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Descriptive Report

Thresholds for Atherosclerotic Cardiovascular Disease Screening in Low-Resource Settings

ASCVD Testing in Low Resource Settings

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Abstract

Background: Establishing appropriate thresholds for initiating cardiovascular and cerebrovascular disease (CVD) screening at a free medical service can be a challenging problem. With CVD remaining a leading cause of death and disability in the United States, atherosclerotic cardiovascular disease (ASCVD) screening is now a cornerstone of preventative primary care. Yet, limited financial resources, rotating (often volunteer) providers, and a lack of adequate insurance among patients who frequent free medical services can make wide-scale screening costly and even counter-productive.
Methods: This retrospective quality improvement project assessed CVD screening at the Worcester Evening Free Medical Service Program in Worcester, MA. Inclusion criteria consisted of acute or chronic medical encounters with patients ≥ 18 years of age who were seen between January 1, 2010 and August 31, 2021. Data included patient demographics; social and economic status; hypertension, diabetes, and hypercholesteremia status; CVD risk stratification; and treatment.
Results: We found that we were consistently under-screening patients at risk for CVD.
Conclusions: Results were paired with a polysocial risk score (PsRS) created by Javed, Valero-Elizondo, Dudum et al. to propose an ASCVD screening algorithm appropriate for low-resourced settings. The algorithm recommends screening patients with: (1) A systolic blood pressure >139 mm/hg; or (2) A systolic blood pressure >120 mm/hg and one known CVD risk factor (diabetes, smoking, family history) *or* 3 or more social and economic factors associated with CVD risk.

Background

Cardiovascular and cerebrovascular diseases (CVD) remain leading causes of death and disability in the United States with an annual cost estimated to be > $200 billion annually in medical services, medications, and lost productivity.[1] Risk factors for disease severity include hypertension (HTN), diabetes mellitus (DM), hyperlipidemia, smoking, unhealthy diet, excessive alcohol use, lack of physical activity, and family history.[2,3,4,5] This retrospective quality improvement project assessed CVD screening at the Worcester Evening Free Medical Service Program in Worcester, MA. Working as a collaborative team from the Chan School of Medicine at the University of Massachusetts, the Tan Chingfen Graduate School Nursing at the University of Massachusetts, and Worcester Polytechnic Institute, we used results to develop appropriate screening thresholds for our patient population.

The initial American Heart Association (AHA) consensus panel statement on preventing heart attack and death in patients with coronary disease was published in 1995.[6] Expanded guidelines and

updates were published in 1997,[7] 2001[8] (co-developed with the American College of Cardiology [ACC]), 2002 (AHA/ACC),[9] 2010 (ACC/AHA),[10] 2013 (ACC/AHA),[11] and 2019 (ACC/AHA).[1] The 2002 recommendations advocated calculating a patient-specific quantitative CVD 10-year risk score developed from epidemiological research (age, sex, smoking status, blood pressure, cholesterol, and diabetes status).[9] This score assessed the percent risk that a patient could have a major CVD incident (ischemic stroke or myocardial infarction) within 10 years.

Since 2002, guidelines have recommend that CVD screening be made routinely available to adults 40-75 years of age as one component of a comprehensive risk-reduction strategy that includes a healthy lifestyle and diet, regular exercise, hypertension and diabetes management, and regular follow-up with a primary care physician.[1,9,10,11,12] Statin therapy has consistently been recommended for patients with CVD risk scores in intermediate or high-risk categories.[1,9,10,11,12]

The 2010 guidelines expanded risk scoring to recommended "low risk," "intermediate risk," and "high risk" CVD categories and used a risk score of ≥10% over 10 years as the definition for intermediate risk and ≥20% over 10 years for high risk.[10] The 2013 guidelines introduced race-and sex-specific pooled cohort equations.[11] The 2013 guidelines recommended a blood pressure threshold of 140/90 mmHg for "satisfactory blood pressure control" consistent with the 2009 Performance Measures for Primacy Prevention of Cardiovascular Disease in Adults and the 2003 Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.[11,13,14]

The 2019 ACC/AHA guideline introduced substantial changes in process and thresholds for screening. The guidelines recommended routine screening for asymptomatic adults aged 40 to 75 years of age and atherosclerotic cardiovascular disease (ASCVD) management for patients with a systolic blood pressure (SBP) >129 mm/Hg and for patients with diabetes who have one or more additional risk factors (e.g., HTN, DM, smoking, family history of CVD).[1] The 2019 guidelines also recommended new 10-year atherosclerotic cardiovascular disease (ASCVD) risk categories: low (<5%), borderline (5% - <7.5%), intermediate (≥ 7.5% to <20%), or high (≥ 20%).[1] The 2019 guidelines use HTN definitions established by the 2017 Hypertension Clinical Practice Guidelines.[15] Stage 1 hypertension is defined as a SBP of 130-139 and a diastolic blood pressure (DBP) of 80-89 mm Hg. Stage 2 hypertension is defined as a SBP ≥140 mm Hg or a DBP ≥90 mm Hg.[1,15]

While the exact mechanisms remain poorly understood, socioeconomic status (SES) has also been found to be a strong predictor of cardiovascular and stroke disease outcomes.[16,17] Income level, education, unemployment, and geographic factors such as pollution, availability of recreational spaces, availability and cost of healthy food, and loneliness have been associated with higher levels of CVD risk.[18,19] Moreover, these social determinants of health (SDOH) disproportionately affect the health of patients who are served by free clinics.[20] However, current ASCVD risk estimators do not include SES or SDOH as part of their algorithms. In response, Javed, Velero-Elizondo, Dudum, et al., have proposed a polysocial risk score (PsRS) that integrates SDOH as additional measures of CVD risk. Their PsRS model includes unemployment, inability to pay medical bills (low income), psychological distress, lack of transportation, food insecurity, and less than high school education.[21]

Limited resources and infrastructure make routine, wide-scale screening, follow-up, and longitudinal CVD treatment difficult at many free medical programs, including our own.[22,23] Wide-scale screening (e.g., any patient with a SBP >129[1]) could divert resources from other important programs like vaccinations, sexually transmitted infection (STI) testing, chronic disease management, and, as has been reported, may overestimate actual CVD risk.[24]

Anticipating that we have been under-screening patients for CVD risk, we conducted a retrospective quality improvement study to assess our historic effectiveness at CVD risk screening. Our objective was to identify a threshold for a future screening program that was in line with ACC/AHA recommendations yet appropriate and workable for a lower-resourced medical service.

Methods

Individual encounter data was extracted from a REDCap (2023, Vanderbilt University, Nashville, TN) electronic dataset populated from written encounter forms (2010-2019) and electronic health records (2019-2021).[25,26] Inclusion criteria consisted of patients ≥ 18 years of age who were seen between January 1, 2010 and August 31, 2021 and whose primary reason for visit was for acute or chronic medical services. Exclusion criteria consisted of patients whose primary reason for visit was STI testing, school physicals, work physicals, or vaccinations. Data included individual patient demographics; social and economic status; measured blood pressure, laboratory tests ordered and resulted, hypertension, diabetes, and hypercholesteremia status; CVD risk stratification; prescriptions ordered, and treatment prescribed. Data analysis was conducted with Microsoft Excel (2011, Microsoft Redmond, WA). Analysis was descriptive and we used chi-squared values to validate comparative results.

Given that the HTN definitions in place during most of the encounters we examined were prior to the 2019 ACC/AHA guidelines, we assumed patients at the time would have been eligible for CVD screening if they had a measured SBP >139 mmHg.[10,11,13,14] A CVD screen was defined as a lipid panel or a formal "ASCVD risk panel with scores." Baseline Cardiovascular Risk Category was calculated separately for each patient who received a CVD screen using the American Heart Association 2018 Prevention Guidelines Tool CV Risk Calculator.[27] ASCVD risk stratification was based on the 2010 ACCF/AHA Guidelines because these were in place during most of the study encounters.[10] To assess Zip Code relationships to SES, zip codes were entered into the Housing and Urban Development Office of Policy Development and Research Qualified Census Tracts searchable database. The Zip Code was classified as "Lower SES" if was part of a Qualified Census District or a Difficult Development Area.[28] Income and school information was obtained for specific zip codes from US Census Data available at zipdatamaps.com.[29] The project was approved by Worcester Polytechnic Institute's (WPI) Institutional Review Board.

Results

Between January 1, 2010 and August 31, 2021, the service saw 690 qualifying individual patients over 1248 qualifying encounters. The majority of patients did not have healthcare insurance (77%) and resided in an urban setting. Approximately 80% of patients resided in zip codes with higher unemployment rates than the state average (median 4.2%, State average 3.4%), lower median incomes than the county average (median $46,529 vs $77,155), poorer school test results, and higher rates of children eligible for free or reduced lunch (median, 74%).[28] The median patient age was 44 years, 55% of patients were female, and the mean number of visits per patient was 2.8. Hypertension

Table 1. Patient characteristics

Total unique encounters	1248
Total unique patients seen	690
Mean patient age in years (range)	44 (18-82)
Percent female (%)	55
Percent uninsured (%)	77
Percent encounters marked "left without being seen"	6
Acute care visits per patient median (range)	2 (1-35)
Acute care visits per patient mean (SD)	2.8 (3.6)

SD: standard deviation

Table 2. Screening for patients with systolic blood pressures

SBP	Number of Patients	Percent of Patients (%)	Number of Patients with DM	Percent of Patients with DM (%)	Number of Patients with-out DM	Percent of Patients with-out DM (%)
>139	188	27	28	57	160	25
120-139	89	13	6	12	83	13
>129	413	60	15	31	398	62
Total Patients	**690**		**49**		**641**	

DM: diabetes mellitus; SBP: systolic blood pressure

Table 3. ASCVD patient characteristics

Total ASCVD screens performed	26
Total resulted	21
For resulted tests:	
Percent female	43%
Percent uninsured patients	90%
Percent lower SES zip code	67%
Mean patient age in years (range)	56 (36-69)
Number of patients with diabetes mellitus (percent)	9 (43%)
Mean systolic blood pressure (SD, range)	157 (26, 130-238)

ASCVD: atherosclerotic cardiovascular disease; SD: standard deviation; SES: socioeconomic status

was the most common diagnosis (15%). Table 1 presents patient demographics and Table 2 presents the blood pressures of our patients organized by diabetes diagnosis.

A total of 14% (n=26) of patients with stage 2 hypertension received a lipid panel blood test. Patients with both hypertension and diabetes were more likely to be screened for CVD risk (32% vs 11%; X^2 = 6.53, *df* = 1, p=0.01). Over the study period, our service received results from 21 of the 26 lipid panels (Table 3). The non-resulted tests were due to laboratory errors. Of the 21 patients who received lipid panel results, 58% (n=15) had high positive lipid panel results or were formally diagnosed with hyperlipidemia (hypercholesterolemia) (Table 4).

A total of 11 patients (52% of the resulted tests) were found to have intermediate or high CVD risk (Table 4): 73% of these patients had been diagnosed with diabetes, and 82% had an elevated PsRS as assessed by zip codes and insurance status.[28,29]

Of those tested for hyperlipidemia, statin therapy was prescribed for 25% of patients with DM; 33% of patients diagnosed with DM and hypertension; and 100% of patients diagnosed with DM, hypertension, and hyperlipidemia. ACCF/AHA guidelines for statin therapy were met in 50% of patients whose 10-year risk was considered intermediate or high according to 2010 guidelines (>10%).[10]

Discussion

Over the past decade, our free care program provided CVD screens for approximately 14% of patients, who, at the time, would have been considered at-risk (patients with SBP >139).[10,11,13,14] We

Table 4. ASCVD screening results for n = 21 patients

Total Cholesterol (mg/dl)	**n**	**%**
Mean = 213		
Distribution		
<200 mg/dl	10	48
≥200 to 240 mg/dl	8	38
≥240 mg/dl	3	14

LDL Cholesterol (mg/dl)	**n**	**%**
Mean = 118		
Distribution		
<100 mg/dl	8	38
≥130 to 160 mg/dl	9	43
≥160 mg/dl	3	14
Not reported	1	5

Triglycerides (mg/dl)	**n**	**%**
Mean = 220		
Distribution		
<150 mg/dl	5	24
≥150 to 250 mg/dl	8	38
≥250 mg/dl	8	38

HDL Cholesterol (mg/dl)	**n**	**%**
Mean = 56.1		
Distribution		
<40 mg/dl	6	29
≥40 to 60 mg/dl	9	42
≥60 mg/dl	6	29

Cholesterol/HDL Ratio (mg/dl)	**n**	**%**
Mean = 4.2		
Distribution		
<5 mg/dl	14	66
≥5	6	29
Not reported	1	5

Calculated ASCVD Risk Score*	**n**	**%**
Mean = 10.5		
Distribution		
<5 low risk	5	24
≥5-10% borderline risk	6	29
≥10-20% intermediate risk	8	38
≥20% high risk	2	9

ASCVD: atherosclerotic cardiovascular disease; HDL: high-density lipoprotein; LDL: low-density lipoprotein
**Cardiovascular risk category calculated using 2010 ACCF/AHA Guideline for Assessment of Cardiovascular Risk[10]*

CVD screens to 32% of patients with a SBP >139 and a diagnosis of diabetes and 11% of patients with a measured SBP >139 mmHg but no diagnosis of diabetes. While screening rates were low, screening appeared effective as just over half of the screening results we received returned results indicating intermediate or high CVD risk. We recognize that the lower rates may be due to some patients with elevated blood pressures not meeting the then-criteria for CVD risk assessment; other patients may have presented solely for episodic care, were in the process of transitioning to a full-time primary care practice, and others may have refused testing. We also note that some rotating clinicians did not know the screen was available or appropriate for our service. At the same time, results suggest missed opportunities for more expanded screening.

Adopting the 2019 guidelines and routinely screening all patients with a SBP >129 mmHg could identify more patients who are at risk. However, the approach would result in screening at least 40% of our patients, would be expensive, and as mentioned above, may overestimate actual CVD risk.[24] Yet, implementing a higher, now out-of-date threshold for screening (e.g., SBP >139 mmHg) would continue to miss patients with potential CVD risk.

Recognizing our dilemma, we consulted the current CVD risk assessment literature and discussed possible approaches with our medical director (author J. Ledwith, MD) and other volunteer clinicians. We were aware of the greater CVD risk associated with SDoH as reported in the literature and in various courses and conferences. In the PsRS developed by Javed, Velero-Elizondo, Dudum, et al., we found a tool consistent with the medical literature that could allow us to be more selective in screening decisions while lowering the SBP threshold to ≥120 mmHg.[21] From this process, we developed an algorithm that recommends screening patients with Stage 2 hypertension (SBP >139

Figure 1. ASCVD Screening Algorithm Integrating Social and Economic Status

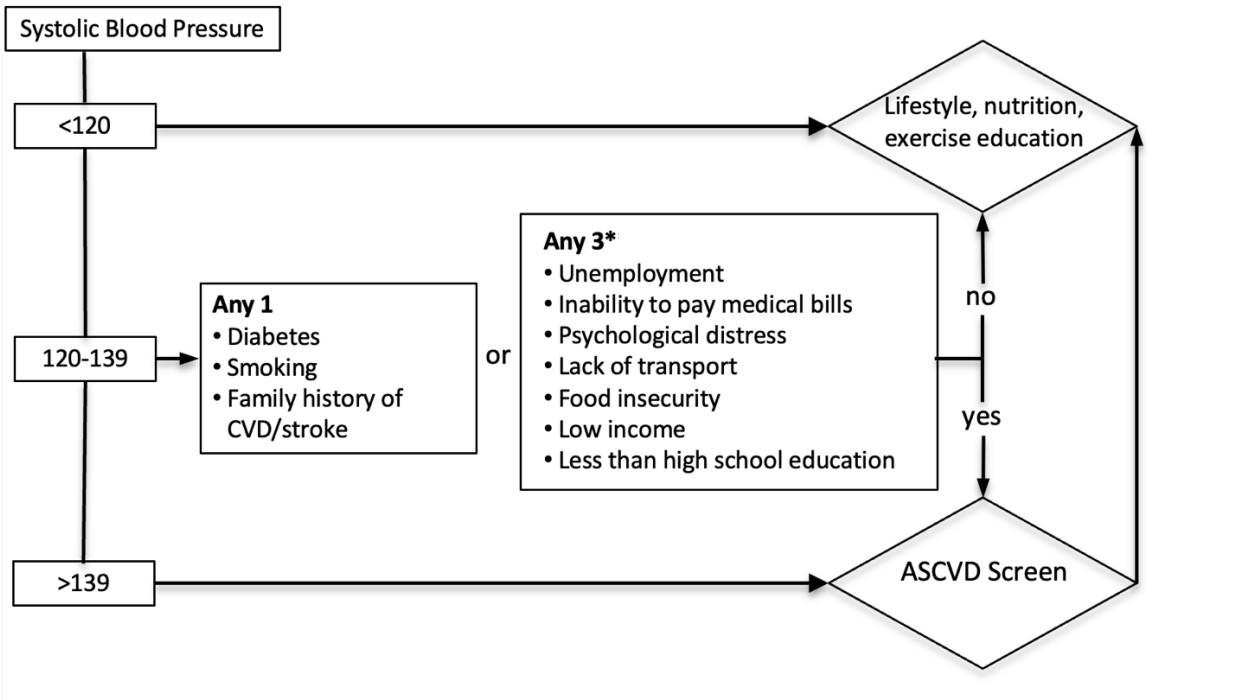

Figure 1 shows the proposed screening algorithm. All patients receive lifestyle, nutrition, and exercise counselling. ASCVD (atherosclerotic cardiovascular disease) screening is recommended to patients with a systolic blood pressure between 120-139 mmHg who also have a prior history of diabetes, smoking, or family history of CVD (cardiovascular disease) or stroke or meet any three social and economic factors. Patients with a systolic blood pressure > 139 mmHg are offered ASCVD screening.
*Social and Economic Status factors are from Javed Z, Valero-Elizondo J, Dudum R, et al.[21]

mmHg) and patients with lower blood pressures but elevated PsRS or other CVD risk factors.

Figure 1 offers a flowchart we propose to help guide screening considerations in low-resource services like our own. The proposed algorithm would recommend screening patients with Stage 2 hypertension (SBP >139 mm Hg), or patients with elevated blood pressure (SBP 120-139 mmHg) and one or more CVD risk factors (smoking, DM, or first-degree family history of cardiac disease or stroke) or three or more PsRS risk factors. Following the current understanding of the relationship between the SDoH and CVD, we propose that integrating a social determinants screen into ASCVD testing will better align resources to targeted needs and bring this service to a more appropriate patient demographic than expensive wide-scale screening.

If patients have a SBP <120 mmHg, they are provided education on lifestyle, nutrition, and exercise as ways to longitudinally manage their blood pressure. This pathway is consistent with the 2019 ACC/AHA guidelines to slow the development of CVD.[1] Patients with a SBP between 120-139 mm Hg and either one risk factor (diabetes, smoking, family history) or any three SES risk factors (e.g., unemployment, food insecurity, low income) will be offered an ASCVD screen.

Patients with a SBP between 120-139 but no additional risk factors will be offered education and potential treatment to reduce and longitudinally manage their BP. Patients with a SBP >139 mm Hg will be offered an ASCVD screen. The algorithm is designed to provide our volunteers with a reminder and educational tool to guide and incentivize ASCVD screening for our patients. It is not a replacement for clinical judgement, patient preferences, or requests. It also does not influence other treatment considerations (HTN, diabetes). Our hope is that the algorithm will increase our screening in a way that is financially and operationally sustainable.

We estimate that retrospectively applied to our data, the proposed algorithm would have

increased ASCVD screens from 26 to approximately 245 screens over the study period or approximately 22/year.

Using the algorithm, we anticipate approximately 18-25 screens per year, an increase of 579%. At approximately $31.50 per screen (Quest Laboratories) we anticipate budgeting $800/year for the program. These expenses will be covered through a corporate donation we have received from a local company. We will implement the program with the assistance of an undergraduate pre-medical student. The undergraduate student will prepare educational materials for clinicians, the medical students who complete our triage process, and patients. The algorithm will be included in our triage forms. The student will also gather data from patient encounters to assess our screening rate, effectiveness, and program outcomes. Results will be used collaboratively with patients to determine longitudinal treatment (risk discussion and lifestyle education, EKG, statin, hypertension management, diabetes management, expedited primary care referral). We plan to start a longitudinal follow-up study to assess the program's outcomes. With an anticipated three-year timeline, the study will compare testing pre- and post-algorithm to determine if we improved our screening frequency and our ability to identify and manage CVD risk in our patient population. We invite other programs to provide their own assessments and revisions of the algorithm.

Our project is limited by the single site analysis, the smaller numbers that ultimately populated the cohort groups and CVD screens, and an inability to conduct patient follow-up. As such, our experience and data may not be representative of other free services. We also recognize that as a retrospective review, the results are limited by the quality and accuracy of the data gathered and recorded by multiple researchers and the data that was selected for inclusion in the database.

As we noted above, CVD screening is not a novel addition to primary care. At the same time, our project contributes to similar studies from free medical services (vital signs measurement, prevention services, quality improvement programs, lab result monitoring, mental health screens) showing that the context of a free medical service creates unique challenges for what might be routine activities in other clinical sites.[30,31,32,33,34] Free medical services do not always have the resources, insurance coverage, patient preferences, or longitudinal care systems that permit ideal implementation of testing guidelines. At the same time, free medical services provide important and crucial safety net medical care for highly vulnerable populations. Learning how other free medical programs have addressed such challenges provides useful and relevant ways to address recurring problems. We hope that this project will help us to better identify patients who are at risk of atherosclerotic disease and help our service provide better preventative care to this patient population.

Disclosures

The authors have no conflicts of interest to disclose.

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