Chest Pain, Atherosclerotic Cardiovascular Disease Risk, and Cardiology Referral in Primary Care

Vishaal Buch¹, Hayley Ralph¹, Joanne Salas¹, Paul J. Hauptman¹, Dawn Davis¹, and Jeffrey F. Scherrer¹

Abstract

Background: The atherosclerotic cardiovascular disease (ASCVD) 10-year risk estimate is recommended by cardiologists for determining risk of a cardiac event. However, the majority of patients presenting to primary care with chest pain have noncardiac etiologies. Therefore, we determined if high versus low ASCVD risk was associated with primary care physicians’ referral to cardiology in patients with and without chest pain. Methods: Deidentified electronic health record (EHR) data was obtained from 5795 patients treated in academic primary care clinics from 2008 to 2015. Referral to cardiology was defined by an EHR code, chest pain was defined by ICD-9-CM code (786.5) and ASCVD was modeled as high versus low risk. Separate logistic regression models were computed to estimate the association between chest pain and referral to cardiology, ASCVD risk and referral, and both chest pain and ASCVD risk and referral with adjustment for potential confounding factors. Results: More patients with (n = 95, 7.8%) versus without (n = 75, 2.0%) chest pain were referred to cardiology (P < .0001). Separate unadjusted models revealed chest pain and high versus low ASCVD risk were significantly associated with referral (odds ratio [OR] = 4.20; 95% confidence interval [CI] 3.07-5.73 and OR = 1.41; 95% CI 1.04-1.91, respectively). After adjusting for ASCVD risk and confounders, chest pain but not high ASCVD risk remained significantly associated with referral (OR = 1.75; 95% CI 1.24-2.47 and OR = 1.15; 95% CI 0.72-1.82, respectively). Conclusions: In primary care patients presenting with chest pain, ASCVD risk scores are not associated with referral to cardiology. Overall, less than 8% of patients with chest pain were referred. While there is no evidence to indicate excessive referral to cardiology, we posit that implementing ASCVD risk tools in decision aids could contribute to referring those most in need of cardiology care.

Keywords
cardiology, chest pain, retrospective cohort, epidemiology

Introduction

Chest pain accounts for 1% of all primary care visits¹ and for the majority (>97%) of patients these presentations are for noncardiac chest pain (NCCP) etiologies.² Chest pain in primary care is often due to gastroesophageal reflux,³ anxiety, depression, musculoskeletal pain, and other noncardiac etiologies.²,³ Although per patient costs of NCCP are lower than those of patients with ischemic heart disease, costs of diagnostic testing (occurring in 83% of patients with chest pain),⁴ the high prevalence of NCCP, and absenteeism associated with the diagnosis contribute to costs that exceed those associated with cardiac chest pain.⁵ Health care burden could be reduced by limiting testing for cardiovascular disease to those patients at greatest risk. The American College of Cardiology/American Heart Association (ACC/AHA) guideline on assessment of cardiovascular risk advocates for the use of the ASCVD (atherosclerotic cardiovascular disease) 10-year risk estimate to determine which individuals are at a quantifiable risk of a cardiac event. A risk percentage greater than 7.5% is considered high risk.⁶,⁷ Whether to implement the ASCVD risk tool or use other clinical prediction rules in primary care continues to be debated.⁸,⁹

¹Saint Louis University School of Medicine, St Louis, MO, USA

Corresponding Author:
Jeffrey F. Scherrer, Family and Community Medicine, Saint Louis University School of Medicine, 1402 North Grand Boulevard, St Louis, MO 63104, USA
Email: jeffrey.scherrer@health.slu.edu
It is not known if the elements of the ASCVD risk tool contribute to primary care physician decisions to refer patients with chest pain to cardiology specialists in real-world academic primary care practice. Therefore, we used a retrospective cohort design to determine if this risk, chest pain or both were associated with likelihood of cardiology referral before and after adjusting for covariates in a large sample of patients seen in academic family medicine and general internal medicine settings.

**Methods**

**Subjects**

Data were obtained from the Primary Care Patient Data (PCPD) Registry from a medical school located in the Midwest. The PCPD captures electronic health record (EHR) data generated from patient visits between July 1, 2008 and June 30, 2015 to any 1 of 3 family medicine and 3 general internal medicine clinics located in urban and suburban areas of eastern Missouri. The PCPD Registry contains deidentified medical data on 33,661 patients, including International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, laboratory results, referral codes, medication orders, vital signs and limited demographics, and has been used in several prior studies of cardiovascular disease. The creation of the PCPD for primary care research was approved by the medical school’s institutional review board.

**Eligibility**

Eligibility criteria were designed to calculate 10-year ASCVD risk per the 2013 ACC/AHA guidelines, for patients 40 to 79 years of age, free of ASCVD, and with a low-density lipoprotein (LDL) <190 mg/dL. The sample was restricted to age 40 to 79 years (n = 17,381) and limited to patients with complete demographic data, leaving 16,977 eligible patients (Figure 1). To permit measurement of comorbidities and laboratory results prior to a cardiology referral, we limited the cohort to patients with 2 or more visits during the observation period (n = 13,906). Patients with a cardiology referral on their first encounter in primary care were excluded (n = 132). Patients had to be free of ASCVD diagnosis (ICD-9-CM codes: 410.x, 412.x, 413.x, 414.x, 433.x, 435.x, 436.x, 440.x, 441.x, 437.0, 437.1, 443.9) prior to cardiology referral date or last visit date if there was no referral before the end of observation. A 10-year ASCVD score of ≥ 7.5 is high risk and < 7.5 is low risk.

**Covariates**

We selected covariates that occurred before the end of follow-up if they were theoretically potential confounders of the association between ASCVD risk, chest pain and cardiology referral. Covariates included ICD-9-CM codes for hypertension, diabetes (type 1 or 2), hyperlipidemia, BMI on or closest to before follow-up end date, last available diastolic blood pressure and LDL before end date (the latter 2 variables were used only in descriptive analysis), statin medications, either prescribed by a primary care provider or on the medication history list (the latter indicating they were prescribed elsewhere), and an order for cardiac testing from the primary care physician. Cardiac testing orders included Current Procedural Terminology (CPT) codes for electrocardiography, cardiac monitoring, stress tests, arterial and venous Doppler studies, or cardiac echocardiography.

Demographics included gender, race (African American vs other), marital status (married/partnered vs other) and neighborhood socioeconomic status (nSES). The nSES variable links patient zip code to United States census information on poverty, public assistance, unemployment, household income, and similar data elements and is associated with type of treatments received in this primary care database. The score was quartiled into lower, lower middle, upper middle, and high nSES.

We adjusted for volume of clinic utilization to control for detection bias by computing the distribution of the average number of clinic visits per month. We created quartiles from the distribution and modeled the top 25th percentile as high health care utilization versus the bottom 75th percentile.

**Outcome Variable**

Referral to cardiology was defined by an EHR-specific referral code.

**Predictor Variables**

Chest pain was defined by ICD-9-CM code 786.5.

The ASCVD pooled cohort risk equations (PCRE), developed by the ACC/AHA Task Force on Practice Guidelines, were used to calculate 10-year ASCVD risk.

The 10-year ASCVD risk is applicable to patients without known coronary disease, documented LDL <190 mg/dL and ages 40 to 79 years. The PCRE are race- and gender-specific equations using: age (years), total cholesterol (mg/dL), high-density lipoprotein cholesterol (HDL; mg/dL), systolic blood pressure (mm Hg), hypertension treatment (yes/no indicated by a prescription for an antihypertensive), diabetes (type 1 or type 2 diagnosis), and self-reported smoking status (yes/no). Total cholesterol, HDL, and systolic blood pressure were the last available laboratory values before cardiology referral date or last visit date if there was no referral in the observation period. Diabetes and hypertension treatment had to occur before end of observation. A 10-year ASCVD score of ≥ 7.5 is high risk and < 7.5 is low risk.

**Analytic Approach**

All analyses were conducted using SAS v9.4 (SAS Institute, Cary, NC). Patients were followed from their first visit in the observation period to the end date defined as either date of...
cardiology referral or, if not referred, the last recorded visit date. The distribution of sociodemographics, comorbidities, laboratory values, and referral to cardiology were assessed separately by chest pain and high versus low ASCVD risk. The distribution of chest pain, ASCVD risk and covariates was also assessed by referral to cardiology. Measures of association were computed using chi-square tests for categorical variables and independent-samples t tests for continuous variables. Separate bivariate logistic regression models first evaluated the unadjusted associations (odds ratios [ORs] and

---

**Figure 1. Eligibility criteria.**

- PCPD July 1, 2008 to June 30, 2016 (n=33,661)
  - Age 40 to 79 years
    - Missing race: 204
    - Missing marital: 138
    - Missing SES: 76
  - Non-missing demographic (n=16,977)
    - < 2 visits July 1, 2008 to June 30, 2015: 3,071
  - ≥ 2 visits July 1, 2008 to June 30, 2015 (n=13,906)
    - Referral to cardiology on first visit date: 152
  - Referral to cardiology cannot occur on first visit date (n=13,774)
  - ASCVD before end date:
    - No Total cholesterol: 6,276
    - No HDL: 6,303
    - No LDL: 6,362
  - Free of ASCVD on/before end date (n=12,464)
    - LDL ≥ 190: 147
  - Metabolic panel data available
    - LDL < 190 (n=5,919)
      - No blood pressure: 0
      - No BMI: 124
    - BMI and blood pressure available

---

Buch et al
95% confidence intervals [CIs]) of chest pain and ASCVD risk on cardiology referral. A third model calculated the independent contributions of chest pain and ASCVD risk on cardiology referral. A final, fully adjusted model included chest pain, ASCVD risk, sociodemographics, BMI, hypertension, hyperlipidemia, and statin treatment.

**Sensitivity Analysis**

Because the ASCVD risk tool was published in 2013, it was not available to physicians during the first half of our observation period. Therefore, we conducted sensitivity analysis by replacing ASCVD with the Framingham risk score.14 We defined Framingham risk score as low (≤10%), medium (>10% to ≤20%), and high (>20%). The reference group was low risk. Regression models estimated the association of Framingham risk and chest pain with cardiology referral before and after adjusting for all covariates.

**Results**

As shown in Table 1, the sample was 40.8% African American, 38.6% male, and relatively young (mean age 56.7 years, SD 9.7 years). Less than 2.0% (n = 966) had an encounter for chest pain, and among these patients, 7.8% were referred to cardiology versus 2.0% of patients without chest pain (P < .0001). Older age (P = .026) and African American race (P = .007) were positively associated with chest pain. Males were less likely to have chest pain encounters (P < .001). Patients with high clinic utilization (P < .0001), higher BMI (P < .0004), hypertension (P = .0004), hyperlipidemia (P < .0001), lower mean HDL (P < .0001), statin prescriptions (P < .019), antihypertensive prescriptions (P < .0001), cardiac testing orders (P < .0001), and high ASCVD risk (P = .025) were more prevalent in patients with chest pain.

As shown in Table 2, referral to cardiology was significantly more common among patients with high ASCVD risk (3.5% vs 2.5%, P = .028). Older age, African American race, and male gender were significantly more common among patients with high ASCVD risk while being married and having a higher nSES were significantly less common among patients with high ASCVD risk. High clinic utilization, higher mean BMI, hypertension, hyperlipidemia, statin treatment, and receipt of cardiac testing orders were significantly more prevalent among patients with high ASCVD risk (P < .0001).

Figure 2 shows the percent referred to cardiology by chest pain and ASCVD risk group. Patients with chest pain versus without were significantly more likely to be referred (P < .0001). ASCVD risk was not significantly associated with referral in patients with and without chest pain.

**Discussion**

In a cohort of nearly 6000 primary care patients, results from fully adjusted models revealed that chest pain, but not high ASCVD risk, was significantly associated with referral to cardiology. Results from fully adjusted models revealed orders for cardiac testing, BMI and high clinic utilization were significantly associated with referral. For patients presenting with chest pain in primary care, there was no statistically significant association between ASCVD risk and referral to cardiology (OR = 1.15; 95% CI 0.72-1.82) after adjusting for all covariates.

Our results suggest the presence of chest pain drives decisions about referral, but this may be attributed to patient behavior. Patients may ask for referral even when the provider believes there is little evidence to support this decision. Another possibility is that the 15-minute primary care visit limits time for thoughtful shared decision making about the source of chest pain symptoms. Last, low-risk patients may be referred as a means of ruling out a cardiac event.

Our findings are partly consistent with previous studies on referral to cardiology. In a large claims database, only a quarter of patients referred were confirmed to have ischemic chest pain,15 which suggests most referrals for chest pain are not for patients at risk for near-term cardiac events. In a sample of
807 primary care patients presenting with non-specific chest pain in German primary care practices, 14.5% eventually had a cardiology encounter, though not necessarily following a primary care referral. In comparison to these prior studies, the percent referred to cardiology in our sample is low (2.5% for patients with low ASCVD risk and 3.5% among patients with high ASCVD risk). Although the ASCVD tool may not influence referral to cardiology for patients with chest pain in primary care, in a previous study of the risk tool in our primary care patient data registry, ASCVD risk score was associated with an increase in the appropriate use of statins and a reduction of undertreatment of high-risk patients.

**Limitations**

We did not have information on referrals to the emergency department (ED) and our results do not apply to patients with chest pain referred to the ED. The database is limited to one geographic region and academic primary care clinics; therefore, results may not generalize to other parts of the country or to private practice settings. We lacked measures of other symptoms such as shortness of breath but most are unlikely to reliably distinguish cardiac vs. non-cardiac chest pain. Missing metabolic laboratory results could lead to misclassification of ASCVD risk and would confound our results if missing was associated with cardiology referral; however, we found no significant association between missing metabolic panels and referral to cardiology ($P = .30$; data not shown). Additionally, our observation period was 2008-2015 and therefore our analysis included years prior to the 2013 publication of the ASCVD risk tool. However, sensitivity analysis revealed the Framingham risk score, available throughout the observation period, was also not associated with referral after adjusting for chest pain.

### Table 1. Sociodemographic, ASCVD PCRE Risk Factors, and Other Health-Related Characteristics of 5795 Primary Care Patients Aged 40 to 79 Years Free of ASCVD and LDL<190 mg/dL, Overall and by Presence or Absence of Chest Pain (July 1, 2008 to June 30, 2015).

|                          | Overall (n = 5795) | No Chest Pain (n = 4829) | Chest Pain (n = 966) | P        |
|--------------------------|-------------------|--------------------------|---------------------|----------|
| Referral to cardiology, n (%) | 170 (2.9)         | 95 (2.0)                 | 75 (7.8)            | <.0001   |
| **Sociodemographics**    |                   |                          |                     |          |
| Age, years, mean (SD)*   | 56.7 (9.7)        | 56.6 (9.8)               | 57.3 (9.4)          | .026     |
| African American race,* n (%) | 2365 (40.8)     | 1933 (40.0)              | 432 (44.7)          | .007     |
| Male gender,* n (%)      | 2239 (38.6)       | 1912 (39.6)              | 327 (33.9)          | .001     |
| Married, n (%)           | 3064 (52.9)       | 2567 (53.2)              | 497 (51.4)          | .331     |
| nSES, n (%)              |                   |                          |                     |          |
| Lowest                   | 1551 (26.7)       | 1281 (26.5)              | 270 (27.9)          |          |
| Lower middle             | 1251 (21.6)       | 1038 (21.5)              | 213 (22.1)          | .721     |
| Upper middle             | 1465 (25.3)       | 1229 (25.5)              | 236 (24.4)          |          |
| Highest                  | 1528 (26.4)       | 1281 (26.5)              | 247 (25.6)          |          |
| **Health-related characters** |                  |                          |                     |          |
| High clinic utilization, n (%) | 2366 (40.8)     | 1808 (37.4)              | 558 (57.8)          | <.0001   |
| BMI, kg/m², mean (SD)    | 31.5 (7.8)        | 31.3 (7.8)               | 32.3 (7.8)          | .0004    |
| Smoker,* n (%)           | 1215 (21.0)       | 996 (20.6)               | 219 (22.7)          | .154     |
| Diabetes (type 1 or 2),* n (%) | 1147 (19.8)     | 935 (19.4)               | 212 (21.9)          | .066     |
| Hypertension, n (%)      | 3195 (55.1)       | 2612 (54.1)              | 583 (60.4)          | .0004    |
| Hyperlipidemia, n (%)    | 2711 (46.8)       | 2204 (45.6)              | 507 (52.5)          | <.0001   |
| Total cholesterol, mg/dL, mean (SD) | 191.5 (34.9) | 191.5 (34.7)             | 191.6 (189.4)       | .966     |
| HDL, mg/dL, mean (SD)    | 54.5 (15.8)       | 54.9 (15.9)              | 52.7 (15.0)         | .0001    |
| LDL, mg/dL, mean (SD)    | 112.0 (31.0)      | 111.9 (30.9)             | 113.2 (31.2)        | .228     |
| Systolic BP, mm Hg,* mean (SD) | 126.5 (15.5)    | 126.5 (15.6)             | 126.4 (15.3)        | .963     |
| Diastolic BP, mm Hg, mean (SD) | 78.2 (9.9)     | 78.2 (9.9)               | 78.2 (10.0)         | .825     |
| Antihypertensives,* n (%) | 3382 (58.4)      | 2744 (56.8)              | 638 (66.1)          | <.0001   |
| Statin treatment, n (%)  | 1691 (29.2)       | 1379 (28.6)              | 312 (32.3)          | .019     |
| Cardiac testing order, n (%) | 1693 (29.2)     | 989 (20.5)               | 704 (72.9)          | <.0001   |
| ASCVD 10-year risk, mean (SD) | 10.3 (10.6)    | 10.2 (10.6)              | 10.8 (10.7)         | .098     |
| ASCVD 10-year risk ≥7.5% (high), n (%) | 2725 (47.0) | 2239 (46.4)              | 486 (50.3)          | .025     |

Abbreviations: ASCVD, atherosclerotic vascular disease; nSES, neighborhood socioeconomic status (lowest, 25th percentile; lower middle, 26th to 50th percentile; upper middle, 51st to 75th percentile; highest, >75th percentile; PCRE, pooled cohort risk equation; BMI, body mass index; BP, blood pressure; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

*Risk factors for ASCVD PCRE.
and covariates. The binary high versus low 10-year ASCVD score may be too broad and very high risk scores could have contributed to referral. Therefore, we conducted post hoc analysis and computed the percent referred to cardiology among the following ASCVD categories: (A) <2.5, (B) 2.5 to <5, (C) 5 to <7.5, (D) 7.5 to <10, (E) 10 to <15, (F) 15 to <20, and (G) >20. The percent referred from each category was (A) 13.3%, (B) 14.7%, (C) 16.0%, (D) 21.3%, (E) 14.7%, (F) 5.3%, and (G) 14.7%. This suggests similar referral rates at the lowest and highest ASCVD risk and further supports the conclusion that decisions to refer patients to cardiology are not associated with ASCVD score. In addition, among the subset of 143 patients referred to cardiology with available follow-up time after referral, we observed 16.7% of patients at high ASCVD risk with chest pain had an ASCVD event and 12.5% of those with high ASCVD risk without chest pain had an event. No events
## Table 3. Sociodemographic, ASCVD PCRE Risk Factors, and Other Health-Related Characteristics of 5795 Primary Care Patients Aged 40 to 79 Years Free of ASCVD and LDL<190 mg/dL, by Cardiology Referral (July 1, 2008 to June 30, 2015).

|                              | No Cardiology Referral (n = 5625) | Cardio Referral (n = 170) | P  |
|------------------------------|------------------------------------|---------------------------|----|
| **Sociodemographics**        |                                     |                           |    |
| Age, years, mean (SD)        | 56.6 (9.7)                         | 58.3 (9.1)                | .029|
| African American race, n (%) | 2286 (40.6)                        | 79 (46.5)                 | .128|
| Male gender, n (%)           | 2188 (38.9)                        | 51 (30.0)                 | .019|
| Married, n (%)               | 2982 (53.0)                        | 82 (48.2)                 | .219|
| nSES, n (%)                  |                                     |                           |    |
| Lowest                       | 1502 (26.7)                        | 49 (28.8)                 |    |
| Lower middle                 | 1217 (21.6)                        | 34 (20.0)                 | .900|
| Upper middle                 | 1421 (25.3)                        | 44 (25.9)                 |    |
| Highest                      | 1485 (26.4)                        | 43 (25.3)                 |    |
| **Health-related characteristics** |                                  |                           |    |
| High clinic utilization, n (%)| 2256 (40.1)                        | 110 (64.7)                | <.0001|
| BMI, kg/m², mean (SD)        | 31.4 (7.7)                         | 34.7 (9.7)                | <.0001|
| Smoker, n (%)                | 1174 (20.9)                        | 41 (24.1)                 | .306|
| Diabetes (type 1 or 2), n (%)| 1100 (19.6)                        | 47 (27.7)                 | .009|
| Hypertension, n (%)          | 3085 (54.8)                        | 110 (64.7)                | .011|
| Hyperlipidemia, n (%)        | 2620 (46.6)                        | 91 (53.5)                 | .074|
| Total cholesterol, mg/dL, mean (SD) | 191.6 (34.8)                | 191.3 (37.5)               | .932|
| HDL, mg/dL, mean (SD)        | 54.5 (15.8)                        | 53.5 (16.1)                | .422|
| LDL, mg/dL, mean (SD)        | 112.1 (30.9)                       | 111.9 (34.3)               | .955|
| Systolic BP, mm Hg, mean (SD)| 126.4 (15.4)                       | 128.7 (19.1)               | .060|
| Diastolic BP, mm Hg, mean (SD)| 78.2 (9.9)                         | 79.9 (10.3)                | .022|
| Antihypertensives, n (%)     | 3254 (57.8)                        | 128 (75.3)                 | <.0001|
| Statin treatment, n (%)      | 1632 (29.0)                        | 59 (34.7)                  | .108|
| Cardiac testing order, n (%) | 1566 (27.8)                        | 127 (74.7)                 | <.0001|
| ASCVD 10-year risk, mean (SD)| 10.2 (10.6)                        | 12.3 (12.2)                | .013|

Abbreviations: ASCVD, atherosclerotic vascular disease; nSES, neighborhood socioeconomic status (lowest, 25th percentile; lower middle, 26th to 50th percentile; upper middle, 51st to 75th percentile; highest, >75th percentile; PCRE, pooled cohort risk equation; BMI, body mass index; BP, blood pressure; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

## Table 4. Logistic Regression Models\(^a\) Estimating the Association of Chest Pain and ASCVD Risk With Referral to Cardiology in 5795 Primary Care Patients Aged 40 to 79 Years Free of ASCVD and LDL<190 mg/dL (July 1, 2008 to June 30, 2015).

|                              | Model 1; OR (95% CI) | Model 2; OR (95% CI) | Model 3; OR (95% CI) | Model 4; OR (95% CI) |
|------------------------------|----------------------|----------------------|----------------------|----------------------|
| Chest pain                   | 4.20 (3.07-5.73)     | 4.15 (3.4-5.67)      | 1.75 (1.24-2.47)     | 1.15 (0.72-1.82)     |
| ASCVD 10-year risk \(≥7.5\%\) (high) | 1.41 (1.04-1.91) | 1.35 (0.99-1.84) | 1.15 (0.72-1.82) |
| Age                          | 1.01 (0.98-1.03)     |                      |                      |                      |
| African American race        | 0.98 (0.66-1.45)     |                      |                      |                      |
| Male gender                  | 0.81 (0.56-1.17)     |                      |                      |                      |
| Married                      | 0.98 (0.69-1.37)     |                      |                      |                      |
| nSES                         |                      |                      |                      |                      |
| Lowest                       | 1.00                 |                      |                      |                      |
| Lower middle                 | 0.96 (0.60-1.53)     |                      |                      |                      |
| Upper middle                 | 1.13 (0.71-1.80)     |                      |                      |                      |
| Highest                      | 1.10 (0.66-1.83)     |                      |                      |                      |

(continued)
were observed for patients with low ASCVD risk with and without chest pain. These results provide further rationale for following ASCVD risk scores when referring to specialty care.

Conclusions

We found that patients with both high and low ASCVD risk scores were referred to cardiology at similar rates when they endorsed chest pain. Without chest pain, a similarly low percent of high and low ASCVD risk patients were referred. Whether ASCVD risk scores should be adopted as the gold standard predictive tool for evaluating patients in primary care remains uncertain. Our study fills a gap in the literature in primary care management of NCCP, and to our knowledge is the first study on this topic that used data from primary care encounters in the United States. The majority of existing research in this field has been done with European patient cohorts. Further research is warranted to determine if dissemination over time results in more primary care providers using the ASCVD risk tool when making referrals to cardiology. Replication in practice-based research networks is warranted and primary data collection is needed to measure whether and how primary care physicians use ASCVD risk score in making clinical decisions.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Ruigómez A, Rodríguez LA, Wallander MA, Johansson S, Jones R. Chest pain in general practice: incidence, comorbidity and mortality. *Fam Pract*. 2006;23:167-174.

2. McConaghy JR, Oza RS. Outpatient diagnosis of acute chest pain in adults. *Am Fam Physician*. 2013;87:177-182.

3. Ruigómez A, Massó-González EL, Johansson S, Wallander MA, García-Rodríguez LA. Chest pain without established ischaemic heart disease in primary care patients: associated comorbidities and mortality. *Br J Gen Pract*. 2009;59:e78-e86.

4. Nilsson S, Scheike M, Engblom D, et al. Chest pain and ischaemic heart disease in primary care. *Br J Gen Pract*. 2003;53:378-382.

5. Mourad G, Alwin J, Stromberg A, Jaarsma T. Societal costs of non-cardiac chest pain compared with ischemic heart disease—a longitudinal study. *BMC Health Serv Res*. 2013;13:403.

6. Goff DC, Jr, Lloyd-Jones DM, Bennett G, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(suppl 2):S49-S73.

7. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2014;63(25 pt B):2889-2934.

8. Cainzos-Achirica M, Desai CS, Wang L, et al. Pathways forward in cardiovascular disease prevention one and a half years after publication of the 2013 ACC/AHA cardiovascular disease prevention guidelines. *Mayo Clin Proc*. 2015;90:1262-1271.

9. Scherrer JF, Salas J, Brieler JA, Miller BJ, Meyer BD, Schneider FD. Depression leads to incident vascular disease: evidence for the relevance to primary care. *Fam Pract*. 2015;32:147-151.

10. Schoen MW, Salas J, Scherrer JF, Buckhold FR. Cholesterol treatment and changes in guidelines in an academic medical practice. *Am J Med*. 2015;128:403-409.

11. Schoen MW, Tabak RG, Salas J, Scherrer JF, Buckhold FR. Comparison of adherence to guideline-based cholesterol treatment goals in men versus women. *Am J Cardiol*. 2016;117:48-53.

12. Roblin DW. Validation of a neighborhood SES index in a managed care organization. *Med Care*. 2013;51:e1-e8.
13. Gebauer S, Salas J, Scherrer JF. Neighborhood socioeco-
nomic status and receipt of opioid medication for new back 
pain diagnosis. *J Am Board Fam Med*. 2017;30:775-783.
14. D’Agostino RB, Sr, Vasan RS, Pencina MJ, et al. General 
cardiovascular risk profile for use in primary care: the Framingham Heart Study. *Circulation*. 2008;117: 
743-753.
15. Rask KJ, Deaton C, Culler SD, et al. The effect of primary 
care gatekeepers on the management of patients with chest 
pain. *Am J Manag Care*. 1999;5:1274-1282.
16. Glombiewski JA, Rief W, Bosner S, Keller H, Martin A, 
Donner-Banzhoff N. The course of nonspecific chest pain 
in primary care: symptom persistence and health care usage. 
*Arch Intern Med*. 2010;170:251-255.
17. Pelter MM, Riegel B, McKinley S, et al. Are there symptom 
differences in patients with coronary artery disease presenting 
to the ED ultimately diagnosed with or without ACS? *Am J 
Emerg Med*. 2012;30:1822-1828.
18. Bruyninckx R, Van den Bruel A, Aertgeerts B, Van 
Casteren V, Buntinx F. Why does the general practitioner 
refer patients with chest pain not-urgently to the specialist 
or urgently to the emergency department? Influence 
of the certainty of the initial diagnosis. *Acta Cardiol*. 
2009;64:259-265.
19. Hoorweg BB, Willemse RT, Cleef LE, et al. Frequency of 
chest pain in primary care, diagnostic tests performed and 
final diagnoses. *Heart*. 2017;103:1727-1732.

**Author Biographies**

**Vishaal Buch**, MD, is a graduate from the Saint Louis University Department of Family Medicine Residency Program at St. Elizabeth’s Hospital and Southern Illinois Health Foundation.

**Hayley Ralph**, MD is a graduate from the Saint Louis University Department of Family Medicine Residency Program at St. Elizabeth’s Hospital and Southern Illinois Health Foundation.

**Joanne Salas**, MPH, is the senior biostatistician.

**Paul J. Hauptman**, MD, is professor and director of Clinical Trials, Division of Cardiology, Saint Louis University School of Medicine.

**Dawn Davis**, MD, is faculty in the Department of Family and Community Medicine, Saint Louis University School of Medicine.

**Jeffrey F. Scherrer**, PhD, is faculty in the Department of Family and Community Medicine, Saint Louis University School of Medicine.