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Screening Strategies for Cardiovascular Disease in Asymptomatic Adults

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Synopsis

The purpose of this manuscript is to update the primary care community on evidence and guidelines for cardiovascular disease screening in a general risk adult population, with the goal of assisting clinicians in developing an evidence-based approach towards screening. This manuscript discusses global risk assessment and screening strategies including blood pressure, lipids, c-reactive protein, homocysteine, coronary artery calcium score, carotid intima-media thickness, ultrasound of the abdominal aorta, and electrocardiography.

Epidemiology and Risk Factors

Heart disease is the leading cause of death in the United States (US),[1] with heart attack and stroke accounting for about a third of all US deaths.[2] Cardiovascular diseases (CVDs) are also a leading cause of disability, with over 4 million reporting a related disability in the US.[2] The total cost of CVDs in the US was estimated at $444 billion in 2010.[2] This number is expected to increase significantly as the US population ages.[2] Abdominal aortic aneurisms

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(AAA) affect 5-10% of men aged 65 to 79 years, and mortality following rupture of an abdominal aneurism is very high.[3]

Risk factors for CVD include family history, hypertension (HTN), dyslipidemia, smoking history, and diabetes mellitus. Smoking is associated with a three to fivefold increase in the risk of AAA and AAA mortality.[4] While the majority of people with CVD have at least one conventional risk factor, it is important to know that almost 15% of men and 10% of women with CVD do not have any of the conventional risk factors.[5]

Risk for CVD varies across different populations, including race/ethnicity, age, and gender. While a leading cause of death in the US as a whole, heart disease has higher prevalence, morbidity, and mortality in African Americans.[6,7] The reasons for these disparities have been debated. Risk factors such as smoking, HTN, diabetes mellitus, and physical inactivity are more common in African Americans; however non-disease factors such as genetic differences, health behaviors, and social factors also play a role.[6] Race and ethnicity often correlate with social conditions or a person's environment, including education level, access to health care, and socioeconomic status. Lower socioeconomic status is linked to calorie-rich and nutrient poor diets, which increases risk of developing CVD.[8]

As the main point of contact within the health care system for the majority of individuals, primary care providers play a critical role in the detection and management of risk factors for the primary prevention of CVD.

Global Risk Assessment Tools

While evaluating cardiac risk is crucial for both determining the need for preventive treatment as well as specifying treatment intensity,[9-11] research suggests that health care providers tend to be poor estimators of a patient's CVD risk.[12] The relative risk reduction from a given treatment tends to be constant across populations.[13] For example, if a treatment produces a relative risk reduction of approximately 30%, an individual with a baseline risk of 10% would have an absolute risk reduction of 3%. However, an individual with a baseline risk of 20% would have an absolute risk reduction of 6%. Thus, risk assessment is critical because the absolute risk reduction observed from treatment is a function of an individual's baseline risk, and treatment benefits may not outweigh treatment harms (which are likely constant) in low risk individuals.

A variety of screening tools exist to help providers estimate the risk of first cardiovascular event in adult patients,[12] including the Pooled Cohort Atherosclerotic Cardiovascular Disease (ASCVD) Risk Equations,[14] Framingham Risk Score (FRS), QRISK®2 (version two of the QRISK® CVD risk algorithm), Assessing Cardiovascular Risk using Scottish Intercollegiate Guidelines Network (ASSIGN), Systematic Coronary Risk Evaluation (SCORE), Prospective Cardiovascular Münster (PROCAM), and UKPDS. Each tool is derived from a different sample and has associated advantages and disadvantages. As delineated in Table 1, consideration of unique characteristics and the source population are useful in guiding the selection of an appropriate risk assessment tool for a particular patient.

Description of Commonly Employed Screening Methods

Blood Pressure Measurement

Hypertension is a common, preventable risk factor for the development of CVD and death.[15] Individuals with HTN have a much higher risk of stroke, myocardial infarction, heart failure, peripheral vascular disease, and AAA than those without HTN.[16] Office blood pressure measurement with an appropriately sized upper arm cuff is the standard screening test for HTN. In practice, errors may occur in measuring blood pressure as a result of instrument, observer, or patient factors. This includes issues with the manometer, stethoscope, poorly fitting cuffs for the patient's arm size, trouble hearing Korotkoff sounds, inattention on the part of the observer, rapid release of air from the blood pressure cuff, and many more.[16] Precision in identifying those with HTN improves with the number of blood pressure measurements taken.[16]

When performed properly, office blood pressure measurement is highly correlated with the intra-arterial measurement and is predictive of cardiovascular risk.[16] The relationship between blood pressure and cardiovascular risk is continuous.[17] Individual blood pressure measurements tend to be variable, and thus HTN diagnosis should be made after at least two elevated readings taken on at least two visits.[17]

Blood Tests

Dyslipidemia is considered a major risk factor for the development of CVD. Lipid lowering therapies, especially statins, are widely used in the primary and secondary prevention of CVD.[9] There are known associations between elevations in total cholesterol, low-density lipoproteins (LDL), and triglycerides as well as reductions in high-density lipoproteins (HDL) and CVD. Fasting lipid profiles including these four lipid biomarkers are widely used in screening and decision-making in contemporary medicine. In recent years, some have advocated for measuring elevations in lipoprotein(a) as well.[18]

Inflammation appears to play an important role in the development of atherosclerosis. C-reactive protein (CRP) is a biomarker that rises in response to inflammation in the body. An elevated CRP level has been suggested as a potential nontraditional risk factor to use in estimating risk for those without known CVD.[19]

Homocysteine first became of interest in the prediction of CVD after observing that the majority of children with genetic homocysteinuria die from premature vascular disease. Severe homocysteine elevations can be the result genetic mutations causing enzyme abnormalities. Insufficient consumption of folate, vitamin B_6 and vitamin B_{12}–vitamins which play a large role in homocysteine metabolism–accounts for most homocysteine elevations in the US.[20]

Imaging

A variety of imaging tools have been studied and are increasingly used in practice to screen for CVD, including coronary artery calcium (CAC) obtained by computed tomography (CT), carotid artery ultrasound, and abdominal aorta ultrasound. CAC and carotid artery

imaging are both used as markers of atherosclerosis,[21,22] although the interpretation of the two modalities differs in prediction of specific cardiovascular risk.[23]

Carotid intima-media thickness (cIMT) reflects primarily hypertensive medial hypertrophy, which is more predictive of stroke than myocardial infarction and is weakly associated with traditional cardiovascular risk factors.[23] Alternatively, carotid plaque area is more predictive of myocardial infarction than stroke and is often associated with traditional risk factors.[23] CAC scores predict cardiovascular events in asymptomatic adults[24] as well as both cardiovascular events and all-cause mortality in people with type 2 diabetes.[25] Screening for abdominal aneurism is conducted using ultrasonography to detect asymptomatic aneurisms for which surgery may reduce the risk of future rupture.[3]

Electrocardiography

Electrocardiography (ECG) has been used since the late 1800s in the diagnosis of CVD. Electrocardiography is frequently used to detect cardiac irregularities such as ventricular hypertrophy or conduction system delays. Electrocardiography abnormalities are associated with an increased risk of coronary heart disease (CHD) events[26] and mortality.[27]

Genetic Screening

Family history plays an important role in assessing risk of CVD. In most cases, multiple genetic changes, which individually do not result in disease, are working together with environment and behavior to cause disease. Genetic screening is not yet sophisticated enough to detect this complex interplay between genes. However, some less common inherited heart diseases are caused by one or a few genetic changes that work to cause disease. Examples of these include familial hyperlipidemia, some forms of hypertrophic and dilated cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, long-QT syndrome, and Brugada syndrome. Genetic testing can help determine which relatives are at risk for developing a condition, but cannot predict whether it will develop or its severity.[28]

Evidence for Risk Assessment and Screening

Global Risk Assessment

An impressive body of research demonstrates the treatment of some cardiovascular risk factors reduces the rate of cardiovascular events. Numerous risk prediction models have been developed, but relatively few have been externally validated. A US Preventive Services Task Force (USPSTF) evidence review identified 17 risk prediction models that were validated in a population other than the one in which the model was developed. Risk prediction models are considered general population first-outcome incidence calculators, meaning they are intended to assess the individual risk of a first CVD event in a general risk population.[12]

US models (ie, Framingham) validated in nationally representative US cohorts performed well in white and black populations, but performed poorly among Hispanics and people of Asian descent living in the US.[12,29,30] Social, cultural, and ethnic differences appear to influence CHD risk; thus, models are more likely to perform well in populations resembling

the source population.[12,30] Models that excluded diabetes mellitus performed well in a general population. There are currently no externally validated models for use in a diabetic population in the US.[12] US models had mixed performance when tested in European cohorts: US models under-predicted risk in European cohorts from high risk populations (eg, people with diabetes) and over-predicted risk in the general population.[12]

More recently, the American College of Cardiology and American Heart Association (ACC/AHA) have jointly developed new Pooled Cohort ASCVD Risk Equations in 2013 to estimate both the 10-year and lifetime risks for developing a first ASCVD event, defined as CHD death, nonfatal myocardial infarction, and fatal or nonfatal stroke.[14] Participants from several large cohort studies were ultimately included for analysis and equation development, including participants in the ARIC (Atherosclerosis Risk in Communities) study[22], Cardiovascular Health Study[21], and the CARDIA (Coronary Artery Risk Development in Young Adults) study,[31] in combination with data from the Framingham Study cohorts. The Pooled Cohort Equations include age, total and HDL cholesterol, systolic blood pressure (treated or untreated), diabetes, and current smoking status as statistically warranted variables, and are only validated for use in African American and non-Hispanic White men and women due to insufficient data from the pooled cohorts for other racial/ethnic groups.[14]

In general, US models such as the Pooled Cohorts Equations or FRS should be used for screening in the US, while European models such as SCORE or PROCAM should be used in European patients. Recognize that these models have significant limitations when used in populations that do not resemble the source population with regard to social, cultural, and ethnic characteristics. A major concern of the new Pooled Cohort Risk Equations is that it systematically overestimated risks by roughly 75-150% based on its performance in five external validation cohorts. This is thought to be due to the use of cohort data from studies conducted over two decades ago that do not necessarily reflect current levels of morbidity or improvements in overall health and health care since that time.[32] This suggests the need for routinely performing new external validation studies for any of these risk assessment models in contemporary cohorts to maintain model predictive value. Outcomes and cohort characteristics of several validated risk prediction models are described in Table 1.

Blood Pressure

While there have been no randomized controlled trials (RCTs) evaluating the direct effect of screening for HTN on CVD event rates, trials evaluating HTN treatment demonstrated improved outcomes in the treatment of patients who were enrolled as a result of elevated blood pressures detected in screening.[16] Additionally, no studies have evaluated the relative effectiveness of selective versus universal blood pressure screening or the optimal frequency for blood pressure screening.[16] While no direct evidence for HTN screening exists, indirect evidence supports screening adults for HTN because it is an important risk factor for CVD events and is reliably detected through office blood pressure screening. Additionally, treatment with lifestyle and pharmacologic therapy can effectively reduce blood pressure and CVD events.[16]

Lipids

Lipid screening in individuals with known CHD has been widely supported for some time. The benefits of lipid screening in a general risk population are relatively unknown because there have been no RCTs evaluating the direct effect of screening on CVD event rates. Because there is growing evidence demonstrating that statins reduce rates of CVD events in both intermediate and high-risk individuals, dyslipidemia is considered a modifiable risk factor and lipids have become a target for CVD screening.[41] Nevertheless, there has not been clear consensus on whom, how, and when to screen for dyslipidemia for primary prevention of CHD.[42,43]

Because the absolute benefit of treating dyslipidemia is a function of baseline risk, a 10% baseline risk of events has been commonly used as a threshold for producing a meaningful difference in CVD outcomes given the significant drop-off in effectiveness for reducing CVD events in individuals with lower than a 10-year risk.[41,44] A 2008 USPSTF evidence review demonstrated that no combination of FRS ATP-III (Adult Treatment Panel III) risk factors in men aged 18 to 35 years or women younger than 40 years would result in a 10-year risk of cardiovascular events greater than 10% in nonsmokers or those without a history of HTN or diabetes mellitus. This means that limiting screening in men aged 18 to 35 or women less than age 40 to those with a smoking, HTN, or diabetes history will sufficiently identify those most likely to benefit from treating dyslipidemia.[43]

In 2013, the ACC/AHA released new guidelines for both cardiovascular risk assessment and treatment of cholesterol with statins that defined the threshold for 10-year risk at 7.5% rather than 10% as previously defined by ATP-III.[14,45] This was based on data from both primary prevention statin RCTs and meta-analyses of statin RCTs included in the 2013 Cochrane review on statins for primary prevention of CVD that suggested that the ASCVD risk reduction benefit clearly outweighed the risks of statin therapy at a ≥7.5% 10-year risk threshold.[41,45,46] However, this redefinition of low ASCVD risk was met with controversy based on conflicting evidence for statin benefits in low-risk individuals, as well as the methodology for setting the new threshold.[47-50] Indeed, the meta-analysis performed by the Cholesterol Treatment Trialists' (CTT) Collaborators showed a 20% decrease in major vascular events for roughly every 40 mg/dL reduction in LDL cholesterol with statin treatment in low risk individuals (the most significant finding for the meta-analysis of the 27 RCTs). However, 35% of the major vascular events were actually coronary revascularization procedures, and not hard cardiovascular endpoints.[46,49]

Additionally, data from the CTT meta-analyses do not demonstrate that statins have a significant effect on overall mortality among low-risk individuals, and the CTT Collaborators did not consider the effect of statins on serious adverse effects despite having access to patient-level data.[49] Regardless of whether the threshold for low ASCVD 10-year risk is <7.5% or <10%, more research is currently needed to determine whether statin treatment in low-risk individuals actually provides a net benefit when taking into account the potential risks and harms of treatment. Future studies addressing this may very well influence the 10-year risk cutoff for risk assessment, and more accurately determine whom and when to screen for dyslipidemia.

Screening for lipid disorders is recommended by both the ATP-III and USPSTF guidelines. There are no trials that evaluate the effect of screening for triglycerides on clinical endpoints in individuals who would not otherwise qualify for lipid lowering therapy. While triglycerides appear to be a significant predictor when used as the sole predictor of CHD events, this association is reduced or eliminated when adjusting for other variables such as those included in the FRS.[43] According to a 2001 USPSTF evidence synthesis, a Framingham-based algorithm that incorporates total cholesterol and HDL is the most accurate approach for predicting CHD events.[42] The updated 2013 ACC/AHA risk assessment guidelines retain both total and HDL cholesterol as statistically significant variables in the new Pooled Cohort Risk Equations.[14] Table 2 displays the reliability and accuracy, patient acceptance, and provider feasibility of different lipid screening strategies.

Evidence from epidemiologic studies and RCTs supports the use of CHD risk equivalents (ie, peripheral artery disease, AAA, carotid artery disease, and diabetes)[9] in targeting individuals who may benefit from lipid-lowering therapy.[43] There is not sufficient evidence to inform the recommended frequency of lipid screening in asymptomatic adults, although ATP-III suggests once every five years and the 2013 ACC/AHA guidelines recommend risk factor assessment (including total and HDL cholesterol) every 4-6 years among adults.[14,42,43]

Lipoprotein(a)

There is insufficient evidence that using lipoprotein(a) improves risk stratification in asymptomatic adults, compared to traditional risk factors alone.[51,52] A plasma lipoprotein(a) level of 30 mg/dL or greater is associated with an increased risk of CVD. There is little correlation between lipoprotein(a) and traditional CHD risk factors, and studies have not evaluated the additive value of lipoprotein(a) with traditional risk factors in predicting CHD.[52]

C-Reactive Protein

Several studies have reported associations of CRP with CVD event rates; nevertheless, there is insufficient evidence that using CRP to stratify risk in asymptomatic adults leads to a reduction in CHD.[52] Adjusting for all Framingham risk factors in the evaluation of CRP, a meta-analysis of 10 studies of good quality from the 2009 USPSTF evidence review found an increased relative risk (1.58; CI 1.37-1.83) for those with high CRP (> 3.0 mg/L) compared to those with low CRP (< 1.0 mg/L). The included studies did not directly assess the impact of adding CRP to the assessment of FRS to reclassify individuals at intermediate risk. Several studies have evaluated the impact of CRP in reclassifying intermediate risk individuals as high risk; however, the results of these studies are imprecise and conflicting and are not able to quantify how many people would be reclassified.[53]

Homocysteine

Homocysteine levels are positively associated with CVD and can be lowered by folic acid and other nutrients;[54] however, there is no evidence that screening with a homocysteine level in asymptomatic adults leads to a reduction in the prevalence of CHD events. An increase in homocysteine by 5 μmol/L was associated with a small increase in relative risk

for total CHD (1.18; CI 1.10-1.26) when those with known CHD were excluded from the cohort. Administering folic acid can result in a reduction in homocysteine, though two large randomized trials–Health Outcomes Prevention (HOPE) trial and the Norwegian Vitamin Trial (NORVIT)–testing whether folic acid can result in a decrease in myocardial infarction or recurrent CVD events were both negative.[55,56] The HOPE trial demonstrated a decreased relative risk of stroke from decreasing homocysteine with folic acid;[56] however, this was not confirmed in the NORVIT trial.[55] The Swiss Heart Study, which included 553 individuals following successful angioplasty of at least one coronary stenosis, demonstrated decreased relative risk of myocardial infarction or repeat revascularization after percutaneous coronary intervention with the use of homocysteine lowering therapy.[57] These effects have not been confirmed in other studies.[52]

Coronary Artery Calcium Score

There is insufficient evidence that screening using a CAC score in asymptomatic adults leads to a reduction in the rate of CHD events.[51,52] A meta-analysis of three good quality population-based cohort studies demonstrated increased relative risk for coronary events as CAC score increased. Adjusted for other Framingham risk factors, CAC score demonstrated the ability to better predict individuals at an increased risk over estimated 10-year risk using FRS alone. Nevertheless, it is important to know that older studies overestimated the independent effect of CAC scores, and that no studies have shown that CAC screening leads to better outcomes.[52]

A population-based cohort study from Rotterdam, Netherlands evaluated the utility of using twelve newer risk factors with standard risk factors. This study found that relative to the other emerging risk factors, CAC score contributed significantly to the standard risk factors to predict CHD risk. However, these results are from a primarily white, European population and did not assess whether CAC screening results in better clinical outcomes.[58]

A cost-effectiveness modeling analysis of CAC score screening in an intermediate risk population was conducted based on the Rotterdam study. In this analysis, CAC score screening in men just met a commonly used threshold for cost-effectiveness. Because of its retrospective nature, however, many assumptions were made. Sensitivity analysis demonstrated that by altering these assumptions, CAC screening was no longer cost-effective. In women, CAC screening was not cost-effective, even when using assumptions that generally favor CAC screening.[59]

Carotid Intima-Media Thickness

A 2009 USPSTF evidence synthesis evaluating emerging risk factors for CHD found three cohort studies evaluating the potential utility of cIMT in screenings. However, these studies had serious limitations, such as including patients with known CAD, symptomatic peripheral vascular disease, or not reporting CHD events as end points. While cIMT is predictive of some CVD events after adjusting for traditional risk factors, there is not consensus on examination technique or standards for interpreting the cIMT measures. The studies included in the analysis had differing methods for evaluating cIMT, making the synthesis of

results unreliable.[51,52] A cohort study published following the 2009 USPSTF report demonstrated similarly modest improvements in CHD risk prediction.[58]

Ultrasound of Abdominal Aorta

A Cochrane Review evaluating ultrasound screening of asymptomatic adults for AAA identified four studies with 127891 men and 9342 women randomly assigned to receive ultrasound screening or no screening.[3] Only one trial included women. None of the trials were conducted in the US (two were in the United Kingdom, one in Denmark, and one in Australia). In three of these trials, screening was associated with a reduction in death from AAA in men aged 65 to 83 years (OR 0.60; range 0.47 to 0.78). There was no reduction in mortality among women. Three to five years following the screening, all-cause mortality was not significantly different between the screened and unscreened groups. Screened men were more likely to have undergone surgery for AAA than men who were not screened (OR 2.03; range 1.59 to 2.59). Screening among men aged 65 to 74 years appears to be cost-effective, but there is no evidence related to life expectancy, complications from surgery, or quality of life.[3]

In 2005, the USPSTF also completed an evidence synthesis. This synthesis included the same four trials identified in the Cochrane Review; however, the USPSTF review focused on answering questions related to screening in a high-risk population, repeat screening in individuals without AAA on initial screening, harms associated with AAA screening, and harms associated with repairing AAAs 5.5 cm or greater in diameter.[4] Age, smoking, family history, coronary artery disease, hypercholesterolemia, and cerebrovascular disease are risk factors for AAA. Only one trial evaluated mortality from AAA in different age groups. Invitation to screen was associated with significantly reduced mortality in men aged 65 to 75 years (OR 0.19, CI 0.04, 0.89), and increased mortality in older men.[4] The authors of the USPSTF evidence syntheses developed a model to evaluate the impact of selectively screening those with a history of smoking. This model demonstrated that invitation to screen men aged 65 to 74 years with a lifetime history of smoking 100 or more cigarettes accounts for 89% of the expected reduction in mortality from screening all men aged 65 to 74 years.[4] However, limiting screening to current smokers was too restrictive and resulted in many missed AAAs. Population screening strategies based on coronary artery disease, hypercholesterolemia, and cerebrovascular disease do not perform better than approaches using age, sex, and smoking history in identifying high risk populations for screening.[4]

Repeat screening in men with a negative AAA ultrasound at age 65 does not appear to be advantageous. In men with negative AAA screening at age 65, incidence of new AAA was low in 10 years of periodic AAA screening. When AAAs were found in follow-up screening, they were most commonly less than 4.0 cm and did not have a significant risk of rupture.[4] Ultrasonography is not associated with any physical harm in adults. Participants with positive ultrasonography compared to negative ultrasonography had slightly more anxiety and lower mental and physical health scores initially, but soon returned to normal within six weeks of screening. Elective AAA repair has risks and is associated with significant morbidity and mortality. Outcomes are improved in hospitals conducting more AAA repairs and when repairs are done by experienced vascular surgeons.[4]

Electrocardiography

The USPSTF published an evidence synthesis evaluating the use of ECG in screening asymptomatic adults in 2011.[60] There were no RCTs or prospective cohort studies evaluating clinical outcomes following screening versus no screening in asymptomatic adults. No studies assessed the improved accuracy of stratifying cardiovascular risk by using traditional risk factors plus resting or stress ECG compared to traditional risk factors alone. A pooled analysis including 63 prospective cohort studies demonstrated that ST-segment or T-wave abnormalities, left ventricular hypertrophy, bundle branch block, or left-axis deviation on resting ECG or ST-segment depression with exercise, failure to reach maximum target heart rate, or low exercise capacity on exercise ECG are associated with an increased risk of cardiovascular event after adjusting for traditional risk factors.[60]

Genetic Screening

While most CVD results from a complex interaction of genetic and environmental influence, thereby precluding effective genetic screening, familial hypercholesterolemia (FH) is a monogenic disease that can be identified with genetic testing. The rate of FH varies greatly by region and ethnicity and responds well to treatment.[61] Genetic screening in family members of people with known FH demonstrated cost-effectiveness in analysis from the Netherlands. This type of screening allows detection of FH before it is symptomatic.[62] A second cost-effectiveness analysis in the United Kingdom demonstrated superiority of DNA-testing in family members of people with known or probable FH followed by LDL-testing in individuals in which a genetic mutation was not identified.[63] Importantly, these studies employed a cascade design, meaning all first-degree relatives of those with known or probable FH are tested, rather than general population-based genetic screening, which is not recommended.

Cardiovascular Disease Prevention and Screening Recommendations

Evidence-based research has allowed for the development of clinical practice guidelines as professional recommendations to guide clinical and health policy decision-making. The US Preventive Services Task Force (USPSTF), the ACC/AHA, and other organizations have provided assessments of the current evidence for CVD prevention and screening through professional recommendations. The USPSTF is an independent group of 16 US experts in prevention and evidence-based medicine from the fields of preventive medicine and primary care assembled to provide recommendations based on scientific evidence reviews on a variety of clinical preventive medicine services.[64] USPSTF provides recommendations for services where benefits clearly outweigh the harms, with a focus on health and quality of life. USPSTF assigns a grade definition (A, B, C, D, or I) based on strength of evidence and net benefit, and grade A and B services have clear benefit and should be offered to patients.[65]

The ACC and AHA have jointly produced guidelines for CVD since 1980, with experts in the subjects under consideration providing recommendations based on thorough evidence review. The experts rank supporting evidence for recommendations according to previously established methodology, with Level A evidence coming from multiple randomized clinical

trials, Level B evidence derived from a single randomized trial or nonrandomized studies, and Level C evidence largely based on consensus opinion, case studies, or standard of care. In 2010, the ACC/AHA published a clinical guideline for assessing CVD risk in asymptomatic adults, addressing many of the screening strategies discussed in this paper.[66] The updated 2013 ACC/AHA guideline for assessing cardiovascular risk focuses mainly on the new model for global risk assessment–the Pooled Cohort ASCVD Risk Equations.[14]

The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC) was established to provide an evidence-based approach to the prevention and management of HTN.[67] JNC is made up of a panel of experts and the most recent set of guidelines, JNC8, was published in 2013 focusing on the treatment of HTN in adults.[15] The National Heart, Lung, and Blood Institute (NHLBI) established the National Cholesterol Education Program (NCEP) in 1985 with the goal of reducing CVD morbidity and mortality by lowering the percent of Americans with high cholesterol. As part of its educational efforts, NCEP has published a series of three clinical practice guidelines for cholesterol management beginning in 1988.[68] The most recent version, published in 2002 and updated in 2004, The Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (ATP-III) was drafted by expert panel members, including representative experts from both ACC and AHA.[44,68] Table 3 provides a summary of guidelines and recommendations for various screening strategies from these organizations.

Current Practice Patterns

Data documenting current practice patterns for CVD screening using most newer testing modalities is limited. Health system reports and observational data provide a source for information on blood pressure measurement, lipid screening, and use of electrocardiograms in the primary care setting.

Studies report variable rates of blood pressure screening in the US. One study of women in central Pennsylvania reported blood pressure measurement as the most commonly received preventive service, with 94.1% receiving screening in a two-year period.[76] Another study demonstrated that blood pressure was measured in 56% of all adult visits and 93% of visits with hypertensive patients in office visits conducted in 2003-2004.[77] Seeing a specialist other than a cardiologist, age over 75 years, lack of insurance, absence of HTN-related comorbidities, and visits other than general medical examination visit were all associated with decreased odds of being screened for HTN.[77] Because blood pressure is one of the most important modifiable risk factors for CVD, this variability in blood pressure screening indicates that efforts are needed to improve the consistency of blood pressure screening in clinical practice.

Lipid screening is currently performed at highly variable rates throughout the US. Among 6830 patients from 44 primary care practices in the Midwest, the rate of cholesterol screening every five years varied from 45% to 88%.[78] Similarly, cholesterol screening rates varied widely among 5071 patients at 60 non-university based primary care practices in North Carolina. While the median clinic screening rate of 40% every two years met the

frequency recommended by ATP-III guidelines (once every five years), the rate of screening varied broadly from 26% to 54% among the different clinics.[79] Additionally, the 2-year screening rate differed significantly by specialty, with internal medicine providers screening at higher rates than family medicine providers (54% versus 38%) across the clinics.[79]

Lipid screening rates differ based on both patient and contextual factors. Patient factors associated with higher rates of lipid screening include older age, a diagnosis of diabetes, and higher BMI.[76,79,80] Additionally, having a regular provider, having continuous health insurance coverage for the past year, and the presence of at least one chronic medical condition are associated with higher lipid screening rates.[76] At the contextual level, primary care provider density by county is positively associated with lipid screening.[76] While some studies suggest no difference in lipid screening rates between men and women,[76,81] Rifas-Shiman et al. found that women were screened at lower rates than men across all risk levels.[80] Although there is clear evidence for racial and ethnic disparities in CVD prevalence,[6,7,82] outcomes,[6,7] and some treatment modalities,[6,83] evidence for such disparities in lipid screening rates is less consistent. Analysis of data from the Medical Expenditure Panel Survey (MEPS), which constructs a nationally representative sample with oversampling of Hispanics and non-Hispanic blacks, from both 1996[84] and 2007[85] did not find significant racial or ethnic differences in cholesterol screening rates. In contrast, two independent studies using data from the National Health and Nutrition Examination Survey (NHANES) during the periods 1988-1994[86] and 1999-2006[87] conveyed that African Americans and Mexican Americans were less likely than whites to report serum cholesterol screening.

Given the lower absolute benefit from statin treatment in low risk individuals,[41,49] variation in lipid screening rates based on some clinical factors may reflect appropriate risk stratification by providers (rates less than once every 5 years may very well be appropriate for low risk patients). However, the widespread variation in lipid screening rates based on nonclinical factors suggests a non-systematic approach to incorporating evidence-based preventive health services in primary care. While differences between groups or clinics may seem inevitable, as some practices are more efficient in delivering preventive services than others, Solberg et al. found significant variation between the delivery of different preventive services within individual clinics.[78] This “marker of haphazard provision of clinical preventive services” highlights the need for interventions aimed to systematically deliver evidence-based preventive measures such as lipid screening.[78(p 124)] Complicating this task is the difficulty of implementing ATP-III guidelines in clinical practice as evident by data illustrating that higher risk patients are more likely to be undertreated for dyslipidemia than those at lower risk. It is suggested that this is related to a lack of provider comfort with the complexity of ATP-III-based risk categorization.[81] Conversely, in a study of 24 primary care offices, higher global patient-centered medical home (PCMH) scores were associated with greater receipt of preventive health services, including lipid screening.[88] In particular, the relational principles of PCMH (such as identifying a personal physician, having continuity of care, and whole person-oriented care) were more strongly associated with lipid screening than the information technology capabilities of PCMH organizational structure.[88]

There is less available data on current use of electrocardiograms (ECGs) for screening in the primary care setting. In one study of 10 urban academic group internal medicine practices, ECGs were obtained in 4.4% of asymptomatic patients without known CVD.[89] There was significant variability among both group practices and providers, with the rate of ECG performance ranging from 0.8-8.6% among the 10 practices, and from 0.0-24% among providers.[89] Clinical predictors of ECG use include older age, male sex, and clinical comorbidities. Additionally, older male providers, those who billed for ECG interpretation, and Medicare as a payment source were associated with obtaining ECGs.[89] Race and ethnicity were not analyzed as predictors of ECG screening.[89] Overall, variation in ECG screening was not well explained by patient characteristics, and likely reflects the lack of sufficient evidence for the role of ECG screening in the primary care setting.[89]

Impact of Changes within Health Care

The true impact of recent transformations within the health care system–such as widespread use of electronic health records (EHR), implementation of the Affordable Care Act (ACA), development of accountable care organization (ACOs), and expansion of PCMH principles–are yet to be seen.

Electronic Health Records

Advocated for as a facilitator of quality health care delivery, EHRs are becoming increasingly prevalent. Reports of the effects of EHR implementation, however, are mixed.[90-95] While proponents have pointed to increased use of clinical decision support within the EHR as a benefit, this has not consistently led to improvements in the quality of care;[92] however, EHRs have been used to successfully identify individuals at risk of developing CVD by readily identifying risk factor clustering.[93]

Accountable Care Act and Accountable Care Organizations

While many provisions of the ACA have been implemented, the law will not be fully employed until 2018, and the effects of many of the recently implemented provisions have not yet been realized. There are several provisions, however, which will likely impact CVD screening and prevention in primary care. A Prevention and Public Health Fund was established by the ACA, which supports prevention and public health programs. Specifically, this fund will be used to increase the primary care workforce and develop programs to prevent tobacco use, obesity, heart disease, stroke and cancer, and to increase immunization rates.[96] Additionally, the ACA requires new health plans and Medicare to provide coverage for preventive services rated A or B by the USPSTF (including AAA screening for men aged 65 to 75 years who have ever smoked, and cholesterol screening in men over age 35 or women over age 45 or younger if at an increased risk for CHD).[96,97] There will also be federal matching payments for preventive services in Medicaid for states that offer A and B recommended services with no patient cost-sharing.[96]

Through the ACA, the Centers for Medicare & Medicaid Services' Shared Savings Program promotes the growth of ACOs, the aims of which are to improve care for individuals, better the health of populations, and slow the growth of costs. Importantly, prevention is a key

component of improving care, bettering health, and slowing costs.[98,99] To accomplish these aims, ACOs must not only effectively manage a patients' health care information, but use this information to inform patients about preventive care and increase patients' engagement in prevention through shared-decision making.[98]

Patient-Centered Medical Home

The concept of the PCMH has been present for some time. In 2008, the American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, and American Osteopathic Association developed joint principles describing the characteristics of the PCMH.[100] These principles describe a model in which patients have an ongoing relationship with a physician who provides continuous and comprehensive care. This physician leads a team of people who work together to provide care and arrange for care by other professionals when needed. Patients have enhanced access to care and increased options for communication with providers and staff. All of these principles are aligned to improve coordination of care, quality, and safety.[100] Research evaluating principles of the PCMH and the receipt of preventive services found a positive relationship with regard to lipid screening, suggesting that PCMH characteristics of practice organization may facilitate CVD screening best practice.[88]

Summary

Any summary of scientific evidence is somewhat constrained as a particular snapshot in time, and lack of current evidence must not be equated with evidence against effectiveness. Many methods for CVD screening have insufficient evidence to currently recommend use in a general, asymptomatic adult population. This corresponds well with a 2012 Cochrane Review evaluating the impact of general health checks (including screening measures) that found general health checks did not improve either overall health or cardiovascular morbidity and mortality.[101] Nonetheless, there is good evidence for some specific CVD screening modalities when used in the proper risk setting. Lipid measurement and abdominal aortic ultrasound, for example, are two screening techniques with strong data regarding who benefits from screening and the impact of screening on outcomes. While current evidence does not support the use of other newer screening modalities for primary prevention of CVD, this may very well change as more high-quality trials are completed in the future.

Risk assessment is a vital first step in determining the appropriate approach to CVD screening. As discussed above, even with elevated LDL, younger adults without other risk factors such as HTN, smoking, or diabetes will not likely qualify for cholesterol lowering medications according to the ATP-III or ACC/AHA guidelines. In this segment of the population, lipid screening may not be necessary. One study found that prescribed lipid management (ie, lifestyle counseling and medication initiation) was more closely related to pretreatment LDL than to calculated 10-year risk despite a body of research to the contrary, resulting in under-treatment of many intermediate and high-risk individuals.[81] This highlights the importance of moving the assessment of CVD risk factors beyond the traditional focus on LDL and dyslipidemia to a more holistic and individualized approach as outlined by the 2013 ACC/AHA risk assessment guidelines and championed by the PCMH movement.

Risk assessment tools, such as the Pooled Cohort Risk Equations or Framingham calculator in a US population and SCORE cards or PROCAM calculator in a European population can facilitate the estimation of risk and open the door for shared decision-making regarding interventions to reduce cardiovascular risk. Shared decision making tools are sometimes built into risk assessment tools (eg, QINTERVENTION tool for use in the UK: http://qintervention.org/; Mayo Clinic Shared Decision Making National Resource Center Statin/Aspirin Choice tool http://shareddecisions.mayoclinic.org/decision-aids-for-diabetes/cardiovascular-prevention/). These tools are designed to support patient-provider conversations regarding risk factor identification and the potential benefits and harms of screening for and/or treating a health condition. Including patients in the conversation regarding evidence, potential risks, and the various options for CVD screening will provide patients with the knowledge to make informed decisions regarding their health. Further research is needed on the facilitators of and barriers to efforts to implement global risk assessment strategies in a primary care setting.

The absolute benefit of treating risk factors to prevent CVD varies considerably as a function of baseline risk. In light of the current evidence, health organizations should be encouraged to reprioritize quality metrics by shifting the focus away from measuring individual biomarkers to performing global risk assessment to achieve CVD screening best practice.

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Abbreviations

AAA	abdominal aortic aneurism
ACA	Affordable Care Act
ACC	American College of Cardiology
ACO	accountable care organization
ACPM	American College of Preventive Medicine
AHA	American Heart Association
ASCVD	atherosclerotic cardiovascular disease
ASSIGN	Assessing Cardiovascular Risk using Scottish Intercollegiate Guidelines Network
ATP-III	Adult Treatment Panel III
CAC	coronary artery calcium
cIMT	carotid intima-media thickness

CHD	coronary heart disease
CRP	c-reactive protein
CTT	Cholesterol Treatment Trialists'
CVD	cardiovascular disease
ECG	electrocardiography
EHR	electronic health record
FH	familial hypercholesterolemia
FLP	fasting lipid panel
FRS	Framingham Risk Score
HDL	high-density lipoproteins
HTN	hypertension
JNC	Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
LDL	low-density lipoproteins
NCEP	National Cholesterol Education Program
PROCAM	Prospective Cardiovascular Münster
PCMH	patient-centered medical home
RCT	randomized controlled trial
SCORE	Systematic Coronary Risk Evaluation
USPSTF	United States Preventive Services Task Force
US	United States

References

1. Kochanek KD, Xu J, Murphy SL, Minino AM, Kung H-C. Deaths: final data for 2009. Natl Vital Stat Rep. 2011; 60(3):1–17. [PubMed: 22670489]
2. Centers for Disease Control and Prevention. [Accessed May 16, 2013] Heart disease and stroke prevention addressing the nation's leading killers: at a glance 2011. Prev Chronic Dis. 2011. Available at: http://www.cdc.gov/chronicdisease/resources/publications/aag/dhdsp.htm2013
3. Cosford PA, Leng GC, J T. Screening for abdominal aortic aneurysm (Review). The Cochrane Database Syst Rev. 2011
4. Fleming C, Whitlock E, Beil T, Lederle F. Screening for abdominal aortic aneurysm: a best-evidence systematic review for the US Preventive Service Task Force. Ann Intern Med. 2005; 142:203–211. [PubMed: 15684209]
5. Khot UN, Khot MB, Bajzer CT, et al. Prevalence of conventional risk factors in patients with coronary heart disease. JAMA. 2003; 290(7):898–904. [PubMed: 12928466]
6. Harold JG, Williams KA. President's page: disparities in cardiovascular care: finding ways to narrow the gap. J Am Coll Cardiol. 2013; 62(6):563–565. [PubMed: 23906196]

7. Ford ES. Trends in predicted 10-year risk of coronary heart disease and cardiovascular disease among U.S. adults from 1999 to 2010. J Am Coll Cardiol. 2013; 61(22):2249–2252. [PubMed: 23563124]
8. Drewnowski A. Obesity, diets, and social inequalities. Nutr Rev. 2009; 67(Suppl 1):S36–39. [PubMed: 19453676]
9. Expert Panel on Detection Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA. 2001; 285(19):2486–2497. [PubMed: 11368702]
10. Wood D, De Backer G, Faergeman O, Graham I, Mancia G, Pyorala K. Prevention of coronary heart disease in clinical practice: recommendations of the Second Joint Task Force of European and other Societies on Coronary Prevention. Atherosclerosis. 1998; 140(2):199–270. [PubMed: 9862269]
11. Califf, RM.; Armstrong, PW.; Carver, JR.; D'Agostino, RB.; Strauss, WE. Task Force 5. Stratification of patients into high, medium and low risk subgroups for purposes of risk factor management. J Am Coll Cardiol; 27th Bethesda Conference: matching the intensity of risk factor management with the hazard for coronary disease events; 1996. p. 1007-1019.
12. Matheny M, McPheeters M, Glasser A, et al. Systematic review of cardiovascular disease risk assessment tools. AHRQ Publication. May.2011 85 2011.
13. Barratt A, Wyer PC, Hatala R, et al. Tips for learners of evidence-based medicine: 1. Relative risk reduction, absolute risk reduction and number needed to treat. CMAJ. 2004; 171(4):353–358. [PubMed: 15313996]
14. 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. 2013
15. James PA, Oparil S, Carter BL, et al. 2014 Evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA. 2013
16. Sheridan S, Pignone M, Donahue K. Screening for high blood pressure: a review of the evidence for the U.S. Preventive Services Task Force. Am J Prev Med. 2003; 25(2):151–158. [PubMed: 12880884]
17. US Preventive Services Task Force. Screening for high blood pressure: US Preventive Services Task Force reaffirmation recommendation statement. Ann Intern Med. 2007; 147(11):783–786. [PubMed: 18056662]
18. Emerging Risk Factors C. Di Angelantonio E, Sarwar N, et al. Major lipids, apolipoproteins, and risk of vascular disease. JAMA. 2009; 302(18):1993–2000. [PubMed: 19903920]
19. Akhabue E, Thiboutot J, Cheng J-w, et al. New and emerging risk factors for coronary heart disease. The American Journal of the Medical Sciences. 2013:1–8. 0(0).
20. Humphrey LL, Fu R, Rogers K, Freeman M, Helfand M. Homocysteine level and coronary heart disease incidence: a systematic review and meta-analysis. Mayo Clin. Proc. 2008; 83(11):1203–1212. [PubMed: 18990318]
21. O'Leary DH, Polak JF, Kronmal RA, Manolio TA, Burke GL, Wolfson SK Jr. Carotid-artery intima and media thickness as a risk factor for myocardial infarction and stroke in older adults. Cardiovascular Health Study Collaborative Research Group. N Engl J Med. 1999; 340(1):14–22. [PubMed: 9878640]
22. Chambless LE, Heiss G, Folsom AR, et al. Association of coronary heart disease incidence with carotid arterial wall thickness and major risk factors: the Atherosclerosis Risk in Communities (ARIC) Study, 1987-1993. Am J Epidemiol. 1997; 146(6):483–494. [PubMed: 9290509]
23. Spence JD. Technology insight: ultrasound measurement of carotid plaque--patient management, genetic research, and therapy evaluation. Nat Clin Pract Neurol. 2006; 2(11):611–619. [PubMed: 17057748]
24. Pletcher MJ, Tice JA, Pignone M, Browner WS. Using the coronary artery calcium score to predict coronary heart disease events: a systematic review and meta-analysis. Arch Intern Med. 2004; 164(12):1285–1292. [PubMed: 15226161]

25. Kramer CK, Zinman B, Gross JL, et al. Coronary artery calcium score prediction of all cause mortality and cardiovascular events in people with type 2 diabetes: systematic review and meta-analysis. BMJ. 2013; 346:f1654. [PubMed: 23529983]
26. Moyer VA, US Preventive Serivces Task Force. Screening for coronary heart disease with electrocardiography: US Preventive Services Task Force recommendation statement. Ann Intern Med. 2012; 157(7):512–518. [PubMed: 22847227]
27. Ashley EA, Raxwal VK, Froelicher VF. The prevalence and prognostic significance of electrocardiographic abnormalities. Curr Probl Cardiol. 2000; 25(1):1–72. [PubMed: 10705558]
28. Cirino AL, Ho CY. Genetic testing for inherited heart disease. Circulation. 2013; 128(1):e4–8. [PubMed: 23817488]
29. Liao Y, McGee DL, Cooper RS, Sutkowski MB. How generalizable are coronary risk prediction models? Comparison of Framingham and two national cohorts. Am Heart J. 1999; 137(5):837–845. [PubMed: 10220632]
30. Orford JL, Sesso HD, Stedman M, Gagnon D, Vokonas P, Gaziano JM. A comparison of the Framingham and European Society of Cardiology coronary heart disease risk prediction models in the normative aging study. Am Heart J. 2002; 144(1):95–100. [PubMed: 12094194]
31. Okwuosa TM, Greenland P, Ning H, Liu K, Lloyd-Jones DM. Yield of screening for coronary artery calcium in early middle-age adults based on the 10-year Framingham Risk Score: the CARDIA study. JACC Cardiovasc Imaging. 2012; 5(9):923–930. [PubMed: 22974805]
32. Ridker PM, Cook NR. Statins: new American guidelines for prevention of cardiovascular disease. Lancet. 2013; 382(9907):1762–1765. [PubMed: 24268611]
33. 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. J Am Coll Cardiol. 2013
34. The Atherosclerosis Risk in Communities (ARIC) Study: design and objectives. The ARIC investigators. Am J Epidemiol. 1989; 129(4):687–702. [PubMed: 2646917]
35. Fried LP, Borhani NO, Enright P, et al. The Cardiovascular Health Study: design and rationale. Ann Epidemiol. 1991; 1(3):263–276. [PubMed: 1669507]
36. Friedman GD, Cutter GR, Donahue RP, et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. J Clin Epidemiol. 1988; 41(11):1105–1116. [PubMed: 3204420]
37. Govindaraju DR, Cupples LA, Kannel WB, et al. Genetics of the Framingham Heart Study population. Adv Genet. 2008; 62:33–65. [PubMed: 19010253]
38. Wilson PW, D'Agostino RB, Levy D, Belanger AM, Silbershatz H, Kannel WB. Prediction of coronary heart disease using risk factor categories. Circulation. 1998; 97(18):1837–1847. [PubMed: 9603539]
39. Assmann G, Cullen P, Schulte H. Simple scoring scheme for calculating the risk of acute coronary events based on the 10-year follow-up of the prospective cardiovascular Munster (PROCAM) study. Circulation. 2002; 105(3):310–315. [PubMed: 11804985]
40. Conroy RM, Pyorala K, Fitzgerald AP, et al. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J. 2003; 24(11):987–1003. [PubMed: 12788299]
41. Taylor F, Huffman MD, Macedo AF, et al. Statins for the primary prevention of cardiovascular disease. The Cochrane Database Syst Rev. 2013; 1 CD004816.
42. Pignone MP, Phillips CJ, Atkins D, Teutsch SM, Mulrow CD, Lohr KN. Screening and treating adults for lipid disorders. Am J Prev Med. 2001; 20(3 Suppl):77–89. [PubMed: 11306236]
43. Helfand M, Carson S. Screening for lipid disorders in adults: selective update of 2001 US Preventive Services Task Force Review. AHRQ Publication. 2008; 49
44. National Cholesterol Education Program Expert Panel on Detection Evaluation, and Treatment of High Blood Cholesterol in Adults. Third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation. 2002; 106(25):3143–3421. [PubMed: 12485966]
45. Stone NJ, Robinson J, Lichtenstein AH, et al. 2013 ACC/AHA Guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American

College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2013

46. Mihaylova B, Emberson J, Blackwell L, et al. The effects of lowering LDL cholesterol with statin therapy in people at low risk of vascular disease: meta-analysis of individual data from 27 randomised trials. Lancet. 2012; 380(9841):581–590. [PubMed: 22607822]
47. Taylor F, Ward K, Moore TH, et al. Statins for the primary prevention of cardiovascular disease. The Cochrane Database of Syst Rev. 2011; 1 CD004816.
48. Cooper A, O'Flynn N. Risk assessment and lipid modification for primary and secondary prevention of cardiovascular disease: summary of NICE guidance. BMJ. 2008; 336(7655):1246–1248. [PubMed: 18511800]
49. Abramson JD, Rosenberg HG, Jewell N, Wright JM. Should people at low risk of cardiovascular disease take a statin? BMJ. 2013; 347:f6123. [PubMed: 24149819]
50. Mosca L, Benjamin EJ, Berra K, et al. Effectiveness-based guidelines for the prevention of cardiovascular disease in women--2011 update: a guideline from the american heart association. Circulation. 2011; 123(11):1243–1262. [PubMed: 21325087]
51. Helfand M, Buckley D, Freeman M, et al. Emerging risk factors for coronary heart disease: a summary of systematic reviews conducted for the US Preventive Services Task Force. Ann Intern Med. 2009; 151:496–507. [PubMed: 19805772]
52. Helfand M, Buckley D, Fleming C, et al. Screening for intermediate risk factors for coronary heart disease: systematic evidence synthesis. AHRQ Publication. 2009; 73
53. Buckley DI, Fu R, Freeman M, Rogers K, Helfand M. C-reactive protein as a risk factor for coronary heart disease: a systematic review and meta-analyses for the US Preventive Services Task Force. Ann Intern Med. 2009; 151(7):483–495. [PubMed: 19805771]
54. Homocysteine Studies Collaboration. Homocysteine and risk of ischemic heart disease and stroke: a meta-analysis. JAMA. 2002; 288(16):2015–2022. [PubMed: 12387654]
55. Bonaa KH, Njolstad I, Ueland PM, et al. Homocysteine lowering and cardiovascular events after acute myocardial infarction. N Engl J Med. 2006; 354(15):1578–1588. [PubMed: 16531614]
56. Lonn E, Yusuf S, Arnold MJ, et al. Homocysteine lowering with folic acid and B vitamins in vascular disease. N Engl J Med. 2006; 354(15):1567–1577. [PubMed: 16531613]
57. Schnyder G, Roffi M, Flammer Y, Pin R, Hess OM. Effect of homocysteine-lowering therapy with folic acid, vitamin B12, and vitamin B6 on clinical outcome after percutaneous coronary intervention: the Swiss Heart study: a randomized controlled trial. JAMA. 2002; 288(8):973–979. [PubMed: 12190367]
58. Kavousi M, Elias-Smale S, Rutten JH, et al. Evaluation of newer risk markers for coronary heart disease risk classification: a cohort study. Ann Intern Med. 2012; 156(6):438–444. [PubMed: 22431676]
59. van Kempen BJ, Spronk S, Koller MT, et al. Comparative effectiveness and cost-effectiveness of computed tomography screening for coronary artery calcium in asymptomatic individuals. J Am Coll Cardiol. 2011; 58(16):1690–1701. [PubMed: 21982314]
60. Chou R, Arora B, Dana T, Fu R, Walker M, Humphrey L. Screening asymptomatic adults with resting or exercise electrocardiography: a review of the evidence for the US Preventive Services Task Force. Ann Intern Med. 2011; 155:375–385. [PubMed: 21930855]
61. Austin MA, Hutter CM, Zimmern RL, Humphries SE. Genetic causes of monogenic heterozygous familial hypercholesterolemia: a HuGE prevalence review. Am J Epidemiol. 2004; 160(5):407–420. [PubMed: 15321837]
62. Wonderling D, Umans-Eckenhausen MA, Marks D, Defesche JC, Kastelein JJ, Thorogood M. Cost-effectiveness analysis of the genetic screening program for familial hypercholesterolemia in The Netherlands. Semin Vasc Med. 2004; 4(1):97–104. [PubMed: 15199439]
63. Nherera L, Marks D, Minhas R, Thorogood M, Humphries SE. Probabilistic cost-effectiveness analysis of cascade screening for familial hypercholesterolaemia using alternative diagnostic and identification strategies. Heart. 2011; 97(14):1175–1181. [PubMed: 21685482]
64. United States Preventive Services Task Force. [Accessed October 21, 2013] US Preventive Services Task Force. 2013. Available at: http://www.uspreventiveservicestaskforce.org/

65. US Preventive Services Task Force. [Accessed May 23, 2013] US Preventive Services Task Force grade definitions. 2012. Available at: http://www.uspreventiveservicestaskforce.org/uspstf/grades.htm
66. Greenland P, Alpert JS, Beller GA, et al. 2010 ACCF/AHA guideline for assessment of cardiovascular risk in asymptomatic adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2010; 56(25):e50–103. [PubMed: 21144964]
67. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA. 2003; 289(19):2560–2572. [PubMed: 12748199]
68. [Accessed October 21, 2013] National Cholesterol Education Program- NHLBI, NIH. 2013. Available at: http://www.nhlbi.nih.gov/about/ncep/
69. Minhas R, Humphries SE, Qureshi N, Neil HA, Group NGD. Controversies in familial hypercholesterolaemia: recommendations of the NICE Guideline Development Group for the identification and management of familial hypercholesterolaemia. Heart. 2009; 95(7):584–587. discussion 587-591. [PubMed: 19168470]
70. US Preventive Services Task Force. [Accessed January 2, 2014] Screening for high blood pressure: US Preventive Services Task Force Reaffirmation Recommendation Statement. 2007. Available at: http://www.uspreventiveservicestaskforce.org/uspstf07/hbp/hbprs.htm
71. U.S Preventive Services Task Force. [Accessed May 23, 2013] Recommendations and rationale: screening for lipid disorders in adults. 2008. Available at: http://www.uspreventiveservicestaskforce.org/uspstf08/lipid/lipidrs.htm
72. US Preventive Services Task Force. Using nontraditional risk factors in coronary heart disease risk assessment: US Preventive Services Task Force recommendation statement. Ann Intern Med. 2009; 151:474–482. [PubMed: 19805770]
73. Lim LS, Haq N, Mahmood S, Hoeksema L. Atherosclerotic cardiovascular disease screening in adults: American College Of Preventive Medicine position statement on preventive practice. Am J Prev Med. 2011; 40(3):381, e381–310. [PubMed: 21335273]
74. US Preventive Services Task Force. Screening for abdominal aortic nneurysm: recommendation statement. Ann Intern Med. 2005; 142:198–202. [PubMed: 15684208]
75. US Preventive Services Task Force. [Accessed May 23, 2013] Screening for coronary heart disease: recommendation statement. 2004. Available at: http://www.uspreventiveservicestaskforce.org/3rduspstf/chd/chdrs.htm
76. McCall-Hosenfeld JS, Weisman CS, Camacho F, Hillemeier MM, Chuang CH. Multilevel analysis of the determinants of receipt of clinical preventive services among reproductive-age women. Womens Health Issues. 2012; 22(3):e243–251. [PubMed: 22269668]
77. Ma J, Stafford RS. Screening, treatment, and control of hypertension in US private physician offices, 2003-2004. Hypertension. 2008; 51(5):1275–1281. [PubMed: 18347229]
78. Solberg LI, Kottke TE, Brekke ML. Variation in clinical preventive services. Eff Clin Pract. 2001; 4(3):121–126. [PubMed: 11434075]
79. Bertoni AG, Bonds DE, Steffes S, et al. Quality of cholesterol screening and management with respect to the National Cholesterol Education's Third Adult Treatment Panel (ATPIII) guideline in primary care practices in North Carolina. Am Heart J. 2006; 152(4):785–792. [PubMed: 16996859]
80. Rifas-Shiman SL, Forman JP, Lane K, Caspard H, Gillman MW. Diabetes and lipid screening among patients in primary care: a cohort study. BMC Health Serv Res. 2008; 8:25. [PubMed: 18234107]
81. Barham AH, Goff DC Jr. Chen H, et al. Appropriateness of cholesterol management in primary care by sex and level of cardiovascular risk. Prev Cardiol. 2009; 12(2):95–101. [PubMed: 19476583]
82. Allison MA, Ho E, Denenberg JO, et al. Ethnic-specific prevalence of peripheral arterial disease in the United States. Am J Prev Med. 2007; 32(4):328–333. [PubMed: 17383564]

83. Rowe VL, Weaver FA, Lane JS, Etzioni DA. Racial and ethnic differences in patterns of treatment for acute peripheral arterial disease in the United States, 1998-2006. J Vasc Surg. 2010; 51(4 Suppl):21s–26s. [PubMed: 20080006]
84. Stewart SH, Silverstein MD. Racial and ethnic disparity in blood pressure and cholesterol measurement. J Gen Intern Med. 2002; 17(6):405–411. [PubMed: 12133153]
85. Vaidya V, Partha G, Howe J. Utilization of preventive care services and their effect on cardiovascular outcomes in the United States. Risk Manag Healthc Policy. 2011; 4:1–7. [PubMed: 22312222]
86. Nelson K, Norris K, Mangione CM. Disparities in the diagnosis and pharmacologic treatment of high serum cholesterol by race and ethnicity: data from the Third National Health and Nutrition Examination Survey. Arch Intern Med. 2002; 162(8):929–935. [PubMed: 11966345]
87. Ford ES, Li C, Pearson WS, Zhao G, Mokdad AH. Trends in hypercholesterolemia, treatment and control among United States adults. Int J Cardiol. 2010; 140(2):226–235. [PubMed: 19081646]
88. Ferrante JM, Balasubramanian BA, Hudson SV, Crabtree BF. Principles of the patient-centered medical home and preventive services delivery. Ann Fam Med. 2010; 8(2):108–116. [PubMed: 20212297]
89. Stafford RS, Misra B. Variation in routine electrocardiogram use in academic primary care practice. Arch Intern Med. 2001; 161(19):2351–2355. [PubMed: 11606151]
90. Rabinowitz I, Tamir A. The SaM (Screening and Monitoring) approach to cardiovascular risk-reduction in primary care--cyclic monitoring and individual treatment of patients at cardiovascular risk using the electronic medical record. Eur J Cardiovasc Prev Rehabil. 2005; 12(1):56–62. [PubMed: 15703507]
91. Linder JA, Ma J, Bates DW, Middleton B, Stafford RS. Electronic health record use and the quality of ambulatory care in the United States. Arch Intern Med. 2007; 167(13):1400–1405. [PubMed: 17620534]
92. Romano MJ, Stafford RS. Electronic health records and clinical decision support systems: impact on national ambulatory care quality. Arch Intern Med. 2011; 171(10):897–903. [PubMed: 21263077]
93. Hivert MF, Grant RW, Shrader P, Meigs JB. Identifying primary care patients at risk for future diabetes and cardiovascular disease using electronic health records. BMC Health Serv Res. 2009; 9:170. [PubMed: 19772639]
94. Walsh MN, Yancy CW, Albert NM, et al. Electronic health records and quality of care for heart failure. Am Heart J. 2010; 159(4):635–642. e631. [PubMed: 20362723]
95. Zhou L, Soran CS, Jenter CA, et al. The relationship between electronic health record use and quality of care over time. J Am Med Inform Assoc. 2009; 16(4):457–464. [PubMed: 19390094]
96. Kaiser Family Foundation. [Accessed August 7, 2013] Health reform implementation timeline. Health Reform. 2013. Available at: http://kff.org/interactive/implementation-timeline/2013
97. US Preventive Services Task Force. Affordable Care Act: A and B recommendations for preventive ervices. 2013. Available at: http://www.uspreventiveservicestaskforce.org/uspstf/uspsabrecs.htm
98. Berwick DM. Launching accountable care organizations--the proposed rule for the Medicare Shared Savings Program. N Engl J Med. 2011; 364(16):e32. [PubMed: 21452999]
99. Quality Measurement & Health Assessment Group Center for Medicare andMedicaid Services. [Accessed August 8, 2013] Quality performance standards narrative measure specifications. Accountable Care Organization 2013 Program Analysis. 2012. Available at: http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/ACO-NarrativeMeasures-Specs.pdf
100. American Academy of Family Physicians. Joint principles of the Patient-Centered Medical Home. Del Med J. 2008; 80(1):21–22. [PubMed: 18284087]
101. Krogsboll L, Jorgensen K, Gronhoj L, Gotzche P. General health checks in adults for reducing morbidity and mortality from disease (Review). The Cochrane Database Syst Rev. 2012:10.

Key Points in Screening for Cardiovascular Disease

- Assessment of risk factors (eg, age, smoking, hypertension, family history) is key in determining need for additional screening.
- Use of risk assessment tools–such as the Pooled Cohort Atherosclerotic Cardiovascular Disease (ASCVD) Risk Equations or Framingham in a United States population, or SCORE or PROCAM in a European population–improves estimation of individual risk; however, these tools do not perform as well in Latinos or Asian Americans.
- Guidelines recommend assessment of risk factors, including lipid levels, every 4 to 6 years in adults 20 to 79 years of age without evidence of ASCVD, including estimation of 10-year risk for ASCVD in those aged 40-79 years.
- Abdominal aortic ultrasound is recommended one-time in men aged 65 to 75 years who have ever smoked.
- There is insufficient evidence to recommend the use of lipoprotein(a), homocysteine, carotid intima-media thickness, or electrocardiography in a general risk, asymptomatic, adult population.
- If risk-based decisions are uncertain after quantitative risk assessment, some guidelines suggest that family history, high sensitivity c-reactive protein, or coronary artery calcium score may be considered to further inform decision-making.
- Cardiovascular disease results from a complex interplay of multiple genetic, environmental, and behavioral factors. Genetic screening is not recommended.

Outline

- Epidemiology and risk factors
- Global risk assessment tools
- Description of commonly employed screening methods
- Evidence for risk assessment and screening
- Cardiovascular Disease Prevention and Screening Recommendations
- Current practice patterns
- Impact of changes within health care
- Summary

Table 1

Commonly used externally validated risk prediction models[12]

Model	Outcome	Number of external evaluations	Source Population(s)	Online Tool
Pooled Cohort Equations[33]	Non-fatal MI, CHD death, fatal and non-fatal stroke		Atherosclerosis Risk in Communities Study - United States - Age 45-64 years - Men and women - Whites and African Americans[34] Cardiovascular Health Study - United States - Age 65 years and older - Men and women[35] Coronary Artery Risk Development in Young Adults Study - United States - Age 18-30 years - Men and women - White and African American[36] Framingham Heart Study - United States - Age 30-62 years - 55% female - Primarily white Framingham Offspring Study - United States - Age <10-70 years - 52% female - primarily white[37]	http://my.americanheart.org/professional/StatementsGuidelines/PreventionGuidelines/Prevention-Guidelines_UCM_457698_SubHomePage.jsp

Model	Outcome	Number of external evaluations	Source Population(s)	Online Tool
1991 Framing-ham Risk Score Model	CVD	26	Framingham Heart Study - United States - Age 30-62 years - 55% female - Primarily white Framingham Offspring Study - United States - Age <10-70 years - 52% female - primarily white[37]	
1998 Framing-ham Risk Score Model	Total CHD (ie, angina, MI, sudden CHD death, cardiac procedure)	24	Framingham Heart Study, Framingham Offspring Study [38] - United States - Age 30-74 years - 53% female - Primarily white[37]	http://reference.medscape.com/calculator/framingham-coronaryrisk-ldl
Framing-ham Risk Score Adult Treatment Panel III	Hard CHD (ie, sudden CHD death or MI)	16	Framingham Heart Study - United States - Age 30-62 years - 55% female - Primarily white Framingham Offspring Study - United States - Age <10-70 years - 52% female - Primarily white[37]	http://cvdrisk.nhlbi.nih.gov/calculator.asp

Model	Outcome	Number of external evaluations	Source Population(s)	Online Tool
			Excludes people with diabetes	
PROCAM	Hard CHD (ie, sudden CHD death or MI)	11	PROCAM [39] - Germany - Age 35-65 - White *excludes women*	http://www.chdtaskforce.de/procam_interactive.html
SCORE	CVD mortality	11	SCORE [40] - Finland, Russia, Norway, UK, Denmark, Sweden, Belgium, Germany, Italy, France, Spain - Age 19-80 - Pooled dataset from cohort studies in 12 European countries; Most of the cohorts were populationbased; Some occupational cohorts were included to increase representation from lower risk areas	Access from the European Society of Cardiology

CHD: coronary heart disease

CVD: cardiovascular disease

MI: myocardial infarction

PROCAM: Prospective Cardiovascular Münster

SCORE: Systematic Coronary Risk Evaluation

Table 2

Features of different lipid screening strategies for adults[43]

Test	Reliability	Accuracy	Patient Acceptability	Feasibility for Providers
Nonfasting TC	Intermediate	Lower	Higher	Higher
Nonfasting TC/HDL	Lower	Intermediate	Higher	Intermediate
LDL/HDL ratio requires fasting TC, HDL, triglicerides	Higher	Intermediate	Lower	Intermediate
Nonfasting TC + HDL and NCEP guidelines	Intermediate	Intermediate	Intermediate	Lower
Nonfasting TC + HDL with calculation of Framingham risk	Intermediate	Higher	Intermediate	Lower

TC: total cholesterol

HDL: high-density lipoproteins

LDL: low-density lipoproteins

NCEP: National Cholesterol Education Pane;

From: Helfand M, Carson S. Screening for lipid disorders in adults: selective update of 2001 US Preventive Services Task Force Review. *AHRQ Publication*. 2008;49.

Table 3

Summary of guidelines

Screening	United States Preventive Services Task Force Guideline (Evidence Grade)[a]	American College of Cardiology Foundation/American Heart Association Guideline (Evidence Grade)[b]	Other Guidelines
Global Risk Assessment		The race- and sex-specific Pooled Cohort Equations should be used in non-Hispanic African Americans and non-Hispanic Whites 40 to 79 years of age (B) Use of the sex-specific Pooled Cohort Equations for non-Hispanic Whites may be considered when estimating risk in patients from populations other than African Americans and non-Hispanic Whites (C) It is reasonable to assess traditional ASCVD risk factors (Age, sex, total and HDL-cholesterol, systolic blood pressure, use of antihypertensive therapy, diabetes, and current smoking) every 4 to 6 years in adults 20 to 79 years of age who are free from ASCVD (B) Assessing 30-year or lifetime ASCVD risk based on traditional risk factors may be considered in adults 20 to 59 years of age without ASCVD and who are not at high short-term risk (C)[33]	
Genetic Screening		Genotype testing for CHD risk assessment in asymptomatic adults is not recommended (B)[66]	National Institute for Health and Clinical Excellence: Recommends cascade screening with both cholesterol and DNA testing for the diagnosis of FH[69]
Blood Pressure	Recommends screening for high blood pressure in adults aged 18 and older (A)[70]	Blood pressure screening is not specifically addressed; however, blood pressure is included in the Pooled Cohort Equation recommended for estimating risk[33]	Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: Blood pressure screening is not specifically addressed[15]
Blood Tests			
Lipids	Strongly recommends FLP	Measurement of lipid parameters beyond a	National Cholesterol Education Program

Screening	United States Preventive Services Task Force Guideline (Evidence Grade)[a]	American College of Cardiology Foundation/American Heart Association Guideline (Evidence Grade)[b]	Other Guidelines
	screening men aged 35 and older for lipid disorders (A) Recommends FLP screening men aged 20 to 35 for lipid disorders if they have additional risks, such as smoking, HTN, or diabetes (B) Strongly recommends FLP screening women aged 45 and older (A) Recommends FLP screening women aged 20 to 45 for lipid disorders if they are at increased risk for coronary heart disease, such as smoking, HTN, or diabetes (B) No recommendation for or against routine screening for lipid disorders in men aged 20 to 35, or in women aged 20 and older who are not at increased risk for coronary heart disease (C)[71]	standard FLP (total cholesterol, HDL, LDL, triglycerides) are not recommended in asymptomatic adults (C)[66]	(NCEP) ATP-III: Recommends a complete FLP (total cholesterol, LDL, HDL, and triglycerides) as the preferred initial test, rather than screening for total cholesterol and HDL alone Recommends screening all adults age 20 years and older every 5 years, or more frequently with a borderline result[44]
High Sensitivity CRP	Current evidence is insufficient to the balance of benefits and harms of using nontraditional risk factors to screen asymptomatic men and women with no history of CHD to prevent CHD events (I)[72]	If, after quantitative risk assessment, a risk-based treatment decision is uncertain, assessment of high sensitivity CRP may be considered to inform treatment decision making (B)[33]	American College of Preventive Medicine (ACPM): Does not recommend routine screening of the general adult population using high sensitivity CRP[73] NCEP ATP-III: Does not recommend routine measurement of inflammatory markers for the purpose of modifying LDL-cholesterol goals in primary prevention.[44]
Homocysteine	Current evidence is insufficient to the balance of benefits and harms of using nontraditional risk factors to screen asymptomatic men and women with no history of CHD to prevent CHD events (I)[72]	Not addressed	NCEP ATP-III: Does not recommend routine measurement of homocysteine as part of risk assessment to modify LDL-cholesterol goals for primary prevention[44]
Imaging			

Screening	United States Preventive Services Task Force Guideline (Evidence Grade)[a]	American College of Cardiology Foundation/American Heart Association Guideline (Evidence Grade)[b]	Other Guidelines
CAC Score	Current evidence is insufficient to the balance of benefits and harms of using nontraditional risk factors to screen asymptomatic men and women with no history of CHD to prevent CHD events (I)[72]	If, after quantitative risk assessment, a risk-based treatment decision is uncertain, assessment of CAC score may be considered to inform treatment decision making (B)[33]	NCEP ATP-III: Does not recommend indiscriminate screening for CAC in asymptomatic persons, particularly in persons without multiple risk factors Measurement of CAC is an option for advanced risk assessment in appropriately selected persons[44] ACPM: Does not recommend routine screening of the general adult population using computed tomography scanning[73]
cIMT	Current evidence is insufficient to the balance of benefits and harms of using nontraditional risk factors to screen asymptomatic men and women with no history of CHD to prevent CHD events (I)[72]	cIMT is not recommended for routine measurement in clinical practice for risk assessment for first ASCVD event (B)[33]	ACPM: Does not recommend routine screening of the general adult population using cIMT[73]
Ultrasound of Abdominal Aorta	Recommends one-time screening for AAA by ultrasonography in men aged 65 to 75 years who have ever smoked (B) No recommendation for or against screening for AAA in men aged 65 to 75 years who have never smoked (C) Recommends against routine screening for AAA in women (D) [74]	Not addressed	ACPM: Recommends one-time AAA screening in men aged 65-75 years who have ever smoked Routine AAA screening in women is not recommended[73]
ECG			
Stress	Recommends against routine screening with exercise treadmill test in adults with low risk for CHD events (D)[75]	An exercise ECG may be considered for cardiovascular risk assessment in intermediate-risk asymptomatic adults (including sedentary adults considering starting a vigorous exercise program), predominantly when attention is paid to non-	ACPM: Does not recommend routine screening of the general adult population using exercise-stress testing [73]

Screening	United States Preventive Services Task Force Guideline (Evidence Grade)[a]	American College of Cardiology Foundation/American Heart Association Guideline (Evidence Grade)[b]	Other Guidelines
		ECG markers such as exercise capacity (B)[66]	
Resting	Insufficient evidence to recommend for or against routine ECG in adults at increased risk for CHD events (I)[75]	A resting ECG is reasonable for cardiovascular risk assessment in asymptomatic adults with HTN or diabetes (C) A resting ECG may be considered for cardiovascular risk assessment in asymptomatic adults without HTN or diabetes (C)[66]	ACPM: Does not recommend routine screening of the general adult population using ECG7[3]

[a] Strength of recommendation. Grade A: The USPSTF recommends the service. There is high certainty that the net benefit is substantial. Grade B: The USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial. Grade C: The USPSTF recommends selectively offering or providing this service to individual patients based on professional judgment and patient preferences. There is at least moderate certainty that the net benefit is small. Grade D: The USPSTF recommends against the service. There is moderate or high certainty that the service has no net benefit or that the harms outweigh the benefits. I: The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of the service. Evidence is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.[65]

[b] Evidence based on certainty of treatment effect. Level A: Multiple populations evaluated, data derived from multiple randomized clinical trials or meta-analyses. Level B: Limited populations evaluated, data derived from a single randomized trial or nonrandomized study. Level C: Very limited populations evaluated, only consensus opinion of experts, case studies, or standards of care.[66]

AAA: abdominal aortic aneurism; ASCVD: atherosclerotic cardiovascular disease; ATP-III: Adult Treatment Panel III; cIMT: carotid intima-media thickness; CAC: coronary artery calcium; CHD: coronary heart disease; CRP: c-reactive protein; FH: familial hypercholesterolemia; FLP: fasting lipid panel; HDL: high-density lipoproteins; HTN: hypertension; LDL: low-density lipoproteins