CDSSs FOR CVD RISK MANAGEMENT: AN INTEGRATIVE REVIEW

A Scholarly Project Proposal

Submitted to the

Faculty of Liberty University

In partial fulfillment of

The requirements for the degree

Of Doctor of Nursing Practice

By

Elisabeth Mary Campbell, BSN, RN

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Table of Contents

Abstract

Cardiovascular disease (CVD) is a preventable disease affecting almost half of adults in the United States (U.S.) and can have significant negative outcomes such as stroke and myocardial infarction, which can be fatal. Utilizing clinical decision support systems (CDSSs) in the primary care and community health setting can improve primary prevention of CVD by supporting evidence-based decision making at the point of care. This integrative review synthesizes the most up-to-date literature on the use of clinical decision support (CDS) tools to support guideline-based management of CVD risk. Using Whittemore and Knafl's framework for integrative reviews, a systematic search of CINAHL, Cochrane, and Medline and ancestry search yielded 492 results; 17 articles were included in the final review after applying inclusion and exclusion criteria. Evidence-based CDSSs for CVD prevention improved guideline-based initiation and intensification of pharmacological treatment, increased frequency and accuracy of CVD risk screening, and facilitated shared decision-making discussions with patients about CVD risk; however, they were not effective in promoting smoking cessation and only sometimes effective in improving blood pressure (BP) control. This integrative review supports future evidence-based practice projects implementing CDSSs designed to improve guideline-based primary prevention of CVD as an, albeit partial, solution to improving prevention of CVD in the U.S. and globally.

Keywords: Clinical decision support system, cardiovascular disease, prevention

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List of Tables and Figures

List of Abbreviations

ACC:	American College of Cardiology
AHA:	American Heart Association
ASCVD:	Atherosclerotic Cardiovascular Disease
BMI:	Body Mass Index
BPA:	Best Practice Alert
CDC:	Centers for Disease Control and Prevention
CDS:	Clinical Decision Support
CDSS:	Clinical Decision Support System
CITI:	Collaborative Institutional Training Initiative
CMS:	Centers for Medicare and Medicaid
CPG:	Clinical Practice Guideline
CPSTF:	Community Preventive Services Task Force
CVA:	Cerebral Vascular Accident
CVD:	Cardiovascular Disease
DBP:	Diastolic Blood Pressure
EHR:	Electronic Health Record
NASSS:	Non-Adoption, Abandonment, Scale-Up, Spread, and Sustainability
NCCDPHP:	National Center for Chronic Disease Prevention and Health Promotion
PCP:	Primary Care Provider
PICO:	Population Intervention Comparison Outcome
RCT:	Randomized Control Trial
SBP:	Systolic Blood Pressure
SimCard:	Simplified Cardiovascular Management
TeleHAS:	Tele-Hipertensão Arterial Sistêmica
TORPEDO:	Treatment of Cardiovascular Risk using Electronic Decision Support
U.S.:	United States

CDSSs for CVD Risk Management: An Integrative Review

Cardiovascular disease is a preventable, yet highly prevalent disease and is the leading cause of death worldwide (World Health Organization, 2020). In the U.S., atherosclerotic cardiovascular disease (ASCVD) affects 48.0% of adults ≥20 years old (Benjamin et al., 2019; Blackwell & Villarroel, 2018). Two potential consequences of ASCVD are cerebral vascular accidents and myocardial infarctions, which incur significant morbidity and mortality (Benjamin et al., 2019). Claiming more lives than cancer and chronic lung disease combined, CVD accounted for 360,000 deaths in the U.S. in 2016 alone (Benjamin et al., 2019).

Despite the availability of well-established clinical practice guidelines for the primary prevention of CVD, implementation of evidence-based guidelines remains low globally (Arnett et al., 2019; Bonner et al., 2019; Chalasani et al., 2017; Grundy et al., 2018; Tian et al., 2015). Evidence-based CDSSs targeted at managing CVD risk factors have been associated with decreased CVD risk, improved blood cholesterol control, and enhanced CVD management (Devarajan et al., 2016; Gill et al., 2019; Njie et al., 2015; O'Connor, 2018; Sperl-Hillen et al., 2018). Thus, guideline based CDSSs have the potential to improve primary prevention of CVD.

Formulating the Review Question

Though CVD is largely preventable, heart disease is still the leading cause of death in the U.S., and strokes are the fifth leading cause of mortality in the U.S. per the National Vital Statistics Reports (Kochanek, et al., 2019). Heart disease affects 28.2 million U.S. adults, and 795,000 people in the U.S. are estimated to have a stroke each year (Centers for Disease Control and Prevention [CDC], 2017a; CDC, 2017b). Stroke prevalence is projected to increase to 3.4 million U.S. adults by the year 2030 (Benjamin et al., 2019).

CPG Compliance

Though there are established guidelines for the primary prevention of CVD, implementation of these guidelines remains modest (Arnett et al., 2019; Bonner et al., 2019; Chalasani et al., 2017; Grundy et al., 2018; Pokharel et al., 2017; Tian et al., 2015). This may be due to time constraints placed on PCPs and the overwhelming volume of CPGs that are indicated for the management of patients with multiple comorbidities (Bucher et al., 2017; Yarnall et al., 2003). Depending on patient comorbidity burden, annual time required to provide recommended preventive services to a single patient can range from 9.7 to 26.4 minutes per year (Bucher et al., 2017). Another study estimated that 7.4 hours per workday would be required to provide all the preventive services recommended by the United States Preventive Services Task Force to a patient panel of 2,500 patients (Yarnall et al., 2003).

Increasing time pressures placed on providers in primary care can impede the implementation of some aspects of CVD primary prevention CPGs. For example, current American Heart Association (AHA)/American College of Cardiology (ACC) guidelines for CVD primary prevention and blood cholesterol management require 10-year ASCVD risk calculation in order to determine eligibility for statin therapy for patients without clinical CVD, but this risk assessment may only be done 20% of the time (Arnett et al., 2019; Goff et al., 2014; Grundy et al., 2018; Meschia et al., 2014; Sekaran et al., 2013). This is a significant practice gap in primary prevention since the ACC/AHA guidelines recommend estimating 10-year ASCVD risk for patients 40-79 years old every four to six years (ACC/AHA COR IIa, ACC/AHA LOE B) (Arnett et al., 2019; Goff et al., 2014; Grundy et al., 2018; Meschia et al., 2014).

Another study found that 80% of surveyed providers believe that coronary heart disease risk assessment is useful, but only 41% of providers reported using coronary heart disease risk assessments in practice, which means 59% were not performing this risk assessment essential to identifying patients at high CVD risk (Shillinglaw et al., 2012). The time-consuming nature of CVD risk calculation and the fact that it is not part of a streamlined workflow have been cited as barriers to completing these risk assessments and discussing lifestyle modification in practice; however, automating risk calculations using a CDSS is one way to overcome these barriers and improve adherence to CPGs (Foraker et al., 2016; North et al., 2016; Shillinglaw et al., 2012).

Attitudinal factors can impact the implementation of CPGs in practice. For instance, provider attitudes toward CPG recommendations for statin therapy vary across the spectrum from acceptance to hesitancy and may be influenced by negative media coverage (Abimbola et al., 2019; Housholder-Hughes et al., 2017; Setia et al., 2015). Even in some cardiology practices, adoption of the 2013 AHA/ACC Cholesterol Management Guidelines was found to be modest at best (Pokharel et al., 2017). One survey of providers found that the majority agreed with the recommendations of the 2013 AHA/ACC Adult Cholesterol Guideline, yet only 67% of patients with established coronary artery disease were receiving appropriate high-intensity statin therapy for secondary prevention (Housholder-Hughes et al., 2017). In a different study, 68% of patients with high CVD risk were not prescribed statins even though these are recommended by CPGs (Hennessy et al., 2016). This highlights the discrepancy that can sometimes exist between intention to treat and prescriptions for statin-eligible patients (Housholder-Hughes et al., 2017)

Low implementation of CPGs has resulted in practice gaps in primary and secondary prevention of CVD (Hennessy et al., 2016; Housholder-Hughes et al., 2017; Sekaran et al., 2013; Shillinglaw et al., 2012). This highlights the need to develop timesaving, evidence-based strategies to close practice gaps related to guideline-based primary CVD prevention and support clinician decision making at the point of care. One of the key outcomes this integrative review examines is how CDSSs can close the gap between intention to treat and actual prescriptions for preventive medications like antihypertensives and statins.

Meaningful Use

Given the burden of CVD in the U.S. population, the Million Hearts initiative was established by United States Department of Health and Human Services to promote compliance with evidence-based CPGs aimed at improving primary and secondary prevention of CVD through the focus on Aspirin when appropriate, BP control, cholesterol management, and smoking cessation (Million Hearts, n.d.-a). This initiative partnered with Centers for Medicare and Medicaid to align meaningful use criteria with these objectives; cholesterol management, for example, is addressed in the CMS Quality Payment Program under quality ID 438 (CMS, 2018; Million Hearts, n.d.-b). Thus, implementing CDSSs aimed at improving guideline-based primary prevention of CVD has the potential to increase reimbursement as a meaningful use of health information technology by increasing the proportion of patients receiving appropriate statin therapy per CPG recommendations (CMS, 2018; Foraker et al., 2016; Grundy et al., 2018). For example, integrating the AHA-ASCVD Risk Estimator paired with a CDS tool into the EMR at Mayo Clinic increased the accuracy of provider ASCVD 10-year risk calculations and selection of guideline-based treatments from 60.61% to 100% (Scheitel et al., 2017).

CDSS

Clinical decision support systems provide pertinent information to aid provider decision making and are frequently built to fit into the provider workflow (Agency for Healthcare Research and Quality, 2019; Hopkins & Community Preventive Services Task Force [CPSTF], 2015; Njie et al., 2015). Examples of CDSSs include order sets and best practice alerts (BPAs) about dangerous situations or recommended preventative health interventions (Agency for

Healthcare Research and Quality, 2019). Many CDSSs designed to support primary prevention of CVD do not require the provider to query the system but are instead "'system-initiated'" and provide recommendations automatically (Hopkins & CPSTF, 2015, p. 797; Njie et al., 2015). Examples of CDSSs for CVD prevention include automatically calculated CVD risk estimates, alerts when CVD risk factors are uncontrolled or when labs are missing, evidence-based recommendations for treatment initiation or intensification, and reminders to educate patients about lifestyle modification (e.g. smoking cessation, exercise, and sodium intake moderation) (Hopkins & CPSTF, 2015). A systematic review by Njie et al. (2015) found the most successful CDSSs for CVD prevention were locally developed and tailored to meet practice needs.

Clinical decision support systems are typically computer-based tools which analyze data within the electronic health record (EHR) and can generate evidence-based alerts to remind providers to implement CPG recommendations regarding cardiovascular health (National Center for Chronic Disease Prevention and Health Promotion [NCCDPHP], 2018). The third domain of NCCDPHP's (2020) *Best Practices for Cardiovascular Disease Prevention Programs* is health care system level interventions. Because guideline-based CDSS tools are health system-level interventions, CDSS tools that support PCP evidence-based decision making for CVD prevention align with the third domain in NCCDPHP's (2020) approach to chronic disease prevention.

Rationale for Conducting the Review

A systematic review by Njie et al. (2015) is the most recent review this writer was able to locate on this topic; Njie et al.'s (2015) review used a sample of articles published between 1975 and 2011. Since health information technology is continuously evolving, this integrative review is needed to synthesize the most up-to-date evidence using peer-reviewed articles published in the last five years. This integrative review will answer the population intervention comparison outcome (PICO) question: How do CDSS tools support primary prevention of CVD in primary care? This integrative review's results will help guide future evidence-base practice initiatives.

This integrative review synthesizes the extant literature on the use of CDSSs in the primary care setting for primary prevention of CVD. Enhancing CVD primary prevention is significant as both stroke and myocardial infarction can cause considerable morbidity and mortality (Benjamin et al., 2019). Actions targeted at improving modifiable risk factor management through implementation of CDS tools in primary care can, therefore, improve population health by preventing CVD and CVD events. Thus, this integrative review aims to evaluate how CDSS tools support primary prevention of CVD in primary care.

Review Questions

This integrative review seeks to answer the following PICO question:

How do CDSS tools support primary prevention of CVD in primary care?

Questions to help guide and focus this integrative review include:

1. How do CDSS tools affect adherence to CPGs for primary prevention of CVD?
2. How do CDSS tools impact CVD risk factors such as hypertension and smoking?
3. What design features are preferred by clinicians and improve satisfaction with CDSS tools?

Formulation of Inclusion and Exclusion Criteria

Separate inclusion and exclusion criteria were used for the database-assisted and ancestry searches. Table one represents inclusion and exclusion criteria applied to the articles obtained in the database search. The inclusion and exclusion criteria for the ancestry search are the same except with a narrower date range (one year vs. five-year date range).

Table 1

Database Search Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Original quantitative or qualitative research studies, systematic reviews, or theoretical literature or framework	Published before January 1, 2015
Examines the use of CDSSs in the primary care setting to support provider decision making regarding primary prevention of CVD	Not available in full text
Published in a peer-reviewed journal in English	The study/clinical trial is ongoing, and no results are reported

Note: These inclusion and exclusion criteria apply to the database and hand searches.

This writer completed an ancestry search, also known as reference search, by examining the titles of sources cited in the reference lists of articles included in the final sample obtained using the above database search (Toronto & Remington, 2020; Whittemore & Knafl, 2005). Articles in the ancestry search were included if they met the following criteria: 1) original quantitative or qualitative research studies, systematic reviews, or theoretical literature or framework, 2) examines the use of CDSSs in the primary care setting to support provider decision making regarding primary prevention of CVD, and 3) published 01/01/2019-05/01/2020. Articles were excluded if not available in full-text and in English.

Methods

Conceptual Framework

Whittemore and Knafl's (2005) model guided the data collection and literature synthesis of this integrative review. This model builds on the integrative review framework pioneered by Cooper (1998) and is made up of four stages: 1) problem identification, 2) literature search, 3) data evaluation, and 4) data analysis. Built upon the foundation laid by Cooper's (1998) framework, the Whittemore and Knafl (2005) model further delineates methods for data analysis into four steps: 1) data reduction, 2) data display, 3) data comparison, and 4) conclusion drawing and verification.

Problem Identification Stage

As described above, providers who deliver primary care to adult patients at high risk for CVD are faced with increasing pressures caused by the sheer volume of guideline-based recommendations indicated for patients with multiple comorbidities (Bucher et al., 2017; Yarnall et al., 2003). This is further complicated by high overhead and shrinking margins in a pay-for-performance reimbursement system which cause providers to allot shorter time slots for annual and periodic disease management visits in order to increase patient volume and meet the demands of practice quotas. As the central touchpoint for patient care coordination, the PCP plays a vital role in disease management but also primary prevention of conditions such as CVD. Thus, supporting CVD primary prevention in primary care is vital to decreasing the burden of disease in the U.S. and globally.

Currently, implementation of CPGs for primary and secondary prevention of CVD remains suboptimal (Hennessy et al., 2016; Shillinglaw et al., 2012). Thus, there is an opportunity for improvement, which may be accomplished through the application of healthcare information technology (Scheitel et al., 2017). Evidence-based CDSSs may be able to improve adherence to CPGs for CVD primary prevention, CVD risk factors, and clinician satisfaction with the process of applying CVD primary prevention CPGs in practice.

Literature Search Stage

Following the Whittemore and Knafl (2005) framework, this writer assembled and vetted relevant empirical and theoretical literature related to CDSSs used to support primary prevention of CVD in primary care and community health settings. This DNP systematically searched the literature using a combination of computer-assisted database and ancestry searches as recommended by Whittemore and Knafl (2005). Multiple methods were chosen for the literature search since database searches may only yield ~50% of relevant articles; thus, broadening this search helped maximize the inclusion of applicable primary sources for this integrated review (Whittemore & Knafl, 2005). Using robust methods for article selection helped minimize bias and allow for greater confidence in the results and conclusions. Using robust literature searching methods helped strengthen the evidence regarding implementation of CDSS tools for primary prevention of CVD in primary care and community health settings.

Data Evaluation Stage

Systematically evaluating article quality is vital to weighing the strength of the evidence (Whittemore & Knafl, 2005). This integrative review included empirical research with diverse methodologies and settings as well as theoretical literature. This DNP student evaluated the quality of the included articles using Melnyk's (2016) levels of evidence and the SIGN tools which provide critical appraisal notes and checklists for various research methodologies (Healthcare Improvement Scotland, n.d.). These tools were used to evaluate each article individually and identify strengths and limitations, which are summarized in the results section.

Data Analysis Stage

Whittemore and Knafl's (2005) model "requires that the data from primary sources are ordered, coded, categorized, and summarized into a unified and integrated conclusion about the research problem" (p. 550). In the Whittemore and Knafl (2005) model for integrative reviews, the four steps of data analysis are data reduction, data display, data comparison, and conclusion drawing and verification. Following the Whittemore and Knafl (2005) framework for integrative reviews, this writer extracted the data from primary sources and organized them into their respective categories. She then displayed data in matrices created in Microsoft Excel® and compared the extracted data to identify patterns and themes. After drawing conclusions, this DNP student verified that these conclusions aligned with original articles by comparing them to the primary sources.

Data Reduction. Data from each article was extracted using the Whittemore and Knafl (2005) model and organized into three outcome categories: 1) adherence to clinical practice guidelines for primary prevention of CVD, 2) impact on BP and smoking cessation, 3) clinician satisfaction with and preferences for CDSS design and implementation. The evidence for each of these outcome categories were subclassified based on type of research and level of evidence (Whittemore & Knafl, 2005). Thus, this writer used Melnyk's (2016) levels of evidence to evaluate the quality of primary sources and organize data in matrices (Whittemore & Knafl, 2005).

Data Display. This writer used MS Excel® to manage citations and organize the data extracted from primary sources into matrices to facilitate data analysis (Whittemore & Knafl, 2005). Data extracted from primary sources were assembled into an article matrix and organized by level of evidence (Whittemore & Knafl, 2005). Using this matrix allowed detailed representation of the data and eased the process of interpretation (Whittemore & Knafl, 2005).

Data Comparison. Relationships between variables were identified and displayed using handwritten notes. This allowed the DNP student to identify themes among the data and draw comparisons (Whittemore & Knafl, 2005). Visualizing the data allowed the writer to recognize patterns during the data analysis process (Whittemore & Knafl, 2005).

Conclusion Drawing and Verification. In the final step of data analysis, this writer subsumed particulars from individual sources into the general, describing patterns identified in the above steps and summarizing themes at a higher level of abstraction (Whittemore & Knafl, 2005). The summary of patterns and themes was compared to the primary sources from which they were extracted to verify accuracy (Whittemore & Knafl, 2005). Verifying the accuracy of conclusions also involved identifying conflicts between primary sources and possible confounding factors that may be contributing to the conflict (Whittemore & Knafl, 2005). After resolving conflicts where possible, the writer described the results in a broad summary of findings (Whittemore & Knafl, 2005).

Presentation Stage

In the final stage of the Whittemore and Knafl (2005) model, the results of an integrated review are presented and disseminated. Key findings of this integrative review are summarized in a table at the end of this manuscript; see Appendix A. This writer may submit an abbreviated description of this integrated review to the Sigma Theta Tau Publication: *WORLDViews on Evidence-Base Nursing*.

Comprehensive and Systematic Search

Search Strategy, Terminology, and Study Selection

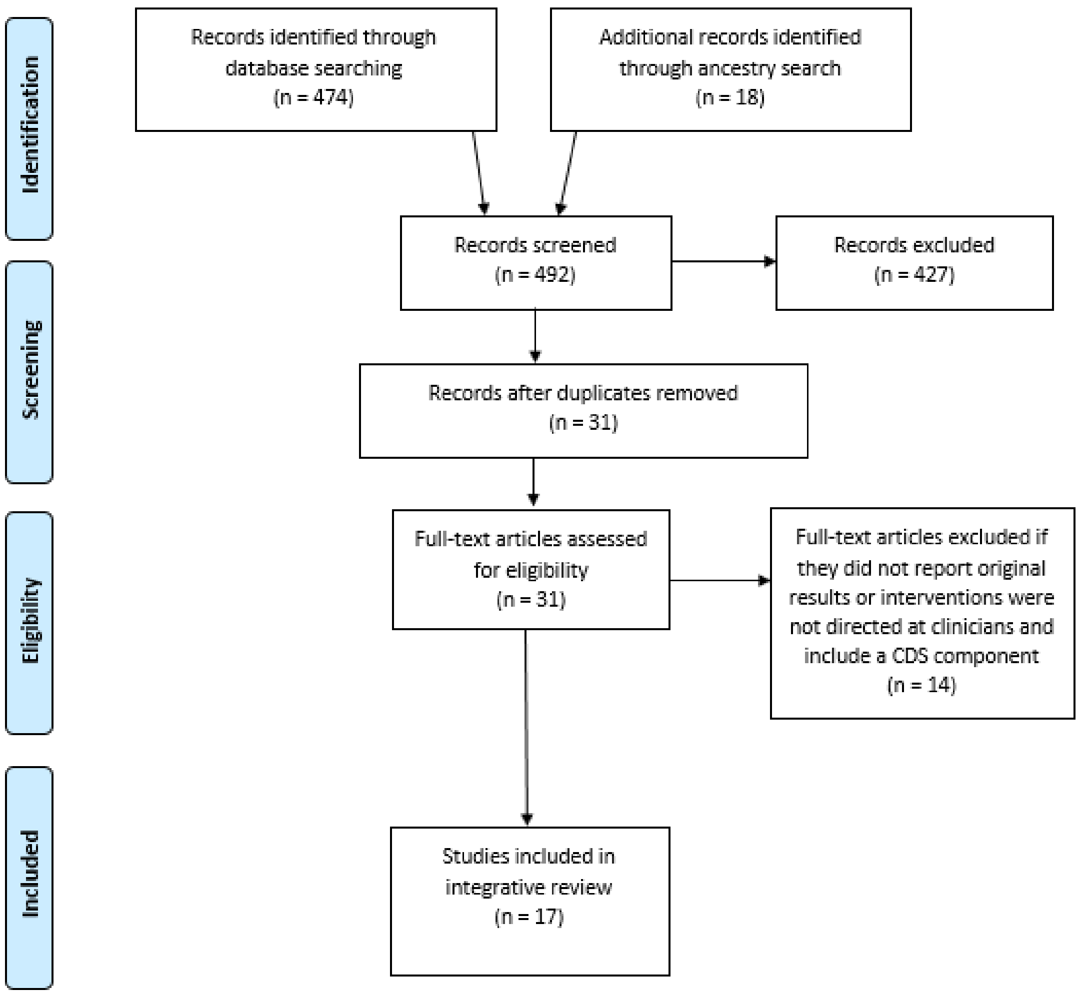
A systematic search of the literature was completed by this researcher May 25, 2020 through July 10, 2020 using computer-assisted searches of CINAHL, Cochrane, and Medline with Full Text using the search terms: (clinical decision support OR CDSS OR CDS OR informatics) AND (card* disease OR atherosclerotic cardiovascular disease OR ASCVD OR

CVD) AND (primary) AND (prevent*) and an ancestry search of included articles. A university librarian specializing in nursing research topics was consulted and confirmed that the search terms were appropriate and comprehensive. Articles in the data-based assisted search were selected based on the inclusion and exclusion criteria listed in Table 1; ancestry and database search inclusion and exclusion criteria are described above.

The database search generated 474 results and the ancestry search 18 results. This writer reviewed titles and abstracts of 492 articles for relevance and excluded 427 articles based on the inclusion and exclusion criteria listed previously. After eliminating 12 duplicates, 31 articles were evaluated through in-depth evaluation of contents and aims; articles were excluded if they did not report original results or did not evaluate CDSSs targeted at providers. Fourteen articles were excluded after this evaluation, which left 17 articles in the final integrative review sample. See the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Flowchart in Figure 1 for article selection.

Figure 1

Literature Search Flow Diagram



Note: Adapted from Moher et al. (2009).

Quality Appraisal

Sources of Bias

Publication bias and selective reporting are two potential sources of bias that may have affected the articles included in this integrative review as researchers tend to be more motivated to publish successful outcomes than negative ones (Toronto & Remington, 2020). A common limitation of these studies was lack of random sampling methods (Bonner et al., 2019; Chaudhry et al., 2019; DeJonckheere et al., 2018; Patel et al., 2019; Raghu et al., 2015; Williams et al., 2016; Ye et al., 2018). Many studies used a sample size with less than 100 participants (Bonner et al., 2019; Chaudhry et al., 2019; DeJonckheere et al., 2018; Raghu et al., 2015; Silveira et al., 2019; Williams et al., 2016; Ye et al., 2018). Nevertheless, several of these studies used large sample sizes with 1,000-38,725 participants (Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Sperl-Hillen et al., 2018; Tian et al., 2015).

Appraisal Tools

Melnyk (2016) levels of evidence was used to differentiate types of research. The SIGN checklist was used to critique each randomized control trial (RCT) for its strengths and weaknesses and methodological integrity; unfortunately, SIGN checklists were not available for other types of evidence included in this review: quasi-experimental, mixed methods, and qualitative research (Healthcare Improvement Scotland, n.d.). To promote the internal validity of this review, this writer evaluated each study for limitations and methodological flaws; see Appendix A (Toronto & Remington, 2020). Overall, the quality of the 17 included articles was good, and the five RCTs included in this review were evaluated to be high quality using the SIGN checklists.

Data Analysis Synthesis

Data Analysis Methods

Data from each study was analyzed and categorized into broad categories based on the three outcomes of interest and then subcategorized based on themes identified in the literature. Results in each outcome category were analyzed and compared in order to identify patterns and themes. Conclusions were verified by comparing results to primary sources. This data analysis process aligns with the Whitmore and Knafl (2005) methodology.

Descriptive Results

This literature search focused on how CDSS tools support primary prevention of CVD in the primary care setting. Of the 17 studies included in the final review, five were RCTs (Level II Evidence) (Chalasani et al., 2017; Peiris et al., 2015, 2019; Sperl-Hillen et al., 2018; Tian et al., 2015). Four of the included studies were quasi-experimental (Level III Evidence) (Alameddine et al., 2020; Patel et al., 2019; Persell et al., 2020; Ye et al., 2018). One was a cohort study (Level IV evidence) (Bonner et al., 2019). Three were descriptive studies (Level VI Evidence) (Raghu et al., 2015; Silveira et al, 2019; Williams et al., 2016). Three qualitative studies were also included (Level VI Evidence) (Abimbola et al., 2019; Chaudhry et al., 2019; DeJonckheere et al., 2018). Lastly, one described the development of a framework and was included because it qualified as theoretical literature (Level VII Evidence) (Benson, 2019). A detailed summary of these articles is provided in Appendix A.

Articles included in this integrative review were up-to-date and representative of CDSSs implementation efforts in low-, middle-, and high-income countries. Articles included in this review showed how CDSSs can be implemented in diverse settings with variations in availability of resources. Resource-limited settings were more likely to implement mobile-based CDSSs on a tablet or smart phone device; some, but not all, of these apps interfaced with a server connecting patient data to an EHR system (Patel et al., 2019; Peiris et al., 2019; Raghu et al., 2015; Silveira et al., 2019; Tian et a., 2015). In these resource-poor settings, Wi-Fi and EHRs were not always available, so researchers leveraged the wide dissemination of smart devices in these regions to promote cardiovascular health (Patel et al., 2019; Peiris et al., 2019; Raghu et al., 2015; Silveira et al., 2019; Tian et a., 2015).

Of the 17 included articles, six were set in the United States, four in Australia, two in rural India, one in China and India, one in Indonesia, one in Brazil, one in Lebanon, and one in the United Kingdom. Most articles included in the final sample were published recently with 70% (12/17) published in the last two and a half years (2018 to present) (Abimbola et al., 2019; Alameddine et al., 2020; Benson, 2019; Bonner et al., 2019; Chaudhry et al., 2019; DeJonckheere et al., 2018; Patel et al., 2019; Persell et al., 2020; Peiris et al., 2019; Silveira et al, 2019; Sperl-Hillen et al., 2018; Ye et al., 2018). Thus, included studies provided the most up-to-date evidence and included data collected from multiple countries around the world.

Synthesis

After analyzing the results reported in the literature included in this integrative review, the first outcome category, adherence to CPGs, was broken down into three outcome subcategories: CVD risk screening, appropriate CVD prevention prescriptions, and CVD risk discussions with patients. The second outcome for this integrative review, patient outcomes, was subcategorized into the following patient parameters: BP and smoking cessation. Finally, the third outcome included factors that impacted provider satisfaction and provider preferences for CDSS design and implementation. Results are discussed below subcategorized by outcome and in descending order of level of evidence based on Melnyk's (2016) pyramid.

Adherence to CPGs

Implementation of evidence-based CDSSs for prevention and management of CVD in primary healthcare and community healthcare settings led to statistically and clinically significant increases in the frequency and accuracy of CVD risk screenings in the majority of included studies (Bonner et al., 2019; Chalasani et al., 2017; Peiris et al., 2015; Sperl-Hillen et al., 2018). Impact of evidence-based CDSSs on prescriptions for appropriate preventative therapy was mostly positive with clinical but not always statistical significance (Alameddine et al., 2020; Abimbola et al., 2019; Bonner et al., 2019; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Persell et al., 2020; Tian et al., 2015). Thus, evidence-based CDSSs can help support adherence to CPGs when they are carefully aligned with guideline recommendations.

CVD Risk Screening. In most included studies, implementation of a CDSS for CVD prevention and management led to statistically and clinically significant increases in CVD risk screening completed in primary care and community health settings (Bonner et al., 2019; Chalasani et al., 2017; Peiris et al., 2015; Sperl-Hillen et al., 2018). In the Treatment of Cardiovascular Risk using Electronic Decision Support (TORPEDO) study involving 60 Australian primary healthcare clinics (n=38,725 patients), implementation of CDSS and audit and feedback tools led to statistically and clinically significant improvements in CVD risk screening; 62.8% of patients randomized to intervention clinics were screened for CVD risk factors compared to 53.4% in the usual care group (p=0.02) (Chalasani et al., 2017; Peiris et al., 2015). This represents a statistically significant difference of 9.4% (p=0.02) (Level II Evidence) (Chalasani et al., 2017; Peiris et al., 2015).

In the TORPEDO study, the intervention group had a statistically significant higher recording of high-density lipoproteins (HDL) and total cholesterol in the last 24 months in the EHR, 75.5% vs. 66.5% (p=0.02) (Peiris et al., 2015). While the percentage of patients having a systolic BP (SBP) recorded in the previous 12 months was higher in the intervention group, the difference was not statistically significant, 84.8% vs. 80.6%, p=0.09 (Peiris et al., 2015). In contrast, there was neither a clinically or statistically significant difference in the recording of smoking status, BMI, albuminuria, and estimated glomerular filtration rate between intervention and usual care arms of this study (Peiris et al., 2015). While the CDSS significantly improved appropriate screening for CVD risk factors (62.8 vs 53.4%, p=0.02), this was mainly driven by increased recording of SBP and cholesterol levels (Level II Evidence) (Peiris et al., 2015).

Another RCT by Sperl-Hillen et al. (2018) involving 20 U.S. primary care clinics (n=7,914 patients) randomized intervention clinics to have access to an EHR-integrated, web-based CDSS that was co-designed with input from PCPs and nurse leaders to match clinic workflow (Sperl-Hillen et al., 2018). This CDSS provided personalized and prioritized recommendations targeted at patients and providers (Sperl-Hillen et al., 2018). During the "vanguard" phase of this study, rooming nurses were responsible for triggering the CDSS printout; in this phase, rooming staff only triggered the CDSS for 20% of study eligible, high CVD risk patients (Sperl-Hillen et al., 2018, p. 1140).

In the second phase, the CDS BPA automatically fired and then required only two clicks for rooming staff to print the lay and professional versions of the CDS tool (Sperl-Hillen et al., 2018). The lay version was given to the patient with instructions to discuss with their provider, and a more detailed version was given to providers with specific recommendations based on patient's calculated CVD risk and clinical data (Sperl-Hillen et al., 2018). At the 18-month follow-up, 73% of providers in the CDS arm reported they often use calculated CVD risk while seeing patients compared to 25% in the usual care group (p=0.006) (Sperl-Hillen et al., 2018). This represents a statistically and clinically significant difference of 48% (p=0.006) (Level II Evidence) (Sperl-Hillen et al., 2018). A potential explanation for magnitude of the improvement in CVD screening observed in the Sperl-Hillen et al. (2018) RCT may be related to the fact that it engaged several levels of the healthcare team—the nurse, provider, and patient—whereas the intervention in the TORPEDO trial by Peiris et al. (2015) was aimed chiefly at the provider.

A mixed methods study used in resource-limited primary care clinics in Brazil evaluated the feasibility, utility, and usability of a mobile-based CDSS for the management of hypertension (Silveira et al., 2019). In contrast to the more successful studies mentioned above, in this pilot study only three out of 10 providers who piloted the CDSS used the tool to calculate cardiovascular risk using the 10-year global risk score chart (Silveira et al., 2019). Nevertheless, the TeleHAS (tele-hipertensão arterial sistêmica which translates to arterial hypertension) tool had other functions that supported hypertension management and was used with 535 patients in a total of 632 patient encounters (Silveira et al., 2019). Physician surveys indicated that this tool caused delays in care due to the work duplication it required and would have been more helpful if it could have been auto populated with patient data (Level VI Evidence) (Silveira et al., 2019). This was not possible due to the lack of EHRs and Wi-Fi in these clinics (Silveira et al., 2019).

In a cohort study by Bonner et al. (2019), a web-based CDS with a built-in CVD risk calculator was linked to an existing audit and feedback tool to support provider implementation of Australian CVD prevention guidelines and facilitate provider-patient CVD risk discussions. Bonner et al. (2019) used a five-stage, iterative process informed by the Behaviour Change Wheel framework to develop a web-based tool integrating the Framingham 5-year CVD risk calculator with an audit and feedback and guideline-based decision aid. After providers trialed the final product in the fifth phase of the study, providers' ability to accurately identify patients at high CVD risk significantly increased compared to baseline without the use of the CDS (Bonner et al., 2019). Correct identification of low risk patients increased by 16% (95% confidence interval 0-32%), moderate risk patients by 32% (95% confidence interval 6-57%), and high-risk patients by 50% (95% confidence interval 35-65%) (Level IV Evidence) (Bonner et al., 2019). As patients at high CVD risk are the most likely to benefit from primary prevention medications, it is significant that the magnitude of improvement from baseline was highest in identifying patients at highest risk, 50% improvement compared to 16% and 32% improvements in in the low- and moderate-risk patient categories, respectively (Bonner et al., 2019).

While the accuracy of screening increased in this pilot, there was no increase in self-reported use of CVD risk calculators by providers post-intervention (Bonner et al., 2019). This may be because there was a relatively high proportion of providers (95%) who reported using other absolute CVD risk calculators at baseline (Bonner et al., 2019). However, this CDSS used a risk calculator and decision support functions uniquely designed to support implementation of Australian guidelines, a function not provided by other available tools (Bonner et al., 2019).

Pharmacological Prevention. In the TORPEDO RCT, 60 Australian primary healthcare clinics were cluster randomized to receive either usual care or a combination of quality improvement interventions (Chalasani et al., 2017; Peiris et al., 2015). Baseline data was collected for 53,164 patients and follow-up data extracted for 38,725 patients (Chalasani et al., 2017; Peiris et al., 2015). Practices in the intervention group had access to a guideline-based screening and algorithm for management of CVD, chronic kidney disease, BP, and cholesterol through a CDSS that pulled patient data from within the EHR to prepopulate the tool and generate point-of-care recommendations based on patient's absolute CVD risk as well as a software to generate site-specific audits and performance feedback for providers (Chalasani et al., 2017; Peiris et al., 2015).

These quality improvement interventions led to clinically but not always statistically significant differences in appropriate prescriptions in the intervention group compared to usual care (Chalasani et al., 2017). There was only a 5.6% net increase in appropriate prescriptions for high CVD risk patients in the intervention group compared to usual care (56.8% vs. 51.2%, p=0.09) (Peiris et al., 2015). Compared to usual care, the intervention improved escalation of antiplatelet and lipid-lowering therapy by 15.4% and 16.5% (p=<0.001), respectively (Peiris et al., 2015).

Clinically significant improvements were observed in appropriate prescriptions for antihypertensives and combination therapy (at least 1 antihypertensive + statin for high CVD risk patients and at least 1 antihypertensive, a statin, and antiplatelet medication for patients with CVD diagnosis), but they were not statistically significant (Peiris et al., 2015). When compared with baseline levels for each group, there was no statistically significant increase in the prescription of appropriate medications for patients at high risk of CVD (Peiris et al., 2015). There were, however, statistically significant increases in individual medication intensification (Peiris et al., 2015).

A different RCT by Peiris et al. (2019) implemented the SMARTHealth India Android app (available in Telugu and English) used by community health workers in 18 rural, resource-limited Indian villages using a stepped-wedge approach. The app incorporates 10-year CVD risk assessment and lifestyle modification education that were executed by community health workers as well as a version with pharmacological decision support for physicians (Peiris et al., 2019). Seventy percent of patients identified by community health workers as high risk for CVD received physician follow-up, and, at follow up, there was a significant improvement in patients reporting taking antihypertensives, from 47.9% in the control to 54.3% in the intervention group (p=0.02) (Level II Evidence) (Peiris et al., 2019).

Increases in prescriptions of antihypertensive and aspirin medications were seen in a similar cluster RCT using a mobile-based CDS in villages in Tibet, China and Haryana, India called the Simplified Cardiovascular Management (SimCard) study (Level II Evidence) (Tian et al., 2015). In China, the CDS tool was used by non-physician "village doctors" who had basic medical training and prescriptive authority and by volunteer community health workers in India who did not have prescriptive authority but were able to send recommendations to physicians for prescriptions (Tian et al., 2015, p. 816). There were increases in anti-hypertensive medication prescriptions in both the intervention and control groups in both China and India with a net differences between intervention and control groups which were statistically significant for both countries: 24.4% in China (p=<0.001) and 26.6% in India (p=0.02) (Tian et al., 2015). Finally, improvements were seen in patient-reported aspirin use in the last month with a net increase of 24.5% in Chinese intervention group (p=<0.001) and 9.8% net increase in Indian intervention group (p=0.003) (Tian et al., 2015).

Another mobile-based CDSS was used by community health workers (*kaders*) in four intervention villages in rural Indonesia and compared to usual care in four control villages in a quasi-experimental study by Patel et al. (2019). High CVD risk patients were referred for either nurse or physician follow-up (Patel et al., 2019). At follow-up, 15.5% of patients identified by researchers as high risk for CVD in the intervention villages were receiving appropriate preventive treatment compared to 1.0% in the control villages (p=<0.001), 56.8% were receiving antihypertensives compared to 15.7% in the control group (p=<0.001), 19.9% were receiving lipid-lowering medications vs. 2.4% in the control (p=<0.001), and 24.6% of patients with established CVD were receiving antiplatelet medications vs. 12.7% in the control (p=0.06) (Level III Evidence) (Patel et al., 2019).

A quasi-experimental study in Lebanon by Alameddine et al. (2020) used a phased approach to evaluate effects of different ways of displaying ASCVD risk scores on provider behaviors. The first phase involved displaying the patient's ASCVD risk score passively in the vital signs section of the EHR; this resulted in no significant improvement in statin prescriptions for high-risk patients (9.1% to 11.1%) (Level III Evidence) (Alameddine et al., 2020). In contrast, the second phase requiring nurses to manually calculate ASCVD risk and write a nurse's note visible to physicians stating the patient's risk and evidence-based recommendations resulted in initiation of statin therapy for 33.3% of moderate-risk patients (compared to 0% prescriptions at baseline) and statin prescriptions for 28.6% high risk patients (compared to 9.1% at baseline and 11.1% after the first intervention) (Level III Evidence) (Alameddine et al., 2020). Major limitations of this study were that patient ASCVD risk had to be manually calculated and methodology may have allowed for selection bias by nurses (Alameddine et al., 2020).

Overall, implementation of CDSSs for primary prevention of CVD led to improved statin prescribing for moderate- and high-risk patients (Alameddine et al., 2020; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015; Persell et al., 2020). While not all included studies reported the effect of CDSS implementation on statin prescribing, all studies which reported this outcome demonstrated clinically significant and mostly statistically significant increases in lipid-lowering prescriptions (Alameddine et al., 2020; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015; Persell et al., 2020). Nevertheless, these CDSSs did not completely close the gap between guideline recommendations for statin therapy and practice (Alameddine et al., 2020; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015; Persell et al., 2020). Outside factors may have negatively affected guideline-based statin prescribing in these studies. Using the non-adoption, abandonment, scale-up, spread, and sustainability (NASSS) framework to retrospectively analyze the TORPEDO program, Abimbola et al. (2019) noted that the degree of improvement in statin prescriptions observed in this RCT may have been less than it could have been since providers reported reducing statin prescriptions at the same time as this study due to negative media coverage of statins (Abimbola et al., 2019).

Finally, in all of the included studies CDSSs resulted in clinically, and sometimes statistically, significant improvements in antihypertensive prescriptions compared to usual care or control groups (Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Persell et al., 2020; Tian et al., 2015). The CDSS implemented in the cohort study by Bonner et al. (2019) resulted in improved recognition of patients who would benefit from antihypertensive and anti-lipid prescriptions; this is significant since recognition of patient CVD risk is a key step in closing this practice gap in preventive care for patients at risk for CVD. Finally, this cohort study noted that this increased recognition of patients who would benefit from preventive medications did not result in increases in overtreatment of low-risk patients, which helps relieve concerns that these CDS tools will result in inappropriate treatment of patients not likely to benefit from pharmacological treatment (Bonner et al., 2019).

CVD Risk Discussions. Guidelines from the AHA and ACC recommend providers use shared decision making to guide prescribing of statins (Grundy et al., 2018). A CDSS tool which automatically provides the patient's individualized 10-year ASCVD risk provides a piece of information vital to this conversation (Ye et al., 2018). The cluster RCT by Sperl-Hillen et al. (2018) demonstrated that providing PCPs with automatically calculated individualized patient CVD risk combined with treatment recommendations resulted in twice as many providers in the intervention group reporting they often discuss CVD risk reduction with patients compared to usual the care group (60% vs. 30%, p=0.06) at the 18-month follow-up (Level II Evidence).

A U.S. quasi-experiment study by Ye. et al. (2018) evaluated the effect of an EHR-based CDS tool that automatically calculates 10-year ASCVD risk combined with physician education on the Mayo Clinic Statin Choice decision aid. While providers' self-evaluations of shared decision-making competence increased after education on the statin decision aid at the three-month follow-up, providers attitudes did not change on shared decision making and utilization of the Mayo Clinic Statin Choice decision aid tool only increased from 3.4 to 5.2 times per 1,000 patient visits (p=0.002) after the intervention (Ye et al., 2018). While this is statistically significant, it is unclear how clinically significant this increase is since patient demographics and who would have benefited from a shared decision-making conversation were not reported along with the results. Nevertheless, implementation of CDSS tools seems to help providers initiate more CVD risk discussions, facilitate shared decision making, and improve provider confidence with shared decision-making conversations (Sperl-Hillen et al., 2018; Ye et al., 2018).

CVD Risk Related Outcomes

Clinical decision support tools for CVD prevention and management had mixed effects on BP in the studies included in this review. Evidence-based CDSSs did not mediate improvements in mean BP in the majority of RCTs included in this review (Level II Evidence) (Peiris et al., 2015, 2019; Tian et al., 2015). However, in the RCT by Tian et al. (2015) the mobile-based CDSS intervention mediated a decrease in mean SBP in the Chinese intervention group with a net difference of -4.1 mm Hg (p=0.006) but no improvement in the Indian intervention group, which may stem from the higher prevalence of hypertension in the Chinese cohort (51%) at baseline compared to the Indian cohort (25%) (Level II Evidence). Also, in the Peiris et al. (2015) RCT, 61.0% of patients in the intervention group achieved BP goals compared to 55.0% in the usual care group (p=0.05) (Level II Evidence). Finally, in Patel et al.'s

(2019) quasi-experimental study, the mobile-based CDSS was associated with clinically and statistically significant improvements in achievement of BP targets among high CVD risk patients and mean reductions in SBP and diastolic BP (DBP) in the intervention group compared to the control (Level III Evidence).

In the RCTs included in this integrative review, evidence-based CDSSs for CVD management and prevention had little to no effect on smoking cessation (Level II Evidence) (Peiris et al., 2019; Sperl-Hillen et al., 2018; Tian et al., 2015). Modest improvement was seen in the quasi-experimental study by Patel et al. (2019) as evidenced by 16.0% of Indonesian patients in the intervention group who were smoking at follow-up compared to 18.4% in the control (Level III Evidence). Clearly, other interventions are needed to increase smoking cessation among patients, especially those at high risk for CVD.

Satisfaction and Preferences

Overall, surveys and interviews with end-users found that CDSSs helped support evidence-based practice, preventative management and control of CVD risk factors, and provider thought processes and decision making (Chaudhry et al., 2019; Silveira et al., 2019; Sperl-Hillen et al., 2018). While end-users of the CDSS used in the Sperl-Hillen et al. (2018) RCT believed it saved time calculating risk, providers in the mixed methods study by Silveira et al. (2019) believed that using TeleHAS tool led to delays in care. In the Sperl-Hillen et al. (2018) trial, printing the CDSS only required two clicks by rooming nurses; in contrast, the CDSS used in the Brazilian study required providers to manually enter data into the app loaded on an Android device, which caused work duplication in a health system where Brazilian physicians already had an "excessive workload" (Silveira et al., 2019, p. 9).

Qualitative research indicates that clinicians prefer accurate, simple, and straightforward prompts that are arranged logically and support evidence-based statin prescribing with the option to dismiss the prompt if it is inaccurate or irrelevant (Level VI Evidence) (DeJonckheere et al., 2018). Interviews with providers also indicated a preference for clear and direct language, easy-to-use formatting, and a CDSS that would improve efficiency (DeJonckheere et al., 2018). Referring to the calculation of 10-year ASCVD risk, one participant in the study by DeJonckheere et al. (2018) stated, "'If the reminder already calculated the risk, I'd love that. I hate having to go to the internet, or look on my smartphone, so I think the ideal reminder would calculate the risk for you'" (p. 6).

Feedback from end-users indicated that they preferred CDSSs to be integrated into the EHR or, if this was not possible, for patient data from the EHR to auto-populate the CDSS and also flow back into the EHR from the CDSS (Abimbola et al., 2019; Bonner et al., 2019). If neither were possible, providers requested data to flow from one section of the CDSS to another and for the CDSS to require minimal data entry and not force providers to fill out every field (Bonner et al., 2019; Silveira et al., 2019; Williams et al., 2016). Issues like system bugs and glitches, lack of technical support at the clinic or system level, and time-consuming processes were predictors of increased frustration and decreased uptake and sustainability of CDSSs in the studies included in this review (Abimbola et al., 2019; Raghu et al., 2015; Silveira et al., 2019).

Taking a theory-informed approach, Abimbola et al. (2019) applied the NASSS framework to retrospectively interpret data collected in each phase of the TORPEDO program as well as new qualitative data gleaned from interviews with researchers. Using the seven domains of the NASSS framework, Abimbola et al. (2019) were able to identify key facilitators and barriers to multi-site implementation of CDS tools. Major barriers to implementation included lack of access to technical support to work through system glitches and no financial incentive to perform cardiovascular assessments in the Australian health system (Abimbola et al., 2019). Clinics enrolled in the TORPEDO program also varied widely in their ability and desire to innovate (Abimbola et al., 2019).

Finally, Abimbola et al. (2019) suggest that task-sharing with non-physician healthcare workers, such as nurses or community health workers, may alleviate the burden on providers. The successes of this type of task-sharing are highlighted above in the studies by Patel et al. (2019), Sperl-Hillen et al. (2018), and Tian et al. (2019). These studies demonstrate how existing primary and community health care infrastructures can be leveraged to promote cardiovascular health at the population level (Patel et al., 2019; Sperl-Hillen et al. 2018; Tian et al., 2019).

Implications for Practice

There is clear support for the application of CDSSs in practice to improve adherence to clinical practice guidelines for primary prevention of CVD (Alameddine et al., 2020; Bonner et al., 2019; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Persell et al., 2020; Sperl-Hillen et al., 2018; Tian et al., 2015; Ye et al., 2018). In the U.S., utilizing CDS tools to support primary prevention of CVD can increase reimbursement if certain quality goals are met as this qualifies as a meaningful use of health information technology (Centers for Medicare and Medicaid, 2018; Million Hearts, n.d.-a; Million Hearts, n.d.-b). Practices considering integrating the use of a CDSS into their workflow would do well to consider the technical expertise that will be required as lack of technical support can contribute to reduced long-term sustainability and uptake among providers (Abimbola et al., 2019). Seeking input from end-users in the planning, implementation, and evaluation stages will also likely yield valuable insights into provider needs and how the technology can be tailored to fit the clinic's workflow (Bonner et al., 2019; Sperl-Hillen et al., 2018; Williams et al., 2016).

Areas for Future Research

The significant practice gaps that were noted in the initial review of the literature were only partially closed by implementation of a CDSS in the included studies. Further research is needed to determine what quality improvement measures can further close these gaps in primary prevention of CVD in the U.S. and worldwide. Specifically, more research is needed to delineate how technology can be leveraged to facilitate motivational interviewing and utilization of the five A's (Ask, Advise, Assess, Assist, and Arrange) to promote patient smoking cessation as this patient outcome was not significantly impacted by CDSSs in this review (Dart, 2011; Fiore et al., 2008; Patel et al., 2019; Peiris et al., 2019; Sperl-Hillen et al., 2018; Tian et al., 2015). Similarly, since improvements in BP control were inconsistent between studies, further research is needed to determine how CDS tools can be better utilized to address this complex issue and guide intensification of antihypertensive therapy (Peiris et al., 2015, 2019; Tian et al., 2015).

Ethical Considerations

Since this DNP scholarly project does not involve human subject research and instead examines the extant literature on the topic of interest, this project did not require approval from Liberty University's or any other organization's institutional review board. The project leader has completed ethics training from the Collaborative Institutional Training Initiative (CITI) on the protection of privacy and confidentiality of human subjects. See Appendix B for this student's CITI Social and Behavioral Research training certificate. The project chair has also completed CITI training on protection of human subjects.

Conclusion

Overall, CDSSs were successful in improving the provision of evidence-based care to patients; however, they offer only a partial solution to the issue of inadequate compliance with CVD prevention guidelines since significant practice gaps remained even after implementation of CDSSs designed to promote evidence-based CVD prevention (Alameddine et al., 2020; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Persell et al., 2020; Sperl-Hillen et al., 2018; Tian et al., 2015). Though CDSSs mediated improvements in CVD risk screening and prescriptions for CVD prevention and treatment, there remained a significant gap between guideline-based recommendations and actual prescriptions in these studies (Alameddine et al., 2020; Chalasani et al., 2017; Patel et al., 2019; Peiris et al., 2015, 2019; Persell et al., 2020; Sperl-Hillen et al., 2018; Tian et al., 2015). Improvements in BP mediated by CDSS implementation was patchy in the included studies, and CDSSs showed minimal to no effect on smoking cessation (Patel et al., 2019; Peiris et al., 2015, 2019; Tian et al., 2015). The CDSSs evaluated in each study varied in delivery and capability; however, tools that were co-designed with end-users to fit workflows and save time were more likely to be accepted and successfully implemented than tools which caused provider frustration through work duplication and system glitches (Bonner et al., 2019; Silveira et al., 2019; Sperl-Hillen et al., 2018). In summary, well-designed, evidence-based CDSSs offer a potential, albeit partial, innovative solution to improving prevention of CVD in the U.S. and globally.

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Appendix A

Evidence Table

Name: Elisabeth Campbell

Clinical Question: How do CDSS tools support primary prevention of CVD in primary care?

Article reference	Level of Evidence	SIGN Form Rating	Study Purpose/ Objectives	Design, Sampling Method, & Subjects	Interventions & Outcomes	Adherence to CPGs	Patient Outcomes:	Clinician Satisfaction/ Preferences:	Study Strengths & Limitations
Chalasani, S., Peiris, D. P., Usherwood, T., Redfern, J., Neal, B. C., Sullivan, D. R., Colagiuri, S., Zwar, N. A., Li, Q., & Patel, A. (2017). Reducing cardiovascular disease risk in diabetes: A randomised controlled trial of a quality improvement initiative. *Medical Journal of Australia, 206*(10), 436-441. doi:10.5694/mja16.00332	II: RCT	++	To compare effect of quality improvement interventions including audit and feedback and CDSS tools on cardiovascular risk screening and primary preventive treatment of diabetic and non-diabetic patients.	The TORPEDO study was a parallel arm cluster randomized trial with a final sample of 60 Australian primary healthcare clinics (1 small size practice withdrew early in the trial); final sample: 30 in each study arm. Baseline data was collected for 53,164 patients and follow up data was extracted for 38,725 patients. Patients were included based on the following	Guideline-based screening and algorithm for management of CVD, chronic kidney disease, BP, and cholesterol were implemented through a CDSS that pulled patient data from within the EHR to prepopulate the tool and generate point-of-care recommendations based on patient's absolute CVD risk; a risk communication tool was used to guide patient-provider conversations about individualized risk. Practices in the intervention group also used a software to generate site-specific audits and performance feedback for providers. These	Primary outcomes: 1) proportion receiving appropriate screening for CVD risk factors - 62.8% in the intervention group vs. 53.4% in the usual care group (p=0.01); 2) high CVD risk patients receiving appropriate prescriptions - 56.8% in the intervention group vs. 51.2% in the usual care group (p=0.10). Secondary outcomes: increased antiplatelet therapy - 17.8% in intervention group vs. 2.7% in usual care (p=0.08), increased lipid-lowering therapy 19.2% in treatment group vs. 4.7% (p=0.08), and increased BP-lowering therapy 23.3% vs 12.1% in the intervention vs control, respectively. See Table 3 for corresponding P	Not evaluated	Not evaluated	The sites spread out and were representative of the geographic region of Australia under investigation. Relying on EHR data limited the ability to account for clinical judgement in treatment decisions, and the type of diabetes mellitus was not distinguished in the analysis.

				criteria: attended the practice ≥3x in the previous 24 months and at least once in the previous 6 months and Aboriginal and Torres Strait Islander people ≥35 years and all others ≥45 years which aligns with the Australian guideline vascular risk screening guidelines.	QI interventions were supplemented by clinical workforce training and IT support for the tools being used in the intervention arm of the study. Primary outcomes: 1) proportion receiving appropriate screening for CVD risk factors and 2) proportion of patients deemed high CVD risk when baseline data was collected and were receiving appropriate treatment at follow up (median follow up=17.5 months). Secondary outcomes: 1) individual CVD risk factor measurements (smoking status, BP, lipid levels, body mass index [BMI], estimated glomerular filtration rate, and albuminuria), 2) escalation of pharmacological therapies, and 3) BP and serum lipid levels of high-risk patients	values. The intervention was only effective for the initiation and intensification of medications for patients undertreated at baseline and was not influenced by diabetes status: 38.4% in the intervention group vs 20.9% in the usual care group, p=0.28. The intervention was only partially effective in closing the significant gap between guideline-based recommendations and actual prescriptions.			
Peiris, D., Praveen, D., Mogulluru, K., Ameer, M. A., Raghu, A., Li, Q., Heritier, S., MacMahon, S., Prabhakaran, D.,	II: RCT	++	To determine if a mobile-based CDSS implemented by non-physician community	This two-year stepped-wedge, cluster randomized, control trial had a final sample of 18	Villages received the intervention using a stepped-wedge approach. For the first six months, data was collected by independent	There was major discordance between identification of high-risk individuals between the independent research team and community	There was not a clinically or statistically significant difference in the proportion of patients achieving BP targets (SBP <140 mm Hg) between the	Not evaluated	Both independent researchers collecting data and statisticians were blinded

Clifford, G. D., Joshi, R., Maulik, P. K., Jan, S., Tarassenko, L., & Patel, A. (2019). SMARTHealth India: A stepped-wedge, cluster randomised controlled trial of a community health worker managed mobile health intervention for people assessed at high cardiovascular disease risk in rural India. *PloS One, 14*(3), e0213708. doi:10.1371/journal.pone.0213708			health workers in rural India would increase the proportion of high-risk patients achieving guideline-recommended BP levels.	villages which were selected using a combination of cluster randomization and stratification based on village size and association with a primary health center. Criteria for inclusion were age of ≥40 years, requiring antihypertensive medication based on guidelines, and high CVD risk defined as the presence of at least one of the following: diagnosis of CVD, SBP >160 mm Hg or DBP >100 mm Hg, 10-year CVD risk ≥30%, or a 10-year CVD risk 20-29% and a SBP >140 mm Hg).	researchers to establish baseline outcome measures and determine qualifying patient population and sample. In six month increments for the following year and a half, two primary health centers (6 villages) were incrementally randomized to receive the intervention until all villages were receiving the intervention in the final 6-month period. The intervention had multiple components including: implementation of the SMARTHealth India Android app (available in Telugu and English) which incorporates 10-year CVD risk assessment and lifestyle risk reduction strategies education that can be executed by community health workers as well as a version with pharmacological decision support for physicians; community health workers were able to make referrals to physicians based on risk assessments	health workers; this was mostly attributable to variations in BP readings between evaluations. This led to some patients identified at baseline as high risk by independent researchers not being identified at risk by community health workers and vice versa. Factors that may have led to this discordance was normal variation with regression to the mean; extremely high temperatures (48 degrees Celsius or 118 degrees Fahrenheit) during the second step of the trial when one group was receiving the intervention and the other two groups were in the control. Since extreme temperatures can cause decreases in BP, researchers hypothesized this could have been the explanation for the 13.68 mm Hg decrease in SBP among untreated patients and 14.6 mm Hg decrease in SBP overall. Patients who would have been previously identified as high risk at baseline, when exposed to the	control and intervention groups, confirming the null hypothesis. There was an increase in self-reported physical activity in the intervention group (42.1% intervention vs 39.0% control, p=0.10); patients reporting an active lifestyle increased from 25.9% to 27.7% post-intervention (p=0.23) and a minimally active lifestyle from 35.5% to 38.8% (p=<0.01), and reports of an inactive lifestyle decreased from 36.6% to 33.5% (p value not reported). There was no statistically or clinically significant differences in mean BPs, CVD risk factors (i.e. BMI, smoking status, and self-reported dietary intake), difference in quality of life measured by EuroQol quality of life instrument (EQ-5D), and difference in reported new CVD events.		to village allocation. As discussed previously, seasonal fluctuations may have influenced the null hypothesis outcome; however, a national initiative was strengthened during the study period which gave patients in Andhra Pradesh region new access to a mobile health service and free access to medications. This may have contributed to patients in the control group receiving antihypertensive medications, blurring the overall picture of effect.

					completed during home visits; there was also a computer-based system to support tracking and prioritizing patient follow-up; alerts were designed to remind community health workers to follow-up with high-risk patients; and automated telephone messages were used to remind patients of follow-up visits and promote medication adherence. The primary outcome was the difference in proportion of patients achieving BP targets (SBP <140 mm Hg) between the intervention and control periods. Secondary outcomes included difference in mean BPs, difference in reported use of BP medications, difference in CVD risk factors (i.e. BMI, smoking status, self-reported dietary intake and exercise), difference in quality of life measured by EuroQol quality of life instrument (EQ-5D), and difference in reported new CVD	intervention, had reciprocal decreases in estimated CVD risk or no longer met criteria for antihypertensive treatment. Nevertheless, there was a significant improvement in high-risk patients reporting taking antihypertensives, from 47.9% in the control vs 54.3% in the intervention group (p=0.02). Also, 70% of patients determined to be at high risk by community health workers received physician follow-up.			

					events. Outcome measures were evaluated by both community health workers delivering the intervention and independent researchers using the same equipment and CDSS tool as the community health workers.				
Peiris, D., Usherwood, T., Panaretto, K., Harris, M., Hunt, J., Redfern, J., Zwar, N., Colagiuri, S., Hayman, N., Lo, S., Patel, B., Lyford, M., MacMahon, S., Neal, B., Sullivan, D., Cass,A., Jackson, R., & Patel, A. (2015). Effect of a computer-guided, quality improvement program for cardiovascular disease risk management in primary health care: The treatment of cardiovascular risk using electronic decision support cluster-randomized	II: RCT	++	To determine the effect of quality improvement interventions including audit and feedback and CDSS tools on screening of cardiovascular risk factors and appropriate prescriptions for primary or treatment of CVD.	The TORPEDO study was a parallel arm cluster randomized trial with a final sample of 60 Australian primary healthcare clinics (1 small size practice withdrew early in the trial); final sample: 30 in each study arm. Outcomes were evaluated for 38,725 patients with 10,308 patients defined as high CVD risk at baseline. Patients were included based on the	Guideline-based screening and algorithm for management of CVD, chronic kidney disease, BP, and cholesterol were implemented through a CDSS that pulled patient data from within the EHR to prepopulate the tool and generate point-of-care recommendations based on patient's absolute CVD risk; a risk communication tool was used to guide patient-provider conversations about individualized risk. Practices in the intervention group also used a software to generate site-specific audits and performance feedback for providers. These QI interventions were	Primary outcomes: proportion receiving appropriate screening for CVD risk factors - 62.8% in the intervention group vs. 53.4% in the usual care group (p=0.02); high CVD risk patients receiving appropriate prescriptions - 56.8% in the intervention group vs. 51.2% in the usual care group (p=0.09). Secondary outcomes: no statistically significant difference in the recording of smoking status, BMI, albuminuria, and estimated glomerular filtration rate between intervention and usual care arms (see Figure 2 on p. 92); however, there were clinically significant increases in recording of SBP in previous 12 months (84.8% vs. 80.6%,	Not evaluated	Not evaluated	The sites spread out and were representative of the geographic region of Australia under investigation. Relying on EHR data limited the ability to account for clinical judgement in treatment decisions, and the type of diabetes mellitus was not distinguished in the analysis.

trial. *Circulation. Cardiovascular Quality and Outcomes, 8*(1), 87-95. doi:10.1161/CIRCOUTCOMES.114.001235				following criteria: attended the practice ≥3x in the previous 24 months and at least once in the previous 6 months and Aboriginal and Torres Strait Islander people ≥35 years and all others ≥45 years which aligns with the Australian guideline vascular risk screening guidelines.	supplemented by clinical workforce training and IT support for the tools being used in the intervention arm of the study. Primary outcomes: 1) proportion receiving appropriate screening for CVD risk factors and 2) proportion of patients deemed high CVD risk when baseline data was collected and were receiving appropriate treatment at follow up (median follow up=17.5 months). Secondary outcomes: 1) individual CVD risk factor measurements recorded (i.e. smoking status, BP, lipid levels, BMI, estimated glomerular filtration rate, and albuminuria), 2) escalation of pharmacological therapies (i.e. BP, lipid-lower, and antiplatelet medications), 3) current prescription for at least one BP med and statin for high CVD risk patients, and 4) prescriptions for at least one BP medication, statin,	p=0.09) and total and HDL cholesterol recorded in previous 24 months (75.5 vs. 66.5%, p=0.02); escalation of antiplatelet therapy - 17.8% in intervention group vs. 2.7% in usual care (p=<0.001); escalation of lipid-lowering therapy 19.2% in treatment group vs. 4.7% (p=<0.001); and increased BP-lowering therapy 23.3% vs 12.1% (p=0.42) in the intervention vs control, respectively; current prescription for at least one BP med and statin for high CVD risk patients - 58.3% in intervention vs 54.1% in usual care (p=0.16); prescriptions for at least one BP medication, statin, and antiplatelet medication for patients with CVD diagnosis - 55.3% in intervention vs 48.4% in usual care (0.10). Hence, the intervention was effective appropriate screening for CVD risk factors (62.8 vs 53.4%, p=0.02), which were mainly driven by increased recording of SBP and cholesterol levels. When compared with			

					and antiplatelet medication for patients with CVD diagnosis.	baseline levels for each group, there was no statistically significant increase in the prescription of appropriate medications for patients at high risk of CVD; however, there were statistically significant increases in individual medication intensification; see above. No statistically significant differences were seen in mean SBP or cholesterol levels; however, more patients in the intervention group achieved BP goals compared to the usual care group (611.0% vs 55.0%, p=0.05)			
Sperl-Hillen, J. M., Crain, A. L., Margolis, K. L., Ekstrom, H. L., Appana, D., Amundson, G., Sharma, R., Desai, J. R., & O'Connor, P. J. (2018). Clinical decision support directed to primary care patients and providers reduces cardiovascular risk: A randomized trial. *Journal of the American Medical*	II: RCT	++	To determine if a CDSS implemented in primary care clinics can reduce patient CVD risk.	This RCT established two levels of strata based on practice size and number of providers who agreed to participate at individual sites. Pairs of matched clinics were randomized to either CDS arm or usual care arm based on which clinic	This EHR-integrated, web-based CDSS was designed with input from PCPs and nurse leaders to match clinic workflow and provides personalized and prioritized recommendations targeted at patients and providers. Rooming staff were responsible for triggering the CDSS printout in the "vanguard" phase of the project (p. 1140). In the second phase,	During the initial "vanguard" phase of the project, staff were responsible for triggering the CDSS printout but only printed for 20% of study-eligible patients who could have benefited (p. 1140). At 12-month follow-up for the second phase of the study, patients in the CDS group had 2.2% lower 10-year CV risk compared to the usual care group (p=<0.001). Decreases in CV risk	Per Table 1 on page 1143, there was either no improvement or only modest improvement on patient risk factors such as smoking status and LDL cholesterol levels at follow-up. P values were not provided for the effect on clinical patient factors, making statistical significance unclear from results.	Of surveyed providers, 98% responded that they either agreed or strongly agreed that the CDS improved CV risk factor control in patients, 93% that the CDS saved time during CV risk reduction discussions, 90% that it efficiently elicited patient preferences for treatment, 95% that it was useful for shared decision making, 94% that the	P-values for patient clinical outcomes were not included, limiting the ability to interpret the results.

Informatics Association, 25(9), 1137-1146. doi:10.1093/jamia/ocy085				was assigned the highest random number. Providers who achieved a CDS print rate of at least 80% within 3 months of rollout were compensated $500. Patients were included based on the following criteria: visit during index period and post-index visit during 14-month follow-up period; aged 18-75 years old; non-diabetic; no history of CVD, no hospice care, current cancer therapies, or pregnancy in the last 12 months; high CVD risk at index visit (i.e. potential for a reduction of ≥10% if uncontrolled CVD risk factors were	the CDS BPA automatically fired and then required only two clicks for rooming staff to print the lay and professional versions of the CDS tool. The lay version was given to the patient with instructions to discuss with their provider the fields that had the most caution symbols next to it, and a more detailed version was given to providers with specific recommendations based on patient's calculated risk and clinical data. The web-based CDSS interfaced with the EHR and used several firewalls to protect confidential patient information. Outcomes examined for this study include print rates over the course of the study, provider satisfaction, provider perception of patient satisfaction, change in 10-year CVD risk, and effect on provider behaviors related to CVD primary prevention.	were greatest in patients in the 40-60th percentile and 60-80th percentile risk categories. Providing automated clinic- and provider-specific monthly CDS use reports to clinic leadership had a significant impact on CDS use, increasing from ~62% to 72-77% (See Figure 6). At 18-month follow-up, 60% of surveyed providers in the CDS group reported they often discuss CV risk reduction with patients compared to 30% in the usual care group (p=0.06); 73% of providers in the CDS arm reported they often use calculated CV risk while seeing patients compared to 25% in the usual care group (p=0.006). 98% of providers in the CDS group felt well prepared to discuss CV risk reduction priorities with patients compared to 78% in the usual care group (p=0.03), and 75% believed they were able to provide accurate advice on aspirin for primary prevention in the CDS		CDS help initiate CV risk discussions, 89% that it influenced treatment recommendations, and 85% that patients liked the CV Wizard (the CDSS).	

				controlled to optimal levels) or one of the following: SBP ≥140 mm Hg, LDL cholesterol ≥130 mg/dl, or current tobacco smoker.		group vs. 48% in the usual care group (p=0.02).			
Tian, M., Ajay, V. S., Dunzhu, D., Hameed, S. S., Li, X., Liu, Z., Li, C., Chen, H., Cho, K., Li, R., Zhao, X., Jindal, D., Rawal, I., Ali, M. K., Eric D. Peterson, E. D., Ji, J., Amarchand, R., Krishnan, A., Tandon, N., . . . Yan, L. L. (2015). A cluster-randomized, controlled trial of a simplified multifaceted management program for individuals at high cardiovascular risk (SimCard trial) in rural Tibet, China, and Haryana, India. *Circulation, 132*(9), 815-824. doi:10.1161/CIRCULATIONAHA.115.015373	II: RCT	++	To determine if a mobile CDS tool would be effective in improving preventative care for patients in rural India and China at high risk for CVD.	The SimCard study is cluster-randomized, controlled trial stratified villages at the country level and, in China, at the county and township level. After stratification, 47 villages (27 Chinese villages and 20 Indian villages) were either randomized to the intervention or control group (n=2,086). Twenty-three villages were randomized to the intervention group, 14 from China and 9 from India; 24 villages were	Intervention groups had access to and were trained on the use of an Android-powered mobile-based CDS tool that could be implemented in house or clinic visits to screen patients for CVD risk and make recommendations based on a 2+2 model; this model focus on two domains: pharmacological and lifestyle interventions. Pharmacological interventions involved an antihypertensive (low-dose hydrochlorothiazide in China and 2.5-5 mg calcium channel-blocker in India) for patients at high risk for CVD and 75-100 mg aspirin for patients with established CVD or diabetes diagnosis without contraindications (e.g. bleeding diatheses or	There were increases in anti-hypertensive medication prescriptions in both the intervention and control groups in both China and India with a net difference between intervention and control groups which was statistically significant for both countries: 24.4% in China (p=<0.001) and 26.6% in India (p=0.02). Net increase in patient-reported aspirin use in the last month was 24.5% in Chinese intervention group (p=<0.001) vs. 9.8% in Indian intervention group (p=0.003); however, both represent statistically significant improvements.	There was a clinically and statistically significant decrease in mean SBP in the Chinese intervention group with a net difference of -4.1 mm Hg (p=0.006); this was no improvement in the mean SBP in the Indian intervention group which may be due to the fact that fewer patients in the Indian cohort (25%) had hypertension at baseline compared to the Chinese cohort (51%). In both countries, the intervention was neither effective for decreasing proportion of current smokers in the intervention groups nor improving awareness of high salt diet.	Not evaluated	The results in India may be less statistically significant since there was a greater than four-fold increase from baseline (3.9% antihypertensive prescription at baseline and 17.9% at follow-up) in the control group which is likely due to the screening done at baseline and the access to free calcium-channel blockers in this subsample of the study. While this made results less statistically significant, it represents an increase in

				randomized to the control group, 13 from China and 11 from India. Intention to treat analysis utilized data for 1,095 patients in the intervention group and 991 patients in the control. Inclusion criteria were age ≥40 years with SBP ≥160 mm Hg or self-reported history of one of the following: coronary artery disease, stroke, or diabetes mellitus. Patients were excluded if they met any of the following criteria: presence of CVD complications not amenable to management in primary care,	SBP ≥160 mm Hg). The second domain focused on modifiable risk factors: smoking cessation and reducing sodium intake. The intervention was delivered by community health workers who were a part of an established public and community health system in rural China and India. Community health workers in China were non-physician "village doctors" who had basic medical training and prescriptive authority; in India, community health workers were volunteers and did not have prescriptive authority but were able to send recommendations to physicians for prescriptions (Tian et al., 2015, p. 816). Physicians in India providing prescriptions to participants had access to a desktop version of the CDS tool.				access to care for the control group which reaps a public health benefit to the rural Indian community.

				malignancy, life-threatening disease, bed-ridden status, participating in another clinical trial, and not living in one village for ≥8 months/year. The last criteria led to the exclusion of nomadic tribes people residing in China.					
Alameddine, R., Seifeddine, S., Ishak, H., & Antoun, J. (2020). Improving statin prescription through the involvement of nurses in the provision of ASCVD score: A quality improvement initiative in primary care. *Postgraduate medicine*, 1–6. https://doi.org/10.1080/00325481.2020.1755146	III: Quasi-experimental	No SIGN form for this level	To compare the effects of different ways of displaying patient CVD risk scores on provider behaviors.	This quasi-experimental study used random sampling to select 162 out of 547 eligible charts for chart review. Patients were eligible for inclusion if they met the following criteria: non-diabetic, aged 40-75 with recent low-density lipoprotein level, not on a statin at baseline, and without history of clinical CVD.	In the first phase of the study, the researchers manually calculated ASCVD risk score which was displayed in the vital signs section of the EHR. In the second phase of the study, nurses calculated the ASCVD risk score, populated the ASCVD field, and wrote a nurse's note visible to physicians stating the risk score and evidence-based recommendations based on the value.	Passively displaying the ASCVD risk score had no effect on appropriate statin treatment. After the collaborative intervention, appropriate statin initiation for the moderate ASCVD risk (5-7.5%) group increased from 0% at baseline and after the first intervention to 33.3%. Changes in appropriate statin prescribing for patients in the high-risk category were less significant, from 9.1% at baseline, 11.1% after the first intervention, and 28.6% after the second intervention.	Not evaluated	Not evaluated	This study demonstrates a low-cost method that could generate high yield benefits for practices with low-tech EHR systems such as the Lebanese family medicine clinics in this quasi-experimental study. Drawbacks for the second intervention are that it can be tedious and labor intensive which may

									incentivize nurses to only assess ASCVD risk of patients which are perceived to be at highest risk based on patient characteristics; authors theorize that this was the underlying reason why only 10 risk scores were calculated by nurses in the three months following the second intervention. This required extending the follow-up period to 9 months after the second intervention; the profiles of patients whose ASCVD risk seems to suggest that patient selection may not have been random.
Patel, A., Praveen, D., Maharani, A., Oceandy, D.,	III: Quasi-	No SIGN form	To determine if a mobile CDSS would	This quasi-experimental study	The intervention consisted of a mobile-based CDSS	At follow-up, 409 of patients identified by researchers as high risk	Patient outcomes: How do CDSS tools impact ASCVD risk related	Not evaluated	Non-random sample frame was used;

Pilard, Q., Kohli, M. P. S., Sujarwoto, S., & Tampubolon, G. (2019). Association of multifaceted mobile technology-enabled primary care intervention with cardiovascular disease risk management in rural Indonesia. *JAMA Cardiology, 4*(10), 978–986. https://doi-org.ezproxy.liberty.edu/10.1001/jamacardio.2019.2974	experimental	for this level	improve preventive drug treatment of patients with high CVD risk in rural Indonesia.	evaluated outcomes for four intervention and four control villages that were selected based on access to technologies that would support intervention implementation; 11,647 patients were included in the intervention villages and 10,988 patients in the control villages. Control villages were matched to intervention villages based on population demographics and care access to provide consistency between pairs. Patients were considered for inclusion based on the following characteristics: age ≥40 years old and high	implemented by an existing public health infrastructure consisting of community health workers (*kaders*), nurses, and physicians. Patients were screened using the mobile CDSS during home visits and referrals were made to nurses and physicians for further evaluation based on patient's estimated CVD risk. Nurses were given the ability to order antihypertensives in this study; it is unclear how much physician oversight there was for this activity.	for CVD in the intervention villages were receiving appropriate preventive treatment (15.5%) compared to 25 (1.0%) in the control villages (p=<0.001), 56.8% were receiving BP-lowering medications compared to 15.7% in the control group (p=<0.001), 19.9% were receiving lipid-lowering medications vs. 2.4% in the control (p=<0.001), and 24.6% of patients with established CVD were receiving antiplatelet medications vs. 12.7% in the control (p=0.06). The first two outcomes showed a statistically and clinically significant improvement in the intervention group and borderline statistically significant improvement in the final outcome, yet there remains a large gap in the achievement of appropriate preventative treatment in this rural Indonesian population.	quality outcomes such as cholesterol levels, BP, hemoglobin A1c, weight loss, and smoking cessation? Baseline CVD risk factors were similar between intervention and control groups. At follow-up, 31.0% of patients at high CVD risk in the intervention group achieved BP targets compared to 22.2% in the control group (p=<0.001), 17.2 mm Hg decrease in mean SBP in the intervention group compared to 9.2 mm Hg decrease in the control group (p=<0.001), and 8.3 mm Hg decrease in DBP in the intervention group compared to 5.0 mm Hg decrease in the control group (p=<0.001). 16.0% of patients in the intervention group were smoking at follow-up compared to 18.4% in the control (p value not available). There was no significant effect on BMI at follow up: change in BMI was 0.0 in the control and -0.3 in the intervention group (p=0.49).		baseline preventative treatment levels were better in the intervention villages than the control. Villages were selected based on the community health workers' evaluation of the feasibility of the intervention in specific villages. Field researchers collecting outcome data were blinded to village allocation.

				estimated 10-year ASCVD risk defined as: a) previously diagnosed CVD, b) SBP >160 mm Hg or DBP > 100 mm Hg, c) 10-year estimated CVD risk of ≥30%, or d) 10-year CVD risk of 20-29% and SBP >140 mm Hg. Median follow-up for this study was 12.2 months.					
Persell, S. D., Liss, D. T., Walunas, T. L., Ciolino, J. D., Ahmad, F. S., Brown, T., French, D. D., Hountz, R., Iversen, K., Lindau, S. T., Lipiszko, D., Makelarski, J. A., Mazurek, K., Murakami, L., Peprah, Y., Potempa, J., Rasmussen, L. V., Wang, A., Wang, J., … Kho, A. N. (2020). Effects of 2 forms of practice facilitation on cardiovascular prevention in primary care: A practice-	III: Quasi-experimental	No SIGN form for this level	To compare facilitation of two combinations of quality improvement strategies for preventative cardiovascular care.	Quasi-experimental design, practices were randomized to two intervention groups to compare effectiveness. While 226 practices agreed to participate, only 179 practices provided follow-up data.	Both intervention arms received one-on-one coaching from a quality improvement facilitator who made several visits to the practice during the 12-month intervention period. The two arm intervention groups were 1) point-of-care study arm and 2) point-of-care + population management group. Practices were given the autonomy to pick which interventions to implement and when. Intervention choices in the point-of-care category included adding CDS, modifying	The mean in achievement of quality outcome measures increased in both intervention groups. With a P value of < 0.001 for each, increases for each category are as follows "Aspirin 0.04 (95% confidence interval: 0.02–0.06), Blood pressure 0.04 (0.02–0.06), Cholesterol 0.05 (0.03–0.07), Smoking 0.05 (0.02–0.07)" (p. 344). Increases from baseline between the two study arms were similar except the increase for the cholesterol measure was somewhat higher	Not evaluated	Not evaluated	While the study did not achieve the sample size intended, there were still 179 small and mid-sized primary care practices included in the final sample. Limitations: lacked control, 20% of clinics did not provide follow-up data (47/226 practices).

randomized, comparative effectiveness trial. *Medical Care, 58*(4), 344–351. https://doi-org.ezproxy.liberty.edu/10.1097/MLR.0000000000001260					workflows, giving provider performance feedback, and improving patient education. The second intervention group were also encouraged to search the EHR for patients with medical gaps in care and follow up to address these gaps and were given the opportunity to use a CDSS which autogenerated personalized referrals to community resources such as smoking cessation. Outcomes were evaluated at baseline, 12 months, and 18 months and were based on the Million Hearts Campaign ABCS measures: "(Aspirin) Aspirin/antiplatelet therapy for ischemic vascular disease, (Blood pressure) Controlling High Blood Pressure, (Cholesterol) Statin Therapy for the Prevention and Treatment of Cardiovascular Disease, and (Smoking) Tobacco Use: Screening and Cessation Intervention,	for the point-of-care + population management arm different of 0.03, 95% confidence interval 0.01-0.07, P=0.055; this difference may have been more clinically significant had the sample size been larger.			

					and the Change Process Capability Questionnaire" (p. 344).				
Ye, S., Leppin, A. L., Chan, A. Y., Chang, N., Moise, N., Poghosyan, L., Montori, V. M., & Kronish, I. (2018). An informatics approach to implement support for shared decision making for primary prevention statin therapy. *MDM Policy & Practice, 3*(1), 2381468318777752. https://doi-org.ezproxy.liberty.edu/10.1177/2381468318777752	III: Quasi-experimental	No SIGN form for this level	To evaluate the effect of an EHR tool that automatically calculated 10-year ASCVD risk and educating providers regarding the Mayo Clinic Statin Choice decision aid on utilization of the decision aid tool and provider attitudes toward shared patient-provider decision making and confidence with shared decision-making conversations.	This quasi-experimental study utilized convenience sampling and used participants pre-intervention survey responses and tool utilization as the comparison group. Initial surveys had a response rate 30.6% (70 out of 229 family and internal medicine attendings and residents invited to participate). Only 60 physicians completed both surveys. Respondents were more likely to be female (70%), aged 20-39 years old (70%), and be internists (73%).	An easy-to-use EHR tool was designed to automatically calculate patient's individualized 10-year ASCVD risk, which could be used to facilitate share decision-making conversations using the Mayo Clinic Statin Choice decision aid already developed prior to the roll out of this EHR tool. Outcomes examined included provider attitudes toward shared decision making and self-reported and quantitative measurement of the shared decision-making tool's utilization. Data were extracted over the three months preceding and three months after the intervention.	The CDSS tool which automatically provides the patient's individualized 10-year ASCVD risk is a piece of information vital to this conversation which can be facilitated by the Mayo Clinic Statin Choice decision aid. This study was not able to directly measure how many times these shared-decision making conversations were occurring pre- and post-intervention; however, utilization of the Mayo Clinic Statin Choice decision aid tool increased from 3.4 to 5.2 times per 1,000 patient visits (p=0.002) after the intervention. While this is statistically significant, it is unclear how clinically significant this increase is since patient demographics and who would have benefited from a shared decision-making conversation were not reported along with the results. Provider surveys demonstrated modest increases in self-	Not evaluated	Not evaluated	Lacked randomization; utilized pre-post study design which means participants acted as their own control. The sample of included providers did not include any advanced practice providers such as nurse practitioners or physician assistants, which may make the sample less representative of United States providers which frequently include these professionals on the interdisciplinary team. Conducted at one location so may lack external

						reported usage of Mayo Clinic Statin Choice; surveyed providers reporting occasional use of this shared decision-making tool increased from 17% to 28% post intervention and routine use from 2% to 8% use post intervention (p=<0.001).			validity; however, authors provided detailed information about data mapping and decision-support logic within the EHR so that the automated 10-year ASCVD risk calculator CDSS tool could be replicated in other clinics.
Abimbola, S., Patel, B., Peiris, D., Patel, A., Harris, M., Usherwood, T., & Greenhalgh, T. (2019). The NASSS framework for ex post theorisation of technology-supported change in healthcare: Worked example of the TORPEDO programme. *BMC Medicine, 17*(1), 1–17. https://doi-org.ezproxy.liberty.edu/10.1186/s12916-019-1463-x	VI: Qualitative Study	No SIGN form for this level	To describe the application of the NASSS framework to retrospective data set from the Treatment of Cardiovascular Risk using Electronic Decision Support (TORPEDO) research program and new qualitative data extracted from primary interviews	This article applies the NASSS framework retrospectively to data included in previous reports on the TORPEDO program and new data gathered from interviews with researchers. Multiple theories were also used to complement the NASSS framework and interpret themes from	Abimbola et al. (2019) conducted interviews with researchers to clarify questions centered around the following domains within the NASSS framework: condition, technology, value proposition, adopters, organizations, wider system, and embedding and adaptation over time.	NASSS Framework: Condition - Management of cardiovascular disease is more straightforward than the nuanced evaluation and treatment of high cardiovascular risk. The Intended Adopters - Negative media coverage of statins in the news led to changes in providers' prescribing habits that may have negatively affected the results of the TORPEDO program.	Not evaluated	NASSS Framework: Technology - System glitches and bugs led to provider frustration and decreased uptake and satisfaction with the tool; furthermore, providers wanted the information to flow both directions, both into HealthTracker from the EHR but also back into the EHR desktop tool. Lack of technical support as a part of clinic infrastructure was a major barrier, especially for smaller clinics. Value - In the setting of a fee-for-	Abimbola et al. (2019) suggest that there may have been a greater magnitude of effective if the program had taken an iterative quality improvement approach, tailoring the intervention to the needs of each site; this, however, would decrease the level of evidence by trading off the

			with TORPEDO program staff.	the primary and secondary data sets.				service market which did not incentivize quality of care outcomes like cardiovascular risk screening, HealthTracker had a perceived negative financial value due to technical issues that took up valuable provider time. Organizations - Wide variation in the capacity of individual clinics to innovate made the application of a standardized intervention potentially less effective; key influencers on the routinization of HealthTracker use included organizational mission, history, leadership, team dynamics, and technical support. Wider System - Lack of financial incentives for performing cardiovascular risk assessment may also have negatively affected uptake. Adaptation Over Time - Task sharing might help alleviate the burden on	RCT study design for a quality improvement approach. Recall bias may have affected the results of the primary data set since researchers were asked to discuss their impressions of the issues with the TORPEDO program which they had already completed.

								providers and help the issue of high turnover among providers and the need to continuously training providers on HealthTracker use; this could be accomplished by expanding the application of the tool to include community health workers who have long-term relationships with patients from vulnerable populations.	
Bonner, C., Fajardo, M. A., Doust, J., McCaffery, K., & Trevena, L. (2019). Implementing cardiovascular disease prevention guidelines to translate evidence-based medicine and shared decision making into general practice: Theory-based intervention development, qualitative piloting and quantitative feasibility. *Implem entation*	IV: Cohort Study	No SIGN form for this level	To develop, pilot, and evaluate a new website linking risk calculator and existing audit and feedback tools with a decision aid to help providers identify pharmacologic al and nonpharmacol ogical recommendati ons based on Australian CVD prevention guidelines and facilitate	This mixed methods study details the theory-informed iterative process used to develop a web-based tool integrating the Framingham 5-year CVD risk calculator with an audit and feedback and guideline-based decision aid. The study was divided into the following stages: 1)	The first phase of this process was part of another study and methods were detailed in a previous publication by the researchers. In the second phase of this research, two groups of providers meeting at the "'Ask Share Know: Rapid Evidence for General Practice Decisions (ASK-GP) Centre of Research Excellence Clinical Laboratory'" discussed the tool and provided suggestions as part of the co-design process; discussions were audio recorded in order to clarify field	Stage 1 results: in order to address the psychological capability, physical opportunity, and reflective motivation components of the Change Wheel Framework, the CDSS will need to combine CVD risk calculation with evidence-based management algorithms to help providers identify risk category guidelines; shared decision making can be supported by personalized patient decision aids showing the effect of pharmacological, nonpharmacological,	Not evaluated	Stage 3 results: comments from providers who trialed the tool were overall positive and written feedback indicating an average score of 8.4/10 for overall acceptability. Stage 4 results: Feedback from think-aloud interviews led to changes to design and presentation of the tool to be black and white printer friendly and readable for those with visual impairments. Stage 5 results: Baseline open feedback from providers indicated that the most	Because the goal of several of the qualitative stages of the study was to rapidly adopt the changes suggested by end-users, formal qualitative thematic analysis was not completed. For the quantitative portion of the study, a pre-post design was used to maximize user input and

Science, 14(1), 86. https://doi-org.ezproxy.liberty.edu/10.1186/s13012-019-0927-x			provider-patient communication.	Development of the intervention based on Behaviour Change Wheel process and data extracted from the Healthy Heart Study (n=1,000, with 400 providers and 600 patients/consumers), 2) Design content with providers (convenience sample of n=18 providers), 3) Feedback from providers on web tool prototype (convenience sample of conference attendees, n=25 tested the prototype, n=16 of those filled out written feedback form), 4) Patient and provider think-aloud interviews provided feedback on a	notes as necessary (Bonner et al., 2019, p. 4). In the third phase, the tool was piloted at a conference and data was collected from discussions with providers who tried the tool in the researcher's booth as well filled out a brief feedback form. In the fourth phase, think-aloud interviews were conducted via Skype with patients and providers who trialed the tool to provide insight on content and design. In the final phase of this study, providers trialed the final product for 1 month to assess the feasibility of using the tool in practice using one of nine hypothetical patients that the provider was allowed to select; outcomes for this phase included intent to use the tool and accuracy of risk calculations and treatment decisions.	and complimentary treatments. Stage 2 results: feedback from providers led to development of the content of the online CDSS tool including 5-year CVD risk calculator, decision aid to support patient-provider conversations on risk, and information on benefits/harms of pharmacological management and lifestyle modification. Stage 5: using the online CDSS significantly increased accurate identification of high CVD risk patients and appropriate antihypertensive and cholesterol medications for hypothetical patient scenarios; correct identification of low risk patients increased by 16% (95% confidence interval 0-32%), moderate risk patients by 32% (95% confidence interval 6-57%), and high risk patients by 50% (95% confidence interval 35-65%). Using the tool was associated with increased identification of either antihypertensive or		common suggestion was improving access through integration with the EHR was t (48%, n=21), the second being formatting changes (29%, n=13), closely followed by content change suggestions (23%, n=10). Follow-up had similar suggestions for changes: formatting (58%, n=23), improving access (40%, n=41), and changing content (20%, n=8). Three suggestions which were not actionable for this study due to scope and funding include making the risk calculation and decision aid available to patients prior to the visit (provider and patient suggestion, improving efficiency/speed of calculation by auto-populating tool from EHR (provider suggestion), and making low-literacy version of decision aid for patients with low health literacy.	turnaround time for changes. Finally, the tool was designed to support the Australian CVD prevention guidelines specifically, not other national or international guidelines.

				functional version of the website (convenience sample n=19, 10 providers and nine patients), and 5) 1-month study of feasibility based on provider use over the same time period (baseline data from n=123, follow-up data from n=98).		cholesterol medication or both as appropriate treatment for high risk patients; fortunately, this did not increase inappropriate overtreatment of low risk patients; 19% of providers indicated they would prescribe CVD preventative medications for low risk hypothetical patient cases at baseline vs. 22% post-intervention. There was no increase in self-reported use of risk calculators post-intervention. This may be because there was a relatively high proportion of providers who were using other risk calculators at baseline; however, this tool was uniquely designed to support the implementation of Australian guidelines since there was no other available tool to serve this purpose.			
Chaudhry, A. P., Samudrala, S., Lopez-Jimenez, F., Shellum, J. L., Nishimura, R. A., Chaudhry, R., Liu, H., & Arruda-Olson, A. M. (2019). Provider survey on	VI: Qualitative	No SIGN form for this level	To evaluate providers opinions on CDSS used in an old EHR system in order determine if something similar would	Qualitative study which used convenience sampling and emailed 279 providers in the Mayo Clinic health system who provided	Nine-question provider survey evaluated if the CDSS for cardiovascular prevention available in the old EHR system was user-friendly, supported provider decision making, and if it should be added to	Not evaluated	Not evaluated	Survey results indicated that 96.0% of providers felt that the CV risk profile tool supported their thought processes at the point of care and 86.5% felt it was easy to use. These survey results were	As a qualitative study, it can only be applied to the specific context under analysis; however, the article provides insights into what elements

automated clinical decision support system for cardiovascular risk assessment. *AMIA Joint Summits on Translational Science, 64*–71.			be useful as is or with modifications. The tool in question displayed patient information: risk factors, body mass, vascular health, metabolic syndrome, CV mortality risk, lifestyle risk factors, recommendations, and follow-up.	cardiovascular care to patients. With a response rate of 35.8%, 100 providers responded to the survey. Of these 48 providers indicated that they had not used the CDSS for CV risk assessment in the old EHR system and were, thus, not able to finish the survey. Of the 52 providers who remained, 14 were fellows, 7 were NPs/PAs, and 31 were staff physicians or PhD exercise physiologists.	the new system with the same features or more features.			supplemented by a query of the system which revealed that the tool had been used heavily by providers with 39,396 reports generated by 282 users over a 12-year period.	of a CDSS providers see as helpful.
DeJonckheere, M., Robinson, C. H., Evans, L., Lowery, J., Youles, B., Tremblay, A., Kelley, C., & Sussman, J. B. (2018). Designing for clinical change: Creating an intervention to implement new	VI: Qualitative Study	No SIGN form for this level	To describe determinants of provider uptake of new statin guidelines and use provider feedback to develop a multicomponent guideline implementatio	This qualitative study used audiotaped interviews with Veterans Affairs clinicians to obtain input into their preferences for the design of a CDSS tool for	This qualitative study used feedback obtained in semi-structured interviews with providers to ascertain provider knowledge, attitudes, and behaviors related to implementation of the statin guidelines. Information elicited in provider interviews	Not evaluated	Not evaluated	Clinicians prefer accurate, simple, and straightforward prompts that are arranged logically and support evidence-based statin prescribing with the option to dismiss the prompt if it is inaccurate or irrelevant. Interviews	As a qualitative study, it naturally follows a non-experimental design and uses a small sample size of providers; as a result, results may not be generalizable

statin guidelines in a primary care clinic. *JMIR Human Factors, 5*(2), e19. https://doi-org.ezproxy.liberty.edu/10.2196/humanfactors.9030			n intervention (i.e. provider opinions on new statin guidelines, CDSS, audit and feedback) to support provider statin prescribing within a Veterans Affairs medical center.	statin prescribing which would later be developed for a quality improvement project. Semi-structured interviews were conducted with a convenience sample of 13 PCPs and two clinical pharmacists working in primary care at a Veterans Affairs facility.	was used to develop a user-centered CDSS designed to support provider evidence-based statin prescribing.			also indicated a preference for clear and direct language, easy-to-use formatting, and a CDSS that would improve efficiency. Referring to the calculation of 10-year ASCVD risk, one participant stated "If the reminder already calculated the risk, I'd love that. I hate having to go to the internet, or look on my smartphone, so I think the ideal reminder would calculate the risk for you" (p. 6).	to other Veterans Affairs facilities or other non-Veterans Affairs health systems. One strength of this study is it highlights design factors that influence the uptake of guideline-based CDSSs.
Raghu, A., Praveen, D., Peiris, D., Tarassenko, L., & Clifford, G. (2015). Engineering a mobile health tool for resource-poor settings to assess and manage cardiovascular disease risk: SMARTHealth study. *BMC Medical Informatics & Decision Making, 15*(1), 36. https://doi-org.ezproxy.liberty	VI: Descrip-tive Study	No SIGN form for this level	To describe the development and pilot testing of a mobile health solution which provides CDS for CVD primary prevention in rural India.	This pilot study uses a convenience sample of 11 non-physician village health workers to field test the SMARTHealth mobile-based CDS. This all-female workforce provides community health outreach in rural areas of India where the physician	The SMARTHealth mobile app was field tested by 11 community health workers called Accredited Social Healthcare Activists (ASHAs) during home visits to members of their communities. Outcomes of interest included the number of patients who were screened and proportion who were at high CVD risk per screening, system efficiency, user variability, usefulness of point-of-care	Of the 227 patients screened, 57% (n=128) were identified to be at high risk of CVD, which resulted in physician referrals for either high CVD risk (n=88) or impaired fasting glucose (n=40). This intervention was, therefore, useful for identifying high risk individuals in the community and facilitated appropriate referrals for physician follow-up.	Not evaluated	As the field testing progressed, the time required to complete the CVD screening using the tool decreased as the users became more comfortable and proficient with the tool. Questionnaires designed to evaluate community health workers' opinion on the tool's usability after each use found that the tool was perceived as easy to use for the screening procedure 72% of the time.	Lacked randomization and control group; there was no data to compare the number of patients who received CVD screening prior to field testing in the villages.

.edu/10.1186/s12911-015-0148-4				to patient ratio is 1:20,000 (compared to the urban ratio of 1:2,000).	recommendations, usability, and CVD referrals.				
Silveira, D. V., Marcolino, M. S., Machado, E. L., Ferreira, C. G., Alkmim, M. B. M., Resende, E. S., Carvalho, B. C., Antunes, A. P., & Ribeiro, A. L. P. (2019). Development and evaluation of a mobile decision support system for hypertension management in the primary care setting in Brazil: Mixed-Methods field study on usability, feasibility, and utility. *JMIR MHealth and UHealth, 7*(3), e9869. https://doi-org.ezproxy.liberty.edu/10.2196/mhealth.9869	VI: Descrip-tive Study	No SIGN form for this level	To evaluate the feasibility, utility, and usability of a mobile technology based CDSS for the management of hypertension in primary care clinics in Brazil.	This mixed methods field study examines the development of a CDSS called TeleHAS (tele-hipertensão arterial sistêmica which translates to arterial hypertension). Prior to field testing, the CDSS was evaluated by a small panel of experts consisting of five physicians: three PCPs and two cardiologists. In order to obtain a sample of providers from the 88 physicians in Monte Claros, Brazil, researchers invited physicians to a	The TeleHAS (tele-hipertensão arterial sistêmica which translates to arterial hypertension) was developed based on evidence-based practice guidelines and the latest available research supporting best practices; the tool uses the Cockcroft-Gault formula to estimate glomerular filtration rate, calculates BMI, and estimates CVD risk based on the Framingham score; this in addition to patient data entered into the CDSS generates evidence-based recommendations for pharmacological and non-pharmacological treatment. The tool was designed to operate without Wi-Fi since no clinics in the sample had access to Wi-Fi due to high costs. Outcomes of field testing were evaluated at 3 and at	Only three out of the ten providers used to tool to calculate cardiovascular risk using the 10-year global risk score chart.	Not evaluated	Providers on the expert panel provided suggestions for revision but also indicated that they believed it would support implementation of evidence-based practice in the Brazilian primary care context. Providers in the field-testing group used the TeleHAS database with 535 patients and used it in 632 patient encounters. The main criticism of the tool was that it caused work duplication by requiring providers to enter patient data into the Android powered tablet device. Because of lack of Wi-Fi and EHRs at these clinics, a CDSS that automatically populated patient data was not feasible; however, authors concluded that a CDSS which	This study did not quantify the effects on actual provider practice or adherence to guidelines; however, based on provider feedback, the authors suggest that an ideal CDSS would be integrated into an EHR (something not available in this district of Brazil) and would decrease not add to provider workload in order to support best practices of providers who already have an "excessive workload" (Silveira et al., 2019, p. 9). While this tool did support provider

				lecture on hypertension; of 63 physicians who attended, 51 agreed to participate in field testing, and 10 were randomly selected for inclusion. Participants were predominantly young, inexperienced female physicians (<5 years of experience).	6 months post-intervention and included providers' perceptions of feasibility, usability, and utility of the tool; these domains were measured using semi-structured interviews and 5-point Linkert scale surveys.			required minimal data entry by providers would be ideal. Providers in the sample did not have previous experience with CDSS, and many indicated on surveys that they felt that training was essential to use this tool even though the designers had felt the tool navigation was intuitive. Overall, the tool was rated as feasible to use in the Brazilian primary care setting (100%), easy to incorporate into clinic or home visits (80%); nevertheless, 70% indicated the time to fill out the application cause significant delays in service. Eighty percent indicated the tool was good, 100% that the tool was user-friendly and had the potential to improve patient's treatment. Finally, 90% indicated that the tool gave them access to new knowledge about CVD risk and hypertensive	practice, it left providers feeling frustrated by the duplication of efforts which, unless addressed, will likely limit uptake and scalability in other regions of Brazil.

								treatment and believed it promoted preventive treatments and management.	
Williams, P. A., Furberg, R. D., Bagwell, J. E., & LaBresh, K. A. (2016). Usability testing and adaptation of the pediatric cardiovascular risk reduction clinical decision support tool. *JMIR Human Factors, 3*(1), e17. https://doi-org.ezproxy.liberty.edu/10.2196/humanfactors.5440	VI: Descrip-tive Study	No SIGN form for this level	To examine the usability of the mobile-based CDS tool being developed: Pediatric Cardiovascular Risk Reduction CDS Tool.	Snowball recruiting was used to obtain the sample of five providers for the first phase of this study; this convenience sample of providers was obtained from two universities in Raleigh-Durham, North Carolina. In the first phase, five clinicians performed in-person testing of the app with a "think-aloud" approach without any assistance from the researchers; providers tested the CDS using test cases; provider's verbal feedback were audio-recorded for later	The mobile-based CDSS was designed as applications (apps) for Apple iOS and Android and provides recommendations based on national guidelines for cardiovascular health and risk reduction in pediatrics. Outcomes of interest were provider's feedback (positive, negative, and suggestions) in both phases of the study; user experience was quantitatively evaluated using the SUS questionnaire in the final stage.	Not evaluated	Not evaluated	Overall feedback from providers on the second iteration of the mobile-based CDS was positive. Users preferred apps to present data in a streamlined manner and highlight critical results. Providers requested recommendations to be succinct and tailored to patients based on risk factors. Based on provider feedback, the final product allowed providers to enter as much or as little information as they chose in order to obtain the information they required; providers were not forced to enter all data fields and data flowed between different sections of the CDS to avoid redundancy in entering information.	The study did not evaluate the effect of the tool on frequency of provider CVD risk discussions and adherence to evidence-based guidelines. One strength of this study is that it demonstrates how a user-centered mobile-based CDS can be developed using an iterative process informed by end-users.

				analysis. In the second stage, 14 pediatricians tested the CDS in the clinic with real patient encounters. Provider feedback in this two-week study period was elicited via unstructured comments received via email, telephone, or short message service as well as user experience quantified using the 10-item System Usability Scale (SUS) questionnaire.					
Benson, T. (2019). Digital innovation evaluation: User perceptions of innovation readiness, digital confidence, innovation adoption, user experience and behaviour change. *BMJ Health & Care*	VII: Expert Opinion	No SIGN form for this level	To describe a framework designed to understand why healthcare innovations do or do not spread within a system or across systems.	This article describes the design principles followed and iterative process Benson (2019) completed to develop the surveys which evaluate: innovation	Benson (2019) describes the coherence of the five tools developed from various models with the NASSS framework.	Not evaluated	Not evaluated	Not evaluated	This paper describes the development of five measures that users can answer to self-evaluate their readiness for innovation and the likelihood that the innovation

Informatics, 26(1), 0.5-0. doi:10.1136/bmjhci-2019-000018				readiness, digital confidence, innovation adoption, user satisfaction, and behavior change.					with be maintained. The measures were linked to the NASSS framework but Benson (2019) admits that the measures need to be tested with real-world application for validation and evaluation of applicability. Since one of the major barriers identified in application of CVD prevention CDSSs in the clinical setting is resistance to change and less than 100% adoption among clinicians, this framework brings context to the problem and possible solutions by helping to identify providers who feel less comfortable with technology and

									may benefit from additional support.

Notes: SIGN form ratings are as follows ++ = high quality, + = acceptable, - = low quality, and 0 = reject/unacceptable. Table is sorted by level of evidence in descending order and then by author last name in alphabetical order.

Appendix B

Collaborative Institutional Training Initiative (CITI) Certificate

CITI PROGRAM

Completion Date 28-Aug-2019
Expiration Date 27-Aug-2022
Record ID 22479221

This is to certify that:

Elisabeth Campbell

Has completed the following CITI Program course:

Social & Behavioral Research - Basic/Refresher (Curriculum Group)
Social & Behavioral Researchers (Course Learner Group)
1 - Basic Course (Stage)

Under requirements set by:

Liberty University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?wa182aae3-b4e0-4ee7-bcb1-45d7a8a6f95f-22479221