.3
Lipid-lowering medications [c]				
No	1.4 (2.4)	3.4 (4.6)	87.9	73.0
Yes	4.9 (5.7)	7.6 (7.7)	61.6	67.6
BP-lowering medications [c]				
No	1.1 (1.8)	2.8 (3.9)	91.2	72.9
Yes	4.5 (5.2)	7.7 (7.3)	63.4	69.2
Current smoker				
No	2.0 (3.4)	4.4 (5.6)	83.9	71.1
Yes	2.8 (4.6)	5.8 (7.7)	75.9	75.5

[a] Difference defined as the lab-based score subtracted from the BMI-based score. Positive differences indicate the BMI-based score is larger than the lab-based score.

[b] Concordance is the proportion for which the lab-based risk category matched the clinic-based risk.

[c] At least one prescription filled in the past year

BP, blood pressure

Table 4

CVD risk factors among the Framingham and Group Health populations, M (SD) or % unless otherwise noted

	Women			Men		
	Framingham	**GH: Total sample†**	**GH: Both risk scores**	**Framingham**	**GH: Total sample†**	**GH: Both risk scores**
n	4,522	68,827	40,892	3,969	53,443	23,055
Age (years)	49.1 (11.1)	50.6 (11.0)	53.2 (10.2)	48.5 (10.8)	50.9 (10.9)	53.6 (10.3)
Total cholesterol	215.1 (44.1)	205.9 (38.9)	205.6 (38.7)	212.5 (39.3)	198.7 (39.5)	198.2 (39.3)
HDL cholesterol	57.6 (15.3)	63.9 (17.9)	63.9 (17.9)	44.9 (12.2)	50.7 (14.3)	50.5 (14.2)
Systolic BP (mmHg)	125.8 (20.0)	121.4 (16.5)	122.6 (16.5)	129.7 (17.6)	126.5 (15.4)	126.9 (15.5)
BMI	‡	28.9 (7.2)	29.3 (7.3)	‡	29.3 (5.5)	29.5 (5.6)
BP treatment	11.8	22.1	29.0	10.1	26.2	35.8
Current smoker	34.2	10.5	8.9	35.2	14.5	11.8
Diabetes	3.8	6.3	9.0	6.5	7.9	11.9

† Missing data among women: 26,159 cholesterol, 4,666 systolic BP, 5,600 BMI, and 1,905 smoking status; and among men: 20,126 cholesterol, 5,801 systolic BP, 8,403 BMI, and 2,434 smoking status

‡ Data not available

CVD, cardiovascular disease; GH, Group Health; BP, blood pressure; HDL, high-density lipoprotein