Patient safety issues from information overload in electronic medical records: A systematic review

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Abstract

Background and Objective: Electronic health records (EHR) 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 PRISMA (Preferred Reporting Items for 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 upon keywords.

Results: The literature search yielded 31 articles meeting 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. An addition, information overload increased the risk of physician burnout due to clerical burden leading to significantly higher rates of medical error.

Conclusion: Information overload in EHR may result in higher error rates and negatively impact patient safety. Further studies are necessary to define the EHR role in adverse patient safety events and to determine methods to mitigate these errors.

Introduction

Electronic health records continue to increase in usage around the world, with multiple governments requiring implementation, in part due to the improvements in patient safety.[1] The EHR has demonstrated improved patient safety by improving rates of workflows, policies, and practices that promote patient safety when compared to paper charts.[2] Despite its advantages over paper-based documentation, EHR use has resulted in new physician-related challenges that may lead to increased medical errors.[3] Indeed, in 2012, in anticipation of the potential for medical errors, the AMIA Board of Directors convened a task force to produce recommendations on enhancing patient safety by improving the usability of the EHR.[4] Despite highlighting 14 usability principles to improve the design of EHR's, the authors only mentioned the concept of minimizing cognitive load, but did not provide any further discussion or solutions for information overload.

A major complaint of physicians is the large amount of required extraneous patient information in each medical chart.[5] In addition to the expanding written text within the EHR, other datatypes sources such as radiological data, genomic data, and predictive analyses compound the volume of information. Studies analyzing primary care physicians' EHR usage have shown that they spend up to double the amount of time documenting in the EHR than they do interacting with patients. [6] This increased clerical burden on physicians is not only a source of frustration but may compromise patient safety.[7] An overload of information in a patient's chart, or "note bloat", may impair comprehension when reviewing medical

records, leading to potential errors in clinical decision making. [8] This can be compounded by poorly organized EHR software that is optimized for billing rather than patient care. [9] These EHR issues may increase physicians' cognitive load and leave them more susceptible to making mistakes.[10][Figure 1] A study analyzing data from 2013-2016 in Pennsylvania hospitals identified 1,956 adverse patient safety events blamed on the EHR in that time span with 557 of them being directly attributed to EHR usability.[11]

Overload from EHR's can also negatively affect physician well-being, as noted in a Finnish study by Vainiomaki *et al.* where they surveyed 3,781 Finnish physicians and found overload from higher time pressure and lower job control from EHR's.[12]

The purpose of this literature review is to evaluate the effect of EHR information overload on patient safety. Our hypothesis is that information overload negatively effects 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 covering publications from the past 10 years and completed on 8/20/2019. Selected full text articles were obtained and reviewed for those focused on patient safety implications of EHR information overload. Filters were set for English only and full text availability. References of selected articles were also reviewed and used as an additional source of literature. All published study types were included. All data analyses were descriptive. Institutional review board review was not obtained as the study was limited to published information and did not include any human subjects.

Keywords used included "electronic health record" and "electronic medical record" in conjunction with the terms "information overload", "cognitive overload", "note bloat", "usability", and "patient safety". Additional searches with different combinations of these terms included "electronic health record information overload patient safety", "electronic health record usability patient safety", "electronic health record cognitive overload 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 to demonstrate how information overload and poor EHR usability affect physician comprehension of clinical data. Further literature was sought out to understand the effect EHR has on physician burnout, as well as the link between burnout and medical error. Keywords included "EHR physician burnout" and "physician burnout medical error".

Articles were screened by one reviewer by first assessing the title and then the abstract for relevance to the topic. If the title included either (a) no keywords or (b) "electronic health record" or "electronic medical record" but no further keywords of interest, the article was excluded. Titles that were focused on healthcare professionals other than physicians were not chosen.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards for literature review requirements were followed for items applicable to this literature review.

Results

As of 8/20/2019, a total 6,421 records where obtained by searching PubMed and the Web of Science, and adding relevant references from the database articles. 6,031 titles were discarded due to irrelevant topics or duplication. 390 abstracts were reviewed, and 346 were discarded due to lack of original research or not physician-focused. This left 44 full-text articles that were assessed for eligibility, leaving 31 studies that fulfilled the inclusion criteria and used for the study [Figure 2][Table 1]. All of the studies obtained correlated information overload with some level of negative effects on physicians. Based upon the results of these 31 studies, two main topics were consistently raised relating to information overload and patient safety – the resultant cognitive burden and physician burnout.

The cognitive burden of information overload

Beasley *et al.*[13] stated that "information overload occurs when there are too many data, e.g. written, verbal and non-verbal, and physician's memory, for the clinician to organize, synthesize, draw conclusions from, or act on." The overload of information can occur from copying & pasting into charts, use of templates, excessive alerts, and adding data that is necessary for billing but effectively useless for clinical care.[13,14]

Ahmed *et al.*[15] illustrated the effect of cognitive load differences on error rates when using an EHR for clinical decision making. A group of 20 intensive care unit physicians were asked to review patient data in the form of a conventional versus novel streamlined EHR. The novel EHR was specifically designed to only display information that was deemed most salient to these physicians. The National Aeronautics and Space Administration (NASA) task load index (an objective measure of task load from 0-100; higher indicates more work load) was a median of 58 for the conventional EHR versus 38.8 for the novel version. Completion of the task using the conventional EHR took approximately twice as long and was associated with a median four times as many errors per subject as the novel user interface. This was consistent with the hypothesis that increased task load has significant detrimental effects on physicians' ability to analyze data.

Eye tracker technology in the intensive care unit was studied by Wright *et al.* to pinpoint what aspects of a chart physicians actually utilize [16]. They found that dynamic data such as vitals and lab values were reviewed most consistently, and that other routine information is unnecessary and hinders usability.

Koopman *et al.*[9] performed a cognitive task analysis with 16 primary care physicians using simulated patient cases to better understand what information they considered most important for medical decision making. A consistent finding among these physicians was that the assessment and plan was reviewed first because it provided the majority of the necessary information in a concise manner. The physicians

were frustrated by the review of systems section as it mostly provided redundant information and was another source of clutter. Physicians in the study also identified drivers of note overload: Billing (checklists for each section, especially review of systems), quality improvement measures (e.g., diabetic foot examination), avoiding malpractice, compliance (e.g., documenting informed consent, patient education), and the visit history and physical exam. An earlier study by Clarke *et al.* found similar results when they interviewed 15 primary care physicians about their information needs, finding the review of systems "superfluous," and contributing to information overload.[17]

Belden *et al.*[18] expanded on the idea of restructuring the fundamental structure of notes in the EHR to decrease cognitive overload. The traditional "SOAP" (Subjective, Objective, Assessment, Plan) note was compared to a newly proposed "APSO" (Assessment, Plan, Subjective, Objective) format with an option to hide other extraneous information. A simulated case with 16 physicians demonstrated that simply changing the format of the note without changing any of the actual data had a positive effect. The APSO note performed better in regard to usability, and the physicians strongly endorsed this style as more practical.

Information overload can also be mitigated through educating physicians to write more efficient notes. Kahn *et al.*[19] demonstrated that physicians who undergo a training session and use a template write notes that are 25% shorter and take 1.3 hours less time.

A study done by Senathirajah *et al.* with 11 physicians reviewing the same patient data showed a significant increase in reading efficiency with a user composable interface versus a traditional EHR. 72% of patient data was reviewed more than once in conventional EHR's compared to 17% in the user composable version. A conclusion offered by these authors was that the poor usability of conventional EHR's decreases physician comprehension, requiring data to be revisited multiple times until it is fully understood.[20]

However, simply allowing for user composability does not guarantee increased efficiency as illustrated by Ratwani *et al.*[21] The usability and safety of Cerner and Epic were assessed by having 4 different groups of 12-15 physicians at different institutions (two groups using Epic, two groups using Cerner) complete basic tasks such as ordering imaging, labs, and medication for fictitious patients. Performance was assessed by tracking error rates, clicks, and task completion time between the four groups. Results showed up to an 8-fold difference in task completion time and clicks between the groups at different sites using the same EHR. Both EHR's are user composable, but factors such as implementation protocols and physician training varied between the two sites and were hypothesized as reasons for the vast difference in proficiency.

Alert fatigue is another potential source of information overload. In a survey of 2,590 primary care physicians, 69.6% reported receiving more information than they could effectively manage. 29.8% reported incidents where they personally missed test results that delayed patient care.[14] Another study demonstrated that a clinician's likelihood of accepting best practice reminders dropped markedly with

increases in the number of reminders, number of repeated reminders for the same patient, and overall patient complexity.[22] A program to decrease alerts of lower importance in the Department of Veteran's Affairs was developed by Shah *et al.* in 2018, resulting in a reduction of mean daily notifications per physician from 128 to 116, and a concomitant savings of 1.5 hours of work per week per physician.[23]

Khairat *et al.*[24] demonstrated how the burdens of EHR's affected physicians differently depending on the stage of their careers. Six clinical case simulations were performed by ER residents and attendings, followed by a survey to assess perceived workload and satisfaction for EHR's. Attending physicians showed significantly higher levels of frustration with the EHR in general compared to residents. Information overload was rated more significant for residents, while attendings found excessive alerting to be a more negative factor.

Physician burnout

Physician frustration can be a result of information overload, with up to half of a work day spent working on an EHR and an additional 1-2 hours at home, according a study by Sinsky *et al.*[5] Marked decreases in time spent with patients is reported by physicians to be a large source of dissatisfaction and burnout.[24] A 2017 survey of primary care physicians showed that 75% of doctors reporting burnout attributed it to the burden of the EHR as the primary cause.[25] A 2019 survey of 282 clinicians from 3 different institutions gave more insight on the specific factors that lead to EHR burnout. The most significant problems associated with EHR's included information overload, excessive data entry, and notes geared toward billing rather than patient care.[26] Another survey of 1,792 physicians in 2019 revealed that physicians had a 2.8 times the odds of being burned out when they felt there was not enough time in the day for documentation.[27] Burnout increases the risk of depression, substance abuse, strained relationships, and suicide among physicians, in addition to a significantly higher incidence of medical errors.[28,29] Tawfik *et al.*[29] reported that physicians with burnout had more than twice the odds of self-reported medical errors, after adjusting for specialty, work hours, fatigue, and work unit safety rating.

Discussion

Patient safety is paramount in all aspects of medical care and any efforts to improve it should be pursued. The EHR's effect on patient safety is complex. When implemented properly, it can reduce medication errors and provide a potentially safer alternative to paper-based methods.[2,30] However, its use has caused information overload as an unintended consequence.[4] In addition to the growing text within the written notes, information within the EHR has also expanded from radiology results, laboratory results, alerts, demographics, predictive analyses, and more. The massive amount of data required in each patient's chart has become potentially obstructive to patient care, and can hinder the physician-patient interaction. Efficiently extracting clinically relevant information from the EHR can be a difficult task for physicians.[15,16,20,21] This increased cognitive load placed on physicians makes them more prone to clinical errors, which puts patient safety at risk.[15] In addition, the stresses of information overload

contribute to physician frustration and burnout, which can also lead to an increase in medical errors.[29] A worrisome implication of these results in light of the continuous growth of information, is that without any changes, the rate of medical errors will more than likely continue to worsen over time.

In order to minimize the effects of information overload, various solutions have been proposed. One such solution is a customizable EHR to ensure that important data is easier to find.[15,20] Studies that tested this type of software showed significant reductions in error rates and improvements in efficiency. Pickering *et al.*[31] introduced a novel user interface called AWARE (Ambient Warning and Response Evaluation) for use in the intensive care unit. The program synthesizes all of the data on a patient to a more readable and concise format, thus allowing physicians to make significantly quicker and safer decisions on patient care.

However, customizability does not provide the same benefit for all physicians. For example, a physician's level of training has implications on how best to customize an EHR. Attendings and residents have significant differences in what they find challenging with the EHR[24], and thus, their respective interactions with the EHR must be assessed when customizing the EHR to minimize information overload and improve patient safety. In addition, user composability requires proper training techniques with implementation in order to maximize its potential.[21]

Changing the order of the clinical note may also improve usability[18,19]. Putting salient information at the beginning of the note may allow physicians to spend less time searching through extraneous information, and thus reduce the cognitive burden. However, notes are not just read, but also written, and retraining physicians to alter the order of notes may lead to an increased burden in and of itself. Software may potentially be designed to reformat a written SOAP note into presentation as an APSO note, but this has not been developed or studied to our knowledge. Thus, changing the traditional order of notes may require further research before implementation.

Alert fatigue can further contribute to information overload. Excessive alerting has been shown to alter decision making and cause physicians to deviate from best practice.[22] Interventions aimed at reducing unnecessary alerting have been proven to decrease time spent with the EHR.[23] Any addition of alerts in EHR's must be taken with great caution due to the increased risk of information overload, and efforts must constantly be made to minimize their usage.

One unintended consequence of information overload is the potential for physician burnout. Information overload results in an increase in tedious clerical work, reduction in physician-patient time, and a hampering of physician efficiency.[5] This has negatively impacted physician well-being and is a significant cause of physician burnout.[24-28] Physicians with burnout have an increased rate of clinical errors, further increasing the risk of adverse patient safety events.[29] Thus, information overload not only had negative consequences for patient care, but it also negatively effects the well-being of physicians.

Conclusion

A review of the literature demonstrates that EHR information overload can have a negative impact on patient safety, in addition to contributing to physician burnout and further increased medical error rates. Customizable EHR, shortened clinical notes, and reduced alerting may be helpful interventions to minimize cognitive load and improve patient safety. EHR information overload may also contribute to physician burnout and negatively affects physician wellness. Further research to understand the impact of information overload on patient safety is necessary in order to more effectively develop improved EHR's focused on improving patient safety and reducing the burden on physicians.

Abbreviations

EHR: Electronic Health Record

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

AMIA: American Medical Informatics Association

NASA: National Aeronautics and Space Administration

SOAP: Subjective-Objective-Assessment-Plan

APSO: Assessment-Plan-Subjective-Objective

AWARE: Ambient Warning and Response Evaluation

Declarations

Competing interests

There are no conflicts of interest from any of the authors of this manuscript.

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Authors' contributions

SN conducted the literature search and wrote initial drafts of the manuscript. EG provided topic and guidance of the project, as well as wrote many revisions. NL also provided input on the direction of the project.

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Table 1

Author	Year	Type of Study	Level of Evidence	Summary
Beasly JW et al[11]	2011	Expert opinion	VII	Defining information overload
Ahmed et al[13]	2011	Randomized crossover study	II	Assessment of physician cognitive load with 2 different EHR interfaces
March CA et al[5]	2013	Controlled trial	III	Simulation to assess EHR safety in the ICU setting
Singh et al[12]	2013	Descriptive	VI	Assessment of physician information overload due to excessive alerting
King G et al[10]	2014	Expert Opinion	VII	Characterizing clinical benefits of EHR
Adler-Milstein J et al[1]	2015	Cohort	IV	Hospital performance after EHR adoption
Koopman RJ et al[6]	2015	Descriptive	VI	Assessment of primary care physician interpretation of EHR notes
Tanner C et al[9]	2015	Case Control	IV	Assessing safety of EHR
Sinsky C et al[2]	2016	Descriptive	VI	Allocation of physician time in ambulatory practice
Sittig DF et al[4]	2016	Descriptive	VI	Unintended consequences of EHR
Zulman DM et al[7]	2016	Expert Opinion	VII	How EHR takes away from the physician patient interaction
Wright MC et al[14]	2016	Descriptive	VI	Observation of physician EHR viewing patterns
Senathirajah Y et al[17]	2016	Mixed methods	V	Comparing user composable EHR versus non-user composable
Shanafelt TD et al[22]	2016	Descriptive	VI	Physician EHR satisfaction survey
Arndt BG et al[3]	2017	Descriptive	VI	Time spent with EHR amongst primary care physicians
Belden JL et al[15]	2017	Controlled trial	III	Assessing cognitive load based on different note organization

Ancker JS et al[19]	2017	Retrospective cohort study	IV	Studying the effects of alert fatigue on physicians
Robertson SL[23]	2017	Descriptive	VI	Effect of EHR on physician work-life balance survey
Howe JL et al[8]	2018	Descriptive	VI	Measuring contribution of EHR to patient harm
Kahn D et al[16]	2018	Multicenter, nonrandomized prospective trial	III	Assessing improvement in note bloat after intervention
Ratwani RM et al[18]	2018	Controlled trial	III	Comparing differences in physician EHR competency with differing training levels
Khairat S et al[21]	2018	Observational	VI	Survey of physician satisfaction with EHR after performing clinical simulations
Lacy BE et al[25]	2018	Descriptive	VI	Description of EHR contribution to burnout
Tawfik DS et al[27]	2018	Descriptive	VI	Survey of physicians linking burnout and medical error
Shah T et al[20]	2019	Controlled trial	III	Assessing changes in physician workload after reducing unnecessary alerts
Kroth PJ et al[24]	2019	Descriptive	VI	Survey of the effects of EHR on physician happiness
Gardner RL et al[26]	2019	Descriptive	VI	Effects of EHR on physicians

Figures

Figure 1
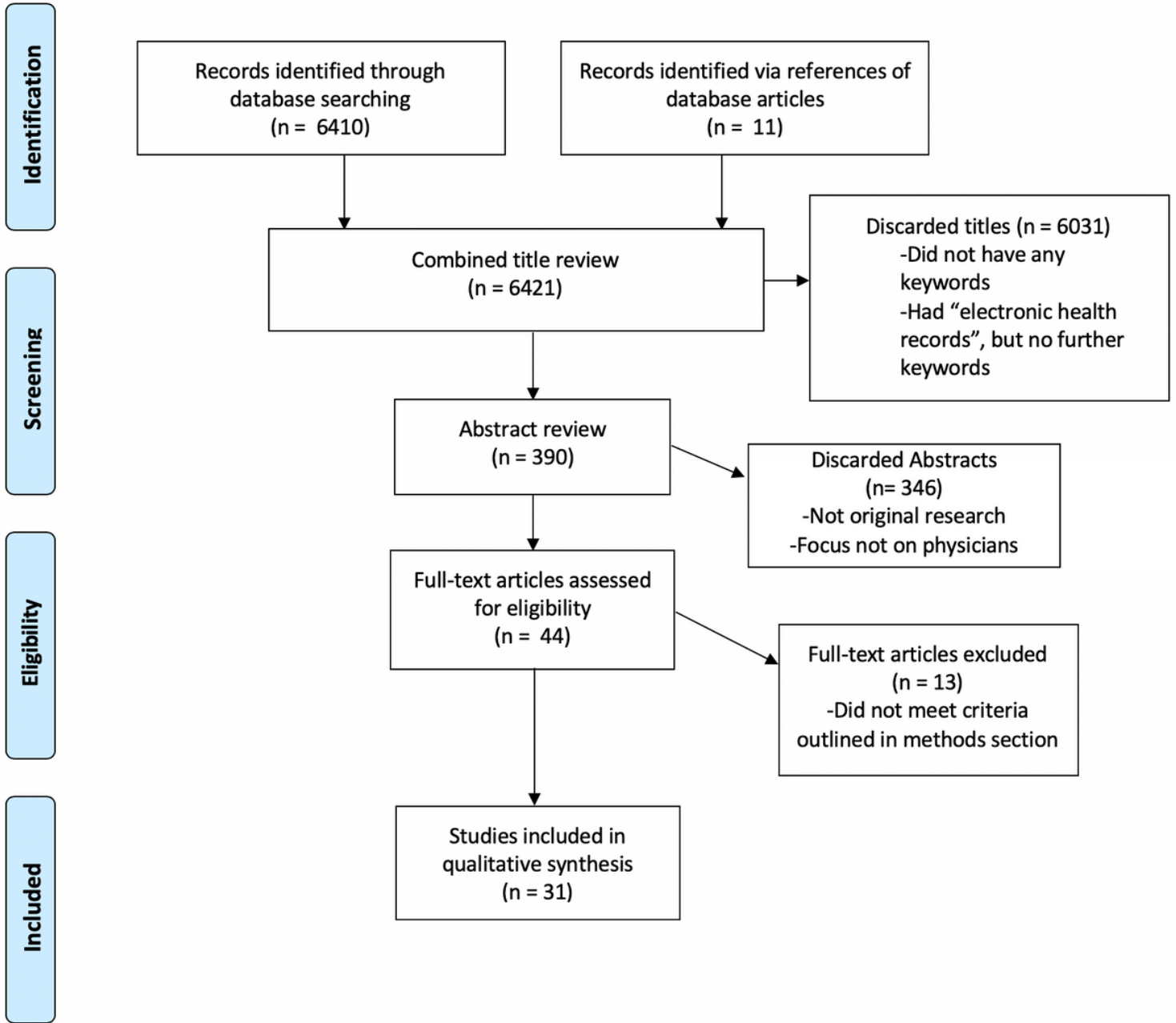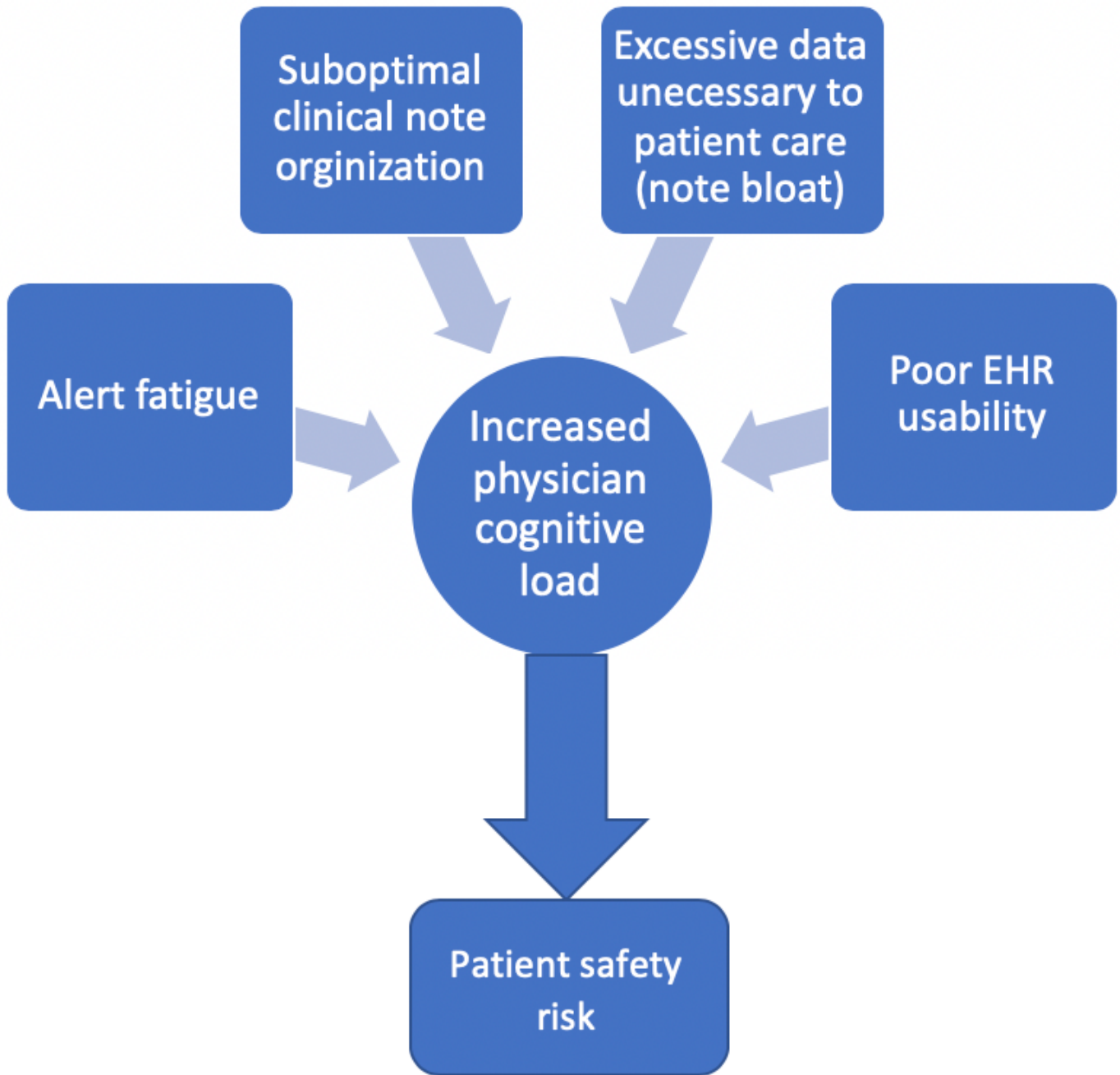
EHR factors that impact patient safety

Figure 2

Literature search algorithm