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User Experience Design for Adoption of Asthma Clinical Decision Support Tools

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Background and Significance

Asthma affects over 200 million people worldwide and uncontrolled cases typically lead to the most morbidity.[1] Guidelines can improve asthma symptom control and patient outcomes, although their use in practice is suboptimal (e.g., <40% documented key components).[2–4] To improve these rates, approaches based on clinical informatics such as guideline-adherent computerized clinical decision support (CDS) tools have been attempted.[5–8] These tools can provide standardized, personalized, and comprehensive care to improve outcomes.[9–11]

Asthma CDS tools have not been readily adopted into practice, thus reducing their effectiveness due to lack of use.[9,12–16] Reasons suggested for low uptake appear similar to general issues with computerized CDS[17–19] (e.g., poor workflow integration, negative end-user beliefs),[20–22] but there has not been an inventory of facilitators and barriers to use in the asthma CDS tool domain. Detailing this could improve the design process for asthma-specific computerized CDS tools by highlighting relevant aspects, centralizing knowledge about key features, and identifying the most effective implementation strategies.[23]

Objectives

Through reviewing the literature, our objective was to identify facilitators, barriers, and strategies for designers and researchers to employ to increase end-user adoption of computerized asthma CDS.

Methods

We followed the PRISMA Extension for Scoping Reviews (PRISM-ScR) framework[24] and searched the PubMed, Embase, Biological Sciences, and Web of Science databases (see ►Supplementary Table S1 for search terms, available in the online version). Using the search terms and reviewing reference lists, three researchers (E.G., H.D., and M.K.R) determined the final studies. We included quantitative and qualitative asthma CDS-related peer-reviewed studies in adult and pediatric populations with tool features included in the HealthIT.gov definition of a computerized CDS: computerized alerts and reminders to care providers and patients, clinical guidelines, condition-specific order sets, focused patient data reports and summaries, documentation templates, diagnostic support, and contextually relevant reference information.[25] We excluded abstracts, nonelectronic (i.e., paper-based), unavailable in English, or non-outpatient (i.e., emergency room) studies. E.G. and I.R. extracted content from the final articles, including year, study design population, setting/duration, provider type, tool/intervention, outcomes, facilitators, barriers, and suggestions to increase end-user adoption. E.G. and H.D. developed initial themes through an inductive approach based on repetitive or relevant content, which were refined by I.R. and M.K.R. through consensus discussion.

Results

Out of 10,199 articles identified with the search terms, 35 articles were included (►Supplementary Fig. S1, available in the online version). The article highlights are discussed below with details in ►Table 1 and ►Supplementary Table S2 (available in the online version). Twenty CDS systems were integrated with the electronic health record (EHR).[10,12,26–43] All but three studies were informed by guidelines,[14,21,44] and 18 used the National Institutes of Health National Asthma Education and

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Table 1 For the included studies, the type of intervention, facilitators, barriers, and suggestions to increase uptake of the clinical decision support tools

Authors	Intervention	Facilitators/positives	Barriers/negatives	Suggestions	Relevant UX design steps of suggestions
Tai et al[26]	• Guideline-based templates	• Appropriate length • Serves as a prompt and teaching tool • Saves time • Simple • Standardized	• Labor-intensive input • Slows down work • No decision-making help • Rigid data entry • Can contain irrelevant info	• Clearer intro about templates • Consider inaccuracies in diagnosis if assigning tools based off diagnosis • Providers should be more involved in development	• Empathize, define, ideate
Eccles et al[27]	• Guideline-based suggestions	N/A	N/A	• Measure interventions with rigorous economic analysis and ensure robust trial design	• Empathize, define, ideate
Shiffman et al[51]	• Guideline-based templates and suggestions • Tablets	• N/A	• Disagreement with guidelines • Recommendations not practical	• Recommendations delivered through handheld devices are effective to influence physician behavior	• Empathize, define, ideate, test
McCowan et al[9]	• Guideline-based suggestions • Risk prediction	• Involve end-users in design • Easy to use • Provided relevant clinical advice • Management recommendations and reminders were valued • Printed care plan	• Risk prediction was not popular • Not integrated into workflow • Learning computer operating system itself • Unable to install software • Lack of time • Lack of resources	• Integrate into practice software	• Empathize, define, test
Eccles et al[12]	• Guideline-based suggestions	• Able to be integrated into the EHR	• Asthma not always reason for visit • Practitioners not used to recommendations • Limited training (1 day) • Resources located outside of system	• Increase training • Integrate into workflows	• Empathize, define, ideate, test, deploy
Adams et al[38]	• Guideline-based suggestions • Telephone • Risk identification	• Interactive • Customizable • Decrease documentation • Data-driven risk calculation • Communicates to EHR	• Potentially difficult with telephone outreach component	N/A	• Empathize, define, ideate
Twiggs et al[45]	• Guideline-based suggestions	• Provides feedback about medication choice • Facilitates updating and tracking medications	• Cannot process if certain variables are missing • Limited in types of medications captured	• Incorporate historical medication into assessment • Suggest more detailed medical recommendations	• Ideate, prototype, test
Tierney et al[46]	• Guideline-based suggestions	• Involved pharmacists • Enhanced pharmacist–patient relationship	• Increased time for physician data entry • Alerts may be ignored • Negative opinion of guidelines	• Find the balance between intrusive alerts and passive recommendations	• Prototype, test, deploy

Table 1 (*Continued*)

Authors	Intervention	Facilitators/positives	Barriers/negatives	Suggestions	Relevant UX design steps of suggestions
Kuilboer et al[52]	• Guideline-based suggestions	• No additional data entry • Similar interface to EHR	• Interruptive to physician if not relevant to asthma • Too many alerts/many ignored	• Even if patient did not come to visit for asthma, alerts can identify issues earlier • Tool may be ignored without hard stops, but too many alerts/stops are a hindrance	• Prototype, test, deploy
Martens et al[42]	• Guideline-based alerts	• Key stakeholder involvement in development • Valued, relevant guideline content • Reminder close to the decision moment	• Technical difficulties • Lack of sufficient support • Lack of time to review messages	• Provide a summary of reminders • Provide personal feedback • Involve the end-user during development and throughout	• Empathize, define, ideate, prototype, test, deploy
Shegog et al[47]	• Guideline-based suggestions	• Simple display • Designed with usability features in mind • Adds discipline to clinical practice • Perceived helpful to enhance patient–clinician relationship	• Increased visit times • Infrequent use, relearn system • Self-selected computer-savvy testing group	• Adequate training • Streamline into workflow • Usability design very important • Consistent use	• Prototype, test, deploy
Martens et al[43]	• Guideline-based suggestions	• Key stakeholder involvement in development	• Technical difficulties with implementation	• Evaluate costs of development	• Empathize
Bell et al[28]	• Guideline-based suggestions	• No disruptive pop-ups • Well-integrated in workflow	• Performance dependent on practice setting	• May have more success in practices with lower adherence to guidelines at start • Strategic prompting • Ensure EHR integration	• Empathize, define, ideate, prototype, test, deploy
Davis et al[29]	• Guideline-based templates	• Check box acts as standardized reminder	• No automatic EHR prompt to remind its use	• Reminders may help end-users remember to use the tool	• Prototype, test, deploy
Hoeksema et al[30]	• Guideline-based intake forms and suggestions	• Recommendations were accurate	• Unable to differentiate asthma symptoms from other conditions • Unable to incorporate text • Unable to consider adherence, inhaler technique, or previous medication	• Modify symptom questions to specify they are asthma-related • Carefully analyze reasons for end-user disagreement with recommendations	• Empathize, ideate, prototype, test, deploy
Shapiro et al[31]	• Guideline-based template	• Concise reminder • Visual reminder • Standardized tool	• Initially, prompt displayed whether asthma diagnosis present or not	• Guideline-based tools should be brief and easy to access • Template integrated into the EHR increased usability • Reminders and training help	• Empathize, define, ideate, prototype, test, deploy

(*Continued*)

Table 1 (*Continued*)

Authors	Intervention	Facilitators/positives	Barriers/negatives	Suggestions	Relevant UX design steps of suggestions
Gupta et al[44]	• Asthma action plan	• Developed with key stakeholders • Human-centered design • Iterative design	• Crowd-sourced has ambiguity about correct treatment • Language barriers	• Include stakeholders • Consider user preferences • Use evidence-based content • Pay attention to appearance and usability	• Empathize, design, ideate, prototype, test, deploy
Lomotan et al[48]	• Guideline-based template and suggestions	• Used for letter writing to referring physicians	• Users documented after visit • Did not seem to fit complexity of patients • Specialists felt experience superseded guidelines • Slow computers led to concern for doctor–patient relationship interference • End-users focused on patient education rather than data entry • No free-text ability	• Ensure recommendations are end-user needs (i.e., specialist vs. generalist) • Focus groups, usability testing • Consider smaller handheld devices, so will interfere less with provider–patient rapport • Incorporate more into workflow	• Empathize, define, ideate, prototype, test, deploy
Buenestado et al[32]	• Guideline-based suggestions	• Iterated tool with end-user feedback • Facilitated communication between providers • No usability flaws • Served as a teaching tool	• Did not integrate into daily workflow easily • Too many buttons and preferred icons	• Continually conduct an evaluation of end-user acceptability of the technology	• Prototype, test, deploy
Fiks et al[41]	• Guideline-based suggestions	• Increased patient–provider communication • Ability to track information • Iterative development	• Changed existing workflow	• Test outside institution • Combine teaching into one area • Mimic current workflow as much as possible	• Empathize, define, ideate, prototype, test, deploy
Fiks et al[10]	• Guideline-based suggestions	• Patient-centric approach developed with key stakeholders • Families felt they could communicate better • Developed with family and clinician input • Physicians received regular updates	• Questionnaires were too long • Questionnaires too frequent	• Feasible and acceptable to families	• Empathize, define, ideate, prototype, test
Kuhn et al[33]	• Guideline-based suggestions • Within EHR	• Embedded in the EHR and workflow • Potential cost savings	• Completion of module was optional, no incentives • Adult providers have competing health maintenance modules • May identify asthma incorrectly	• Is feasible to leverage technology to provide decision support through the asthma action plan	• Prototype, test

Table 1 (*Continued*)

Authors	Intervention	Facilitators/positives	Barriers/negatives	Suggestions	Relevant UX design steps of suggestions
Tamblyn et al[34]	• Guideline-based suggestions	• Visual design engaged end-users • Real-time alerts noted to be beneficial	• Changing or vague guidelines • PCP may not be physician responsible for asthma management	• Tailor to those responsible for the asthma management • Future consideration of patient-specific treatment recommendations, and automated follow-up	• Empathize, define, ideate
Lee et al[35]	• Guideline-based templates	• PDSA approach • Standardization helps teaching • Training is by end-users	• Multiple interventions can take focus from specific aspects of asthma management	• Residency training could benefit from a standardized online-based practice improvement module • Suggest expanding to general pediatric faculty clinics	• Prototype, test, deploy
Matiz et al[36]	• Guideline-based templates • Risk stratification	• Complemented workflow • All members of health care team involved	• Required manual data entry into EHR from paper form	• Standardized templates and displaying risk score made guideline-recommended care feasible, efficient, and enhanced team member collaboration	• Empathize, define, ideate
Penkalski et al[49]	• Guideline-based suggestions	• In-depth end-user training • Favorable attitudes toward EBM and guidelines	• Insufficient time	• Provide consistent messages • Teaching about EBM can improve beliefs • Evaluate sustainability areas of practice change needed • Implementing guidelines into the EHR to facilitate adherence • Identify barriers to address within organization as a whole	• Empathize, define, ideate
Ash et al[50]	• Guideline-based suggestions	• Interviewing staff at all levels helped understand workflow better	N/A	• Evaluating the content and concept of CDS in outlined form before it has been built can be useful to determine context it can work the best	• Empathize, define, ideate
van den Wijngaart et al[53]	• Guideline-based suggestions	• Detailed end-user input into design	• Daily diaries for patients are cumbersome • Relies on internet connectivity	• Continue exploring remote and self-management strategies • Continue exploring cost-effective interventions	• Empathize, define, ideate, prototype, test, deploy
van den Wijngaart et al[20]	• Guideline-based suggestions	• End-users enthusiastic • Positive e-Health attitude • Efficient • Easy to use • More time for complex patients	• Not EHR integrated • No incentives for use • No face-to-face visit • Increased workload • Lack of computer skills • Labor intensive • Not adequate staffing	• Ongoing involvement of key stakeholders in design and development to increase intrinsic motivation. • If negative attitude toward the tool, unlikely to be adopted • Have a training and transition	• Empathize, define, ideate, prototype, test, deploy

(*Continued*)

Table 1 (*Continued*)

Authors	Intervention	Facilitators/positives	Barriers/negatives	Suggestions	Relevant UX design steps of suggestions
			• Concern for privacy • Negative attitudes • Management imposed • Lack of training	period for end-users • Ensure plans for sustainability are in place	
Denton et al[21]	• Guideline-based templates and suggestions	• Plan recommendations generated for practitioners • Auto-populated data/less data entry time	• Not EHR integrated • Requires patient question completion before visit • Lack of computer access • Lack of internet access	• Ensure modules are not too cumbersome for end-users • Integrate into EHR	• Empathize, define, ideate, prototype, test
Gupta et al[37]	• Guideline-based suggestions • Tablet	• Prepopulated data fields • Highly personalized • Reduced data entry burden on clinicians	• Recommendations were not always aligned with physician practice	• Need to understand outcomes further at a patient level	• Empathize, define, ideate
Kercsmar et al[22]	• Guideline-based suggestions	• Aligned end-user practice • Standardized data collection • Self-report was reliable	• Not EHR-integrated	• Ensure fits into workflows • Integrate into EHR	• Empathize, define, ideate, prototype, test
Lam Shin Cheung et al[14]	• Guideline-based suggestions • Tablet	• Automated chart note • Email reminders • Training after/during • Gamification • Able to identify those with poor asthma control	• Many different screens with drop-off after each screen • Difficult to implement during the visit • End-users did not believe in system as useful • Difficult access for new users • Time constraints • Resource issues (tablet low battery, not provided, not enough devices)	• Variable workflows, priorities, and system perceptions influenced uptake • Ensure system is integrated into workflow • Ensure workflow is manageable • Customizable features desired • Usability study likely required	
Mammen et al[39]	• Guideline-based suggestions	• Extensive planning and collaboration with key stakeholders about design	• Clinicians preferred delegation to nursing staff • Resource and time intensive • Frequently met with clinician resistance	• Important to account for real-world constraints • Further work needs to be done to determine cost-effectiveness	• Empathize, define, ideate
Mammen et al[40]	• Guideline-based suggestions	• Saved time, efficient • Less stress for users • Improved workflow • Educational tool • Increased communication • Increased engagement for other chronic conditions	• Resource intense (nurse interventionist and equipment)	• System-level commitment is key to improving outcomes on a wider scale	• Empathize, define, ideate

Abbreviations: AAP, asthma action plan; CDS, clinical decision support; EBM, evidence-based medicine; EHR, electronic health record; NIH, National Institutes of Health; PDSA, Plan-Do-Study-Act.
Note: User-experience (UX) design steps (empathize, define, ideate, prototype, test, deploy) related to the suggestions. If no suggestions were provided, we referred to the listed facilitators and/or barriers

Prevention Program (out of 20 studies from the United States).[10,22,28–31,33,35,36,38–41,45–50] Twenty-seven studies were with general practitioners,[9,10,12,14,26–29,31–43,45,46,49–52] four included subspecialists,[21,22,30,48] and four included both.[20,44,47,53] Common tool functionalities included determination of asthma control status, recommendation of medications, automatic note generation for EHR, and creation of an asthma action plan. After data extraction and consensus discussion, we arrived at three main themes of asthma CDS tools: (1) design, (2) content, and (3) implementation to frame our reporting of perceived facilitators, barriers, and approaches.

Design

We considered design to include both the look and feel of the tool including nonclinical functionalities (e.g., buttons or alerts and technology), as well as the overarching design process and the conceptualized CDS itself. Facilitators related to design were asthma CDS tools perceived as efficient, i.e., saves time and improves workflow[20,26,40,41] (e.g., automatic note generation) and easy (i.e., not labor intensive, simple interface).[9,20,26,47] Readily accessible EHR tools at the point of care were favored.[12,14,20–22,35,37,38,51] Standardized asthma guideline-based tools were seen as a facilitator to routinely capture relevant information[22,26,35,40,52] and educate.[26,32,35]

Barriers to adoption included technology limitations,[9,14,21,42,43,53] incompatible operating systems, inappropriate practice software, manual data entry, or extra steps.[9,12,14,20–22,26,28,29,32–36,38,39,46,49,52] Suboptimal graphical user interfaces (e.g., placement of buttons, alerts) also dampened enthusiasm.[14,29,32,46,52] Additional barriers were if the tool was too complex for a provider's needs[48] or if inappropriate for the visit type or provider's practice[26,34,46] (i.e., alerts displayed in primary care clinics during non-asthma-related visits or the provider was not responsible for asthma management).[12,26,31,34,52]

Suggestions for improved design process included collaboration with end users, asthma experts, and stakeholders early in the process and iterate upon their feedback.[9,21,26,31,33,36,39,42–44,48–50,53] Ideally, designs easily integrated into the EHR and within provider workflow.[30,46,47] A flexible approach for data capture was noted to be preferable (e.g., templates vs. free-text options).[26] Other design recommendations were to include reminder or notifications to use the tools with tolerable frequency.[9,10,14,29,31,34,45]

Content

We considered content to be the specific asthma or clinical-related features of the tool. One facilitator of end-user interest was if asthma CDS tool content was seen as valuable (i.e., enhanced asthma care). Examples included severity/control assessment, medication choice, and asthma action plan assistance.[9,26,47] Valued content also included features that increased communication and patient engagement, increased asthma medication adherence, enhanced patient–provider relationships,[10,40] and allowed more time to focus on asthma care to engage in collaborative problem solving, decisions, goal setting, and patient education.[10,12,20,22,26–40,46,53,54]

Content-related barriers included lack of features to meet provider needs.[9,14,21,53] For example, some systems did not contain all necessary data for useful decisions (e.g., relevant asthma comorbidity data), while others were too rigid without the ability to capture needed information for documentation purposes.[9,26,30,45,48]

Suggestions of content that would appeal to end users were related to customizability because clinic needs vary,[31,52] so it was important to find commonalities of asthma management "must-haves" and then scale up.[14,33,35–37,48] Including end users in the process was also important for context to understand helpful features (e.g., auto-populated asthma action plans),[21,37] ensuring the tools captured relevant information (e.g., asthma-related cough symptoms vs. general cough symptoms),[30] and providing meaningful asthma recommendations.[10,26,30,45,48]

Implementation

Implementation was the process to launch the tool into clinical practice including, but not limited to, training, reminders, and end-user attitudes and constraints. Facilitators of asthma CDS implementation included adequate training that relayed the tool's value.[14,20,22,26,28,32,47] Examples of successful approaches included 30-minute sessions with explanatory slides and tutorial videos,[32] training after launch, experienced users training new users,[35] and supplemental material (i.e., user guides).[14,20,49] E-alerts and physical reminders (e.g., verbal) were seen as potentially helpful.[29,34] Important end-user characteristics were intrinsic motivation and favorable attitudes (toward learning new concepts, e-health, asthma guidelines, and personalized health care).[20] Finally, systems may be used more for severe baseline asthma or when patients are more symptomatic.[14,34]

The most common barrier to adoption related to implementation was time constraint (or fear of it),[9,14,20,26,39,46,47,49,50,52] especially if tools were labor-intensive or lacking staff for proper implementation.[20,26,39] Other implementation barriers were lack of end-user acceptance of asthma guidelines or belief in e-tools (i.e., will not benefit care or hinder provider–patient relationships),[9,14,20,26,34,37,46,48,51] computer/technical skills,[20] training,[12] financial incentive,[20] and intrinsic motivation.[20,33] In addition, it was important to identify concern for data safety and integrity (e.g., patient data leaks),[20] as well as institutional cultural barriers (i.e., lack of funding allocation or improper software/data infrastructure).[39,49]

Implementation suggestions to increase end-user adoption of CDS tools included investment in training.[26,31] Automaticity may seem untrustworthy or nebulous to end users,[54,55] so including the reasoning behind decisions was suggested to provide assurance.[12,30,48] Extrinsic motivation through financial incentives was mentioned but it may not be scalable or sustainable.[20,33] More strategic implementation may help, such as use for those with more severe baseline asthma or who are more symptomatic.[14,34] Considering cost-effectiveness and return on investment was also

suggested.[27,33,43,53,56,57] Postimplementation analysis of tools, continual evaluation of end-user acceptability, and iterative process improvement approaches were important.[9,14,20,26,30,32,35,37,42,45,48,51]

Discussion

Our findings related to CDS facilitators and barriers in the asthma domain aligned with those in other clinical domains. Primary facilitators and barriers of asthma computerized CDS tool uptake were related to our identified themes of design, content, and implementation. Suggestions to address barriers during development of asthma CDS tools included collaboration with end users, seamless EHR integration, adequate training and support, and ongoing iterative feedback.[17] This overall user experience (UX) design approach often seen in product development domains, but is less familiar to academia.[58–61] More common in academia is the quality improvement (QI) approach (e.g., Plan-Do-Study-Act) that tends to focus on the iteration after initial launch.[62] This is a framework that is employed here too, although our research highlights the importance of focusing on the development stages (i.e., planning) with iteration prior to initial launch. Based on our findings, previous literature, and other domains, we advocate for a routine UX design-thinking approach to inform tailored EHR CDS tools for asthma.[63,64] User experience design is versatile and works with existing CDS frameworks and guidance (e.g., the CDS Five Rights, the guideline implementation with decision support [GUIDES] checklist, etc.).[16,18,65,66] Another benefit of a UX framework is a common language for developers and vendors as outside entities continue to enter the CDS tool market. The typical steps of the UX design are: empathize (i.e., analyze), define, ideate, prototype, test, and implement,[60,67–70] which we detail below in relation to asthma CDS tool development and cite in relation to each article (►Table 1).

Empathize

Empathy in the UX design is the ability to understand the user holistically (e.g., problems, needs, wants, values, etc.) to design the most useful products and services.[60,70] The empathizing process provides insight into enthusiastic and hesitant users.[71,72] Methods include usability testing, focus groups, semi-structured interviews, and direct observation within the clinic.[60,73,74] While important for any CDS tool, it is especially important for asthma CDS development to listen to a variety of to end-users (e.g., different specialty, licensure, or practice location) because many types of clinicians provide care in varied patient populations/settings, each with their own workflows and needs.

Define

Information gathered from the "empathize" step is synthesized into key problems to be solved within the framework of end-user needs.[70,75] While the goal in asthma management is to increase providers' use of asthma guidelines with digital solutions, this is approached from the end-users' viewpoint after understanding their needs and values. One specific framework to also approach in defining the problems is the jobs-to-be-done framework,[76] which focuses on the core processes and actions the end user wants and helps clarify gaps in the process for which a product could improve. In addition, in line with the previous step, for asthma specifically, there may be different jobs to be done for the different types of clinicians (e.g., generalist vs. specialist; allergist vs. pulmonologist, etc.).

Ideate

Solutions are then generated for the previously defined problems from an empathetic end-user perspective. In the studies reviewed, barriers discovered were often rooted in a disconnect between the tool and the end-user's needs. Asthma CDS tools were more successful when they solved specific problems for the providers, such as support with documentation that captured information key for asthma management[14,26,35–37,48] or auto-creation of asthma action plans.[14,33]

Prototype

Prototyping is the development of smaller scale versions of the product to test and iterate in an efficient (e.g., time and money) manner to demonstrate improvement in the status quo.[67,77–80] Some studies incorporated this, but detailing the creation of a low-fidelity prototype tested on multiple end users did not appear routine in the asthma computerized CDS domain.[14,33,41,50]

Test

Usability testing is an iterative process with sample users to further clarify potential issues and improve functionality.[69,77,81] This highlights the nonlinear nature of the user design, as testing can lead back to the empathize and define steps, similar to the QI domain.[62] Variables to be tracked and measured (i.e., actual tool use, time in EHR, and asthma outcomes) can be determined at this stage.[82] It may be helpful to create a workflow for a smaller subgroup, perhaps a self-selected group who may have more patience for "bugs" or workflow problems and motivation to improve the tool, and troubleshoot with them before expanding to the full clinic.[83]

Implement

After testing phase iteration and optimization, the tool is launched for end users in clinical practice.[69] This step includes messaging that resonates with end users and adequate training, also recognized as an essential aspect of asthma CDS study uptake.[14,20,22,26,31,32] Once "live," continual process improvements are performed based on chosen measurements for further optimization.[19,54,62,84] Implementation of CDS is especially challenging for chronic conditions such as asthma, which requires detailed and ever-changing care plans. Challenges also exist related to standardization versus customizability, which affects scalability between different clinics within an institution because of different needs. In addition, scalability across institutions

can be limited because components of CDS are not easily transferred across facilities even within the same vendor and rely on local resources for implementation, which is variable. In addition, end users are limited by features within the EHR vendors' systems at their institutions.

A future direction of CDS for asthma tools, and presumably other clinical domains, can be for EHR vendors to provide more facile and versatile CDS tool building blocks at a centralized level not only for general functionality but also for disease-specific conditions (e.g., asthma control classification and medication). Individual institutions can more readily execute desires of the end user while avoiding working in a resource-intense, siloed manner. This would allow for easier scalability across institutions, balance between standardization and customizability, and knowledge sharing.

Limitations of our work included a narrow focus on computerized asthma CDS tools through mostly academic studies not necessarily designed to explore barriers. The main outcomes measured by researchers focused on tool usage or patient outcomes and the design process was not elaborated on by most studies, so more UX design approaches may have been employed in our analyzed studies than we realized and the learning the researchers made during their development cycle may not have been communicated. If not performed or reported, this appears consistent with a practice gap in CDS tool development for asthma management in the academic setting.[59] We may also have missed relevant studies with our search terms. In addition, our work is qualitative experiential-based rather than experimental.

Conclusion

Design processes that apply UX design and continuous process improvement methodologies may contribute to successful implementation of CDS frameworks to build usable tools within the EHR for asthma and beyond.

Clinical Relevance Statement

This work proposes a novel application of UX design to asthma CDS tool development. It is important to understand ways to improve CDS use because while CDS tools have been shown to improve adherence to asthma guidelines, their use in practice is suboptimal and at risk of low impact simply due to nonuse. This work can also likely be applied to other clinical domains in addition to asthma.

Multiple Choice Questions

1. According to HealthIT.gov, which of the following are components of computerized clinical decision support systems?
   a. Patient data reports
   b. Note templates
   c. Order sets
   d. All of the above

   Correct Answer: The correct answer is option d, all of the above. According to the website https://www.healthit.gov/topic/safety/clinical-decision-support, clinical decision support (CDS) provides clinicians, staff, patients, or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care. CDS encompasses a variety of tools to enhance decision making in the clinical workflow. These tools include computerized alerts and reminders to care providers and patients; clinical guidelines; condition-specific order sets; focused patient data reports and summaries; documentation templates; diagnostic support, and contextually relevant reference information, among other tools.

2. In user experience (UX) design, what process helps us understand a user's experience of a product?
   a. Data visualization
   b. Storyboarding
   c. Journey mapping
   d. Prototyping

   Correct Answer: The correct answer is option c. In Ku and Lupton's study titled "Health Design Thinking: Creating Products and Services for Better Health," they note that journey maps help us understand a user's experience of a product, service, or space over time. Journey maps typically represent a process. It is used to imagine a user's interaction with a device or service. It depicts multiple layers of the user experience such as action and emotion.

Protection of Human and Animal Subjects

There were no human subjects in this work.

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Conflict of Interest

None declared.

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