Effect of Clinical Decision Support at Community Health Centers on the Risk of Cardiovascular Disease
A Cluster Randomized Clinical Trial

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Abstract

IMPORTANCE Management of cardiovascular disease (CVD) risk in socioeconomically vulnerable patients is suboptimal; better risk factor control could improve CVD outcomes.

OBJECTIVE To evaluate the impact of a clinical decision support system (CDSS) targeting CVD risk in community health centers (CHCs).

DESIGN, SETTING, AND PARTICIPANTS This cluster randomized clinical trial included 70 CHC clinics randomized to an intervention group (42 clinics; 8 organizations) or a control group that received no intervention (28 clinics; 7 organizations) from September 20, 2018, to March 15, 2020. Randomization was by CHC organization accounting for organization size. Patients aged 40 to 75 years with (1) diabetes or atherosclerotic CVD and at least 1 uncontrolled major risk factor for CVD or (2) total reversible CVD risk of at least 10% were the population targeted by the CDSS intervention.

INTERVENTIONS A point-of-care CDSS displaying real-time CVD risk factor control data and personalized, prioritized evidence-based care recommendations.

MAIN OUTCOMES AND MEASURES One-year change in total CVD risk and reversible CVD risk (ie, the reduction in 10-year CVD risk that was considered achievable if 6 key risk factors reached evidence-based levels of control).

RESULTS Among the 18 578 eligible patients (9490 [51.1%] women; mean [SD] age, 58.7 [8.8] years), patients seen in control clinics (n = 7419) had higher mean (SD) baseline CVD risk (16.6% [12.8%]) than patients seen in intervention clinics (n = 11 159) (15.6% [12.3%]; P < .001); baseline reversible CVD risk was similarly higher among patients seen in control clinics. The CDSS was used at 19.8% of 91 988 eligible intervention clinic encounters. No population-level reduction in CVD risk was seen in patients in control or intervention clinics; mean reversible risk improved significantly more among patients in control (−0.1% [95% CI, −0.3% to −0.02%]) than intervention clinics (0.4% [95% CI, 0.3% to 0.5%]; P < .001). However, when the CDSS was used, both risk measures decreased more among patients with high baseline risk in intervention than control clinics; notably, mean reversible risk decreased by an absolute 4.4% (95% CI, −5.2% to −3.7%) among patients in intervention clinics compared with 2.7% (95% CI, −3.4% to −1.9%) among patients in control clinics (P = .001).

CONCLUSIONS AND RELEVANCE The CDSS had low use rates and failed to improve CVD risk in the overall population but appeared to have a benefit on CVD risk when it was consistently used for patients with high baseline risk treated in CHCs. Despite some limitations, these results provide

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Abstract (continued)
preliminary evidence that this technology has the potential to improve clinical care in socioeconomically vulnerable patients with high CVD risk.

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Introduction
Evidence-based management of modifiable risk factors for cardiovascular disease (CVD) can substantially reduce CVD-related morbidity and mortality risks. However, a deficit persists between recommended and observed CVD risk management, especially among socioeconomically vulnerable patients.1-6 One reason for this is that primary care clinicians must consider multiple factors affecting CVD risk for a given patient7 and determine which to address to optimally affect that patient's risk within a brief encounter.8-15

Electronic health record (EHR)–based clinical decision support systems (CDSS) address such barriers by alerting clinicians when patients have uncontrolled CVD risks and suggesting treatment options.16-31 CV Wizard, for example, is a nonproprietary, web-based CDSS developed at HealthPartners Institute, a large, nonprofit, integrated health care system.32-36 The CV Wizard algorithms reflect current CVD care guidelines37-43 and account for a patient’s blood pressure (BP), laboratory results, distance from goals, medications, and comorbidities. At HealthPartners Institute and in similar settings, rates of use and reported user satisfaction were high, and use was associated with significant decreases in CVD risk measures.32-36

Little evidence exists on the effects of CDSS in underresourced settings23-31,33,44-47 such as community health centers (CHCs), which serve more than 38 million socioeconomically vulnerable US residents annually. Implementing a CDSS that has proven effective in other settings could enhance CVD risk management in CHCs. Evidence is needed about the effect of CDSS such as CV Wizard in CHCs, whose patients have high rates of uncontrolled CVD risk and medical and social complexity.2-4,48,49 This cluster randomized clinical trial is one of the first to assess whether a CDSS developed in an integrated care setting improves outcomes in CHCs.

Methods
Setting
OCHIN Inc is a national nonprofit operating the largest network of community-based care organizations in the country. Its members (96 CHC organizations running 493 clinic sites in 14 states as of September 2018) share an OCHIN Epic EHR. In 2017 to 2018, CV Wizard was set up to work in this EHR50 and pilot-tested in 2 OCHIN Inc member organizations (9 clinics).

Ethics Approval and Safety Monitoring
The Kaiser Permanente Northwest institutional review board approved all research activities and monitored study progress. A data and safety monitoring board monitored safety outcomes. The institutional review board granted a waiver for obtaining patient consent in this cluster randomized clinical trial, and all OCHIN Inc members sign an agreement that their EHR data may be used for research. The original and current institutional review board–approved study protocols are available in Supplement 1. This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guideline.
Sample Size, Recruitment, and Randomization

Our power calculations conservatively estimated needing 30 clinics per group. They then varied effect size associated with group × time interaction and intraclass correlation to assess power to identify a 1.5%, 2.0%, or 3.0% absolute reduction in risk score over time in intervention vs control sites.

In Spring 2018, 70 OCHIN Inc member clinics run by 15 CHC organizations were recruited (10 more than needed, in case of dropout). Eligible clinics served at least 35 adults with hypertension annually and were not the pilot sites. They were cluster randomized 1:1 to the intervention or the control group by organization (to avoid contamination between clinics in the same organization) as follows. Random numbers were generated for each organization, which were then assigned to groups above or below the random numbers’ median. This process was repeated 5 times. The grouping with the most even distribution of organization size (number of encounters in the prior year) and patient characteristics (percentage of tobacco users and percentage with hypertension) was used to assign intervention and control status.

Study Design

CV Wizard was activated in the intervention and control organizations in September 2018. It ran invisibly in the control clinics to collect data without giving access to the tool. Patients seen at study clinics in the first 6 months after tool activation were followed up for at least 1 year during an 18-month comparison period (September 20, 2018, to March 15, 2020). Control sites received the CDSS after follow-up.

Intervention

At the point of care, CV Wizard identified patients aged 40 to 75 years with diabetes or atherosclerotic CVD and at least 1 uncontrolled CVD risk factor, or high reversible risk (>10% ten-year risk of a cardiovascular event), calculated based on other CVD risk factors. Reversible risk was calculated as the difference between the patient’s current state and the expected risk should the patient achieve control goals recommended by national guidelines (details are provided hereinafter). When a patient met CDSS eligibility criteria, roaming staff saw an EHR alert containing a link to the CV Wizard interfaces. The recommended workflow was to then view (1 click) and print (1 click) the interfaces, which show the patient’s 10-year CVD risk and how they could lower it by following personalized care recommendations. Users could access a clinician version (eFigure 1 in Supplement 2) and a patient version (eFigure 2 in Supplement 2), the latter in either English or Spanish. Tool use was defined as the proportion of primary care encounters among eligible patients where the CDSS tool’s output was viewed and/or printed. Tool use counts included use at the index visit or subsequent study period visits, excluding the patient’s last visit during the study period.

Data Source

Data on 10-year CVD risk and reversible risk were collected through CV Wizard’s web service for all eligible patients. Additional EHR-extracted data came from the Accelerating Data Value Across a National Community Health Center Network (ADVANCE) Clinical Research Network, a Patient-Centered Clinical Research Network member, including demographic characteristics, BP, medications, laboratory values, diagnostic codes, and clinic characteristics. Outcomes were assessed using encounter data from all postindex visits.

Study Participants

The target population consisted of patients meeting the aforementioned CV Wizard eligibility criteria excluding those with current or recent pregnancy, active cancer, or hospice or palliative care. Analyses included target patients with an index visit at a study clinic in the 6 months after CV Wizard activation and 1 or more postindex encounters during 12 months of follow-up. This ensured adequate follow-up data for the study analyses.
Patients newly diagnosed with diabetes during the follow-up period (347 [1.9%]) were excluded from CVD risk analyses because diabetes may be diagnosed more often with CDSS use. Because the presence of diabetes substantially raises total CVD risk estimation, this exclusion removed the possibility of confounding based on the likelihood of a new diabetes diagnosis.

Outcomes
The primary outcomes were 1-year change in total CVD risk and 1-year change in reversible CVD risk. Total CVD risk was estimated using the American College of Cardiology/American Heart Association pooled risk equations, which include age, race and ethnicity, sex, systolic BP, total cholesterol level, high-density lipoprotein cholesterol level, and diabetes, smoking, and antihypertensive medication status.51 Race and ethnicity data were extracted from the EHR; these data are collected by the study clinics as part of patient care. These data were considered relevant to the study because rates of uncontrolled CVD risk differ across racial/ethnic groups. Reversible CVD risk was calculated as follows (with additional details in the eMethods in Supplement 2 and methods described previously32-36). Standardized equations estimated the potential reduction in CVD risk if a patient’s uncontrolled risk factors reached evidence-based thresholds. Change was calculated by subtracting reversible risk at follow-up from that at index visit; negative values represent favorable changes. This approach focuses clinical attention on patients with high reversible CVD risk, rather than all patients with high total CVD risk.34 It also focuses on risk factors not adequately addressed by American College of Cardiology/American Heart Association equations: change in hemoglobin A1c (HbA1c) level or body mass index and aspirin use. This estimation of patient-level reversible CVD risk, although imprecise, is likely superior to the demonstrably erroneous estimates of CVD benefits and risks broadly used in primary care and to intuitive estimates of benefit or risk.32,33,52 In exploratory analyses, these outcomes were stratified by baseline risk of less than 10%, 10% to less than 20%, and at least 20%, because analyses in other settings indicated CV Wizard’s potentially greater impact among patients with higher baseline risk.34 Patients with lower baseline risk were less likely to improve, and clinical implications for these groups differ. Secondary outcomes assessed change in BP, low-density lipoprotein (LDL) level, and HbA1c levels for those above goal at baseline; analyses included patients with at least 1 follow-up value.

Statistical Analysis
Descriptive statistics compared baseline characteristics of intervention vs control groups and CHC organizations. We used a 2-tailed \( \chi^2 \) test, unpaired t test, and nonparametric Wilcoxon rank sum test as appropriate. The threshold for statistical significance was \( P < .05 \) and was 2-tailed.

The extent of CDSS adoption drives its population-level impact,53,54 and therefore analyses differentiated between the tool’s population impact and its impact when used. Intention-to-treat (ITT) analyses (all targeted patients at intervention vs control organizations) assessed population impact. The effect of treatment on the treated (ETOT; also termed per protocol) analyses assessed impact when used, comparing patients in the intervention CHC group with matched controls (each group matched separately to control patients) based on exposure to the CDSS.

In 3-level random-intercept models (encounter nested within patient and clinic), the intraclass correlation coefficients at the clinic level were 0.05 for CVD risk, 0.04 for both reversible risk and BP, and less than 0.03 for HbA1c and LDL levels. In 4-level random-intercept models (encounter nested within patient, clinic, and organization), intraclass correlation coefficients at the organization level were at least 0.02 for reversible risk, BP, and HbA1c, and LDL levels, and 0.05 for CVD risk. Because of the complexity of fitting the 4-level models, and the low organization-level intraclass correlation coefficient, all models were fit using a 3-level random intercept.

ITT Analysis
Differences in outcome changes were assessed using multilevel mixed models adjusted for these individual-level fixed effects: baseline CVD risk; distribution of eligible patients by age, race and...
ethnicity, sex, rural-urban commuting area status, and federal poverty level at index visit; and number of ambulatory visits during the follow-up period. These variables, selected a priori, were confirmed by descriptive analyses showing significant differences between baseline intervention and control organization and patient characteristics. Residual distributions indicated that linear-mixed models were appropriate for all outcomes except the reversible risk model that included all study patients, which had a negative binomial distribution.

ETOT Analysis
To assess the CDSS tool’s impact when it was used, analyses were conducted among patients for whom the tool was ever used during follow-up. To assess association with increasing use, we also considered 3 categories of tool use (never, once, and more than once).

Per protocol analyses require adjusting for loss to follow-up and off-protocol therapies or treatments, but if group differences vary too greatly, model misspecification can yield biased estimates. Propensity score methods are an alternative. In ETOT analyses of change in CVD risk, patients in the intervention organizations were matched to those in control organizations based on age, federal poverty level, outcome of interest at baseline, race and ethnicity, sex, count of ambulatory care visits after the index visit, time from the index visit to the last study period visit, and clinic rural or urban status. The BP, HbA1c, and LDL analyses also matched on presence of diabetes. Propensity scores were estimated using nearest-neighbor matching with replacement. Analyses of change in total and reversible CVD risk included all patients meeting study inclusion criteria; for other outcomes, analyses were restricted to patients with uncontrolled baseline risk. Residual distributions indicated that linear mixed models were appropriate for all outcomes. All analyses were performed using Stata, version 15.1 (StataCorp LLC).

Results
Participants
A total of 18,578 eligible patients were seen at the study clinics during the study period. The mean (SD) age was 58.7 (8.8) years, and there were 9,490 (51.1%) women and 9,088 (48.9%) men. In terms of race and ethnicity, 4,934 (26.6%) were Hispanic, 3,351 (18.0%) were non-Hispanic Black, 8,434 (45.4%) were non-Hispanic White, 1,038 (5.6%) were non-Hispanic in another racial group, and 821 (4.4%) did not have documented race and ethnicity data (Table 1). Randomization (Figure) yielded 42 intervention clinics from 8 organizations (11,159 patients) and 28 control clinics from 7 organizations (7,419 patients). Distribution of patient and clinic characteristics differed significantly between intervention and control organizations (3,891 [34.9%] vs 4,543 [61.2%] non-Hispanic White, respectively; urban clinic location, 35 of 42 [83.3%] vs 15 of 28 [53.6%]) (Table 1 and eTable in Supplement 2).

Use Rates
CV Wizard was used at 34.7% of index encounters (clinic range, 0%-59.0%). Among patients for whom it was used, it was used a mean of 2.4 (1.9) times during follow-up. It was used at 19.8% of all 91,988 eligible encounters during the study period, including index and follow-up encounters.

Intervention Impact on 10-Year CVD Risk: ITT Analysis
In the ITT analysis, patients in control clinics had significantly higher mean (SD) baseline 10-year CVD risk (16.6% [12.8%]) than patients in intervention clinics (15.6% [12.3%]: P < .001) (Table 2). Change in this risk did not differ significantly between intervention vs control clinics overall. In a subgroup analysis, mean 10-year CVD risk did not improve among patients with baseline CVD risk of less than 20% (risk <10%, 1.8% [95% CI, 1.0-2.5] vs 1.3% [95% CI, 0.7-2.0], P < .001; risk of 10% to <20%, 0.3% [95% CI, −0.1 to 0.7] vs 0.6% [95% CI, 0.2-1.0], P < .001). Among those with baseline risk of at least 20%, the mean 10-year risk improved significantly more among patients in control clinics.
\((-1.4\% [95\% CI, -1.6\% to -1.2\%])\) than those in intervention clinics \((-1.0\% [95\% CI, -1.2\% to -0.8\%]; \ P = .004)\).

**Intervention Impact on 10-Year CVD Risk: ETOT Analysis**

In ETOT analyses, among patients with baseline CVD risk of less than 10%, risk did not improve in any CDSS use categories (Table 3). However, the mean change in CVD risk was significantly greater among patients in intervention clinics with a baseline risk of at least 20% \((-0.9\% [95\% CI, -1.2\% to -0.7\%])\) compared with matched control patients \((-0.3\% [95\% CI, -0.5\% to -0.1\%]; \ P < .001)\) (Table 4).

### Table 1. Patient Characteristics at Baseline

| Patient group* | Intervention clinics (n = 11 159) | Intervention clinic subsets by times CV Wizard used | Control clinics (n = 7419) |
|----------------|----------------------------------|-----------------------------------------------|---------------------------|
|                | No. of visits/patient after index visit, mean (SD) | 8.6 (7.4) | 7.3 (5.6) | 11.3 (9.0) | 7.0 (5.9) | 8.3 (6.9) |
| Age, mean (SD), y | 58.3 (8.9) | 58.5 (8.9) | 58.9 (8.6) | 57.8 (8.9) | 59.3 (8.7) |
| Sex | | | | | |
| Women | 5872 (52.6) | 1492 (47.2) | 2150 (45.4) | 2230 (50.8) | 3618 (48.8) |
| Men | 5287 (47.4) | 1336 (42.8) | 1789 (54.6) | 2162 (49.2) | 3801 (51.2) |
| Race and ethnicity | | | | | |
| Hispanic | 2785 (25.0) | 731 (25.9) | 676 (17.2) | 1378 (31.4) | 1196 (16.1) |
| Non-Hispanic | | | | | |
| Black | 2385 (21.4) | 631 (22.3) | 1196 (32.3) | 558 (12.7) | 966 (13.0) |
| White | 3891 (34.9) | 963 (34.1) | 1362 (34.6) | 1566 (35.7) | 4543 (61.2) |
| Otherb | 658 (5.9) | 161 (5.7) | 215 (5.5) | 282 (6.4) | 380 (5.1) |
| Unknown | 1440 (12.9) | 342 (12.1) | 490 (12.4) | 608 (13.8) | 334 (4.5) |
| Uncontrolled CVD risk | | | | | |
| Blood pressure >140/90 | 4062 (36.2) | 1098 (38.8) | 1271 (32.3) | 1666 (37.9) | 3501 (47.2) |
| Statin use | 5668 (50.8) | 1427 (50.5) | 2100 (53.3) | 2141 (48.8) | 4089 (55.1) |
| BMI >25 | 9039 (81.0) | 2282 (80.7) | 3223 (81.8) | 3534 (80.5) | 5952 (80.2) |
| Hemoglobin A1c level >8% | 1947 (17.5) | 461 (16.3) | 738 (18.7) | 748 (17.0) | 1163 (15.7) |
| Current tobacco use | 3177 (28.5) | 802 (28.4) | 1171 (29.7) | 1204 (27.4) | 2816 (38.0) |
| Federal poverty level | | | | | |
| ≤138% | 6776 (60.7) | 1679 (59.4) | 2624 (66.6) | 2473 (56.3) | 3385 (45.6) |
| >138% | 2612 (23.4) | 669 (23.7) | 823 (20.8) | 1120 (25.5) | 1062 (14.3) |
| Unknown | 1771 (15.9) | 480 (17.0) | 492 (12.5) | 799 (18.2) | 2972 (40.1) |
| Insurance at index visit | | | | | |
| Uninsured | 2016 (18.5) | 500 (17.7) | 618 (15.7) | 943 (21.5) | 1165 (15.0) |
| Medicare | 3550 (31.8) | 887 (31.4) | 1422 (36.1) | 1241 (28.3) | 2731 (36.8) |
| Medicaid | 3779 (33.9) | 951 (33.6) | 1278 (32.4) | 1550 (35.3) | 2186 (29.5) |
| Private insurance | 1312 (11.8) | 367 (13.0) | 496 (12.6) | 449 (10.2) | 1256 (16.9) |
| Other public insurance | 457 (4.1) | 123 (16.9) | 598 (15.2) | 209 (4.8) | 32 (0.4) |
| Select diagnoses | | | | | |
| Diabetes | 9180 (82.3) | 2316 (81.9) | 3379 (85.8) | 3485 (79.4) | 5264 (71.0) |
| End-stage kidney disease | 224 (2.0) | 54 (1.9) | 79 (2.0) | 91 (2.1) | 63 (0.9) |
| Chronic kidney disease | 1852 (16.6) | 471 (16.7) | 753 (19.1) | 628 (14.3) | 1121 (15.1) |
| Characteristics that trigger the CDSS alertc | | | | | |
| Uncontrolled CVD | 2419 (21.7) | 562 (19.9) | 915 (23.2) | 942 (21.5) | 1824 (24.6) |
| Reversible risk >10% | 3579 (32.1) | 951 (33.6) | 1251 (31.8) | 1377 (31.4) | 3267 (44.0) |
| Uncontrolled diabetes | 9026 (80.9) | 2272 (80.3) | 3331 (84.6) | 3423 (77.9) | 5105 (68.8) |

**Abbreviations:** BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CDSS, clinical decision support system; CVD, cardiovascular disease.

* Unless otherwise indicated, data are expressed as number (%) of patients.

**b** Includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and other race or ethnicity.

**c** These categories are not mutually exclusive.
Intervention Impact on 10-Year Reversible CVD Risk: ITT Analysis

Patients in control clinics had significantly higher mean (SD) baseline reversible risk (9.7% [10.0%]) than those in intervention clinics (7.9% [9.0%]; P < .001). Overall, in ITT analyses, reversible risk improved significantly more among patients in control clinics (mean, −0.1% [95% CI, −0.3% to −0.02%]) compared with patients in intervention clinics (mean, 0.4% [95% CI, 0.3%−0.5%]; P < .001).

In ITT analyses, change in reversible risk did not differ across study groups in patients with baseline risk of less than 10% or at least 20%. Reversible risk improved significantly more among patients in control clinics (mean, −1.2% [95% CI, −1.5% to −1.0%]) compared with patients in intervention clinics (mean, −0.7% [95% CI, −0.9% to −0.5%]; P = .001) with a baseline reversible risk of at least 10% to less than 20% (Table 2).

Intervention Impact on 10-Year Reversible CVD Risk: ETOT Analysis

In ETOT analyses, no improvement was seen among patients with a baseline reversible CVD risk of less than 10%, regardless of tool use. Among patients with a baseline risk of at least 10%, no significant differences were seen when the tool was used once or never (Table 3), but when it was used more than once, reversible CVD risk for patients in intervention clinics improved significantly more than that of patients in control clinics (mean, −1.7% [95% CI, −2.0% to −1.3%] vs 0.1% [95% CI, −0.5% to −0.2%]; P < .001). When stratified, no improvement was seen among those with baseline risk of less than 10% (Table 4), but patients in intervention clinics improved significantly more than patients in control clinics among those with baseline risk of at least 10% to less than 20% (mean, −0.7% [95% CI, −0.9% to −0.4%] vs −0.2% [95% CI, −0.5% to 0.04%], respectively; P = .04) and at least 20% (mean, −4.4% [95% CI, −5.2% to −3.7%] vs −2.7% [95% CI, −3.4% to −1.9%], respectively; P = .001).

Impact on Specific CVD Risk Factors

In ITT analyses, no significant difference was seen in change in systolic BP or diastolic BP (DBP) or in HbA1c or LDL levels among those with high baseline measures of each biomarker (Table 2). In ETOT analyses, LDL levels did not improve significantly more in patients in intervention or control clinics in any tool use categories. Although mean DBP improved significantly more in patients in intervention
Table 2. Results of ITT Analyses Comparing Intervention and Control Clinic Changes in Measures of CVD Risk During Follow-up Period*

| CVD measure                          | Clinic group |          |          |          |          |          |          |          |          | P value |
|--------------------------------------|--------------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
|                                      | Intervention (n = 11 159) | Control (n = 7419) |          |          |          |          |          |          |          |---------|
| 10-y CVD risk results                 |              |          |          |          |          |          |          |          |          |---------|
| All patients                          |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 10 984       | 7247     | NA       |          |          |          |          |          |          |         |
| Baseline CVD risk, mean (SD), %      | 15.6 (12.3)  | 16.6 (12.8) | <.001   |          |          |          |          |          |          |         |
| Mean annual change in CVD risk, % (95% CI) | 0.4 (0.3-0.5) | 0.2 (0.1-0.3) | .001   |          |          |          |          |          |          |         |
| Patients with baseline CVD risk <10%  |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 4234         | 2514     | NA       |          |          |          |          |          |          |         |
| Baseline CVD risk, mean (SD), %      | 4.4 (3.0)    | 4.3 (3.2) | .10      |          |          |          |          |          |          |         |
| Mean annual change in CVD risk, % (95% CI) | 1.3 (1.2-1.4) | 1.8 (1.6-1.9) | <.001 |          |          |          |          |          |          |         |
| Patients with baseline CVD risk ≥10% to <20% |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 3307         | 2229     | NA       |          |          |          |          |          |          |         |
| Baseline CVD risk, mean (SD), %      | 14.7 (2.9)   | 14.7 (2.9) | .29      |          |          |          |          |          |          |         |
| Mean annual change in CVD risk, % (95% CI) | 0.6 (0.5-0.7) | 0.3 (0.1-0.4) | <.001 |          |          |          |          |          |          |         |
| Patients with baseline CVD risk ≥20%  |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 3443         | 2504     | NA       |          |          |          |          |          |          |         |
| Baseline CVD risk, mean (SD), %      | 30.6 (9.4)   | 31.1 (9.6) | .06      |          |          |          |          |          |          |         |
| Mean annual change in CVD risk, % (95% CI) | -1.0 (-1.2 to -0.8) | -1.4 (-1.6 to -1.2) | .004 |          |          |          |          |          |          |         |
| Reversible CVD risk results           |              |          |          |          |          |          |          |          |          |---------|
| All patients                          |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 10 984       | 7247     | NA       |          |          |          |          |          |          |         |
| Baseline reversible risk, mean (SD), % | 7.9 (9.0)   | 9.7 (10.0) | <.001   |          |          |          |          |          |          |         |
| Mean annual change in reversible risk, % (95% CI) | 0.4 (0.3 to 0.5) | -0.1 (-0.3 to -0.02) | <.001 |          |          |          |          |          |          |         |
| Patients with baseline reversible risk <10% |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 7496         | 4090     | NA       |          |          |          |          |          |          |         |
| Baseline reversible risk, mean (SD), % | 3.2 (2.7)   | 3.4 (2.7) | <.001   |          |          |          |          |          |          |         |
| Mean annual change in reversible risk, % (95% CI) | 1.3 (1.2-1.4) | 1.2 (1.1-1.3) | .11      |          |          |          |          |          |          |         |
| Patients with baseline reversible risk 10% to <20% |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 2552         | 2386     | NA       |          |          |          |          |          |          |         |
| Baseline reversible risk, mean (SD), % | 13.6 (2.8)  | 13.6 (2.7) | .53      |          |          |          |          |          |          |         |
| Mean annual change in reversible risk, % (95% CI) | -0.7 (-0.9 to -0.5) | -1.2 (-1.5 to -1.0) | .001   |          |          |          |          |          |          |         |
| Patients with baseline reversible risk ≥20% |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 936          | 771      | NA       |          |          |          |          |          |          |         |
| Baseline reversible risk, mean (SD), % | 29.8 (11.8) | 30.7 (13.3) | .11      |          |          |          |          |          |          |         |
| Mean annual change in reversible risk, % (95% CI) | -4.8 (-5.4 to -4.1) | -4.5 (-5.2 to -3.7) | .54      |          |          |          |          |          |          |         |
| Patients with high baseline BP        |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 4035         | 3503     | NA       |          |          |          |          |          |          |         |
| Baseline, mean (SD), mm Hg            |              |          |          |          |          |          |          |          |          |---------|
| Systolic                              | 152.5 (15.0) | 154.7 (15.2) | <.001   |          |          |          |          |          |          |         |
| Diastolic                             | 85.0 (11.4)  | 86.7 (11.6) | <.001   |          |          |          |          |          |          |         |
| Mean annual change, mm Hg (95% CI)    |              |          |          |          |          |          |          |          |          |---------|
| Systolic                              | -7.5 (-7.9 to -7.0) | -8.0 (-8.5 to -7.6) | .10    |          |          |          |          |          |          |         |
| Diastolic                             | -3.5 (-3.8 to -3.3) | -3.6 (-3.8 to -3.3) | .84    |          |          |          |          |          |          |         |
| Patients with high baseline HbA1c level |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 1947         | 1163     | NA       |          |          |          |          |          |          |         |
| Baseline HbA1c level, mean (SD), %    | 10.2 (1.8)   | 10 (1.7)  | .001    |          |          |          |          |          |          |         |
| Mean annual change in HbA1c level, % (95% CI) | -0.7 (-0.7 to -0.6) | -0.8 (-0.9 to -0.7) | .16    |          |          |          |          |          |          |         |
| Patients with high baseline LDL level |              |          |          |          |          |          |          |          |          |---------|
| No.                                  | 872          | 570      | NA       |          |          |          |          |          |          |         |
| Baseline LDL level, mean (SD), mg/dL  | 135.8 (29.5) | 136.6 (33.2) | .65    |          |          |          |          |          |          |         |
| Mean annual change in LDL level, mg/dL (95% CI) | -19.7 (-22.0 to -16.8) | -17.6 (-20.8 to -14.2) | .34    |          |          |          |          |          |          |         |

Abbreviations: BP, blood pressure; CVD, cardiovascular disease; HbA1c, hemoglobin A1c; ITT, intention to treat; LDL, low-density lipoprotein.

SI conversion factors: To convert HbA1c to proportion of total hemoglobin, multiply by 0.01; LDL to mmol/L, multiply by 0.0259.

* Models adjust for age, race and ethnicity, number of visits, rural-urban commuting area, sex, and federal poverty line.

** Excludes patients with new diabetes diagnosis during study period.
clinics (−3.2 [95% CI, −3.5 to −2.8] mm Hg) than in control clinics (−2.5 [95% CI, −2.8 to −2.2] mm Hg; \( P = .01 \)) when the tool was used more than once, this difference was not clinically significant. Mean levels of HbA1c decreased significantly less among patients for whom the tool was used once (−0.5%)

### Table 3. Results of ETOT (per Protocol) Analyses Comparing Intervention and Control Clinic Changes in Measures of CVD Risk During Follow-up Period by Frequency of CV Wizard Use

| Patient risk level | Intervention group: tool used once (n = 2828) | Matched control group | P value | Intervention group: tool used more than once (n = 3939) | Matched control group | P value | Intervention group: tool never used (n = 4392) | Matched control group | P value |
|--------------------|---------------------------------------------|-----------------------|--------|-------------------------------------------------------|-----------------------|--------|---------------------------------------------|-----------------------|--------|
| **10-y CVD risk**  |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| Baseline risk <10% |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 1034                                        | 686                   | NA     | 1335                                                  | 674                   | NA     | 1865                                        | 881                   | NA     |
| Mean (SD) baseline CVD risk, % | 4.4 (2.9) | 4.3 (3.1) | .54 | 4.6 (2.9) | 4.3 (3.1) | .03 | 4.3 (3.0) | 4.1 (3.2) | .13 |
| Mean annual change in CVD risk, % (95% CI) | 1.3 (1.1-1.5) | 1.5 (1.3-1.7) | .19 | 1.4 (1.3-1.6) | 1.6 (1.5-1.8) | .03 | 1.1 (1.0-1.3) | 2.0 (1.9-2.2) | <.001 |
| Baseline risk ≥10% |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 1741                                        | 1023                  | NA     | 2569                                                  | 1115                  | NA     | 2440                                        | 1250                  | NA     |
| Mean (SD) baseline CVD risk, % | 23.1 (10.6) | 23.6 (11.4) | .27 | 23.1 (10.5) | 24.0 (11.2) | .03 | 22.2 (10.7) | 22.9 (11.1) | .10 |
| Mean annual change in CVD risk, % (95% CI) | −0.6 (−0.9 to −0.3) | −0.8 (−1.1 to −0.6) | .23 | <0.1 (−0.2 to 0.2) | −0.4 (−0.6 to −0.2) | .002 | −0.4 (−0.6 to −0.2) | −0.9 (−1.1 to −0.7) | .001 |
| **Reversible CVD risk** |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| Baseline risk <10% |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 1855                                        | 1125                  | NA     | 2673                                                  | 1120                  | NA     | 2968                                        | 1441                  | NA     |
| Mean (SD) baseline reversible risk, % | 3.1 (2.7) | 3.2 (2.6) | .32 | 3.4 (2.7) | 3.2 (2.7) | .02 | 3.1 (2.7) | 3.2 (2.7) | .25 |
| Mean annual change in reversible risk, % (95% CI) | 1.2 (1.1-1.4) | 1.3 (1.2-1.5) | .29 | 1.5 (1.3-1.6) | 1.7 (1.5-1.8) | .02 | 0.9 (0.8-1.1) | 1.1 (1.0-1.2) | .09 |
| Baseline risk ≥10% |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 920                                         | 613                   | NA     | 1231                                                  | 604                   | NA     | 1337                                        | 847                   | NA     |
| Mean (SD) baseline reversible risk, % | 17.6 (8.6) | 17.7 (10.3) | .84 | 18.9 (10.2) | 18.3 (9.8) | .17 | 17.3 (9.9) | 17.7 (9.7) | .38 |
| Mean annual change in reversible risk, % (95% CI) | −2.4 (−2.9 to −1.8) | −2.3 (−2.8 to −1.8) | .83 | −1.7 (−2.0 to −1.3) | 0.1 (−0.5 to −0.2) | <.001 | −2.4 (−2.8 to −1.9) | −2.9 (−3.3 to −2.5) | .10 |
| **High baseline blood pressure** |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 1098                                        | 725                   | NA     | 1271                                                  | 723                   | NA     | 1666                                        | 973                   | NA     |
| Mean (SD) baseline, mm Hg |                                      |                       |        |                                                       |                       |        |                                             |                       |        |
| Systolic           | 152.6 (15.2)                                | 154.9 (15.5)          | .002   | 152.3 (14.6) | 152.6 (14.0) | .73 | 152.5 (15.3) | 154.3 (15.4) | .003 |
| Diastolic          | 85.5 (11.2)                                 | 87.1 (12.4)           | .01    | 84.6 (11.2) | 86.1 (11.2) | .003 | 85.0 (11.6) | 86.9 (12.1) | <.001 |
| Mean annual change, mm Hg (95% CI) | −8.3 (−9.2 to −7.3) | −8.3 (−9.3 to −7.3) | .99 | −6.6 (−7.3 to −6.0) | −6.1 (−6.7 to −5.4) | .22 | −9.6 (−10.4 to −8.8) | −9.4 (−10.2 to −8.6) | .76 |
| **High baseline HbA1c level** |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 461                                         | 284                   | NA     | 738                                                   | 315                   | NA     | 748                                         | 425                   | NA     |
| Mean (SD) baseline HbA1c level, % | 10.2 (1.8) | 10.2 (1.7) | .83 | 10.2 (1.8) | 10.0 (1.7) | .15 | 10.3 (1.8) | 10.0 (1.7) | .005 |
| Mean annual change in HbA1c level, % (95% CI) | −0.5 (−0.7 to −0.4) | −1.0 (−1.2 to −0.9) | <.001 | −0.7 (−0.8 to −0.6) | −1.0 (−1.0 to −0.8) | <.001 | −0.9 (−1.0 to −0.8) | −0.9 (−1.0 to −0.8) | .94 |
| **High baseline LDL level** |                                             |                       |        |                                                       |                       |        |                                             |                       |        |
| No.                | 244                                         | 163                   | NA     | 288                                                   | 124                   | NA     | 340                                         | 198                   | NA     |
| Mean (SD) baseline LDL level, mg/dL | 135.8 (30.2) | 135.7 (29.6) | .98 | 134.0 (28.8) | 135.3 (31.6) | .69 | 137.4 (29.7) | 134.4 (26.7) | .23 |
| Mean annual change in LDL level, mg/dL (95% CI) | −20.8 (−26.0 to −15.7) | −18.2 (−22.5 to −13.8) | .44 | −18.6 (−22.9 to −14.2) | −17.1 (−21.1 to −13.0) | .62 | −21.7 (−26.1 to −17.4) | −19.2 (−23.2 to −15.2) | .41 |

Abbreviations: CVD, cardiovascular disease; ETOT, effect of treatment on the treated; HbA1c, hemoglobin A1c; LDL, low-density lipoprotein; NA, not applicable.  
SI conversion factors: To convert HbA1c to proportion of total hemoglobin, multiply by 0.01; LDL to mmol/L, multiply by 0.0259.

a Regression models included random effects for clinic and patient.

b Counts of tool use exclude use at the last visit of the study period.

c Patients matched on race and ethnicity, sex, age, baseline federal poverty level, rural-urban commuting area, ambulatory visits to a study clinic during the study period, time from index visit to last visit, and baseline score for each outcome.

d Excludes patients diagnosed with diabetes during the study period.

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[95% CI, −0.7 to −0.4%]) compared with controls (−1.0% [95% CI, −1.2% to −0.9%]; P < .001) and among those for whom it was used more than once (−0.7% [95% CI, −0.8% to −0.6%]) compared with controls (−1.0% [95% CI, −1.0% to −0.8%]; P < .001). We note that for most patients with more than 1 uncontrolled risk factor, the CDSS would emphasize more effective ways to reduce CVD risk than tightening control of HbA1c levels.

**Discussion**

CV Wizard was effective in integrated care settings primarily serving insured patients; this trial assessed its impact in CHCs. Because CDSS use rates affect population-level outcomes, ITT and ETOT analyses were conducted. In ITT results, total CVD risk did not improve significantly more in patients in intervention clinics overall but improved more among patients in intervention than control clinics among those with a baseline risk of greater than 20%. No consistent, significant impact on reversible CVD risk was seen. In ETOT analyses, however, among patients for whom the tool was used at least once, CVD risk decreased significantly more among those in the highest baseline risk group compared with controls. Although this risk reduction was modest (absolute improvement of 4.4% vs 2.7%), if maintained over time it could represent a population-level reduction in cardiovascular events. Among those with a baseline reversible risk of at least 10%, intervention patients improved significantly more than controls when the tool was used more than once, suggesting a possible dose-response effect.

**Table 4. Results of ETOT (per Protocol) Analyses Comparing Intervention and Control Clinic Changes in CVD Risk During Follow-up Period, Stratified by Baseline CVD Risk**

| Clinic group                                      | Intervention | Matched control | P value |
|---------------------------------------------------|--------------|-----------------|---------|
| **CVD risk**                                      |              |                 |         |
| Patients with baseline 10-y CVD risk <10%         |              |                 |         |
| No.                                               | 2369         | 852             | NA      |
| Mean (SD) baseline CVD risk, %                    | 4.5 (2.0)    | 4.3 (3.1)       | .06     |
| Mean annual change in CVD risk, % (95% CI)        | 1.4 (1.3-1.5)| 1.5 (1.4-1.6)   | .10     |
| Patients with baseline 10-y CVD risk 10% to <20%  |              |                 |         |
| No.                                               | 2032         | 734             | NA      |
| Mean (SD) baseline CVD risk, %                    | 14.8 (2.9)   | 14.8 (2.9)      | .78     |
| Mean annual change in CVD risk, % (95% CI)        | 0.7 (0.5-0.8)| 0.4 (0.3-0.6)   | .02     |
| Patients with baseline 10-y CVD risk ≥20%         |              |                 |         |
| No.                                               | 2274         | 757             | NA      |
| Mean (SD) baseline CVD risk, %                    | 30.6 (9.2)   | 31.4 (10.0)     | .04     |
| Mean annual change in CVD risk, % (95% CI)        | −0.9 (−1.2 to −0.7)| −0.3 (−0.5 to −0.1)| <.001 |
| **Reversible CVD risk**                           |              |                 |         |
| Patients with baseline reversible risk <10%       |              |                 |         |
| No.                                               | 4528         | 1694            | NA      |
| Mean (SD) baseline reversible risk, %             | 3.3 (2.7)    | 3.4 (2.7)       | .45     |
| Mean annual change in reversible risk, % (95% CI) | 1.4 (1.3-1.5)| 1.2 (1.1-1.3)   | .008    |
| Patients with baseline reversible risk 10% to <20%|              |                 |         |
| No.                                               | 1521         | 719             | NA      |
| Mean (SD) baseline reversible risk, %             | 13.7 (2.8)   | 13.6 (2.7)      | .15     |
| Mean annual change in reversible risk, % (95% CI) | −0.7 (−0.9 to −0.4)| −0.2 (0.5 to 0.04)| .04     |
| Patients with baseline reversible risk ≥20%       |              |                 |         |
| No.                                               | 630          | 243             | NA      |
| Mean (SD) baseline reversible risk, %             | 29.5 (10.9)  | 30.7 (13.1)     | .18     |
| Mean annual change in reversible risk, % (95% CI) | −4.4 (−5.2 to −3.7)| −2.7 (−3.4 to −1.9)| .001    |

**Abbreviations:** CVD, cardiovascular disease; ETOT, effect of treatment on the treated; NA, not applicable.

a Group 1 patients who had the tool used at least once with baseline risk score in each baseline risk group were matched to group 2 patients with baseline risk score in same range.

b Matched on age, race and ethnicity, rurality, number of visits, time from first to last visit, federal poverty level, sex, and diabetes diagnosis.
The ITT results are unsurprising given the overall tool adoption rate and may explain why these findings contrast with the largely positive earlier findings for this CDSS in better-resourced health care systems. In those studies, use of CV Wizard improved glucose levels and BP control in adults with diabetes, overall CVD risk in adults without diabetes or heart disease, and BP management in patients aged 6 to 18 years. In those studies, however, CDSS results were printed at 70% to 80% of targeted encounters. Many other CDSS studies were unable to demonstrate impact owing to low adoption (eg, a recent implementation in Belgium that had single-digit use rates and no improvement in targeted outcomes).

Factors that affect point-of-care CDSS use include workflow integration, competing clinical demands, number of clicks to access the CDSS, and clinician confidence in the validity of the advice provided. This CDSS achieved much higher use rates in centralized care systems with established tool use workflows. The present study included numerous care organizations in which heterogeneity in rooming protocols impeded training and sustained high CDSS use. Future studies should identify strategies for increasing CDSS use in CHCs. Analyses designed to understand CDSS adoption in this setting will be presented in future reports.

Limitations
In this cluster randomized clinical trial, randomization accounted for organization size, but could not balance on other characteristics, so analyses controlled for baseline factors likely to affect outcomes. Other variables may have affected outcomes. In addition, intraclass correlation coefficients for key study outcomes indicated high heterogeneity across intervention and control clinics, which dilutes power to detect intervention effects. This study was conducted in a heterogenous network of CHCs sharing a single EHR. Extrapolation to different settings requires caution. CV Wizard supports both CDS and shared decision-making, but these analyses did not assess which elements were used. Similarly, even if the tool’s output was viewed or printed, we do not know how it was used to engage individual patients; however, further analyses are underway.

Conclusions
This CDSS intervention appeared to have a benefit for CVD risk when it was consistently used for CHC patients with high baseline risk. Future research is needed on how CDSS tools are used in clinical encounters and to develop strategies to increase CDSS use in CHCs and similar settings. Despite limitations, these results provide preliminary evidence that this technology has the potential to improve clinical care among CHC patients with high CVD risk.

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REFERENCES
1. Davis AM, Vinci LM, Okwuosa TM, Chase AR, Huang ES. Cardiovascular health disparities: a systematic review of healthcare interventions. Med Care Res Rev. 2007;64(5)(suppl):295-100S. doi:10.1177/1077558707305416
2. Graham G. Disparities in cardiovascular disease risk in the United States. Curr Cardiol Rev. 2015;11(3):238-245. doi:10.2174/1573403X15666641122220003
3. Lewey J, Choudhry NK. The current state of ethnic and racial disparities in cardiovascular care: lessons from the past and opportunities for the future. Curr Cardiol Rep. 2014;16(10):530. doi:10.1007/s11886-014-0530-3
4. Mueller M, Purnell TS, Mensah GA, Cooper LA. Reducing racial and ethnic disparities in hypertension prevention and control: what will it take to translate research into practice and policy? Am J Hypertens. 2015;28(6):699-716. doi:10.1093/ajh/hpu233
5. Centers for Disease Control and Prevention, National Center for Health Statistics. Health, United States spotlight—racial and ethnic disparities in heart disease. April 2019. Accessed September 21, 2020. https://www.cdc.gov/nchs/hus/spotlight/HeartDiseaseSpotlight_2019_0404.pdf

6. Schultz WM, Kelli HM, Lisko JC, et al. Socioeconomic status and cardiovascular outcomes: challenges and interventions. Circulation. 2018;137(20):2166-2178. doi: 10.1161/CIRCULATIONAHA.117.029652

7. Koopman RJ, Kochendorfer KM, Moore JL, et al. A diabetes dashboard and physician efficiency and accuracy in accessing data needed for high-quality diabetes care. Ann Fam Med. 2011;9(5):398-405. doi: 10.1370/afm.1286

8. Parchman ML, Pugh JA, Romero RL, Bowers KW. Competing demands or clinical inertia: the case of elevated glycosylated hemoglobin. Ann Fam Med. 2007;5(3):196-201. doi: 10.1370/afm.679

9. Yawn B, Goodwin MA, Zyzanski SJ, Stange KC. Time used during acute and chronic illness visits to a family physician. Fam Pract. 2003;20(4):474-477. doi:10.1093/fampra/cmg425

10. Beasley JW, Wetterneck TB, Temte J, et al. Information chaos in primary care: implications for physician performance and patient safety. J Am Board Fam Med. 2011;24(6):745-751. doi: 10.3122/jabfm.2011.06.100255

11. Karsh BT, Holden RJ, Alper SJ, Or CK. A human factors engineering paradigm for patient safety: designing to support the performance of the healthcare professional. Qual Saf Health Care. 2006;15(suppl 1):i59-i65. doi: 10.1136/qshc.2005.015974

12. Wickens CD. Multipleresources and mental workload. Hum Factors. 2008;50(3):449-455. doi:10.1518/001872008X288394

13. Altman EM, Gray WD. Forgetting to remember: the functional relationship of decay and interference. Psychol Sci. 2002;13(1):27-33. doi:10.1111/1467-9280.00405

14. Committee on Patient Safety and Health Information Technology. Health IT and Patient Safety: Building Safer Systems for Better Care. Institute of Medicine; 2011.

15. Stead WW, Lin HS, eds. Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions. National Academies Press; 2009.

16. Jean-Jacques M, Persell SD, Thompson JA, Hasnain-Wynia R, Baker DW. Changes in disparities following the implementation of a health information technology-supported quality improvement initiative. J Gen Intern Med. 2012;27(1):71-77. doi:10.1007/s11606-011-1842-2

17. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. BMJ. 2009;338:b1440. doi: 10.1136/bmj.b1440

18. López L, Green AR, Tan-McGrory A, King R, Betancourt JR. Bridging the digital divide in health care: the role of health information technology in addressing racial and ethnic disparities. Jt Comm J Qual Patient Saf. 2011;37(10):437-445. doi:10.1017/S14679280110055-9

19. Jaffe MG, Lee GA, Young JD, Sidney S, Go AS. Improved blood pressure control associated with a large-scale hypertension program. JAMA. 2013;310(7):699-705. doi: 10.1001/jama.2013.108769

20. Shaw KM, Handler J, Wall HK, Kanter MH. Improving blood pressure control in a large multiethnic California population through changes in health care delivery, 2004-2012. Prev Chronic Dis. 2014;11:E191. doi: 10.5888/pcd11.140173

21. Ash JS, Sittig DF, Guappone KP, et al. Recommended practices for computerized clinical decision support and knowledge management in community settings: a qualitative study. BMC Med Inform Decis Mak. 2012;12(1):6. doi: 10.1186/1472-6947-12-6

22. Ash JS, Sittig DF, Dykstra R, et al. Identifying best practices for clinical decision support and knowledge management in the field. Stud Health Technol Inform. 2010;160(pt 2):806-810.

23. Bright TJ, Wong A, Dhurjati R, et al. Effect of clinical decision-support systems: a systematic review. Ann Intern Med. 2012;157(1):29-43. doi:10.7326/0003-4819-157-1-201207030-00450

24. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ. 2005;330(7494):765. doi:10.1136/bmj.38398.500764.8F

25. Lobach D, Sanders GD, Bright TJ, et al. Enabling health care decisionmaking through clinical decision support and knowledge management. Evid Rep Technol Assess (Full Rep). 2012;(203):1-784.

26. Souza NM, Sebaldt RJ, Mackay JA, et al; CCDSS Systematic Review Team. Computerized clinical decision support systems for primary preventive care: a decision-maker-researcher partnership systematic review of effects on process of care and patient outcomes. Implement Sci. 2011;6:87. doi:10.1186/1748-5908-6-87
27. Roshanov PS, You JJ, Dhaliwal J, et al; CCDSS Systematic Review Team. Can computerized clinical decision support systems improve practitioners’ diagnostic test ordering behavior? A decision-maker-researcher partnership systematic review. *Implement Sci*. 2011;6:88. doi: 10.1186/1748-5908-6-88

28. Jaspers MW, Smeulers M, Vermeulen H, Peute LW. Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings. *J Am Med Inform Assoc*. 2011;18(3):327-334. doi: 10.1136/amiajnl-2011-000094

29. Cleveringa FG, Gorter KJ, van den Donk M, van Gisjel J, Rutten GE. Computerized decision support systems in primary care for type 2 diabetes patients only improve patients’ outcomes when combined with feedback on performance and case management: a systematic review. *Diabetes Technol Ther*. 2013;15(2):180-192. doi: 10.1089/dia.2012.0201

30. Moja L, Kwag KH, Lytras T, et al. Effectiveness of computerized decision support systems linked to electronic health records: a systematic review and meta-analysis. *Am J Public Health*. 2014;104(12):e12-e22. doi: 10.2105/AJPH.2014.302164

31. Murphy EV. Clinical decision support: effectiveness in improving quality processes and clinical outcomes and factors that may influence success. *Yale J Biol Med*. 2014;87(2):187-197.

32. Sperl-Hillen JM, Rossum RC, Kharbanda EO, et al. Priorities wizard: multisite web-based primary care clinical decision support improved chronic care outcomes with high use rates and high clinician satisfaction rates. *EGEMS (Wash DC)*. 2019;7(1):9. doi: 10.5334/egems.284

33. O’Connor PJ, Sperl-Hillen JM, Rush WA, et al. Impact of electronic health record clinical decision support on diabetes care: a randomized trial. *Ann Fam Med*. 2011;9(1):12-21. doi: 10.1370/afm.1196

34. Sperl-Hillen JM, Crain AL, Margolis KL, et al. Clinical decision support directed to primary care patients and providers reduces cardiovascular risk: a randomized trial. *J Am Med Inform Assoc*. 2018;25(9):1137-1146. doi: 10.1093/jamia/ocy085

35. O’Connor P. Opportunities to increase the effectiveness of EHR-based diabetes clinical decision support. *Appl Clin Inform*. 2011;2(3):350-354. doi: 10.4338/ACI-2011-05-SE-0032

36. Sperl-Hillen JM, Crain AL, Ekstrom HL, Margolis KL, O’Connor PJ. A clinical decision support system promotes shared decision-making and cardiovascular risk factor management. *J Patient Cent Res Rev*. 2017;4(3):158-159. doi: 10.17294/2330-0698.1490

37. Bibbins-Domingo K, Grossman DC, Curry SJ, et al; US Preventive Services Task Force. Statin use for the primary prevention of cardiovascular disease in adults: US preventive services task force recommendation statement. *JAMA*. 2016;316(19):1997-2007. doi: 10.1001/jama.2016.15450

38. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Hypertension*. 2018;71(6):e13-e115.

39. American Diabetes Association. 6. Glycemic targets: standards of medical care in diabetes-2018. *Diabetes Care*. 2018;41(suppl 1):S55-S64. doi: 10.2337/dc18-S006

40. Obesity Expert Panel. Managing overweight and obesity in adults: systematic evidence review. 2013. National Heart, Lung, and Blood Institute, National Institutes of Health, US Department of Health and Human Services. Accessed December 8, 2020. https://www.nhlbi.nih.gov/sites/default/files/media/docs/obesity-evidence-review.pdf

41. U.S. Preventive Services Task Force. Final recommendation statement; tobacco smoking cessation in adults, including pregnant persons: interventions. January 19, 2021. Accessed April 8, 2019. https://www.uspreventiveservicestaskforce.org/uspstf/document/RecommendationStatementFinal/tobacco-use-in-adults-and-pregnant-women-counseling-and-interventions

42. Rothwell PM, Cook NR, Gaziano JM, et al. Effects of aspirin on risks of vascular events and cancer according to bodyweight and dose: analysis of individual patient data from randomised trials. *Lancet*. 2018;392(10145):387-399. doi: 10.1016/S0140-6736(18)31133-4

43. Casey DE Jr, Thomas RJ, Bhalla V, et al. 2019 AHA/ACC clinical performance and quality measures for adults with high blood pressure: a report of the American College of Cardiology/American Heart Association task force on performance measures. *Circ Cardiovasc Qual Outcomes*. 2019;12(11):e000057. doi: 10.1161/HQC.0000000000000057

44. Gilmer TP, O’Connor PJ, Sperl-Hillen JM, et al. Cost-effectiveness of an electronic medical record based clinical decision support system. *Health Serv Res*. 2012;47(6):2137-2158. doi: 10.1111/j.1475-6773.2012.01427.x
45. Dudd R, Wang MC, Wong M, Bellows J. Preventing myocardial infarction and stroke with a simplified bundle of cardioprotective medications. Am J Manag Care. 2009;15(10):e88-e94.

46. Wong W, Jaffe M, Wong M, Dudd R. Community implementation and translation of Kaiser Permanente’s cardiovascular risk-reduction strategy. Perm J. 2011;15(1):36-41. doi:10.7812/TPP/10-115

47. Feldstein AC, Perrin NA, Unitan R, et al. Effect of a patient panel-support tool on care delivery. Am J Manag Care. 2010;16(10):e256-e266.

48. Lillie-Blanton M, Rushing OE, Ruiz S, Mayberry R, Boone L. Racial/ethnic differences in cardiac care: the weight of the evidence [summary report], September 29, 2002. Accessed November 4, 2021. https://www.kff.org/racial-equity-and-health-policy/fact-sheet/racial-ethnic-differences-in-cardiac-care-the-weight/

49. Heselmans A, Delvaux N, Laenen A, et al. Computerized clinical decision support system for diabetes in primary care does not improve quality of care: a cluster-randomized controlled trial. Implement Sci. 2020;15(1):5. doi:10.1186/s13012-019-0955-6

50. Ancker JS, Kern LM, Edwards A, et al; HITEC Investigators. Associations between healthcare quality and use of electronic health record functions in ambulatory care. J Am Med Inform Assoc. 2015;22(4):864-871. doi:10.1093/jamia/ocv030

51. Colantonio LD, Richman JS, Carson AP, et al. Performance of the atherosclerotic cardiovascular disease pooled cohort risk equations by social deprivation status. J Am Heart Assoc. 2017;6(3):e005676. doi:10.1161/JAHA.117.005676

52. Lloyd-Jones DM, Braun LT, Ndumele CE, et al. Use of risk assessment tools to guide decision-making in the primary prevention of atherosclerotic cardiovascular disease: a special report from the American Heart Association and American College of Cardiology. Circulation. 2019;139(25):e1162-e1177. doi:10.1161/CIR.0000000000006383

53. Kharbanda EO, Asche SE, Sinaiko A, et al. Evaluation of an electronic clinical decision support tool for incident elevated BP in adolescents. Acad Pediatr. 2018;18(1):43-50. doi:10.1016/j.acap.2017.07.004

54. Buntin MB, Burke MF, Hoaglin MC, Blumenthal D. The benefits of health information technology: a review of the recent literature shows predominantly positive results. Health Aff (Millwood). 2011;30(3):464-471. doi:10.1377/hlthaff.2011.0178

SUPPLEMENT 1.
Trial Protocol

SUPPLEMENT 2.
eFigure 1. CV Wizard Provider View (Prioritizes Patient Risks and Provides Decision Support Suggestions)
eFigure 2. CV Wizard Patient View (Prioritizes Patient Risks and Presents the Information Visually)
eMethods. Reversible Risk Calculations
eTable. Clinic Characteristics by Study Group at Baseline
eReferences

SUPPLEMENT 3.
Data Sharing Statement