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ORIGINAL RESEARCH

CARDIO-OBSTETRICS

Cardiovascular Risk Assessment as a Quality Measure in the Pregnancy and Postpartum Period

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ABSTRACT

BACKGROUND Cardiovascular disease (CVD) is the leading cause of maternal mortality in the United States, accounting for over one-third of all pregnancy-related deaths. Contributing factors such as lack of recognition and delayed diagnosis of CVD are primarily due to the overlap of signs and symptoms of a normal pregnancy with those of CVD.

OBJECTIVES This study aimed to demonstrate the feasibility of introducing CVD risk assessment into clinical practice using the California Maternal Quality Care Collaborative algorithm to detect CVD during pregnancy and postpartum periods.

METHODS We implemented the CVD risk assessment algorithm into electronic health records at 3 large hospital networks serving over 14,000 patients at 23 sites. We determined the percentage of pregnant and/or postpartum patients who were screened for CVD risk and the follow-up rate for patients in whom the tool recommended a follow-up assessment. Rates were stratified according to clinical site characteristics. We obtained clinician feedback regarding the feasibility and acceptability of the tool.

RESULTS The rate of patients screened for CVD risk in the 3 hospital networks was 57.1%, 71.5%, and 98.7%. For those with a positive screen, follow-up rates were 65.8%, 72.5%, and 55.9% in the 3 networks. The rates of screening and follow-up varied based on the clinic size and specialty. Clinician-identified barriers were busy clinics, competing priorities, and the type of clinical practice.

CONCLUSIONS This innovative population-based approach for universal CVD risk assessment during pregnancy is feasible and may be a helpful strategy to decrease CVD-related maternal morbidity and mortality.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

BNP = brain natriuretic peptide
CMQCC = California Maternal Quality Care Collaborative
CVD = cardiovascular disease
EHR = electronic health record
HN = hospital network
IT = information technology
OB = obstetrics
SNR = signal-to-noise ratio
TEP = technical expert panel

Cardiovascular disease (CVD) is the leading cause of maternal mortality in the United States. Pregnancy is recognized as a state of hemodynamic stress that may lead to signs and symptoms that are very similar to those of CVD such as shortness of breath, fatigue, and swelling. This may not only lead to delays in the recognition and treatment but may also contribute to serious short- and long-term morbidity.[1-7] In addition to high maternal morbidity, CVD increases future pregnancy risks and carries a lifetime risk of CVD complications.[8] It is important to note that most patients who died of CVD during pregnancy did not have a diagnosis prior to pregnancy, and one-third of these deaths were deemed preventable.[9] This may either be due to an underlying undiagnosed CVD that was aggravated by the hemodynamic changes of pregnancy or the development of a de novo cardiac condition, ie, peripartum cardiomyopathy. A California maternal mortality review found that 93% of the symptomatic women who died of CVD would have been identified as high risk for CVD with the use of a CVD risk assessment algorithm, thus potentially saving the mother's life.[10]

Currently, there is no Healthcare Effectiveness Data and Information Set indicator that monitors CVD detection and/or CVD risk assessment in the general population using a validated tool. The existing CVD-related Healthcare Effectiveness Data and Information Set indicators focus on the follow-up care of nonpregnant hypertensive adults with target blood pressure control; continuation of beta-blocker treatment after a heart attack; and statin therapy for patients with CVD and diabetes.[11-13]

There is, however, a need for a standardized risk assessment tool to identify pregnant and postpartum patients at high risk of CVD to allow for timely interventions and to measure the performance of the health care system, outpatient clinics, and individual clinicians serving this population. To date, no validated pregnancy-related CVD risk assessment tool exists. Furthermore, CVD risk factors evaluation are not part of routine pregnancy care.[14,15] The only risk assessment tool that has been recognized as an emerging best practice is the CVD Assessment Algorithm for Pregnant and Postpartum Women from the California Maternal Quality Care Collaborative (CMQCC).[16] The CMQCC developed the algorithm to stratify pregnant and postpartum patients into low and high risk for CVD.[17] It also guides the clinician on follow-up of patients who screen positive for CVD including cardiac diagnostic testing, laboratory testing, and specialty consultation. While a positive risk assessment for CVD risk may not always lead to a diagnosis of CVD, it may identify early risk factors that require individualized monitoring and management as indicated.

The CVD risk assessment strategy was successfully piloted at 2 clinical sites with the potential for widespread use[14,15] and was used to prospectively screen obstetrical patients at both UC Irvine in California and Montefiore Medical Center in New York.[14] Of 846 patients screened, 8% screened positive (5% in California vs 19% in New York) and underwent further cardiac testing. The true positive rate at both institutions was 1.5%.

In this study, we examined the feasibility of introducing the risk assessment tool into clinical practice at 3 large hospital systems. We examined the percentage of obstetric patients who had CVD risk assessment performed at least once during pregnancy or postpartum period (measure #1) and the percentage of patients identified as high risk for CVD that received appropriate follow-up (measure #2).[18]

METHODS

STUDY SITES. This study was conducted in 3 geographically and ethnically diverse hospital networks (HNs): University of California-Irvine which we will refer to as HN-1 (1,500 births per year), University of California-San Diego, HN-2 (3,000 births per year), and St. Thomas Health-University of Tennessee, and HN-3 (11,000 births per year) between September 2020 and February 2022. The implementation of the algorithm was staggered for logistical reasons in HN-3; therefore, data are available for a 6-month period only (September 2020 to February 2021). The HNs located in Southern California and Tennessee include regional level 3 birthing centers with the full scope of inpatient and outpatient hospital services and affiliated community and private medical clinics. All hospitals have obstetrics (OB)/gynecology residency training programs, a high volume of Medicaid patients, and a diverse racial/ethnic demographic mixture. In total, the study involved over 250 clinicians at 23 sites, serving 14,968 patients over an 18-month period (**Table 1**).

INTEGRATION OF CVD RISK ASSESSMENT ALGORITHM INTO ELECTRONIC HEALTH RECORD. The CVD risk assessment algorithm was built into EPIC and Cerner electronic health record (EHR) systems with help from institutional information technology (IT) teams. Clinicians received education and were prompted at the first antepartum visit to complete the CVD risk

assessment for all pregnant patients with no prior history of CVD (see inclusion/exclusion criteria). This integrated CVD risk assessment tool built based on the CMQCC algorithm automatically pulls in the existing structured data in the EHR including demographics, vital signs, and any risk factors for CVD risk assessment (measure #1). The clinician verifies the additional history and physical examination findings such that the whole process of CVD risk assessment is completed in <60 seconds (Figure 1). The algorithm risk stratifies patients based on 18 parameters that include the patient's history, self-reported cardiac symptoms, vital signs, and physical examination findings into CVD screen negative or CVD screen positive, ie, patients deemed at increased risk of CVD warranting further cardiac workup (Figure 2). Once the patient is determined to be at high risk of CVD, the provider is prompted to the next screen with an order set for further cardiac testing and follow-up appointments. The follow-up of patients who screened positive, ie, at high risk of CVD, was monitored through EHR review (measure #2).

TECHNICAL EXPERT PANEL. To guide the use of the algorithm as a quality measure, we convened a national 12-member technical expert panel (TEP) involving general obstetricians, cardiologists, epidemiologists, and patient representatives. The TEP met virtually 4 times during the study period and provided input on elements of the algorithm, integration of the algorithm in the EHR, and measures such as the appropriate brain natriuretic peptide (BNP) test cutoffs. Construct and content validity of the CVD risk assessment tool were reviewed by the TEP via discussions on inclusions/exclusions of the patient population.

DATA COLLECTION. The CMQCC algorithm (Figure 2) was implemented at 3 large HNs in California in September 2020 and Tennessee in October 2020. In 2 networks, data were collected over an 18-month period and over 6 months in the third network. We reviewed all 14,958 pregnant or postpartum patients who had a visit to any of the hospital units. Consent was waived for all patients. Clinician feedback was recorded using cross-sectional surveys and open-ended interviews to evaluate clinician experience and patient reactions to the CVD risk assessment tool. The study protocol was approved by Institutional Review Board of the University of California, Irvine (protocol number 2020-5693).

STUDY TEAM AND CLINICIAN TRAINING. The study team provided an overview of the CVD risk assessment project at faculty meetings, grand rounds, and clinic staff meetings. A recorded instructional video with step-by-step instructions and an electronic PowerPoint presentation with handouts were distributed to all clinicians. At each HN, an EHR champion was identified to assist with the implementation and rollout of the process. Clinic sites had flexibility in how to integrate the algorithm into their clinic workflow. At some sites, clinicians had to enter the algorithm manually, whereas, at other sites, IT implemented a hard stop that forced clinicians to complete the algorithm. An electronic attendance log was used to ensure that all clinicians reviewed and acknowledged the instructional video. Clinicians were then advised to use the CVD risk assessment tool at the patient's first visit or any of the subsequent encounters for all pregnant/postpartum patients that did not meet the exclusion criteria. A member of the research team conducted weekly manual reviews of a random sample to monitor the uptake of the algorithm.

CLINICIAN FEEDBACK SURVEY. Two months after the rollout, clinicians completed a feedback survey incentivized by a monthly gift card drawing. After initial data collection, we interviewed a purposive sample of 5 clinicians from each of the 3 HNs to evaluate implementation barriers to the routine use

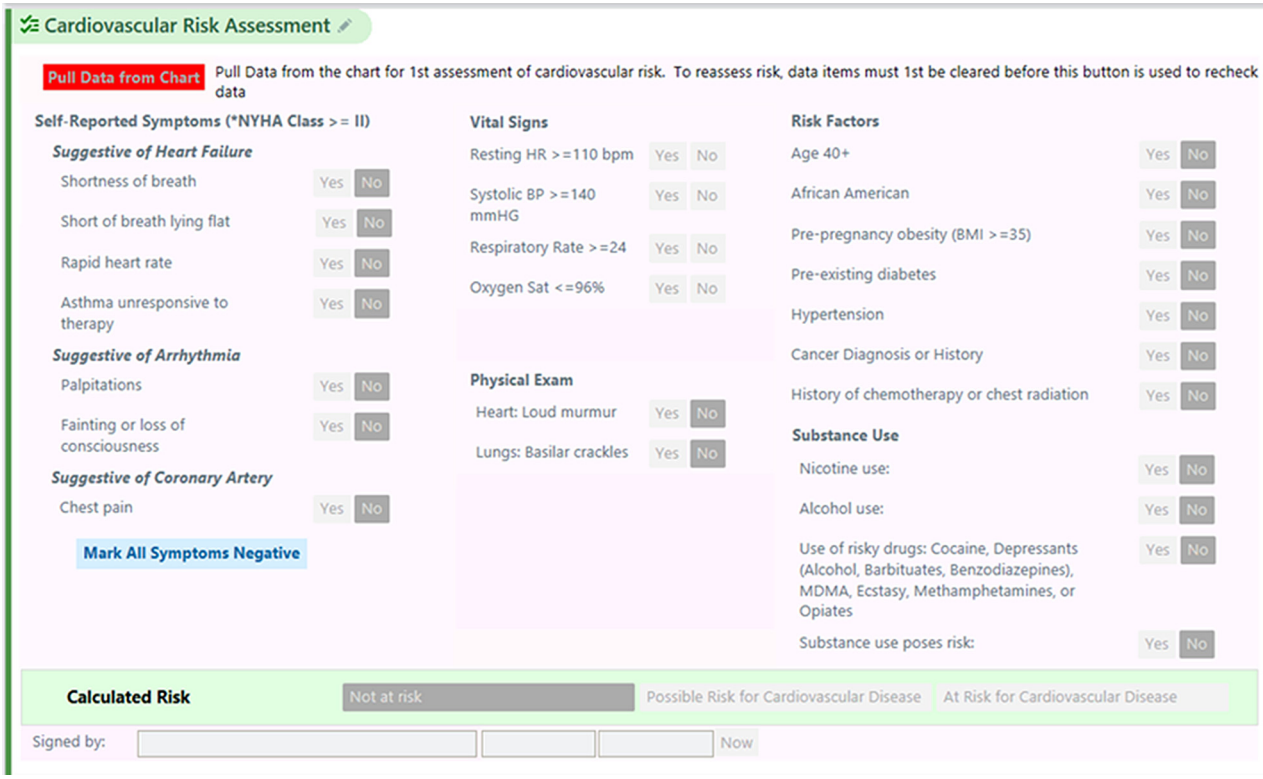
TABLE 1 Description of Clinical Sites

Clinical Sites	Number of Pregnant Patients	Data Collection Type	Specialty	Electronic Health Record System
HN-1 site 1	37	Smartform	Obstetrics and gynecology	EPIC
HN-1 site 2	90	Smartform	Family medicine	EPIC
HN-1 site 3	359	Smartform	Obstetrics and gynecology	EPIC
HN-1 site 4	18	Smartform	Family medicine	EPIC
HN-1 site 5	931	Smartform	Obstetrics and gynecology	EPIC
HN-1 site 6	650	Smartform	Maternal-fetal medicine	EPIC
HN-1 site 7	230	Smartform	Obstetrics and gynecology	EPIC
HN-1 site 8	11	Smartform	Family medicine	EPIC
HN-1 site 9	164	Smartform	Obstetrics and gynecology	EPIC
HN-1 site 10	108	Smartform	Obstetrics and gynecology	EPIC
HN-2 site 1	185	Smartform	Women's health services	EPIC
HN-2 site 2	684	Smartform	Women's health services	EPIC
HN-2 site 3	489	Smartform	Women's health services	EPIC
HN-2 site 4	347	Smartform	Obstetrics	EPIC
HN-2 site 5	867	Smartform	Women's health services	EPIC
HN-2 site 6	71	Smartform	Women's health services	EPIC
HN-2 site 7	163	Smartform	Women's health services	EPIC
HN-2 site 8	2,753	Smartform	Women's health services	EPIC
HN-2 site 9	489	Smartform	Women's health services	EPIC
HN-2 site 10	70	Smartform	Women's health services	EPIC
HN-3 site 1	5,652	Hard stop	General	Cerner
HN-3 site 2	590	Manual	Maternal-fetal medicine	eCW

This table shows the description background of each of the Hospital Network sites that were included in the measurement of the CVD risk assessment. The table is broken down by the total number of patients that were assessed in the measure, the type of data collection (ie, smartform, hard stop, or manual), the specialty of each clinician site, and the electronic health record system used.

HN-1 = hospital network 1; HN-2 = hospital network 2; HN-3 = hospital network 3.

FIGURE 1 **Screenshot of CVD Risk Assessment Algorithm in Electronic Health Record**



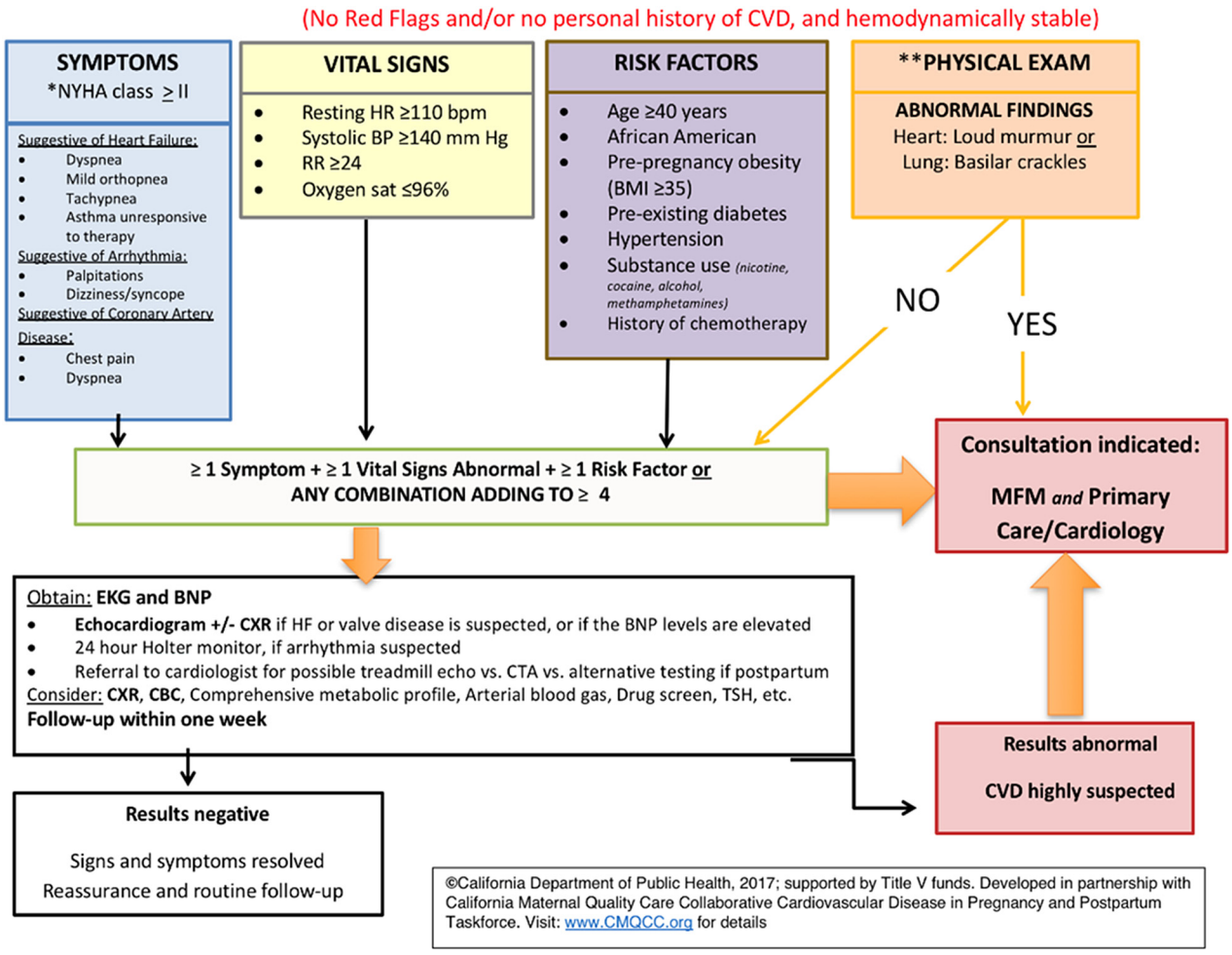
The figure depicts a screenshot of the risk assessment algorithm in the EPIC EHR in which, clinicians see the elements that are part of the CVD risk assessment algorithm. In the EHR, a banner appears if the risk assessment to indicate to the clinician that a CVD risk assessment is needed for that patient. Most of the elements are prepopulated, but they can be changed by the clinician. Based on the selections (yes/no) by the clinician, the risk score is automatically calculated. CVD = cardiovascular disease; EHR = electronic health record.

of the CVD risk assessment tool. Clinical feedback was obtained from a diverse group of clinicians, including attendings, residents, and nurse practitioners. We purposefully selected both high- and low-frequency users of the algorithm for our interviews.

INCLUSION AND EXCLUSION CRITERIA. We included patients who have an active pregnancy or postpartum episode: 1) with at least 1 OB office visit; and 2) without a prior history of a known cardiac disease in an 18-month period (September 2020 to February 2022 HN-1 and HN-2 and September 2020 to February 2021 in HN-3). We included patients of any age, including pregnant and postpartum minors who were allowed to consent to prenatal care without parent permission as per state legislation (CA AB 499 and TN Mature Minor Doctrine). Visits to the hospital systems included labor and delivery, outpatient care at the hospital or in affiliated clinics, and private care providers contracting with the hospital for delivery. Patients with a prior known history of a cardiac disease, identified through International Classification of Diseases-10th Revision, codes (Supplemental Appendix) were excluded from the denominator. Patients who had another reason to visit the clinic (not prenatal or postpartum care) and had a positive pregnancy were excluded.

Patients were considered to have completed a CVD risk assessment if the medical record included the CVD algorithm signed by a clinician (measure #1). For measure #2, patients were considered to have a follow-up after a positive screen if they completed any of the cardiac follow-up services within 60 days after the date of the positive screen. The algorithm guided cardiac diagnostic and laboratory testing and follow-up through linked order set after a patient screened positive for CVD. The recommended testing

FIGURE 2 Cardiovascular Disease Algorithm Risk Assessment Toolkit

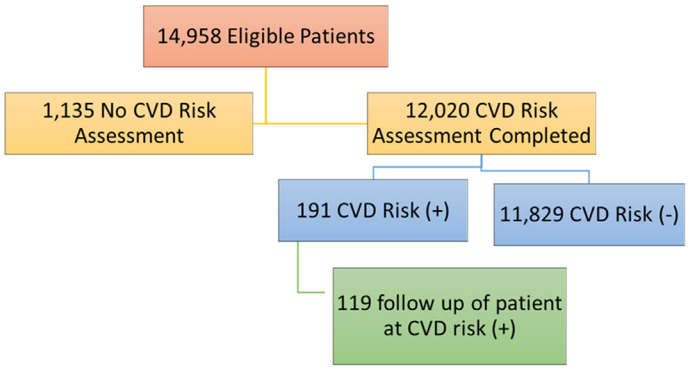


The figure depicts the California Maternal Quality Care Collaborative (CMQCC) CVD risk assessment algorithm toolkit that was integrated into our EHR. The **arrows** depict the direction of flow based on the risk factors and the output results based on the selection. A combination of each of the different factors can trigger an output of risks or no risks, which results in further follow-up. BMI = body mass index; BNP = brain natriuretic peptide; BP = blood pressure; CBC = complete blood count; CTA = computed tomography angiography; CVD = cardiovascular disease; CXR = chest x-ray; EHR = electronic health record; EKG = electrocardiogram (also known as ECG); HF = heart failure; HR = heart rate; MFM = maternal-fetal medicine physician; NYHA = New York Heart Association; oxygen sat = oxygen saturation; RR = respiration rate; TSH = thyroid-stimulating hormone.

included electrocardiogram and BNP levels with additional testing such as cardiac rhythm monitoring and/or echocardiogram at the discretion of the care provider (Supplemental Appendix).

CALCULATION OF THE CMQCC QUALITY MEASURES. At the end of each quarter, the IT departments extracted the variables to calculate the measures and conduct subanalyses from the EHR. We calculated 2 measures. Measure #1 was defined as the number of patients who completed the CVD risk assessment out of the number of total eligible patients during the study period. Measure #2 was calculated as the number of patients who received recommended follow-up tests for CVD out of the number of patients who were deemed to be at increased risk, ie, screened positive. We calculated these for each of the HNs and individual inpatient and outpatient clinics affiliated with the networks. We calculated summary statistics such as mean ± SD and median (IQR) of measures 1 and 2 at the clinic level. For HN-1 and HN-2, we were able to calculate the rate of previously unknown CVD diagnoses based on patient EHR data for each clinic. Using measures and the CVD diagnosis rate at the clinic level, we calculated the Pearson correlation

FIGURE 3 CVD Risk Assessment in Patient Population



The flow chart shows the number of patients that were part of the measures for the CVD risk assessment. It depicts the breakdown of total eligible patients into 2 categories (no CVD risk assessment or CVD risk assessment completed) through the line branches. It further breaks down the number of patients with positive CVD risk (+) or no CVD risk (−) and the number of patients who followed up after a positive risk assessment.
CVD = cardiovascular disease.

coefficient to assess the empirical validity of the measures and the signal-to-noise (SNR) reliability ratio to examine reliability. The SNR analysis assesses the extent to which the variability in the measure is attributable to the systematic difference in performance instead of measurement error. The signal in this case is the proportion of the variability in measured performance that can be explained by systematic differences in performance. A reliability of 1.0 implies that all the variability is attributable to systematic differences in performance.[19] We eliminated clinics with a relatively large sample size (denominator or n) that could have a disproportionate influence on the result. Pearson correlation coefficient, *P* value, and median reliability were also reported for each measure. All statistical analyses were performed using SAS 9.4 (SAS Institute).

RESULTS

The cohort consisted of 14,958 patients of which HN-1 had 2,598, HN-2 had 6,118, and HN-3 had 6,242 total population sample size (Figure 3). The rate of previously unknown CVD was 0.31% for HN-1 and 0.52% for HN-2. The rate of CVD risk assessment (measure #1) in the 3 HNs was 57.1%, 71.5%, and 98.7%, and the rate of follow-up of CVD screen positives in pregnancy and postpartum patients (measure #2) was 65.8%, 72.5%, and 55.9% (Figure 4). Further analysis revealed a significant variation in the CVD risk assessment rates and follow-up in various clinical settings. Several differences were identified in the successful completion of CVD measures between the clinical sites that were primarily based on total obstetric patients and specialty (Table 1). Most of the clinics at HN-3 had a hard stop in their EHR which forced the completion of the algorithm yielding 100% compliance with CVD risk assessment. Within each HN, measure 1 varied by the clinical site (Figure 5).

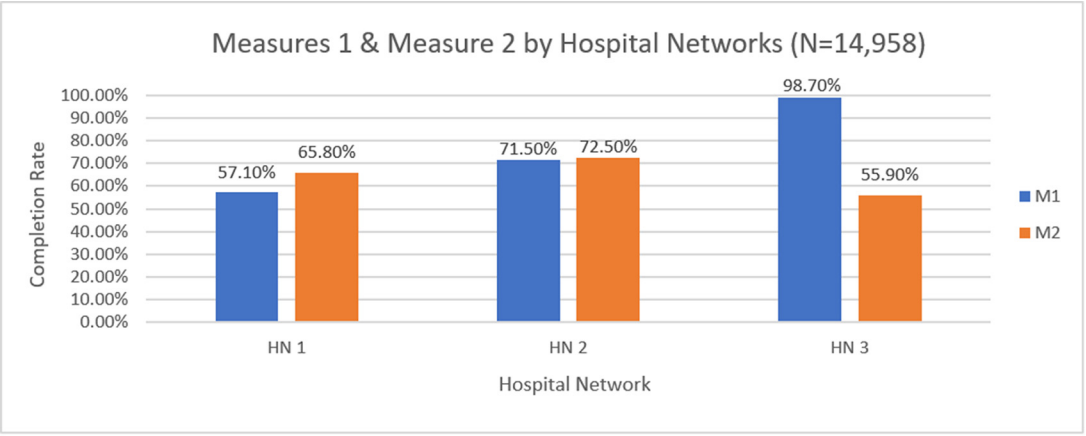
For HN-1 and HN-2, we assessed whether clinics that are more likely to screen patients for CVD risk (measure 1) are more likely to identify patients with a CVD. For each site, we had the rate for measure 1 and the rate for previously unknown CVD diagnosis. We calculated the Pearson correlation coefficient between these 2 values at the clinic level. The coefficient shows a moderate positive correlation of 0.553 ($P = 0.012$), meaning that the CVD risk assessment measure and CVD diagnosis rate are positively correlated at the clinic level. The median SNR for our first measure was 0.977 (close to 1), which means that almost all the variability is attributable to systematic differences in performance. Due to small numbers, the measure 2 calculations by site were deemed unstable, and therefore, only the total measure for the HN was considered meaningful as presented in Figure 5.

The 2-month survey of providers showed that 74.8% of clinicians agreed that the orientation and training on CVD risk assessment facilitated the use of the algorithm in their practices. Furthermore, 67.9% of clinicians agreed that using the CVD algorithm has a positive impact on their patients (Figure 6). We performed weekly audits to review patterns of CVD risk assessment adoption into routine clinical practice and monitored the adoption of the algorithm for individual clinicians. The coinvestigators individually contacted clinicians who did not complete the CVD risk assessment on their patients to identify any implementation barriers. Barriers to the performance of CVD risk assessment were identified as busy clinics, competing priorities, the complexity of medical conditions, and lack of immediate access to stethoscopes to perform cardiovascular examinations. Overall, nurse practitioners and physician extenders were early adopters compared to the more experienced physicians. The feedback on a clinic site's performance in relation to the overall network helped medical directors to identify gaps in services and structural problems that needed to be addressed.

DISCUSSION

Our study demonstrates the feasibility of introducing a CVD risk assessment tool into clinical practice. We

FIGURE 4 Completed Risk Assessment and the Percentage of Patients at Risk for CVD With Follow-Up by Hospital Network



HN 1 M1 N= 2,598	HN 2 M1 N= 6,118	HN 3 M1 N= 6242
HN 1 M2 N= 38	HN 2 M2 N= 51	HN 3 M2 N= 102

The figure shows the percentage of patients with completed risk assessment (measure 1) and the percentage of patients at risk for CVD with follow-up (measure 2) by hospital networks. The total population (n) is broken down by the 2 measures within each hospital network. HN 1 = hospital network 1; HN 2 = hospital network 2; HN 3 = hospital network 3; M1 = measure 1; M2 = measure 2; N = total population.

integrated a CVD risk assessment tool, the CMQCC algorithm, into the 3 large HNs' EMR. The rates of patients screened for CVD risk differed between sites but, overall, were reasonably good varying between 57.1% and 98.7%. For those with a positive screen, follow-up rates varied between 55.9% and 72.5%. This CVD risk assessment strategy can identify patients at high risk of CVD during pregnancy and the postpartum period and may be helpful in decreasing CVD-related maternal morbidity and mortality.

CVD is the leading cause of maternal mortality in the United States; a large proportion of deaths were among patients with no prior diagnosis of CVD. This represents either an underlying undiagnosed CVD that was aggravated by the hemodynamic stress of pregnancy or the development of a de novo cardiac condition, ie, peripartum cardiomyopathy. Pregnancy may lead to signs and symptoms that are very similar to those of CVD, and these patients can be either misdiagnosed or their symptoms dismissed, leading to delays in the recognition and treatment of CVD that led to serious short- and long-term morbidities.[1,2] Thus, there is a need for a standardized risk assessment tool to identify pregnant and postpartum patients at high risk of CVD to allow for timely interventions. While a positive screen for CVD risk may not always lead to a diagnosis of CVD, it may identify early risk factors that require individualized monitoring and management as indicated. A well-developed triage algorithm should be sensitive enough to detect the most concerning cases at risk of CVD without missing patients who are at risk to develop CVD in the future. On September 2, 2021, the U.S. Preventive Services Task Force announced the final research plan for screening for hypertensive disorders of pregnancy that involves an evaluation of the effectiveness of different screening programs in the reduction of maternal morbidity and mortality.[20] The CVD risk assessment algorithm is an initial step to guide the stratification and initial evaluation of symptomatic or high-risk pregnant or postpartum patients (**Central Illustration**). It has received support from the American College of Obstetrics and Gynecology, and its inclusion in the Cardiac Conditions in Obstetrical Care bundle by the Alliance for Innovation for Maternal Health is pending further research.[21]

Our CVD quality measures target the childbearing age population who may be at high risk of CVD and access the health care system for maternity services. CVD risk assessment during the pregnancy/postpartum period is bound to increase education and awareness in this population. This most likely will

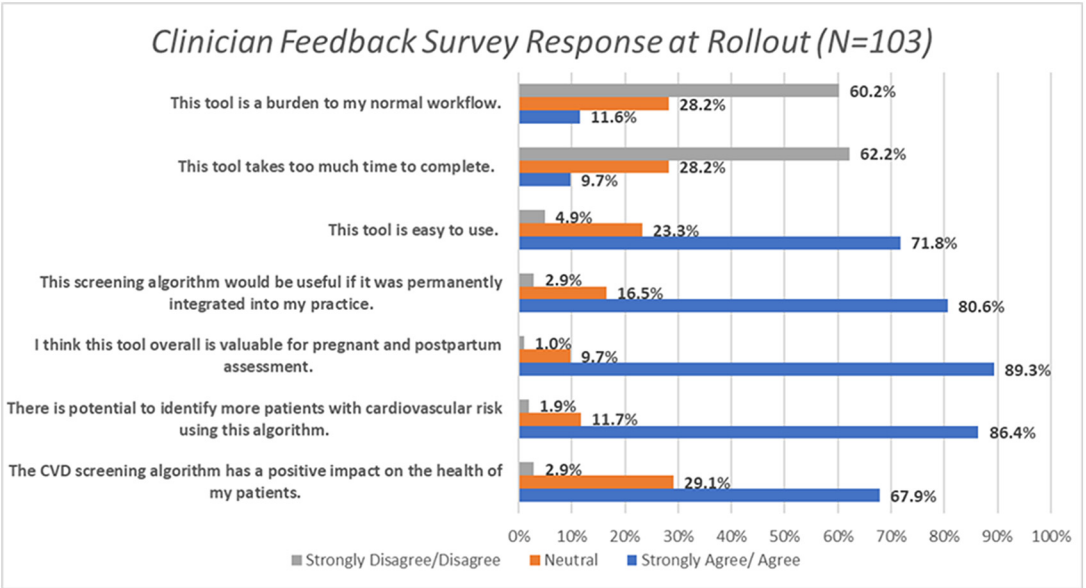
FIGURE 5 **Completed Risk Assessment Rate by Clinical Site Within Hospital Networks**

The following figures show the completed cardiovascular disease risk assessment rates (measure 1) in the 3 different hospital networks by the clinical sites. As can been seen in the different figures, each clinical sites within each network varies in the completion rate.

empower patients to seek early medical care if new signs and symptoms that may be suggestive of CVD appear or if they develop symptoms in the future. CVD risk assessment may be a window of future cardiovascular health, with long-term health outcomes implication through improvements in the CVD risk factor profile.

In this study, we report on a systemwide EHR implementation of the CMQCC CVD risk assessment algorithm to monitor the feasibility and quality of

FIGURE 6 Clinician Feedback Survey Response About Risk Assessment Tool at Rollout



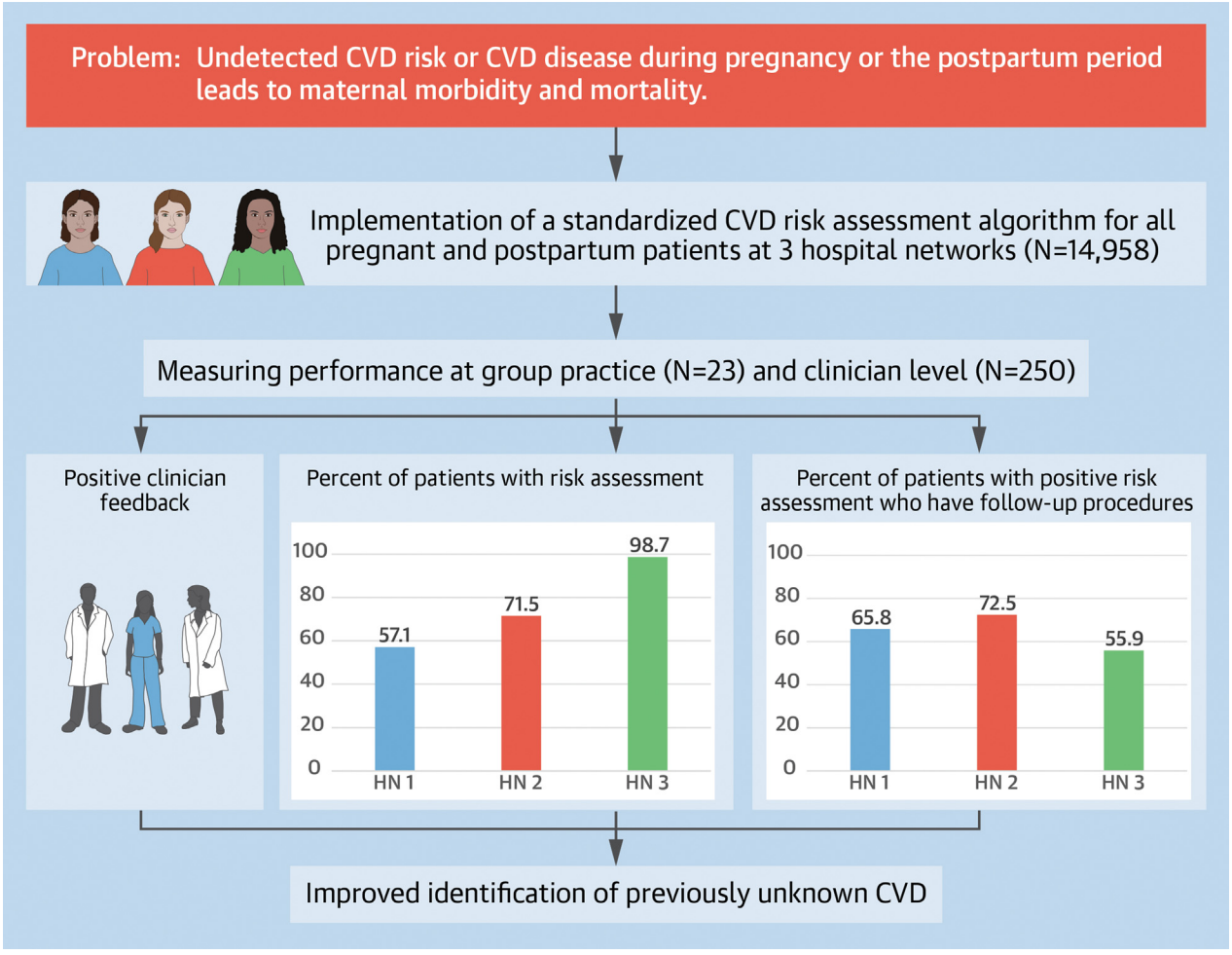
The figure shows the survey response of clinicians on their thoughts on the cardiovascular disease risk assessment usage in the clinical sites. From the total population of 103 clinicians that took the survey, the overall survey responses were positive for the risk assessment tool. The different colors correlate with the response selected from the range of strongly disagree to strongly agree. CVD = cardiovascular disease.

CVD risk assessment, ie, universal screening and follow-up of those who screened positive. Once implemented into the EHR, the tool was determined to be user-friendly as it took <1 minute to complete the CVD risk assessment and appropriately flag patients at risk of CVD during pregnancy and the postpartum period. The tool measured hospital and individual clinician performance. These measures have the potential to become the standard of care for all pregnant and postpartum patients by decreasing CVD-related morbidity and mortality through patient and provider education, identification of those at increased risk, and providing the opportunity for risk factor modification. Clinics that had a hard stop in the EHR ensured a 100% completion rate for the risk assessment (measure 1); however, follow-up of patients who screen positive (measure 2) was considerably lower than that in the clinics without a hard stop. The lack of follow-up may be a combination of patient, clinician, and structural factors such as limited access to medical care due to rural location or insurance status.

The proposed measures identified performance gaps across the 3 large health care systems that provide meaningful and actionable data for improving compliance with CVD risk assessment. The percentage of patients undergoing CVD risk assessment and follow-up of those identified as high risk varied by site specialty, size, and automated vs manual entry of the algorithm and demonstrated quality gaps within the same HN. Our study calculated the measure over 3-month periods, as quarterly calculations may be more useful for quality improvement purposes. However, an annual calculation of the measure may result in more reliable estimates and allow for a subgroup analysis. The calculation of the percentage of pregnant and postpartum patients who received a CVD risk assessment allows clinic management to identify barriers to care and implement a system, provider, and patient quality interventions. Additional data on the feasibility, reliability, and meaningfulness of the measures will facilitate the adoption of these measures. There is also a need for additional research studies to solidify the measures by identifying the higher yield elements of the algorithm and potentially narrowing down the number of elements in the current model for ease of use and broader dissemination.

Future studies are necessary to evaluate enablers and barriers to implementing the study in different

CENTRAL ILLUSTRATION **Early Recognition of CVD Using Risk Assessment Measures**



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The following figure is a central illustration providing a snapshot of our article in a single visual, conceptual manner. The **arrow** depicts the flow of our quality measures within our hospital networks which has led to improved identification of previously unknown CVD. CVD = cardiovascular disease; HN = hospital network.

practice settings. The positive CVD risk assessment will not only lead to timely mitigation during pregnancy and postpartum but the enhanced patient education and awareness may lead to lifestyle changes that improve cardiovascular health over the life course.

STUDY STRENGTHS AND LIMITATIONS. CVD is the number 1 cause of maternal mortality, and most maternal deaths do not carry a pre-existing diagnosis of CVD. There is a need to develop and validate a risk assessment tool to identify those at high risk of CVD, which has the potential of decreasing maternal morbidity through timely recognition and treatment. Our study demonstrates the feasibility of successful implementation of the CVD risk assessment tool at geographically diverse clinic sites with different EHR systems. The variability in the percentage of patients screened and follow-up provides insight into barriers that guide improvement strategies. The relatively small number of patients limits subanalysis for measure 2. As the algorithm is being implemented and adopted at additional clinical sites, data will become available over a longer time period enabling us to provide subanalysis for this measure.

CONCLUSIONS

The proposed CVD risk assessment tool offers an innovative approach for universal CVD risk assessment in the pregnancy and postpartum periods. Timely identification of patients at risk of CVD and follow-up may improve maternal health outcomes and set the stage for transitioning patients to long-term providers (primary care physicians, cardiologists) to assist in preventative measures. Implementation of the algorithm raised awareness of providers on CVD risk assessment, increasing diagnostic accuracy.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS:

CVD is the leading cause of maternal mortality during pregnancy and the postpartum period in the United States. Most pregnant and postpartum patients who died of CVD did not have a known diagnosis of CVD. Diagnosis of CVD in pregnancy may be challenging as signs and symptoms of normal pregnancy mimic those of CVD, which may be missed by the health care providers. The use of a standardized CVD algorithm to risk stratify pregnant and postpartum patients may improve the timely identification of CVD, thereby decreasing maternal morbidity and/or mortality. This study demonstrates the feasibility of integrating a CVD risk assessment tool in EHR. Universal adoption of this algorithm in both obstetric and nonobstetric settings may lead to provider awareness, especially in primary care, cardiology, and emergency department areas as a large proportion of patients present in the postpartum period to non-OB care providers.

TRANSLATIONAL OUTLOOK:

As the landscape of health care has changed, physicians and physician extenders often face short appointment times and overbooked clinics with the need to divert attention to more critical scenarios at hand. This time constraint may compromise the quality of critical communications needed among clinic staff and providers including trainees. Overall decreased time spent with the patient may overshadow recognition of morbid symptoms that may overlap normal physiology of pregnancy. Hence, a standard risk assessment tool may streamline clinical practice and guide further evaluation of a complaint that may have otherwise gone unattended.

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APPENDIX For the Code Book for Developing Cardiovascular Risk Assessment Algorithm, please see the online version of this paper.