

Community-Based Cardiovascular Screening: Detection of Disease in Individuals with No Self-Reported Risk Factors

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Abstract

Introduction: Community-based cardiovascular screening presents an opportunity to detect the presence of cardiovascular disease in individuals who report having no traditional risk factors, and also to identify the presence of those risk factors in those who are unaware of their health status. Identification of both disease and risk factors (e.g. high cholesterol, high blood pressure, diabetes, etc.) creates an opportunity for treatment and management to reduce and prevent cardiovascular events from occurring. **Methods:** Over 230,000 screening records for individuals who had undergone carotid artery stenosis (CAD), abdominal aortic aneurysm (AAA), or peripheral artery disease (PAD) screening were reviewed. Participants were stratified based on self-reported risk factors as having no risk factors, one risk factor, or two or more risk factors. Self-reported risk factors were also compared with results of screening for blood pressure, blood glucose, and lipid level status. **Results:** Abnormal findings of CAS, AAA, and PAD were all uncovered in individuals who self-reported as having no traditional risk factors. These abnormal findings included those defined as severe. The review of self-reported risk factors for accuracy demonstrated varying levels of inaccuracies in both under and over-reporting of risk factors. **Conclusions:** Community-based cardiovascular screening may result in the identification of cardiovascular disease in individuals with no established risk factors. While the underreporting of risk factors has also been demonstrated, it is clear that further research is warranted to better understand the presence of disease in the absence of risk factors.

Keywords

Cardiovascular, Screening, Risk Factors, Carotid Artery Stenosis, Abdominal Aortic Aneurysm, Peripheral Artery Disease

1. Introduction

The risk factors for myocardial infarction and stroke have been well defined [1]-[3]. Some of these risk factors are not modifiable (family history, ethnicity, age, etc.), where others can be managed/treated (e.g. diabetes, high cholesterol, and high blood pressure) or altered (e.g. smoking status, diet, and exercise) [1]-[3]. Community-based cardiovascular screening represents a method for detecting the presence of cardiovascular disease in individuals, including in those who report having no known risk factors. While some individuals may not be knowledgeable about risk factors or solely underreport them, it is possible that screening may detect disease in the absence of risk factors entirely. A recent study found that 3% of the population examined presented with coronary artery disease in the presence of no traditional cardiovascular risk factors [4]. A similar study reported even higher numbers, with 11.7% of study participants with coronary artery disease presenting with no risk factors [5]. While it is clear that traditional risk factors still play an integral role in the etiology of cardiovascular disease, this article seeks to further explore the potential for disease in the absence of the risk factors.

Community-based screening may also help to identify the presence of risk factors in individuals who are unaware of their health status. Identification of risk factors (e.g. high cholesterol, high blood pressure, diabetes, etc.) creates an opportunity for individuals to have these conditions treated and/or managed to reduce the risk of cardiovascular disease. Identification of disease in those with no prior knowledge of having risk factors for disease also represents an individual and public health benefit.

Life Line Screening is the leading provider of community-based preventive health screenings in the United States. Since its inception, the company has screened more than 8 million people and currently screens more than one million people every year at a variety of community-based test sites. Through this experience, it has identified serious health issues and has helped save thousands of lives. This manuscript reviews records from Life Line Screening to assess the relationship between the detection of cardiovascular disease in individuals and self-reports of cardiovascular risk factors. It further seeks to evaluate the screening participant's accuracy in self-reporting three specific risk factors at screening (high blood pressure, high cholesterol, and diabetes).

2. Methods

2.1. Participants

Participants self-selected to receive screening services provided by Life Line Screening (LLS). LLS utilizes direct mail marketing, email and television advertising to promote their service offerings. Participants self-pay for the service.

Participants have been screened in all 48 contiguous states. As reviewed in the recent publication by Drs. Weisman and Manganaro, the total population of screened individuals are largely over the age of 50 (91.2%), includes slightly more women than men (63.3%), and is disproportionately Caucasian (87.8%) [6]. Despite these imbalances, the overall size of the population (more than 6 million screenings completed) allows for extrapolation to the American population as a whole.

The population of screened individuals has also been demonstrated to have similar rates of cardiovascular disease (e.g. carotid artery stenosis [CAS], abdominal aortic aneurysm [AAA], and atrial fibrillation) and cardiovascular risk factors (smoking status, weight, diabetes status, and history of high blood pressure and high cholesterol) as the general U.S. population [6].

At screening, individuals are notified that the results of their screenings may be utilized for research purposes. The authors of this paper had access solely to de-identified data to perform this review. This dataset meets the definition of "de-identified" as described in the CFR Title 45 Section 164.514. According to the HIPPA Privacy Rule, de-identified datasets are not considered Protected Health Information and can be released and used without further authorization (consent) or any further restrictions, including IRB review or approval.

2.2. Study Size

Participants in this study consist of individuals who underwent cardiovascular screening services in 2013. Records were reviewed for 237,293 participants who underwent community-based cardiovascular screening of CAS, AAA and PAD. Participants were stratified by the presence of self-reported risk factors; no risk factors present ($n = 27,614$), 1 risk factor ($n = 55,673$), and 2 or more risk factors ($n = 154,006$).

For an analysis of the accuracy of self-reported risk factors, screening records were evaluated for the same

time period for individuals who received blood pressure, blood glucose, and lipid level results.

2.3. Measured Variables

LLS offers a range of cardiovascular and other health outcome screening services. Of relevance to this manuscript is the carotid duplex ultrasound assessment of CAS, as determined by peak systolic velocity (PSV), abdominal ultrasound assessment of AAA, and ultrasound assessment of peripheral artery disease (PAD), as determined by ankle-brachial index.

LLS has defined CAS as normal, mild/moderate, moderate, and significant based on thresholds of PSV and presence/visualization of plaque. The values for these thresholds are shown in **Table 1**. A normal finding of AAA is defined as <3 cm with an abnormal findings of ≥ 3 cm. Lastly, an abnormal finding of PAD is defined as an ABI < 0.9.

Screening services also include a range of blood tests including those that evaluated: lipids, triglycerides, liver transaminases (AST/ALT), thyroid stimulating hormone, high-sensitivity C-reactive protein, glucose, and hemoglobin A1c.

2.4. Subject-Reported Risk Factors

Each screening incorporated a health questionnaire, which was answered by participants on-site. Depending on the year and type of screening, this survey included up to 82 questions, and covered demographic information, participant medical history, and family medical history, as well as health-related questions about lifestyle. Questions included those regarding cardiovascular history, stroke history, exercise, diet, smoking status, general symptoms, and use of common medications, including aspirin. These questions provide the basis for determining the subject's presence or absence of risk factors.

The following questions were utilized for determining risk factor status for stratifications of CAS, AAA, and PAD results:

- 1) Smoking status (current, former, never)
- 2) Prior diagnosis of
 - Cardiovascular disease
 - Diabetes
 - High cholesterol
 - High blood pressure
 - Stroke/TIA
 - Coronary artery disease
- 3) Family history of
 - Cardiovascular disease
 - Stroke
 - Coronary heart disease
 - Diabetes

For analyses of the self-reported risk factor reporting, the responses to the questions listed above were compared to the results of blood pressure testing and blood panel testing conducted at screening for blood glucose and lipid levels.

2.5. Analyses

The comparison of self-reported risk factors to screening results were assessed as positive and negative agreement values where: a = report of disease and abnormal screening results; b = report of disease and normal screening result; c = report of no disease and abnormal screening result; d = report of no disease and normal screening result. Positive agreements were calculated as: $2a/[N + (a - d)]$ (N = total observations). Negative agreements were calculated as: $2d/[N - (a - d)]$ [7].

3. Results

3.1. Detection of Disease and Self-Reported Risk Factors

Results of abnormal CAS, AAA, and PAD findings by risk factor are shown in **Tables 2-4**, respectively. For all

three diseases, abnormal findings were recorded for individuals who reported no risk factors. Abnormal results for CAS are shown in total and by severity. 34.4% of individuals with no reported risk factors had abnormal findings; 42.4% with one reported risk factor had abnormal findings, and 57.9% of individuals with two or more risk factors had abnormal CAS findings.

Results for AAA demonstrated a similar increase as CAS, but the magnitude of that increase was markedly smaller. While 0.3% of participants with no risk factors presented with abnormal AAA findings, only 0.8% of participants with two or more risk factors also presented with abnormal findings. Lastly, 1.7%, 2.2% and 4.3% of participants presented with abnormal PAD findings with no, one, and two risk factors reported, respectively.

3.2. Reporting of Risk Factor Status

A review of screening data demonstrates that many participants self-report as not having risk factors, but following screening their results indicate the presence of these risk factors. **Table 5** provides an overview of these results.

Of screening records reviewed, 68% of participants who reported having normal blood pressure actually presented with elevated blood pressure levels. This included 43% of participants with pre-hypertensive blood pressure levels and 19% and 5% presenting with Stage 1 and Stage 2 high blood pressure, respectively.

Furthermore, 43% of individuals who reported having normal cholesterol levels presented with elevated amounts, and 21% of individuals who reported normal glucose levels had glucose level abnormalities.

Positive agreement values for all three risk factors ranged from 37.8 to 60.7. Negative agreement values were higher, ranging from 44.8 to 86.1. Positive agreement was highest for blood pressure, while negative agreement was highest for glucose levels. Interestingly, negative agreement was lowest for blood pressure while positive agreement was highest for glucose.

Table 1. Definitions for findings of CAS.

Status	Definition (PSV)
Normal	<110 cm/s, no apparent plaque
Mild/moderate	<110 cm/s, with plaque
Moderate	110 - 139 cm/s, caused by plaque
Possibly significant	140 cm/s or greater, including occlusion

Abbreviations: CAS—carotid artery stenosis; PSBV—peak systolic velocity.

Table 2. Results of CAS finding by self-reported risk factor status.

CAS finding	No risk factors (n = 27,614)	1 risk factor (n = 55,673)	≥2 risk factors (n = 154,006)
Normal	18,105 (65.6%)	32,054 (57.6%)	64,692 (42.0%)
Mild/Moderate	8869 (32.1%)	21,893 (39.3%)	79,332 (51.5%)
Moderate	441 (1.6%)	1148 (2.1%)	6057 (3.9%)
Significant	199 (0.7%)	576 (1.0%)	3890 (2.5%)

Abbreviations: CAS—carotid artery stenosis.

Table 3. Results of AAA finding by self-reported risk factor status.

AAA finding	No risk factors (n = 27,614)	1 risk factor (n = 55,673)	≥2 risk factors (n = 154,006)
Normal (<3.0 cm)	27,543 (99.7%)	55,441 (99.6%)	152,711 (99.2%)
Abnormal (≥3.0 cm)	71 (0.3%)	230 (0.4%)	1284 (0.8%)

Abbreviations: AAA—abdominal aortic aneurysm.

Table 4. Results of AAA finding by self-reported risk factor status.

PAD finding	No risk factors (n = 27,614)	1 risk factor (n = 55,673)	≥2 risk factors (n = 154,006)
Normal (ABI ≥ 0.9)	(98.3%)	54,465 (97.8%)	147,408 (95.7%)
Abnormal (ABI < 0.9)	463 (1.7%)	1201 (2.2%)	6578 (4.3%)

Abbreviations: PAD—peripheral artery disease; ABI—ankle-brachial index.

Table 5. Positive and negative agreement of participant self-reported risk factor and screening result.

Test	Total participants	Self-reported as "normal"	Self-reported as "abnormal"	Abnormal results on screening	Positive agreement	Negative agreement
Blood pressure	169,274	97,930	71,344	126,404	60.7	44.8
Cholesterol	164,383	86,838	77,545	73,571	48.5	56.2
Glucose	156,147	139,341	16,806	40,208	37.8	86.1

4. Discussion

Subjects who report having no risk factors for cardiovascular disease demonstrate disease in various cardiovascular beds (particularly carotid). While this is likely a function of under-reporting (knowing but answering incorrectly on the survey) or lack of knowledge of having a risk factor, there is a possibility that there is a presence of disease in individuals with no risk factors. This finding is corroborated by a recent review demonstrated that ultrasound screening of CAS may identify disease in low-risk individuals who can then be re-classified to higher risk groups and be monitored more closely [8]. Dr. Andrew Nicolaides found that ultrasound screening for CAS found atherosclerotic plaques in 42% of asymptomatic individuals who presented with a low (<10%) Framingham Risk Score [8]. While screening would not be recommended in these individuals based on the current guidelines for screening (the U.S. Preventive Services Task Force recommends against any screening for asymptomatic CAS [7]), clearly disease can be identified and can also create opportunity for the identification of non-traditional risk factors (e.g. homocysteine) [9].

Similarly, a recently published observational study was conducted in a population-based cohort of stable patients who underwent cardiac catheterization to examine the relationship between traditional risk factors and the presence of coronary artery disease [4]. Of 46,490 patients included in the study, 3% of those with disease had no traditional cardiovascular risk factors. A similar study from Iran reported an even higher number of study subjects with no cardiovascular risk factors (11.67%); however study authors do note that the prevalence of the risk factors in their study population was lower when compared to Asian and North American countries, and that further research was needed to understand if this was due to racial or geographic variations [5].

The results of examining self-reported risk factors demonstrate that a large number of screened individuals inaccurately report their risk factor status. Interestingly, participants were almost just as prone to report having a condition for which they tested negatively for as they were prone to reporting they had no condition when they did. This low negative agreement rate is a limitation of the design of the study as these results do not take in to consideration any interventions that the participants may already be receiving (e.g. statins) and did not accurately report. A further limitation of this study is that the subjects examined self-select and self-pay for screening, and therefore the population is subject to selection bias of an uncertain degree.

The positive agreement rates are similar to other studies conducted in populations in the United States. Smith *et al.* conducted a review of over 37,000 military personnel medical records and compared the medical record diagnosis of 38 conditions to self-reported medical data [10]. Study authors found a positive agreement value of 53.5 and 37.4 for hypertension and diabetes respectively [10]. St. Sauver *et al.* conducted a review of over 26,000 patient/family history questionnaires and compared self-reported responses to Mayo Clinical medical records [7]. Authors found a positive agreement rate of 77.9 and 69.4 for hypertension and high cholesterol, respectively.

Agreement rates for self-reported risk factors tend to be higher in studies conducted outside the United States. The Netherlands' Monitoring Project on Cardiovascular Disease Risk Factors, a cross-sectional population study, found 100% and 91% positive agreement for diabetes and hypertension, respectively [11]. Similarly, in Germany, self-reported presence of diabetes was found to be 91% in agreement with medical records in a study over 7000 individuals [12].

The low positive agreement rates of this preliminary review implicate community-based cardiovascular screening as an important tool for detecting unknown risk factors for cardiovascular disease. While the low negative agreement rate calls in to question the actual number of individuals who have cardiovascular disease in the presence of no risk factors, clearly some individuals still may fall into this category. Further research is needed to learn more about the individuals who report having no risk factors for cardiovascular disease, but upon screening present with disease.

5. Conclusion

Community-based cardiovascular screening may result in the identification of unknown risk factors, allowing for participants to seek further medical care to manage or alter their risk factor status. Importantly, the individuals who may have no prior knowledge of an existing risk factor are likely outside of the traditional medical system—creating a niche for community-based screening to identify diseases that may have otherwise been undetected and untreated. This article indicates the need for further research into the possibility of cardiovascular disease in the absence of risk factors.

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Conflict of Interest Statement

Dr. Steven Weisman is an independent scientific consultant that assists Life Line Screening (LLS) in its research efforts. Drs. Manganaro and Garbani are employees of Life Line Screening.

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