Background and Objective: Electronic health records (EHRs) have become ubiquitous in medicine and continue to grow in informational content. Little has been documented regarding patient safety from the resultant information overload. The objective of this literature review is to better understand how information overload in EHR affects patient safety.

Methods: A literature search was performed using the Transparent Reporting of Systematic Reviews and Meta-Analyses standards for literature review. PubMed and Web of Science were searched and articles selected that were relevant to EHR information overload based on keywords.

Results: The literature search yielded 28 articles meeting the criteria for the study. Information overload was found to increase physician cognitive load and error rates in clinical simulations. Overabundance of clinically irrelevant information, poor data display, and excessive alerting were consistently identified as issues that may lead to information overload.

Conclusions: Information overload in EHRs may result in higher error rates and negatively impact patient safety. Further studies are necessary to define the role of EHR in adverse patient safety events and to determine methods to mitigate these errors. Changes focused on the usability of EHR should be considered with the end user (physician) in mind. Federal agencies have a role to play in encouraging faster adoption of improved EHR interfaces.

Key Words: EHR safety, electronic health record, information overload, note bloat

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Electronic health records (EHRs) continue to increase in usage around the world, in part, because of the improvements in patient safety. In the United States, EHR adoption was initially encouraged through financial incentives by congress through the HITECH Act. More recently, the Centers for Medicaid & Medicare Services (CMS) has incentivized EHR adoption by decreasing reimbursement to providers who have not demonstrated themselves as “meaningful users” of EHRs. Despite its advantages over paper-based documentation, EHR use has resulted in new physician-related challenges that may increase medical errors. In anticipation of potential increased medical errors, the American Medical Informatics Association Board of Directors met in 2012 to create recommendations on enhancing patient safety by improving EHR usability. Despite highlighting 14 usability principles to improve EHRs, no further solutions were identified beyond minimizing cognitive load.

A major complaint of physicians is the extraneous patient information in each medical chart. Excessive information in a chart, or “note bloat,” may impair comprehension, leading to potential errors. Studies show that physicians spend nearly twice as much time documenting in EHR than they do interacting with patients. This is a source of frustration for physicians, but may also compromise patient safety. This is compounded by EHR software that is optimized for billing, not patient care. One study looking at adverse patient safety events due to the EHR cited a lack of EHR usability for 28% of these events. Overload from EHRs can also negatively affect physician well-being.

The purpose of this systematic review is to evaluate the effect of EHR information overload on patient safety. Our hypothesis is that information overload in the EHR negatively affects patient safety.

METHODS

A systematic review and qualitative analysis were performed to identify factors related to EHR information overload and patient safety using PubMed and Web of Science. Studies that were published between January 2010 and January 8, 2021, were eligible for inclusion. Eligible articles were reviewed from June 15, 2018, to January 8, 2021, by 2 reviewers. Filters were English only and full-text availability. Articles were screened by first assessing the title and then the abstract for relevance to the topic by keywords. Keywords used included “electronic health record” or “electronic medical record” in conjunction with 1 or more of the following: “information overload,” “cognitive overload,” “note bloat,” “usability,” and “patient safety.” Studies were deemed relevant if they (a) defined the issue of information overload, (b) described how information overload fits into the current model of EHR safety analysis, and/or (c) provided data demonstrating how information overload and poor EHR usability affect physician comprehension of clinical data. References of selected articles were also reviewed as an additional source of literature.

All published study types were included. All data analyses were descriptive. Institutional review board approval was not required for this study.

RESULTS

As of January 8, 2021, a total 7322 records were obtained using PubMed and Web of Science and adding relevant references from the selected articles. Six thousand nine hundred nine titles were discarded because of irrelevant topics or duplication. Of the 413 abstracts reviewed, 339 were discarded because of lack of original research or not being physician focused. This left 51 articles to be assessed for eligibility, of which 29 fulfilled the inclusion criteria (Fig. 1).

Cognitive Burden of Information Overload

Beasley et al defined information overload in the context of clinical practice as excessive data, whether that be from the patient’s chart, history, and physical exam, among others, which hinders the provider’s ability to create an appropriate diagnosis and treatment plan. The overload of information stems from copying and pasting into charts, use of templates, excessive alerts, and adding data that are necessary for billing but effectively useless for clinical care. A study using eye tracker technology determined that vitals and laboratory values in patients’ charts were used the most by

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J Patient Saf • Volume 18, Number 6, September 2022
physicians, whereas other routine information was unnecessary and impaired usability. Another study illustrated that differences in cognitive load can affect error rates when using EHRs via the National Aeronautics and Space Administration task load index. Twenty intensivists reviewed patient data in both a conventional and novel, streamlined EHR only displaying salient information. The median National Aeronautics and Space Administration task load index score for the novel EHR was almost 20 points lower than the conventional EHR. Moreover, the conventional EHR was associated with 4 times as many errors per subject and took approximately twice as long to complete tasks when compared with the novel EHR. A similar study determined that a 1-page EHR with a higher density of pertinent information was preferable to one with multiple tabs and improved cognitive workloads.

Koopman et al performed a cognitive task analysis with 16 primary care physicians. Subjects reviewed the assessment and plan first because it provided most of the necessary information in a concise manner. Identified drivers of note overload were as follows: billing, quality improvement measures, avoiding malpractice, compliance, the visit history, and physical exam. Another study found that EHRs were burdensome because they did not align with residents’ workflow, possibly compromising patient safety. An earlier study interviewed physicians about their information needs, finding the review of systems “superfluous” and contributing to information overload.

Belden et al investigated restructuring the notes in EHR to decrease cognitive overload. The traditional “SOAP” (Subjective, Objective, Assessment, Plan) note was compared with a “APSO” format with an option to hide extraneous information. A simulated case demonstrated that simply changing the format of the note without changing content resulted in better usability, and the physicians endorsed this arrangement as more practical.

The EHR training sessions and the use of templates effectively decrease information overload by helping physicians write more concise notes, ultimately saving 1.3 hours of time. A study of physicians reviewing the same information showed a significant increase in reading efficiency with a user composable interface versus a traditional EHR. Seventy-two percent of information was reviewed more than once in conventional EHRs, compared with 17% in the user composable version. The poor usability of conventional EHRs decreases physician comprehension, requiring data to be revisited.

However, a user composable interface does not guarantee increased efficiency. The usability and safety of 2 user composable EHRs were assessed by having 4 groups of 12 to 15 physicians from different institutions (2 groups using Epic, 2 groups using Cerner) complete specific tasks. Performance was assessed by error rates, number of clicks, and completion time. Results showed up to an 8-fold difference in task completion time and clicks between the groups at different sites using the same EHR. Implementation

FIGURE 1. Inclusion flow diagram.
protocols and physician training varied between the 2 sites and were hypothesized to account for the vast difference in proficiency.

Alert fatigue is another source of information overload. In a survey of 2590 primary care physicians, 69.6% reported receiving more information than they could manage. In addition, nearly 30% of participants reported missing test results and delaying patient care as a result.14 Another study demonstrated that a clinician’s likelihood of accepting best practice reminders decreased with increases in volume of reminders, number of repeated reminders, and overall patient complexity.24 A program to decrease alerts of lesser importance in the Department of Veteran’s Affairs was implemented, which reduced daily notifications from 128 to 116 per physician, saving 90 minutes of work per week.25

Murphy et al26 investigated the shortcomings of the EHR inbox by interviewing physicians. Barriers identified included the following: message processing complexity, inbox interface design, cognitive load, team communication, and message content. The authors argue that these barriers decrease efficiency and situational awareness, which in turn undermines patient care (Table 1).

Efficiency and satisfaction with EHRs have been associated with user characteristics. For example, stage in training (attending versus resident physician) was evaluated by case simulations and a survey assessing perceived workload and EHR satisfaction. Attending physicians had significantly higher levels of frustration with the EHR compared with residents, whereas information overload was more significant in residents.28 Another study investigated how EHR use differs based on gender. Although performance was equal, women were more efficient and reported greater rates of satisfaction when compared with men.29

**DISCUSSION**

Patient safety is paramount in all aspects of medical care, and any efforts to improve it should be pursued. The EHRs’ effect on

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**TABLE 1. Level of Evidence**

| Author                     | Year | Type of Study                  | Level of Evidence | Summary                                                                 |
|----------------------------|------|--------------------------------|-------------------|------------------------------------------------------------------------|
| Pickering et al27          | 2010 | Crossover                      | III               | Simulation cases to test novel EHR in ICU                              |
| Beasley et al13            | 2011 | Expert opinion                 | VII               | Defining information chaos                                             |
| Ahmed et al16              | 2011 | Randomized crossover study     | II                | Assessment of physician cognitive load with 2 different EHR interfaces |
| Middleton et al4           | 2013 | Expert opinion                 | VII               | EHR improvement recommendations                                         |
| March et al8               | 2013 | Controlled trial               | III               | Simulation to assess EHR safety in the ICU setting                     |
| Singh et al14              | 2013 | Descriptive                    | VI                | Assessment of physician information overload due to excessive alerting |
| Clarke et al19             | 2014 | Descriptive                    | VI                | Physicians identifying important sections of notes                      |
| Adler-Milstein et al3      | 2015 | Cohort                         | IV                | Hospital performance after EHR adoption                                |
| Koopman et al10            | 2015 | Descriptive                    | VI                | Assessment of primary care physician interpretation of EHR notes        |
| Sinsky et al7             | 2016 | Descriptive                    | VI                | Allocation of physician time in ambulatory practice                    |
| Sittig et al9              | 2016 | Descriptive                    | VI                | Unintended consequences of EHR                                          |
| Wright et al13             | 2016 | Descriptive                    | VI                | Observation of physician EHR viewing patterns                          |
| Senathirajah et al22       | 2016 | Mixed methods                  | V                 | Comparing user composable EHR versus nonuser composable                |
| Zulman et al7             | 2016 | Expert opinion                 | VII               | How EHR takes away from the physician-patient interaction              |
| Arndt et al8              | 2017 | Descriptive                    | VI                | Time spent with EHR among primary care physicians                       |
| Vainiomäki et al12         | 2017 | Descriptive                    | VI                | EHR factors relating to physician well-being                           |
| Zelmer et al1             | 2017 | Descriptive                    | VI                | International EHR information exchange                                 |
| Belden et al20            | 2017 | Controlled trial               | III               | Assessing cognitive load based on different note organization          |
| Ancker et al14            | 2017 | Retrospective cohort study     | IV                | Studying the effects of alert fatigue on physicians                     |
| Howe et al11              | 2018 | Descriptive                    | VI                | Measuring contribution of EHR to patient harm                          |
| Kahn et al21              | 2018 | Multicenter, nonrandomized prospective trial | III | Assessing improvement in note bloat after intervention |
| Ratwani et al23           | 2018 | Controlled trial               | III               | Comparing differences in physician EHR competency with differing training levels |
| Khairat et al28           | 2018 | Observational                  | VI                | Survey of physician satisfaction with EHR after performing clinical simulations |
| Shah et al25              | 2019 | Controlled trial               | III               | Assessing changes in physician workload after reducing unnecessary alerts |
| Murphy et al26            | 2019 | Expert opinion                 | VII               | Interviews to discuss EMR inbox shortfalls                              |
| Khairat et al29           | 2019 | Cohort                         | VI                | Differences in EHR use between men and women                           |
| Al Ghalayini et al17      | 2020 | Controlled trial               | IV                | Assess performance and perception of modified EHR                      |
| Berg et al18              | 2020 | Descriptive                    | VI                | Residents’ perspectives on EHR use                                     |
| Melnick et al30           | 2020 | Descriptive                    | VI                | Survey to assess usability and EHR perceptions                          |
| Melnick et al31           | 2020 | Descriptive                    | VI                | Survey to assess EHR usability and physician burnout                   |
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