Original research article

Clinicians' perspectives on the adoption and implementation of EMR-integrated clinical decision support tools in primary care

Debora Goetz Goldberg[1,2] [iD]**, Tulay G Soylu[3], Carolyn Faith Hoffman[1], Rachel E Kishton[4] and Peter F Cronholm[4,5,6]**

Abstract

Objective: Understand the perceptions of primary care clinicians on the challenges, barriers, and successful strategies for implementing and disseminating clinical decision support (CDS) tools in primary care.

Methods: Qualitative research involving in-depth interviews with 32 primary care clinicians practicing in a range of settings across the United States. Semi-structured interviews were conducted between July 2021 and September 2023.

Results: All participants reported using CDS tools for patient care, with high variability in the frequency of use and the type of tools used. Fewer clinicians described using machine learning-based systems and risk assessment tools using predictive analytics. Most clinicians were favorable toward enhanced use of CDS tools for patient care if used along with clinical judgment and patient preferences. Clinicians described tremendous barriers to the adoption and implementation of EMR-integrated CDS tools, including clinician resistance, organizational approval, and lack of infrastructure and resources. Clinicians stressed the importance of communicating evidence on the effectiveness of CDS tools, integrating tools with existing EMR systems, and having an easy-to-navigate interface. Strategies for the implementation of CDS tools included an organizational champion, technical assistance, and education and training.

Conclusions: CDS tools have the potential to be valuable assets in treating patients in primary care and could improve diagnostic accuracy, enhance personalized treatment plans, and ultimately advance the quality of patient care. There are many concerns with the use of EMR-integrated CDS tools in primary care that should be considered including evidence of the tool's effectiveness, data security and privacy protocols, workflow integration, and clinician burden.

[1]Department of Health Administration and Policy, College of Public Health, George Mason University, Fairfax, VA, USA
[2]Center for Evidence-Based Behavioral Health, Department of Psychology, George Mason University, Fairfax, VA, USA
[3]Department of Health Services Administration and Policy, College of Public Health, Temple University, Philadelphia, PA, USA
[4]Department of Family Medicine and Community Health, University of Pennsylvania, Philadelphia, PA, USA
[5]Center for Public Health, University of Pennsylvania, Philadelphia, PA, USA
[6]Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA

Corresponding author:
Debora Goetz Goldberg, Department of Health Administration and Policy, College of Public Health, George Mason University, 4400 University Drive MS 1J3, Fairfax, VA 22030, USA.
Email: dgoldbe4@gmu.edu

Introduction

In the last several decades, there have been tremendous advancements in digital health technologies including the electronic medical record (EMR), electronic prescribing systems, telemedicine platforms, and electronic tools designed to enhance clinical decision-making. Clinical decision support (CDS) tools are digital technologies that assist in the capture, assessment, validation of data, and/or interpretation of evidence for point-of-care decisions by clinicians, patients, and families.[1] CDS tools support or provide recommendations to healthcare professionals about the prevention, diagnosis, or treatment of a disease or condition. These tools include automated alerts and reminders, evidenced-based clinical guidelines, condition-specific order sets, documentation templates, medical and pharmaceutical reference information, and clinical workflow tools.[2] While web-based CDS applications administered through desktop, tablet, or smartphones are commonly used, the availability and usage of EMR-integrated CDS tools in office-based primary care settings is less frequent.[3] Many EMR-integrated CDS tools support screening or treatment of chronic diseases such as cardiovascular (CV) disease, diabetes, and depression. More advanced EMR-integrated CDS tools are based on artificial intelligence (AI) or machine learning system(s) that make predictions or recommendations based on machine and human-based inputs.[4] AI has the potential to improve medical treatment, clinical care, and healthcare workflow. From being able to predict health conditions and generate precise treatment plans to organizing appointment scheduling, billing, and patient records, AI offers new opportunities for clinicians and healthcare organizations.[5] In primary care, advanced EMR-integrated CDS tools have tremendous potential to improve the diagnosis and treatment of specific diseases since these tools can be designed to access real-time patient data and combine patient data with data extracted from a computerized knowledge base.[6]

Numerous studies on the effectiveness of CDS tools have found improvements in process-related outcomes such as increased screening rates and a reduction in incomplete or unclear ordering; however, fewer studies have evaluated and reported patient outcomes.[3,7] A meta-analysis review of randomized and quasi-randomized control trials on various CDS tools found significant, yet modest, improvements in the proportion of patients receiving desired care and small improvements in patients receiving standard of care.[8] In primary care, several studies provide supporting evidence on specific CDS tools for improving the quality of patient care, reducing clinician administrative burden, and/or decreasing time to treat patients.[9–11]

Despite a recent surge in research on the effectiveness of specific CDS tools, challenges remain regarding the low adoption of CDS tools among clinicians.[12–14] Previous research found a number of issues that influence adoption and implementation including problems with usability, workflow integration, alert fatigue, lack of clinician training and familiarity with tools, concerns with data quality and reliability, costs and resource constraints, and cultural and organizational barriers.[8,13–19] Many clinicians support the concept of CDS,[20,21] but struggle when incorporating decision support into their workflow for patient care, especially when there are organization-directed changes to the EMR that are forced on clinicians and require changes to clinical routines.[3] Additionally, EMR-integrated CDS tools meant to improve patient outcomes could extend health care disparities due to the algorithms these systems are based on. Such algorithms can exclude risk factors for certain populations and/or lack appropriate representation of all population subgroups.[7] Furthermore, providers and organizations in low-resource settings, such as safety-net organizations, may have limited access to EMR-integrated CDS tools and/or health information technology, further widening disparities in quality of care.

In order to achieve the quadruple aim of healthcare[22]— to improve population health, to provide high-quality, cost-efficient care, in a satisfying and supportive work environment—it is critical to understand the factors that influence clinicians' decisions to use CDS tools so that developers can take this information into account to build innovative tools[23,24] and/or interfaces[25] with appropriate support and guidance for implementation. Therefore, it is central to understand clinician perspectives on the adoption and implementation of CDS tools in primary care practice settings.[26–28]

This research is unique in that our aim was to capture perceptions on the implementation and use of CDS tools from physicians, nurse practitioners, and physician assistants in various primary care settings across the United States. Our research objectives were threefold: (1) to understand primary care clinician perceptions on the adoption and use of CDS tools; (2) to identify facilitators and barriers to adopting and implementing advanced CDS tools in primary care; and (3) to develop a portfolio of implementation strategies to support uptake. It is important to understand primary care clinician viewpoints in order to design CDS tools that meet the clinical and administrative needs of clinicians and to address current challenges with adoption and implementation.

Methods

This qualitative research is part of a larger study conducted in the United States from 2021 to 2023 on clinician well-being and the use of health information technology (HIT) in primary care practice settings. The study received approval from the George Mason University Institutional Review Board (IRB) on March 2, 2021, IRB number 1683652. All participants were informed of privacy and confidentiality procedures during the consent process.

Sample

Inclusion criteria for the sample were physicians, physician assistants, and nurse practitioners with prescribing authority who work in primary care settings in the United States. Exclusion criteria for participation were specified as anyone who was a medical trainee or not a practicing primary care clinician in the United States. We used a maximum variation sampling approach to balance clinician characteristics based on gender, age, and US geographic region. Clinicians were recruited through snowball sampling and recruitment through the North American Primary Care Research Group (NAPCRG) listserv and announcements by the American Academy of Physician Associates. Recruitment of participants continued until thematic saturation was achieved and additional data did not lead to new emergent themes.[29]

Data collection

We conducted private interviews with primary care clinicians (physicians, nurse practitioners, and physician assistants) between July 2021 and September 2023 using Zoom videoconferencing software. To support the integration of innovative findings, interview questions were based on the Unified Theory of Acceptance and Use of Technology (UTAUT)[30] and the Diffusion of Innovation (DOI) theories to provide a strong framework for positioning and disseminating respondent perspectives.[31,32] The UTAUT provides a framework for individual intentions and future use behaviors regarding technological innovations, which consists of four key constructs—effort expectancy, performance expectancy, social influence, and facilitating conditions. The DOI supports the spread of innovations through five main factors that influence adoption including: the relative advantage, or perceived benefit, of using an innovation over the current process or product; compatibility of the innovation with existing systems and processes; complexity of understanding and/or using the innovation; trialability, the ability to use the innovation before adoption; and observability, which is the extent to which the innovation provides tangible results. We used constructs from the UTAUT and the DOI theories to develop interview questions with the goal to capture a broad range of information on factors that influence the decision to adopt and implement CDS innovations in primary care settings. Interview questions used for this study are provided in Supplementary File A.

The interviews were conducted by two experienced qualitative researchers (DGG and TGS) and lasted between 60 and 90 minutes. Primary care clinicians who completed the interview were provided with a $250 gift card for participation.

Data analysis

Interview recordings were transcribed using Zoom video conferencing software and cleaned by the corresponding interviewer. Our qualitative coding process combined deductive coding, where predefined codes were derived from existing theories and inductive codes that emerged through iterative data analysis and interpretation. We developed an initial codebook based on the UTAUT and DOI theories and our knowledge on the adoption and implementation of information technology in clinical settings.

Three qualitative researchers (DGG, TGS, CFH) performed multiple cycles of coding[33] over a nine-month period using NVivo software. Our data analysts met numerous times to discuss the coding process, data interpretation, evolution of the codebook and coding scheme, and the emergence of key themes.[34] After the coding was complete, two physician researchers (PFC, REK) performed a secondary review of key themes and corresponding quotes to evaluate whether there was sufficient evidence to substantiate themes. During this process, physician researchers asked questions to the analytic team regarding the themes and made minor suggestions for rewording theme names and descriptions. There were no major disagreements regarding the key themes between the primary analytic process and the secondary review.

Results

We interviewed a total of 32 primary care clinicians, which included 24 physicians, 3 nurse practitioners, and 5 physician assistants. Participants worked in various practice settings and geographic locations across the United States. Table 1 provides detailed information on participant characteristics.

Key themes from the clinician interviews are presented in three categories: clinicians' perceptions and experiences with HIT; barriers and challenges to adopting and implementing CDS tools; and strategies recommended by clinicians for the adoption and implementation of CDS tools in primary care. Table 2 presents key themes and supporting quotes. Themes related to barriers to the adoption and implementation of CDS tools in primary care and strategies for overcoming these barriers were aligned with the UTAUT and DOI theories. UTAUT theory constructs that stood out as barriers are related to effort expectancy, performance expectancy, and facilitating conditions, while DOI constructs around barriers were related to relative advantage, compatibility, and complexity of the CDS tool. Strategies suggested by clinicians in our study were mostly related to the UTAUT constructs of social influence and facilitating conditions and DOI constructs of complexity, trialability, and observability. Figure 1 presents key themes aligned with UTAUT and DOI theories.

Clinician perceptions and experiences with HIT

Key themes that emerged from clinician interviews were ongoing issues with EMRs, widespread use of digital health

Table 1. Participant characteristics (N = 32).

Characteristics of participants	N (%)
Clinician type	
Physician	24 (75%)
Nurse practitioner	3 (9%)
Physician assistant	5 (16%)
Participant age group (years)	
25 to 34	8 (25%)
35 to 44	9 (28%)
45 to 54	5 (16%)
55 to 64	8 (25%)
65 and older	2 (6%)
Identifying gender	
Female	20 (63%)
Male	12 (37%)
Practice setting	
Academic Medical Center	15 (47%)
Private Practice	13 (41%)
Community Health Center	2 (6%)
Various Settings	2 (6%)
Practice size	
1 to 10	16 (50%)
11 to 20	4 (12%)
21 to 30	6 (18%)
30 or more	6 (18%)
Location	
Urban	19 (60%)
Suburban	7 (22%)
Rural	6 (18%)
United States Region	
Northeast	12 (37%)

(continued)

Table 1. Continued.

Characteristics of participants	N (%)
South	11 (34%)
Midwest	5 (16%)
West	4 (12%)
Experience with health information technology	
High	18 (56%)
Medium	7 (22%)
Varies	6 (18%)
Not answered	1 (3%)
Uses Decision Support Systems (DSS)	
Yes	32 (100%)

technology across clinician types and practice settings, and varied use of CDS tools. Most clinicians (26/32) stated they experience issues with their current EMR system. These issues include not being able to use the EMR platform efficiently; inability to view clinically relevant information; inability to share information because of interoperability issues within components of the same EMR or from the EMR to other systems; and increased work burden associated with entering information in the EMRs. Numerous participants made comments about EMR inefficiencies such as "death by a thousand clicks" (MD55-64F#23) and "numerous hard stops" (MD55-64M#9) that prevented them from completing clinical reporting.

All (32/32) participants reported using CDS tools for patient care, with high variability in the frequency of use and the type of tools used. Clinicians described using alerts and reminders, diagnostic decision trees and algorithms, interactive guidelines, medication management systems, and point-of-care applications such as clinical information and drug databases. Most clinicians (29/32) reported often using mobile CDS applications at the point-of-care such as cardiovascular disease (CVD) risk calculators, treatment guidelines for sexually transmitted diseases (STIs), medical knowledge resources including UpToDate and DynaMed Plus, and the Prevention TaskForce application to identify appropriate screening, counseling, and preventive medication services.

Clinicians of all age groups (32/32) described using simple EMR-integrated CDS tools such as Computerized Provider Order Entry (CPOE), documentation templates, and alerts and reminders. Numerous clinicians described

Table 2. Themes and supporting quotes.

Theme Category/Theme/Quote	Participant indentifier
1. Clinician perceptions and experiences with HIT and CDS	
Theme: Widespread use of Digital Health Technology	
We're a residency site, so I think, given that we tend to embrace trying to be kind of on the cutting edge. We've been doing telehealth for years and then the pandemic came and we went from like 1 or 2% telehealth to 100% telehealth in a week. And we regularly are trying to create tools and applications and integrate them into our systems.	MD45-54M#4
We have some embedded [tools] that calculate cardiovascular risk and I'll use that in terms of treating for cholesterol. I have used a program called the Pap App… Which is, it was a great algorithm for treating abnormal paps. I use Epocrates for looking things up. I mean, there's definitely tools I use that are like the PMP [Prescription Monitoring Programs] which is embedded for evaluating narcotic usage in multiple states.	PA45-54F#30
Theme: Varied use of Clinical Decision Support Tools	
We have screening tools, like we have the PHQ-9 in [the EMR]… I don't use a lot of the [tools in the EMR]. I actually have them on my cell phone.	MD55-64M#12
I will use [CDS tools] to support things. For example, the American College of Cardiology and the American Heart Association have an app for figuring out the probability of developing heart disease in the next several years, and I'll use that with patients to show them what their risk is.	MD65 + M#7
Theme: On-Going Problems with EMR Systems	
And one thing that we see quite a bit here is prior authorizations cause a delay in care. And it causes headaches for a lot of physicians and physicians assistants.	MD55-64F#23
Ease of use, like if there's a lot of clicks involved. That can be frustrating when you're like 'I just need to get through this, I just need to like get this in the system' kind of thing and you're having to like click through a bunch of things…	MD35-44F#2
2. Barriers and challenges to implementation of CDS in primary care	
Theme: Resistance to Change	
… instead of prescribing the way you always have. We're going to use this tool and start prescribing based on this data. You might find kind of a cultural resistance to it.	MD45-54M#21
I think a lot of it is going to be. 'Well, this is the way we've always done it. Um, we hadn't needed a clinical decision support tool… Why do we need it now?'	MD55-64F#23
Theme: Time and Effort Required	
Time is a big factor as well, and so, sometimes you can lean on your past knowledge or your own brief screening before you use a decision aid, for instance, because you are limited, with the visits I mean typically primary care visits are 15 to 20 min and it's just really hard to be able to kind of do multiple things…	MD25-34F#6
Number two is time, you know. You have to take time away from patient care and educate and then you have new employees joining…	NP45-54F#25
Theme: Incompatibility with Current Systems and Processes	
The biggest hurdles to overcome would be if you can get it to sync with EMR. If you can't get it to sync with the EMR you have to have the user interface be as seamless as possible so that we can just spit stuff in and have it coming.	MD35-44M#17
It depends on how you deliver it. If you deliver it as an application that I can use on my smartphone. That's fine. If you	MD65 + M#18

(continued)

Table 2. Continued.

| Theme Category/Theme/Quote	Participant indentifier
can deliver it as an application I can use on my computer. That's fine. If you want me to put it into my electronic medical record, and that there'll be several obstacles.	
Theme: Requirement for Organizational Approval	
…would have to go through a specific committee. That [committee] is under a specific executive and community health center and it would make a decision, and then it has to be discussed by community health center leadership.	MD35-44M#27
It would need to be adopted by the [hospital] system. In other words, we wouldn't be able to implement something like that in our clinic alone. So, there is an Epic team, an informatics team that would have to analyze the tool and decide.	MD55-64M#12
3. Strategies for adoption and implementation	
Theme: Organizational and Leadership Support	
We have, like a few doctors at the top of our leadership, who practice clinically and kind of we get all our updates from them. So, I think if there was someone at the top of an organization that was a proponent of it that would be more likely to encourage the other members [to use the CDS tool]	PA25-34F#28
…for leadership purposes, if a medical director, for example in a practice agrees to implement it, that would be good.	MD25-34F#20
Theme: Designated Champion	
I think that you need multiple champions. In my experience even just having one champion I think is necessary, but sometimes it's insufficient, because sometimes that champion like goes on leave or gets to distracted with other responsibilities they have competing priorities, so it seems like you really need like multiple champions but yes, I think the champion is critical.	MD35-44M#27
Whenever something is new someone has to champion it and it's preferable that it's a clinician that others would relate to.	MD55-64F#26
Theme: Technical Support	
What I honestly think is that a website could be really helpful. You know, maybe, that can be linked to from the tip sheets. You know, if people want more information, that kind of thing. I think that the teaching folks who go around doing coaching [is also helpful].	MD45-54M#9
…like some sort of lunchtime meeting where providers can log in and kind of have someone walk through and talk to them about it and then I think, having like phone support would be important to in case like people came across issues…	MD55-64M#15
Theme: Communication of Scientific Evidence	
It would depend on how it was presented and what the level of evidence was …So you know, presenting the evidence and training. You know that the resistance here is nobody likes to learn new stuff, you know it's going to be more work, and if they think they already know the subject, then you've got to have, I'll use the word evidence again. …	MD65 + M#18
I would say, like also making sure that a tool has been studied appropriately and is evidence based. Like I mentioned some of the older physicians may not buy in as much into evidence-based medicine, but I do think family medicine and primary care is very much moving into the world of evidence-based medicine…	MD25-34F#16
Theme: Need for User Friendly, Efficient CDS Tools	
Making [tools] simple and making them easy to use, and making them sort of as one click as possible.	MD55-64M#14
It needs to be user friendly it needs to be timely, so you have to be able to access it in the moment when you want to access it. And it has to be easy to get the information that you want to get.	MD35-44M#24
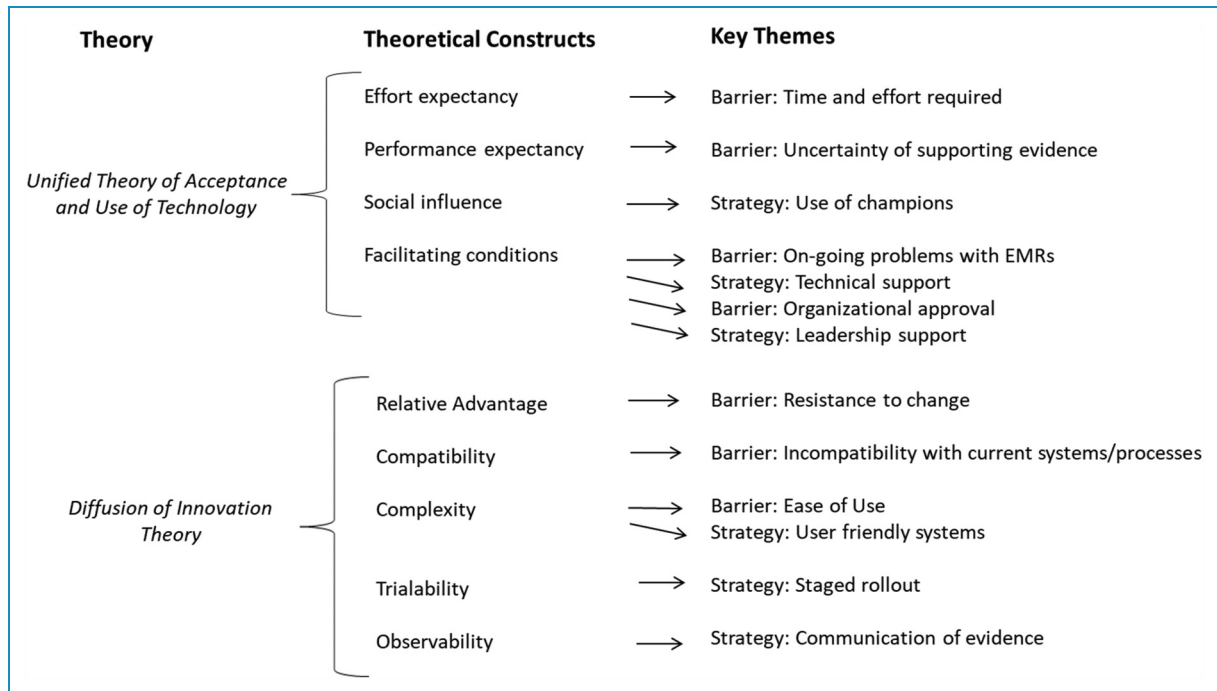
Figure 1. Theoretical constructs related to key themes on the barriers and strategies to implement CDS in primary care.

using EMR-integrated CDS tools such as the Patient Health Questionnaire-9 (PHQ-9) for depression screening. Fewer clinicians (3/32) described using advanced EMR-integrated CDS tools based on AI, machine learning systems, or risk assessment tools using predictive analytics.

All clinicians in our study (32/32) were favorable toward enhanced use of CDS tools for patient care, as long as these systems are used in combination with clinical judgment and patient preferences. Clinicians (32/32) reported that EMR-integrated CDS tools were preferred over CDS mobile applications or desktop tools due to increased efficiency and access to patient data. However, clinicians expressed apprehension toward EMR-integrated CDS tools and reported concerns regarding the potential for misdiagnosis or inappropriate care decisions based on the results provided by CDS tools, particularly tools developed from large databases that may not include appropriate representation of specific populations. Several clinicians (2/32) also raised concerns about the legal ramifications of using CDS tools and questioned whether the use of CDS tools could be subject to medical malpractice liability. Several other clinicians (2/32) were concerned with the potential for overreliance on the results of CDS tools, which may lead to not developing clinical knowledge or losing clinical knowledge over time. During discussions on factors that influence the adoption of CDS tools, the majority of clinicians (26/32) stated they would like to see the "evidence" that a specific CDS tool resulted in improved patient outcomes including published results from pragmatic clinical trials.

Facilitators and barriers to adopting and implementing CDS tools in primary care

Clinicians in our study detailed a range of barriers related to the adoption and implementation of CDS tools in their practice environments, which included resistance to change; a perception of too much time and effort for adoption and implementation; incompatibility with current systems and processes; and the need to get organization approval for adoption.

Multiple clinicians described difficulty in adopting CDS tools due to fellow providers, often those practicing the longest, resisting adoption. One physician stated, "If you've been doing this for thirty years, there might be a risk that you're going to say, 'Well, I already know how to handle this particular decision" (MD45-54M#21). Multiple clinicians made similar comments to the following from a physician assistant "There's always going be somebody who doesn't have a desire, you know, and they're just going to do what they've always done" (PA45-54F#30).

All clinicians (32/32) remarked that their decision to adopt decision support tools depended on how much time and effort would be required of them, particularly due to their high patient workload. As one clinician mentioned, "Even if I'm willing to be adaptive, I have 20 patients to see today and then need to get home and take care of my family" (MD45-54M#9).

There was also a major concern regarding whether CDS tools could be integrated into their EMR system. One clinician referred to the integration of CDS tools in their EMR

as "the biggest hurdle to overcome" (MD35-44M#17). Another commonly reported worry was "minimizing clicks" (MD55-64M#14). As one clinician noted, "If there's a lot of clicks involved, that can be frustrating when you're like, 'I just need to get through this'" (MD35-44F#2). One clinician noted the importance of how such tools would be delivered, stating, "If you deliver [the tool] as an application I can use on my smartphone, that's fine. If you can deliver [the tool] as an application I can use on my computer, that's fine. If you want me to put it into my EMR … there will be several obstacles" (MD65 + M#18). Most clinicians (29/32) stressed the need to get organizational approval before adopting a new decision support tool. One clinician stated, "In order for me to use [new] software, I need to get permission from [the hospital] system, which could be, you know, a five-year process (MD65 + M#18).

Effective approaches for the implementation of CDS tools in primary care

Participating clinicians described a range of strategies for the adoption and effective implementation of CDS tools including designation of an organizational champion, education and training, and technical assistance. For the decision to adopt a specific CDS tool, clinicians (32/32) pointed out the need for tools to be efficient and to have a user-friendly interface. One physician stated "It needs to be user friendly, it needs to be timely, so you have to be able to access it in the moment when you want to access it. And it has to be easy to get the information that you want to get" (MD35-44M#24). Many clinicians (26/32) also expressed the need for supporting evidence of the tool's effectiveness, such as the quote from one physician assistant "…if it comes from a university, a reputable one. You know, if it's not biased and informed with real data" (PA35-44M#31).

Most clinicians (31/32) reported that an organizational champion for the adoption and implementation of new CDS tools was critical. One clinician stated "It would take much longer to get to success if you didn't have a physician champion" (MD55-64F#19). Most (28/32) clinicians believed that technical assistance was important for implementation, including websites, written instructions, how-to guides, and training sessions. One participant suggested "training to introduce the tool to providers and how to use the tool through the EMR … whether it's a five-minute video session or a 30-minute meeting where people could ask questions" (MD55-64F#15).

In discussions with clinicians on whether a new CDS tool should be implemented in stages or all at once, the majority (24/32) indicated that a staged rollout would be more successful. Numerous clinicians made comments similar to the one from this physician "I think a staged roll out would work better … the process lets you get it

settled and stabilized, and then rolling it out more broadly when it's likely to be successful … (MD45-54M#20). Another suggestion was to pilot test the CDS tool. "A pilot program for three months or so…. The people who were comfortable using it could then help to train and show other providers on how to use it and give their tips and tricks" (MD55-64F#15).

Discussion

EMR-integrated CDS tools are being developed at a rapid pace and offer a diverse range of functionalities to aid clinical decision-making.[35] These tools have the potential to improve patient safety, enhance adherence to evidence-based practices, and reduce medical errors.[3]

The main purpose of our study was to gain an in-depth understanding of primary care clinician use of CDS tools and their perspectives on adoption and implementation.

Our study found numerous barriers to implementing CDS tools in primary care including the need for organizational approval for the adoption of new EMR-integrated CDS tools, extensive issues with integration of CDS tools within the EMR, and adjustments to clinical workflow. In addition, some practices may not have the technical staff required to integrate new CDS tools into their EMR systems or may have policies that prohibit modifications.[36] Participants in our study also indicated that other clinicians in their practice may be resistant to the use of new CDS tools. Individual factors that may be related to resistance include a lack of confidence in the tool, an increase in stress related to using the tool, or a lack of knowledge about the tool or required changes in patient care.[37] In addition, clinicians in our study had previous negative experiences with the use of digital technologies that influenced their perceptions on the adoption and implementation of CDS tools. Numerous clinicians reported negative experiences with their EMR, which resulted in disruptions to patient care, additional time required for data entry leading to poor work-life balance, and increased levels of burnout. Similar issues have been reported by other researchers studying clinicians' experience with the EMR and/or CDS tools, including time constraints, staff shortages, increased burnout,[12,15] insufficient training, documentation taking time away from patient care, and becoming exhausted from "button clicking".[16]

Clinicians' suggestions for implementation of EMR-integrated CDS tools included identification of an organizational champion, on-site and web-based training sessions, and technical assistance such as a website, call center help desk, and how to guides. A systematic review of peer-reviewed literature on CDS tools found the most frequently reported implementation strategies included education on the CDS tool, use of external facilitation or practice coaches, identification and use of clinical champions, changes to workflow and procedures, and use of an audit and feedback mechanism.[7] Participants in our study also voiced

strong opinions that the adoption decision for advanced EMR-integrated CDS tools should be based on scientific evidence and that CDS tools have sufficient systems for data security. A mixed quantitative and qualitative study on primary care provider perspectives on CDS tools also reported data concerns among providers, such as data security, privacy, and accuracy, noting "accuracy of data … and the tool should be clinically tested."[38] Other researchers recommend that users have access to clear information on the processes and algorithms that determine the outputs of CDS tools.[13] This transparency is essential so that clinicians have sufficient information on the factors underlying the CDS recommendations so they can compare the recommendation provided by the CDS tool with their own knowledge and experience.[17]

It is critical to include clinician perspectives in the design and testing phases for new CDS tools, which will aid in identifying the functions and features necessary to meet the needs of clinicians.[7,39] The use of a participatory approach that includes clinicians in the design and implementation phase has been found to be an effective method to assure adherence and effective functionality of CDS tools in previous research.[40–42]

For the implementation and dissemination of EMR-integrated CDS tools, an in-depth practice assessment is needed to facilitate planning for modifications in care processes and administrative tasks for the effective use of these tools in primary care. Also, an assessment of CDS tools should consider integration with current HIT systems, modifications to the work process, and clinician and staff time and effort. The process should also include field tests to understand the effectiveness of the tool within realistic practice conditions. Strategies to reduce user distrust include communications that reference expert knowledge and citations of published research that highlight evidence of the CDS tool's effectiveness in primary care.[3]

Our participants also raised concerns regarding ethical issues, liability, and the potential for overreliance on digital technologies. Ethical issues include the introduction of bias that may result in disparities if the CDS tool is based on research or algorithms that lack representation of population subgroups or exclude risk factors for specific population subgroups.[6] The clinician apprehension seen in our study is shared by many groups who are concerned that bias is incorporated into the knowledge base used to support advanced CDS tools that may intensify racial and ethnic bias and result in inappropriate care.[6] To address this issue, experts recommend the development of national standards for collecting and handling healthcare data and additional safeguards to protect the privacy and security of data.[43–45] At a policy level, both President Biden and President Trump issued Executive Orders to advance the development of AI and establish standards for using AI in healthcare and other industries, including supporting responsible development of AI

algorithms and tools for clinical care.[4,46] Experts also raise concern about payment for the purchase of new technologies and suggest that the Centers for Medicare and Medicaid Services (CMS) needs updated methods to monitor and reimburse practices for EMR-integrated CDS tools and implementation processes.[6,47]

The results of our research support previous reports[48–50] that recommend the need for clinicians to be part of the planning, development, implementation, and evaluation processes for new CDS tools and the need for an assessment of whether the use of CDS tools will add to or alleviate clinicians' workload.

Limitations

There are several limitations that should be considered when reviewing the findings. The qualitative approach and sampling issues limit the interpretation of the findings to hypothesis generation. We did, however, include methods to improve the credibility, confirmability, dependability, and transferability of the findings, which include the use of a semi-structured interview guide, a multidisciplinary team for data analysis, secondary review of themes by physician researchers, and maintenance of an audit trail of theme development and analytic decisions.[51] We experienced challenges in recruiting primary care clinicians to participate in the study during the response to the COVID-19 pandemic; in response, we extended enrollment to a 2-year period. Clinicians who responded to our recruitment announcement but declined to participate stated "lack of time" as the reason for not participating. Our approach may have inadvertently involved response bias. We recruited a high number of clinicians from the northeast and southern states and a high number of clinicians in academic settings, which may have introduced a biased discussion of challenges experienced in those settings that do not exist in other primary care settings.

Conclusion

EMR-integrated CDS tools have the potential to improve personalized patient treatment. Most clinicians in our study were favorable toward the use of CDS for patient care, as long as these tools are used along with clinical judgment and patient preferences. There are many concerns with the use of EMR-integrated CDS tools in primary care that should be considered including evidence of the tool's effectiveness, data security and privacy protocols, workflow integration, and clinician burden.

analysis and interpretation of data, or the writing of this manuscript.

ORCID iD
Debora Goetz Goldberg 🆔 https://orcid.org/0000-0003-3121-7942

Statements and declarations

Ethical considerations
The study received approval from the George Mason University Institutional Review Board on March 2, 2021.

Author contributorship/CRediT
DGG designed the study, collected and analyzed data, and wrote large portions of the manuscript. TS participated in data collection, analysis, and writing portions of the manuscript. CFH participated in data analysis and writing of the manuscript. PC and RK participated in a secondary review of the key themes and writing of the manuscript.

Conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Supplemental material
Supplemental material for this article is available online.

References

1. Lopez MH, Weingarten S and Teich JM, et al. (eds). *National Academy of Medicine; The Learning Health System Series. Optimizing Strategies for Clinical Decision Support: Summary of a Meeting Series*. Washington (DC): National Academies Press (US); 2017. PMID: 37733888.
2. HealthIT.gov. *What is Clinical Decision Support (CDS)?*. Clinical Decision Support | HealthIT.gov (Accessed on February 12, 2024).
3. Sutton RT, Pincock D, Baumgart DC, et al. An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ Digit Med* 2020; 3: 17.
4. USC § 9401(3) Chapter 119-National Artificial Intelligence Initiative. https://uscode.house.gov/view.xhtml?req=(title:15%20section:9401%20edition:prelim) (Accessed on April 30, 2024).
5. Reuben JS, Meiri H and Arien-Zakay H. AI's pivotal impact on redefining stakeholder roles and their interactions in medical education and health care. *Front Digit Health* 2024;6: 1458811. PMID: 39564581; PMCID: PMC11573760.
6. Ghaffar N, Kaplanoglu E and Nasab A. Evaluation of artificial intelligence techniques in disease diagnosis and prediction. *Discov Artif Intell* 2023; 3: 5. Epub 2023 Jan 30. PMCID: PMC9885935.
7. Stipelman CH, Kukhareva PV, Trepman E, et al. Electronic health record-integrated clinical decision support for clinicians serving populations facing health care disparities: literature review. *Yearb Med Inform* 2022; 31: 184–198. Epub 2022 Dec 4. PMID: 36463877; PMCID: PMC9719761.
8. Kwan JL, Lo L, Ferguson J, et al. Computerised clinical decision support systems and absolute improvements in care: meta-analysis of controlled clinical trials. *Br Med J* 2020; 370: m3216. PMID: 32943437; PMCID: PMC7495041.
9. 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: 12–21. PMID: 21242556; PMCID: PMC3022040.
10. 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: 1137–1146. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6658854/. PMID: 29982627; PMCID: PMC6658854.
11. Martinez-Franco AI, Sanchez-Mendiola M, Mazon-Ramirez JJ, et al. Diagnostic accuracy in family medicine residents using a clinical decision support system (DXplain): a randomized-controlled trial. *Diagnosis (Berl)* 2018; 5: 71–76.
12. Hooker SA, Solberg LI, Miley KM, et al. Barriers and facilitators to using a clinical decision support tool for opioid use disorder in primary care. *J Am Board Fam Med* 2024; 37: 389–398.
13. Khairat S, Marc D, Crosby W, et al. Reasons for physicians not adopting clinical decision support systems: critical analysis. *JMIR Med Inform* 2018; 6: 24.
14. Meunier PY, Raynaud C, Guimaraes E, et al. Barriers and facilitators to the use of clinical decision support systems in primary care: a mixed-methods systematic review. *Ann Fam Med* 2023; 21: 57–69. PMID: 36690490; PMCID: PMC9870646.
15. Alsalemi N, Sadowski C, Kilpatrick K, et al. Exploring key components and factors that influence the use of clinical decision-support tools for prescribing to older patients with kidney disease: the perspective of healthcare providers. *BMC Health Serv Res* 2024; 24: 26.
16. Upadhyay S and Hu HF. A qualitative analysis of the impact of electronic health records (EHR) on healthcare quality and

safety: clinicians' lived experiences. *Health Serv Insights* 2022; 15: 11786329211070722. PMID: 35273449; PMCID: PMC8902175.

17. Van Biesen W, Van Cauwenberge D, Decruyenaere J, et al. An exploration of expectations and perceptions of practicing physicians on the implementation of computerized clinical decision support systems using a qsort approach. *BMC Med Inform Decis Mak* 2022; 22: 85.

18. Vijayakumar S, Lee VV, Leong QY, et al. Physicians' perspectives on AI in clinical decision support systems: interview study of the CURATE.AI personalized dose optimization platform. *JMIR Hum Factors* 2023; 10: e48476.

19. Walsh K. The perspective of physicians on the value of online clinical decision support. *Proc (Bayl Univ Med Cent)* 2019; 32: 58–60. PMID: 30956582; PMCID: PMC6442882.

20. Trinkley KE, Blakeslee WW, Matlock DD, et al. Clinician preferences for computerised clinical decision support for medications in primary care: a focus group study. *BMJ Health Care Inform* 2019; 26: 0.

21. Carlsson SV, Preston M, Vickers A, et al. Provider perceptions of an electronic health record prostate cancer screening tool. *Appl Clin Inform* 2024; 15: 282–294.

22. Bodenheimer T and Sinsky C. From triple to quadruple aim: care of the patient requires care of the provider. *Ann Fam Med* 2014; 12: 573–576. PMID: 25384822; PMCID: PMC4226781.

23. Vani A, Kan K, Iturrate E, et al. Leveraging clinical decision support tools to improve guideline-directed medical therapy in patients with atherosclerotic cardiovascular disease at hospital discharge. *Cardiol J* 2022; 29: 791–797. Epub 2020. PMID: 32986236; PMCID: PMC9550339.

24. Mathieson K. Predicting user intentions: comparing the technology acceptance model with the theory of planned behavior. *Inf Syst Res* 1991; 2: 173–191.

25. Dillon A and Morris M. User acceptance of information technology: theories and models. In: Williams M (eds) *Annual review of information science and technology*. 31. Medford, NJ: Information Today, 1996, pp.3–32.

26. Johnson JL, Green LW, Frankish CJ, et al. A dissemination research agenda to strengthen health promotion and disease prevention. *Can J Public Health* 1996; 87): S5–10. PMID: 9002336.

27. Rabin B and Brownson R. Developing the terminology for dissemination and implementation research. In: Brownson R, Colditz G and Proctor E (eds) *Dissemination and implementation research in health: translating science to practice*. New York, NY: Oxford University Press, 2012, pp.23–51.

28. Feldstein A and Glasgow RE. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf* 2008; 34: 228.

29. Given LM. *100 Questions (and Answers) About Qualitative Research*. Thousand Oaks, CA, US: Sage; 2016.

30. Venkatesh V, Morris MG, Davis GB, et al. User acceptance of information technology: towards a unified view. *MIS Q* 2003; 27: 425–478.

31. Dearing JW and Cox JG. Diffusion of innovations theory, principles, and practice. *Health Aff* 2018; 37: 183–190.

32. Rogers EM. *Diffusion of Innovations*. Glencoe: Free Press, 1962.

33. Miles MB, Huberman AM and Saldana J. *Qualitative Data Analysis A Methods Sourcebook*, 4th Ed. Los Angeles, CA, US: Sage; 2020.

34. Bradley EH, Curry LA and Devers KJ. Qualitative data analysis for health services research: developing taxonomy, themes, and theory. *Health Serv Res* 2007;42(4): 1758–1772.

35. Alexiuk M, Elgubtan H and Tangri N. Clinical decision support tools in the electronic medical record. *Kidney Int Rep.* 2023;9:29–38. PMID: 38312784; PMCID: PMC10831391.

36. Douthit B, Richesson R, Marsolo K, et al. Designing and Building CDS Tools for Pragmatic Clinical Trials. National Institutes of Health. https://rethinkingclinicaltrials.org/chapters/conduct/real-world-evidence-clinical-decision-support/designing-and-building-cds-tools-for-pragmatic-trials/ (Accessed on April 19, 2024).

37. Darmawan AH and Azizah S. Resistance to change: causes and strategies as an organizational challenge. In: *Advances in social science, education and humanities research*, 2020, paper no. 395, pp.49–53.

38. Areán PA, Friedman EC, Pratap A, et al. Using real-world data for decision support: recommendations from a primary care provider survey. *Perm J* 2021; 25: 20–213. PMID: 33970071.

39. Shah T, Kitts AB, Gold JA, et al. Electronic health record optimization and clinician well-being: a potential roadmap toward action. *NAM Perspect* 2020; 2020: 10.31478/202008a. PMID: 35291737; PMCID: PMC8916811.

40. Jeffery AD, Novak LL, Kennedy B, et al. Participatory design of probability-based decision support tools for in-hospital nurses. *J Am Med Inform Assoc* 2017; 24: 1102–1110. PMID: 28637180.

41. Osheroff JA, Teich JA, Levick D, et al. *Improving Outcomes with Clinical Decision Support: An Implementer's Guide*. 2nd Edition. Chicago, IL: HIMSS, 2012:15.

42. Campbell RJ. The five rights of clinical decision support: CDS tools helpful for meeting meaningful use. *J AHIMA.* 2013; 84, 10: 42–47 (web version updated February 2016).

43. Haroon S, Wooldridge D, Hoogewerf J, et al. Information standards for recording alcohol use in electronic health records: findings from a national consultation. *BMC Med Inform Decis Mak* 2018; 18: 36. PMID: 29879953; PMCID: PMC5992754.

44. Ratwani RM, Bates DW and Classen DC. Patient safety and artificial intelligence in clinical care. *JAMA Health Forum* 2024; 5: e235514.

45. Chen Z, Liang N, Zhang H, et al. Harnessing the power of clinical decision support systems: challenges and opportunities. *Open Heart.* 2023;10:e002432. Published 2023 Nov 28.

46. The White House. Executive Order 13859: Maintaining American Leadership in Artificial Intelligence [Internet]. Federal Register 2019. https://www.federalregister.gov/documents/2019/02/14/2019-02544/maintaining-american-leadership-in-artificial-intelligence. Feb 11 [cited 2025 Feb 12]. Available from.

47. Mittermaier M, Raza MM and Kvedar JC. Bias in AI-based models for medical applications: challenges and mitigation strategies. *NPJ Digit Med* 2023; 6: 13.

48. Jankovic I and Chen JH. Clinical decision support and implications for the clinician burnout crisis. *Yearb Med Inform.* 2020;29:145–154. Epub 2020 Aug 21. PMID: 32823308; PMCID: PMC7442505.

49. Solomon DH and Rudin RS. Digital health technologies: opportunities and challenges in rheumatology. *Nat Rev Rheumatol* 2020; 16: 525–535.

50. Westerbeek L, Ploegmakers KJ, de Bruijn GJ, et al. Barriers and facilitators influencing medication-related CDSS acceptance according to clinicians: a systematic review. *Int J Med Inform* 2021; 152: 104506.

51. Lincoln YS and Guba EG. *Naturalistic Inquiry*. Newbury Park, CA, US: Sage Publications, 1985.