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Research and Applications

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"Everything is electronic health record-driven": the role of the electronic health record in the emergency department diagnostic process

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Abstract

Objectives: There is limited knowledge on how providers and patients in the emergency department (ED) use electronic health records (EHRs) to facilitate the diagnostic process. While EHRs can support diagnostic decision-making, EHR features that are not user-centered may increase the likelihood of diagnostic error. We aimed to identify how EHRs facilitate or impede the diagnostic process in the ED and to identify opportunities to reduce diagnostic errors and improve care quality.

Materials and Methods: We conducted semistructured interviews with 10 physicians, 15 nurses, and 8 patients across 4 EDs. Data were analyzed using a hybrid thematic analysis approach, which blends deductive (ie, using multiple conceptual frameworks) and inductive coding strategies. A team of 4 coders performed coding.

Results: We identified 4 themes, 3 at the care team level and 1 at the patient level. At the care team level, the benefits of the EHR in the diagnostic process included (1) customizing features to facilitate diagnostic workup and (2) aiding in communication. However, (3) EHR-driven protocols were found to potentially burden the care process and reliance on asynchronous communication could impede team dynamics. At the patient-level, we found that (4) patient portals facilitated meaningful patient engagement through timely delivery of results.

Discussion: While EHRs can improve the diagnostic process, they can also impair communication and increase workload. Electronic health record design should leverage provider-created tools to improve usability and enhance diagnostic safety.

Conclusions: Our findings have important implications for health information technology design and policy. Further work should assess optimal ways to release patient results via the EHR portal.

Lay Summary

The emergency department (ED) is a complex environment where patients are evaluated for emergent problems and providers aim to make correct diagnoses. Emergency department providers routinely use electronic health records (EHRs) as part of their workflow and diagnostic process. Understanding how EHRs help or hinder diagnosis for patients and providers in this setting has not been fully explored. We interviewed 10 ED physicians, 15 ED nurses, and 8 ED patients/caregivers about the diagnostic process in the ED, including how they use EHRs in this process. We analyzed the interviews and identified 4 themes: (1) providers customize their EHR dashboards to facilitate diagnostic workup; (2) The EHR is often used for asynchronous communication among members of the care team, though this can sometimes impede team dynamics; (3) EHR-driven protocols can potentially burden the care process; and (4) patient portals facilitate meaningful patient engagement through timely delivery of test results. Our findings have important implications for health information technology design and policy. While EHRs can improve the diagnostic

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process, they can also impair communication and increase workload. Electronic health record design should leverage provider-created tools to improve usability and enhance diagnostic safety. Further work should assess optimal ways to release patient results via the EHR portal.

Key words: emergency department; electronic health record; diagnostic safety.

Background

Diagnostic error is a significant barrier to providing safe and high-quality patient care.[1] Although robust data on emergency department (ED) diagnostic error are lacking,[2,3] the prevalence is estimated to be high.[3] The US Agency for Healthcare Research and Quality's reanalysis of ED diagnostic error rates estimated that 5% of ED visits had a diagnostic error, representing over 6.5 million ED visits per year.[2] Importantly, diagnostic error rates differ across conditions, with leading harm-producing conditions having error rates of 10%-28%.[2] Emergency departments are a high-risk setting for errors given multiple factors including lack of established patient-provider relationships, variable patient acuity, and high cognitive load.[2,4] Factors such as overcrowding and other systemic issues (eg, inadequate community-based social care systems, lack of consult services) can increase provider cognitive load and negatively impact decision-making and the diagnostic process.[5]

The electronic health record (EHR) provides tools that can potentially mitigate the risk of diagnostic errors.[2,6–8] For example, EHRs can aid providers in reducing cognitive load during the diagnostic process by providing timely clinical decision support to facilitate diagnosis.[9–11] Electronic health records and associated patient portals can also provide access to comprehensive patient information (including prior diagnoses and test results) and integrate scoring tools that assist in disease risk stratification. Yet, studies have demonstrated there are barriers within EHRs that might increase risks for diagnostic error and compromise patient safety.[8,12–16] These barriers include information overload, inaccurate data, and impairment of clinical communication.[14,15,17,18] However, the current clinical informatics literature lacks focus on the ED context, including perspectives from patients and providers. Moreover, these studies primarily focus on limitations to EHRs rather than how EHRs can facilitate diagnostic decision-making and reduce diagnostic error.

A deeper understanding of the ED context and engagement of ED care teams and patients may help identify opportunities to reduce diagnostic errors and improve care quality. This qualitative study focused on the ED setting and aimed to understand how providers use the EHR to facilitate the diagnostic process, identify EHR-associated barriers to the diagnostic process, and describe how patients' EHR engagement affects the care process.

Methods

Overview and conceptual model

This qualitative interview study was designed using a descriptive qualitative approach[19,20] and represents 1 subaim of a larger multistage study focused on improving ED diagnostic decision-making.[21] The parent study was informed by a consensus-driven conceptual model of the ED diagnostic process (ie, ED-adapted NASEM Diagnostic Process Framework).[22] The interview guide and coding scheme were informed by the theory of distributed cognition[23,24] and dual process theory.[25,26] The theory of distributed cognition describes how information moves through a system, underscoring the importance of defining the contours of communication including types of communication to understand information flow.[27] Dual process theory describes two types of decision-making processing—automatic and controlled.[28] Applying dual process theory allows us to understand how certain aspects of the EHR influence decision-making (eg, impact of EHR-implemented protocols/algorithms).

Procedures and sample

We conducted semistructured interviews with ED providers (physicians and registered nurses) and patients to identify vulnerabilities within the ED diagnostic process. Providers were recruited via email from 4 hospitals within 2 major US health-care systems via typical case sampling.[29] Health-care system 1 cares for approximately 112 000 patients annually (~29% pediatric), while health-care system 2 has approximately 115 000 ED visits annually (~17% pediatric). Both health-care systems were using EHRs based on the Epic Systems platform at the time of the study. Patient advisors (ie, patients, caregivers, parents of minor patients) who had previously used the ED in health-care system 1 were recruited with assistance from the Office of Patient Experience. Sample size adequacy was informed by the information power framework[30] based on the authors' use of multiple conceptual frameworks, approach of qualitative description, and strength of interview dialogue. In consideration of the well-defined conceptual frameworks, analytic approach, and sample size sufficiency guidelines for qualitative interviews,[31] we anticipated a minimum of 20 interviews.

Interviews were conducted via Zoom by two masters-level researchers working in emergency medicine and involved in the parent study. Interviewers were experienced in qualitative research and used a standardized guide to facilitate the interview (example questions in Appendix S1). Both interview guides (one for patient advisors, one for ED providers) were pilot tested with members of the participant population. Interviews lasted approximately 1 h and were audio-recorded and transcribed verbatim by a professional transcription service. This study was approved by the University of Michigan Institutional Review Board.

Data analysis

We used a hybrid thematic analysis approach, wherein data were coded using both inductive and deductive approaches.[32,33] First, 2 interviewers and an ED physician-scientist developed a codebook (a priori) based on the conceptual model, dual process theory, and theory of distributed cognition (Appendix S2). After codebook development, 4 coders (T.G.J., C.W.M., S.J.P., and C.M.C.) coded a set of 3 interviews to assess congruence. Code definitions were revised to increase consistency, and new codes were developed. The remaining interview transcripts were coded by at least 2 coders, and discrepancies were resolved through discussion. The analytic team met regularly to discuss coding and, when needed, develop new codes. After coding the interviews in MAXQDA 2022 (Verbi Software), we focused on coded segments related to our research question. Codes were

applied to statements focused on provider (ie, physician and nurse) use or nonuse of the EHR and patients' interactions with portals. Themes were developed by assessing memos related to these codes and coded segments, identifying patterns within these data, and using analytic features in MAXQDA, including the Code Relations Browser and Interactive Quote Matrix.[34]

Results

There were a total of 33 participants in this study: 25 providers and 8 patient advisors. In the overall sample, 44% were registered nurses, 74% were women, and 76% were White. Among providers, 44% had more than 10 years of clinical experience and the majority (56%) worked in the general/adult ED.

We developed 4 themes describing the use of EHRs in the ED diagnostic process. Three themes focused on the ED care team and the fourth theme focused on the patient. Figure 1 shows the mapping of these themes to the conceptual model. A mapping of themes, subcategories, and representative quotes is available in Appendix S3.

Theme 1. ED providers customize EHR features to facilitate their diagnostic workup

The first theme describes how ED providers customize their EHR dashboard to reduce cognitive load and improve diagnostic workup. Based on this synthesis, we mapped theme 1 onto the Triage and Diagnostic Decision-Making section of the ED-adapted NASEM diagnostic framework.

Tailoring the display

Several providers discussed tailoring their EHR dashboards to be more efficient for their care processes. These providers took advantage of "favorites" (shortcuts) in EHR software to ready frequently used actions.

> We have our favorites. . .I have my hourly rounding, my notification of provider, my IV start, my patient transport, and my plan of care. . .I want the minimum that I need to get by. . .that's why I have my favorites and I'm using those on every patient. (Nurse, #3)

Note templates

Physicians indicated that they used EHR documentation as a tool to think through differential diagnoses immediately after seeing a patient. Some providers indicated that they created dot-phrases (ie, codes to populate information) and templates to facilitate their diagnostic workup and trigger consideration of a comprehensive list of differential diagnoses.

> When I think about headache, I actually have a smart phrase that I put in for my Impression and Plan. And it lists off like maybe 10 different things. . .then I customize it. Like, I don't think this is meningitis because they don't have fever or neck stiffness. . .I don't think this is a subarachnoid hemorrhage because it didn't come on suddenly. (Physician, #20)

This physician indicated that they created templates for syncope, pediatric fever, headaches, chest pain, and abdominal pain. This participant also described using templates for less frequently seen presentations, such as rashes.

> I think in those situations that it reduces my cognitive load. . .what are the bad rashes that I could be forgetting? Because I have [this] as a reminder, it's like—okay, I thought about all of these things. Like, these are the red flags. . . I like looking at that as a reassurance for me. (Physician, #20)

There was recognition, though, that using these types of notes for too many conditions may lead to standardization and increase cognitive burden—particularly for undifferentiated conditions.

Theme 2. Thoughtful engagement with the EHR can facilitate provider communication

Participants stated EHRs were frequently used for asynchronous (vs synchronous) communication between care team members. The way EHRs were used for communication differed throughout the care process. This theme maps on to the Diagnostic Decision-Making section of the framework, as the communication in this theme is focused on diagnostic work-up—not communicating diagnosis to patients.

Tracking and coordinating care

Providers used asynchronous and synchronous communication through EHRs as a way of monitoring patient acuity and to-do items. In 1 health-care system, providers used EHR sticky notes to track patient acuity throughout the ED encounter.

> We adopted a standardized template to keep track of patients' acuity status and the patients' brief history and exam, and things we want to do for the patient such as some of the lab testing and imaging. So we put everything into that sticky note that all the other providers in the ED can see. (Physician, #6)

This type of sticky note was considered particularly useful during shift changes as a way to communicate the diagnostic plan and highlight pending results or remaining action items.

Direct messaging

Direct chat messaging within the EHR was available and used by some providers. Some physicians messaged with triage nurses or follow-up (post-ED care coordination) nurses, providing a teleconsult through the chat. Other uses of direct messaging focused on communicating about complex cases with care team members who otherwise might not be available to talk.

> The neat feature of the instant messaging system which is super neat for more complicated cases, just because two people being in the same place at the same time, you know, you could go an hour and a half, and never actually be within 2 feet of said nurse. (Physician, #22)

This example was provided to contrast situations where a patient's diagnosis is so clear that the nurse and physician came to the same conclusion, and then "never again text or co-communicate."

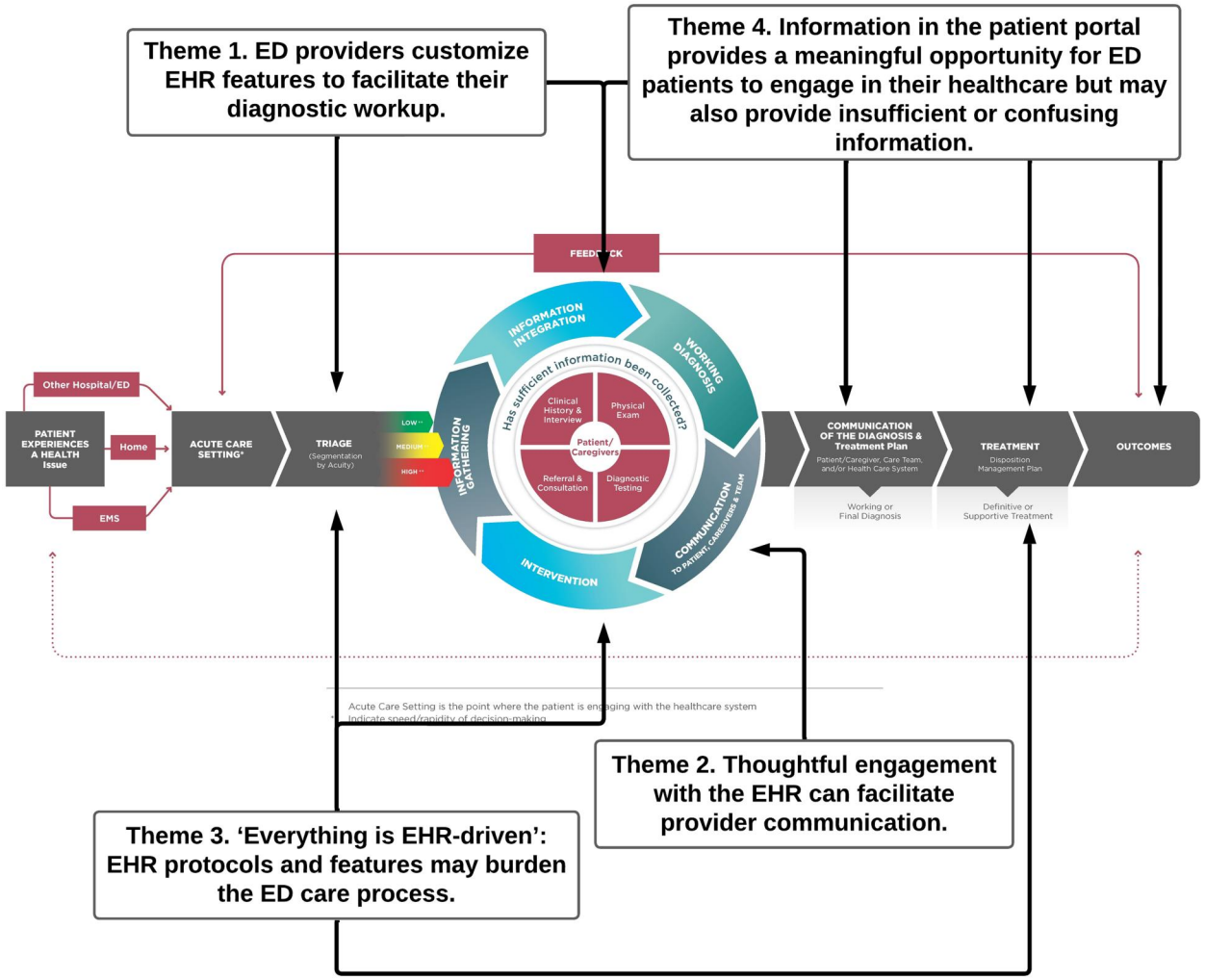

Figure 1. Alignment of identified themes related to EHR use in the ED diagnostic care process on the ED-adapted NASEM diagnostic safety framework.

Acknowledging orders

One barrier of asynchronous communication was not knowing if the intended receiver had viewed and acted on the message. For example, there was a concern that orders placed into the EHR without an alert could be missed and, consequently, negatively impact patient care. A benefit of EHRs was the added level of accountability when orders are placed. For example, some nurses described having to acknowledge orders that were placed; this acknowledgement was viewed positively by nurse participants.

> I think that the acknowledgement of the orders is a really great thing, because there's some level of accountability that you've seen something, and you need to do it. (Nurse, #4)

Avoid reliance on asynchronous communication

Some nurses emphasized that the EHR was limited in its ability to facilitate asynchronous communication and emphasized the importance of synchronous communication during busy times.

> I think that the ED is kind of unique in that we do work so closely with our physicians that oftentimes, there are some sort of discussion between us even before orders are placed. I don't really feel like there's much other than checking orders and like verifying meds, that we can do with [Epic]. I don't really feel like there's any like communication back and forth. (Nurse, #10)
>
> Most of the time. . .[I learn about the order] as they put the order in. . .If the [physician] is busy, usually I just call them to make sure that I'm on the same page with them. (Nurse, #13)

Other types of asynchronous communication standard in the EHR were reported to impede the diagnostic process. For example, care team members were not automatically notified of lab results unless there was a critical alert value.

> You don't have an alert on your phone or anything. It's going back in the chart and looking yourself. . .unless you get like a critical alert value. Then sometimes that's a surprise. (Nurse, #3)

When lab values are within range, providers are not directly contacted by the labs (as is the case in critical value alerts). In these circumstances, nurses must routinely open the patient's chart to see when lab results become available.

Theme 3. "Everything is EHR-driven": EHR protocols and features may burden the ED care process

Despite the benefits of using EHR features as an aid in the diagnosis of patients (eg, theme 1), there was recognition that medical care has become too reliant on EHRs. The timing and consequence of the protocols described by participants informed the alignment with the framework: Triage, Diagnostic Decision-Making, and Treatment.

Nurse-initiated patient care orders

There was significant discussion among nurse participants on the use of nurse-initiated patient care orders (NIPCOs). Nurse-initiated patient care orders were described as orders (or order sets) available for nurses to expedite diagnostic testing (eg, imaging, lab work) or treatment (medications like fever reducers or breathing treatments) for patients presenting with certain complaints or conditions. Some participants, however, indicated a reliance on what the NIPCO recommended.

> If it was more like an elderly person with chest pain or someone with a cardiac history, I can initiate the cardiac protocol, which, you know, you gotta love Epic. It loves to think for you. Based on age, that protocol could end up ordering blood work, including troponins, an ECG, a chest x-ray, and a baby aspirin. (Nurse, #21)

Some providers described that the reliance on NIPCOs may lead providers down an incorrect diagnostic pathway. When NIPCOs are activated from triage, clinicians may anchor on a specific diagnosis or condition. For example, 1 nurse recounted when a patient presented with a headache and was started on the headache protocol, only to later find an ophthalmic issue.

> [We] saw this patient after the headache protocol, or the migraine cocktail. After that had finished and there was no relief, [the attending] had to come look at the patient-. . .she looked at her fundus of her eye because she was unable to really tolerate light. That's when the diagnosis changed for us, because there was some abnormality there and that led us down a different path. (Nurse, #13)

Timing of care

Organization of the EHR led to some areas of additional burden; providers indicated that EHRs could overcomplicate the care process and require too many clicks. For example, the organization of patient care orders created difficulty identifying when certain orders were due.

> It'll say q6hrs. Like, you can do the math, but sometimes the EHR will change your times. And so you have to click forward to find the next time that it's due. (Nurse, #13)

Theme 4. Information in the patient portal provides a meaningful opportunity for ED patients to engage in their health care but may also provide insufficient or confusing information

This theme describes how patients use the EHR patient portal to understand and contribute to their process of care within the ED and how the EHR systems' notification timing may impede patient-provider communication. Consequently, this theme maps onto the framework's constructs of Diagnostic Decision-Making, Communication of the Diagnosis and Treatment Plan, Treatment, and Outcomes.

Empowering patients in the information gathering and care process

Patients described positive engagement with the care team when they had access to the patient portal. Providers also recognize that the portal had the potential to improve information gathering when eliciting a history. This was particularly important when assessing a patient who was not regularly seen within a specific health-care system or when a patient was unable to communicate with providers (eg, due to medical state). Given the lack of information sharing across health-care systems' EHRs, patients who use other health-care organizations and have access to a patient portal were able to provide a more comprehensive and accurate health history.

> My provider is at a different hospital system. So, I could just use the app and then show [the emergency room doctors] the information. . .the majority was blood tests, medicines, and every kind of x-ray. So I could share, well, my app didn't have the actual photos, it had the results. (Patient Advisor, #32)

Additional benefits of using the patient portal were related with follow-up, such as ease with managing discharge instructions.

Patient anxiety about information in the portal

Providers and patients described instances where results were automatically released to the portal in real-time and created anxiety for patients. This was primarily attributed to a lack of knowledge about tests being ordered or the results from the tests. For example, patients described instances when they wished there was more information about the reason the test was ordered.

> When the orders were placed, I got the orders first through the portal, instead of somebody coming to tell me what they meant. . .. maybe explain the reason behind the tests. (Patient Advisor, #27)

In this case, the participant was a pediatric patient's mother who was familiar with the tests but recognized that other parents may find it concerning when they see tests, like a kidney test, being ordered without context.

Additionally, the time delay between results arriving to the patient and the provider's discussion with the patient led to added anxieties as patients "perseverate" over findings.

> Sometimes [patients] can perseverate over clinically irrelevant abnormal blood tests, for example. Or, you know, the typical random ramblings of a radiologist and we sometimes have to explain that—I always use these extra words about this, completely irrelevant finding. (Physician, #22)

Findings pushed to the portal in advance, however, were not always irrelevant. In some situations, a patient described

receiving information about a serious diagnosis prior to seeing a provider and feeling confused and overwhelmed by the information.

Misaligned face-to-face and portal communication

There were clear concerns regarding potentially contradictory patient-provider and patient-portal communication. This primarily occurred with diagnostic tests. First, there were times when patients had expected nurses to have information on tests being ordered by physicians. Nurses recognized a barrier with a lack of communication of the diagnostic plan, leading to patients getting updated on the diagnostic tests before nurses. Yet, patients expected nurses to have this information.

> I started getting the messages from the portal that the blood tests had come back. So, I actually called the nurse to see if she had any input or if the doctor had seen the orders. (Patient Advisor, #27)

Other experiences of misalignment occurred when lab values were outside of reported reference ranges, but the provider indicated otherwise.

> I saw the results in the portal and. . .there were things that they were, like, out of range and then the doctor came back and said it was normal." (Patient Advisor, #27)

Patients recommended that lab reports could have additional information in plain language. This plain language summary of lab reports could also include information on common reasons the test is ordered.

Left before evaluation complete

Providers shared concerns that information presented in the patient portal caused patients to leave the ED before being formally evaluated by the care team.

> Patients who are tech savvy and have their portal, you know, when we have wait times that are five and six hours, and they come in, and they just want to know if these cold symptoms are COVID, and they may get their chest x-ray and their COVID swab negative, and they're like, "You know what? I'm good. Nothing bad is going on. I'm going home." (Nurse, #21)

This nurse also mentioned that they believed patients with lower acuity leaving the ED could help improve efficiency when the ED was overburdened. In stark comparison, physicians felt that leaving without being seen after initial test results were released to the portal was dangerous.

> Some patients come into our waiting room. . .they think they have a urinary tract infection and the nurse [orders the test] from triage. And then they leave without being seen because they can see those results. Which is, I guess a little bit dangerous because we haven't fully evaluated them. (Physician, #24)

Discussion

This study focused on the role of the EHR in the ED diagnostic process, specifically how providers use the EHR to facilitate diagnostic decision-making, barriers accompanying EHR usage during the diagnostic process, and how patients' engagement with the EHR affects the ED care process. Using qualitative interview data, we developed four themes related to EHR use and the ED diagnostic process. We found that providers use EHRs to create a customizable dashboard to facilitate diagnosis and for asynchronous communication to compensate for busy workloads. Despite these benefits, some providers felt that EHR protocols and features burden the care process by being less patient- and provider-centered. We also identified that access to the patient portal can both help and hinder the diagnostic process and delivery of care.

Previous research on EHR use, both inside and outside the ED, has identified the potentially negative impact EHRs have on impairing communication and increasing workload (and cognitive load) for providers.[8,14,15,17,18] Our findings align with this literature, particularly as it relates to the impacts on communication (see theme 2) and the timing of the provision of care (see theme 3).[8,17] However, we also identified ways providers use EHRs to positively impact the ED care process. The finding from theme 1 (customizing the EHR) indicates that providers are not just customizing their EHR workspace to support patient flow and the diagnostic process, but also developing and using cognitive artifacts to aid in the decision-making process. Cognitive artifacts, a facet of the theory of distributed cognition, impact cognition by serving as a reminder for a specific task.[35] In our case, some physicians created cognitive artifacts in the EHR to serve as a checklist/reminder or process of hypothesis generation in working toward a diagnosis (ie, actively combating heuristics). Previous research has identified that EHRs lack optimization for providers, highlighting the lack of user-centered design.[17] Using the EHR as a tool for developing and maintaining physician-centered (and, ideally, physician-developed), cognitive artifacts may be a particularly beneficial way to facilitate medical decision-making that improves EHR optimization and reduces the risk of diagnostic error.

Despite the perceived benefits of using the patient portal for accurate information gathering during care,[8] we found some areas where patient use of the portal in the ED negatively impacts delivery of care. Patient advisors reported becoming confused when seeing orders for diagnostic testing and feeling concerned when results were published before speaking with a provider (see theme 4). These findings are consistent with the literature on patient portal use, finding that patients may experience negative emotions and the lack of context prompt conversations with providers.[36–38] This is particularly important given the current regulatory context of information blocking. Under the 21st Century Cures Act, electronic health information in the United States must be made available to patients (ie, "information blocking" is prohibited; see 42 U.S. Code § 300jj-52). Regulations, however, permit information blocking to prevent harm (45 CFR 171.201). Research has not yet identified the risk-benefit of slight delays of releasing results during ED care, particularly given the risks of patients leaving without being fully evaluated and caregiver anxiety. The present study indicates concern for patient wellbeing and diagnostic safety; therefore, additional research is needed to understand the impact of

immediate release of medical information to patients in the ED and how it impacts their medical care-seeking, as well as the impact on patient-provider communication in already burdened EDs. This research could be used to inform evidence-based, patient-centered policy.

Limitations

While this study focuses on the use of the EHR in the ED, data reported were collected in interviews that were not primarily designed for this purpose. The primary focus of the qualitative interviews was to identify intervention opportunities to improve diagnostic safety in the ED.[21,39] This may have diminished the amount of time discussing EHRs and diagnostic safety in the interview (ie, reduced prolonged engagement), threatening credibility. However, the depth of information given on this topic across participants indicates the central role of the EHR in the ED diagnostic process. The small participant sample size may present another limitation, however, the concept of information power and relative strength of dialogue guided sampling strategy. Additionally, the EHRs used by these 2 large health systems were based on the same platform (ie, Epic); findings may not be reflective of experiences with different EHR platforms with different features in smaller health systems. Future research should consider purposeful sampling based on EHR platform (as some platforms have limited customization options) and the individual provider's role (eg, triage nurse, charge nurse, attending) in the care process. This user-centered research should also consider providers' and patients' perceived advantages and disadvantages to new features and customization options. Lastly, given the uniqueness of the ED setting, future studies may seek to investigate how the EHR is used for diagnostic decision-making in different care settings.

Conclusions

Electronic health records are a powerful tool that have the potential to facilitate the ED diagnostic process. Our findings identify several opportunities to improve EHR design to be responsive to provider needs. Our results indicate that EHRs should be customizable with respect to user workstation layout and ability to make diagnostic workup templates, centering the needs of users. To this end, providers should be encouraged to use EHR features in ways that work best for them. In addition, health systems should adopt policies and procedures to improve provider-to-provider and provider-to-patient communication through the EHR. Additional research is needed to better identify how to provide ED patients information through the portal in a way that does not create confusion.

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Author contributions

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Supplementary material

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Conflicts of interest

The authors have no competing interests to declare.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Research and Applications