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A Systematic Review of Nurses' Experiences With Unintended Consequences When Using the Electronic Health Record

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In response to unprecedented financial government incentives, electronic health record (EHR) adoption has tripled since 2009. While EHR benefits are emphasized, research demonstrates that adoption may result in unintended consequences that nurse administrators can anticipate and mitigate. Unintended consequences are defined as unplanned effects, whether positive or negative. Little is known about nursing perceptions and experience of unintended consequences arising from EHR implementation, and nursing studies are minimal in comparison with research on experience among their interprofessional colleagues. The purpose of this article is to present the state of the science on nurses' experiences with unintended consequences of EHRs derived from a systematic review that includes 4 original studies. Findings demonstrate that nurses experience changes to workflow, must continually adapt to meet patient's needs in the context of imperfect EHR systems, and have difficulty accessing the information they need to make patient care decisions. Even so, most state they would not revert to paper records if given the choice. Implications for nurse administrators include the need for continual engagement with nurses along the continuum of EHR design, as well as the need to encourage nurses to speak up and acknowledge workflow changes that threaten patient safety or do not support work efficiency.
Key words: *barriers, electronic health record, nursing informatics, patient safety, unintended consequences, work-arounds, workflow*

WITH THE PASSING OF the Affordable Care Act, preceded by the Health Information Technology for Economic and Clinical Health (HITECH) in 2009, health organizations are now incentivized to implement electronic health records (EHRs).[1] Adoption of this technology has tripled since 2009 and continues to climb as organizations rush to receive financial incentives while avoiding the impending reduced reimbursement for those who do not conform to prescribed standards. Recognized benefits of adopting EHRs include streamlining communication among clinicians, making the health history available and actionable, and tracking treatments and respective outcomes over time. Yet, swift implementation without considering role-shifting and workflow impacts can threaten patient safety.[2] To support effective implementation and true meaningful use of EHRs, nurse administrators can evaluate, plan

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for, and strategically mitigate the negative unintended consequences that can result from EHR implementation and adoption (heretofore referred to as UC-EHRs).

Despite widespread EHR implementation, little has been formally studied or published about nurses' experience working with UC-EHRs arising from EHR implementation. Most of the evidence about these unintended consequences has come from qualitative studies with physicians,[3-5] outnumbering nursing studies 20 to 1.[6] Nurses, as care coordinators, are often described as the last line of defense between a patient and an error when gaps in communication and system inefficiencies arise. Nurses operate at "sharp-end" error intersections and are directly responsible for administering medications and/or choosing to initiate or delay treatments when errors occur. As they practice in complex, resource-constrained, turbulent, and time-pressured environments, nurses' actions are often resilient to system inefficiency in order to avoid patient harm. They navigate system barriers by devising work-arounds to accomplish tasks.[7,8]

BACKGROUND

Researchers have explored UC-EHRs since as early as 1998.[9] Unintended consequences include a change of the workflow of clinicians, barriers to effective use, and a decrease in efficiency due to increased time and effort of clinicians to "work around" the system, particularly in the context of new barriers introduced by the technology. UC-EHRs are a result of incongruence between the user and the EHR interface. Altering workflow, and impacting the sociotechnical system, UC-EHRs potentially wield both positive and negative impacts on clinical care.[4]

Study of UC-EHRs originated with the advent of computerized provider order entry (CPOE) applications. Among physicians, documented UC-EHRs include perceived added work, persistence of paper-system use, threats to communication, heightened emotions, emergence of unpredicted errors, alteration in power structure, and overdependence on technology.[3-5,10-19] In studies exploring interprofessional experience with UC-EHRs, Ash and colleagues[13] sought to understand the nature, occurrence, and mitigation tasks for reducing the impact of unintended consequences. They interviewed staff from 176 hospitals and conducted nearly 400 hours of observation across hospital units. The 8 most common types of CPOE-induced unintended consequences were categorized. These included (1) addition of more work or new work; (2) alteration of accepted and expected workflow; (3) imposition of new demands on the system; (4) altered communication across professions and within professions; (5) expressions of strong emotions; (6) new kinds of health care errors; (7) a shifting of power across disciplines; and (8) a fostering of overdependence on technology.[13] The alteration of communication and change of workflow were the most concerning to clinicians. Newly identified CPOE unintended consequences included wrong patient identification errors and juxtaposition errors (ie, a clinician clicked on the wrong patient, or ordered the wrong drug). The same research team analyzed 47 examples of unintended consequences to clinical decision support. This revealed 3 more unintended consequences: role shifting, gaps in content updating, and inappropriate content. In addition, physician-directed decision support systems were found to be rigid. They overalert clinicians and induce alert fatigue, which lowers the threshold for new kinds of errors to occur.[4]

Other safety concerns have been identified through studies of physicians new to EHRs. One threat is called "technovigilance," implying that projects are deprioritized to enable keen focus on meeting technology concerns and costs.[20] Another is delayed treatment due to system inefficiency. One example (in a California acute care setting) was when laboratory results for gonorrhea were not uploaded into the EHR because of a system mismatch. As a result, pharmacological treatment was delayed.[21]

Misrepresentation or underrepresentation of EHR data was identified in 45 clinical scenarios gleaned from system logs, vendor reports, and Food and Drug Administration reports. These threaten a clinical team's shared understanding of patient needs because of inconsistencies. Specifically, 5 types of identified misrepresentations include (1) EHR data that are too narrowly focused, (2) EHR data that are too broadly focused, (3) display of data that "miss" the critical reality, (4) contradictory, redundant, or confusing data, and (5) data distortions reflected both by users and by sensors.[22]

While content and workflow needs may overlap between clinical professions, nurses' experience with EHRs is likely to be different from that of their physician colleagues. The purpose of this review is to systematically investigate published literature addressing the nurse experience with EHR-related unintended consequences.

METHODS

A search of CINAHL and PubMed databases, using the terms "nurse [expanded using nurs*]" and "unintended consequences" in early 2014 yielded few results. To expand the search, the authors queried PubMed and CINAHL plus full text by adding the terms "barrier and work-around to electronic health record, unintended, consequences, nurs* (expanded to include nursing, nurse, etc)," and "electronic medical record." Using this approach, 128 references were identified. Two more were added after a "hand" searching. After a review of these 130 article titles, 69 were excluded because of lack of relevance to the research question. They were not health care, not acute care, or not in English. Sixty-one abstracts were reviewed to determine whether they explicitly address unintended consequences and/or patient safety and focus primarily on the RN in acute care. Reviews and editorials (n = 23) were set aside, and 32 articles were excluded because they did not focus on RNs primarily; one was excluded because it was focused on instrument development and did not specifically address nurse experience.[23] Five articles were included and reviewed in depth. Flow of article selection is depicted in the Figure.

RESULTS

Five articles related to the RN experience of unintended consequences are summarized in the Table. Of the 5 studies, 4 used qualitative methods[8,24-26] and 1 utilized mixed methods.[27] Articles were published from 2009 to 2014. Four were found in nursing research journals, with 1 article discovered from the 2012 World Nursing Congress on Informatics. Different research teams originated the 5 reports. The population of interest across studies was the nurse caring for patients directly at the bedside in acute care environments. Qualitative methods with small samples (range, 5-37) and content analysis approaches were most often used. Studies are described historically ranging from the oldest study (2009) to the most recent (2014).

Schoville[25] examined work-around and artifacts used by nurses during a transition in order entry from paper to CPOE. That study examined how CPOE implementation affected nurses' use of artifacts to adapt to their changes in workflow, allowing changes to be made by addressing these selective themes and correcting unintended consequences. Data were collected to identify work-arounds by (1) asking clinical leaders (by e-mail) to identify work-arounds and artifacts they had observed, (2) conducting follow-up open-ended interviews with leaders, and (3) observing 12 RNs for 4 hours each as they completed their work, and (4) reviewing the CPOE internal Web site for reported tips, articles, and frequently asked questions generated by clinicians. Forty work-arounds and 18 artifacts were identified. Of those, 80% of work-arounds and 89% of artifacts were used by nurses to support care coordination, many in response to CPOE design errors. Many work-arounds were used to address workflow timing of events (ie, medication orders), adapt

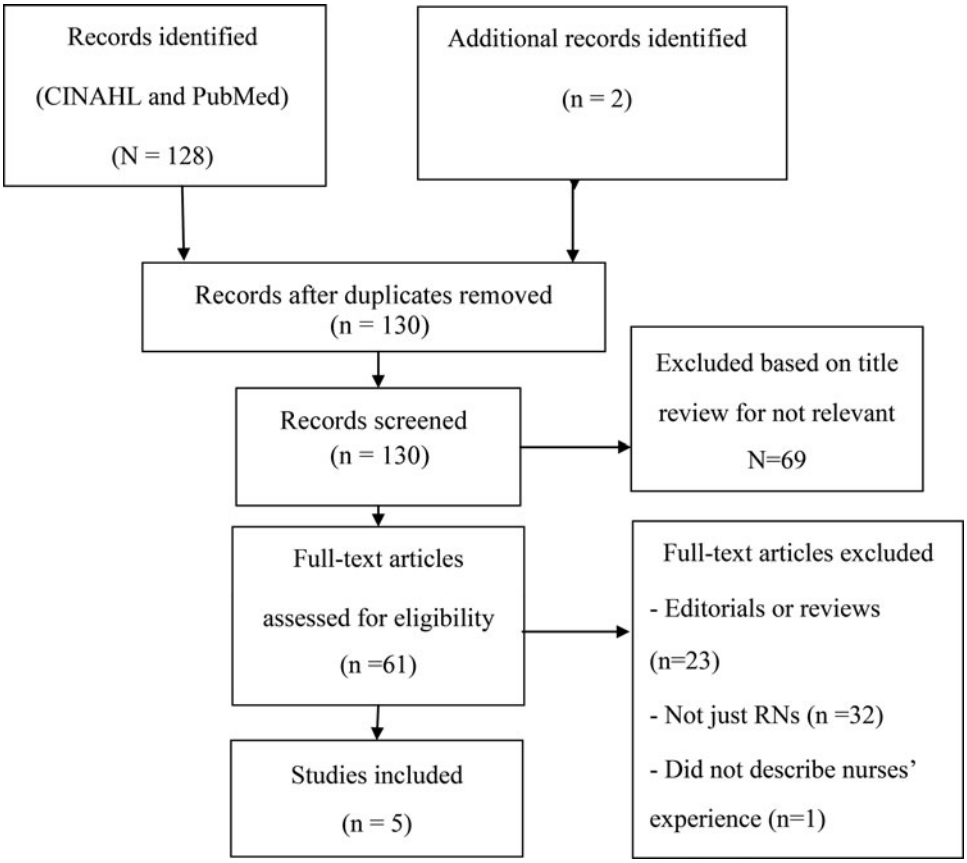

Figure. Flow diagram for article selection. RN indicates registered nurse.

to communication changes (ie, paper lists and verbal order confirmation), overcome system problems (eg, delay in care and lack of coordination between health care providers), and improve work efficiency while learning the system (eg, avoiding charting, excessive training, double-checking computer calculations manually).

Carrington and Effken[8] explored nurses' perceptions of the effectiveness of the EHR to communicate a clinical event or a sudden and unexpected change in patient clinical status. Researchers interviewed 37 nurses, including documenting nurses (those who cared for the patient during the change in status) and receiving nurses (those who continued care for the patient after change of shift). After reviewing the transcripts and applying content analysis, 5 categories emerged. These were EHR-related issues of usability, legibility, communication, work-around, and collaboration.[8] Nurses generally perceived the EHR to be efficient for data entry and retrieval, which they said increased legibility of the text. Nurses indicated that information documented and extracted from the EHR was most often irrelevant for continuing care. Finally, nurses used work-arounds to address issues with electronic signatures, networks, or hardware malfunctions and were concerned about the time required to document.[8]

Collins et al[27] used a mixed-methods approach to analyze work-arounds used by nurses, particularly the use of the optional free-text comments as part of a local EHR in use since 2005. In this case, the EHR design did not link nursing flow sheet data to clinical events. The use of free-text comments was a nursing work-around to make that connection. Researchers collected text

Table. Evidence Synthesis on Nurse Experience With Unintended Consequences of EHRs

Authors (Year)/ Sample/Setting	Purpose/Design/Methods	Unintended Consequences Identified	Strengths/Limitations
Schoville (2009)[25]	*Purpose*: Identify WAs and artifacts RNs use after CPOE adoption	40 WAs and 18 artifacts identified; 80% of WAs were used to improve patient care coordination, many a reaction to CPOE design errors (48%-78%)	*Strengths*: Multiple methods of observation and interview for verification of findings; multisite
Sample: RNs (N = 12)	*Design*: Observational/ethnographic	WAs addressed workflow timing of events (ie, medication orders), communication changes (ie, paper lists and verbal order confirmation), system problems (eg, delay in care and incoordination between health care providers), and learning curve WAs (eg, charting avoidance, excessive training, "double-checking" computer calculations manually).	*Limitations*: Small sample, possible selection bias (1 nursing leader and 12 RNs observed), although RNs were selected randomly
Setting: Two large hospitals in the Midwest employing ~1000 RNs. Subgroups interviewed and observed. United States	*Methods*: Observation, data source review, and interviews including (1) e-mail to clinical leaders about WAs and artifacts, (2) RN interviews, (3) 4 h each observing 12 RNs using CPOE and EHR, and (4) CPOE internal Web site analysis		
Carrington and Effken (2011)[8]	*Purpose*: To reveal themes of nurse-to-nurse communication surrounding a clinical event and compare with EHR documentation	Communication between RNs (documenting nurse to receiving nurse) yielded 260 thematic units. *EHR strengths*: Retrievability, legibility, usability. *Limits*: Lack of relevance and efficiency, barriers. All nurses reported the EHR caused issues. RNs from 1 site stated no strengths of EHR.	*Strengths*: Three judges tested reliability of coding

(*Continues*)

Table. Evidence Synthesis on Nurse Experience With Unintended Consequences of EHRs (*Continued*)

Authors (Year)/ Sample/Setting	Purpose/Design/Methods	Unintended Consequences Identified	Strengths/Limitations
Sample: RNs (N = 37) *Setting*: 2 medical-surgical units from 2 hospitals United States	*Design*: Qualitative description *Methods*: Interviews of documenting and receiving RNs caring for a patient after experiencing a clinical event	RNs expressed desire for involvement in EHR hospital decisions and to identify EHR-related barriers that arise.	*Limitations*: One geographic location (2 hospitals); only full-time nurses; limited RN demographics described
Stevenson and Nilsson (2011)[26] *Sample*: 21 RNs *Setting*: 6 acute care units Sweden	*Purpose*: Identifying acute care nurses' perceptions of using the EHR in their daily work and how this impacts patient safety *Design*: Qualitative/Focus groups *Methods*: RNs were divided and interviewed in groups using unstructured interviews and then thematic analysis conducted	*Negatives:* Documentation in several places, leading to confusion and difficulty/extended time period to locate important information. Complex design hard to navigate. Information easily "missed." Medications easily logged on the wrong day or time. Lack of clarity with medication changes. *Positives:* Collective record and ready access across providers, permanence of information (eg, patient allergies), and less paperwork. Absence of illegible handwriting for scripts. Nurses described a lack of ability to give EHR input.	*Strengths*: Nurses from 6 different acute care settings interviewed; high trustworthiness in interview method and analysis approach *Limitations*: Data collection was conducted in 2008; small sample; first-time nurses had been asked their opinion about the EHR design; limited generalizability
Collins et al (2012)[27]	*Purpose*: To examine nurses' use of free text during clinical events and its perceived clinical significance during a clinical event	No design to link flow sheet data to clinical events. Optional free text considered a WA. Most free text was related to nursing interventions and communications with other health care professionals	*Strengths*: Triangulation of content analysis; intercoder reliability on 10% of the sample was 89%

(*Continues*)

Table. Evidence Synthesis on Nurse Experience With Unintended Consequences of EHRs (*Continued*)

Authors (Year)/ Sample/Setting	Purpose/Design/Methods	Unintended Consequences Identified	Strengths/Limitations
Sample: Acute care RNs (N = 5) and data from 201 cardiac arrest events	*Design*: Mixed methods	*Themes*: Legal coverage, ease of use in entering a note, specific time and date, patient safety. It was expected that physicians would read the notes.	*Limitations*: One hospital setting; 1 unit; only 1 type of clinical adverse event analyzed (cardiac arrest); physicians' level of awareness of nursing note not explored to confirm assumption (expectation information would be read)
Setting: One unit from a large urban medical center using an EHR since 2005	*Methods*: *QUAL*: content analysis of interviews of RNs about free-text documentation related to cardiac arrest	Extra effort from nurses was noted, resulting in improved communication (using WA) after clinical event. *Finding*: Flow sheets alone are suboptimal for representing client events in the EHR.	
United States	*QUANT*: Nursing optional free-text comments for 201 cardiac arrest events 350 notes analyzed		
Sockolow et al (2014)[24]	*Purpose*: Analyze the effectiveness of NIS, a module within the EHR that is designed around nurses' documentation needs and care plans	NIS satisfaction, functionality (documentation completeness, availability of reminders, quick medication information, ability to document at the bedside, ability to fit care to patient needs).	*Strengths*: One of the first articles about the usage of NIS documentation; interrater agreement 100%
Sample: 12 acute care RNs, trained to use the NIS	*Design*: Qualitative, with think-aloud protocol and observation	*Issues*: Usability, copying of patient information, time lag between orders, double documentation needed because physicians did not read the NIS, implementation and training, interruptions while documenting, odd admission questions (eg, "Are your pets safe?"), lack of training for nurses	*Limitations*: Sample was only acute care nurses

(*Continues*)

Table. Evidence Synthesis on Nurse Experience With Unintended Consequences of EHRs (*Continued*)

Authors (Year)/ Sample/Setting	Purpose/Design/Methods	Unintended Consequences Identified	Strengths/Limitations
Setting: Two hospitals (1060 beds total). United States	*Methods*: Interviews and observation of nurses using the EHR to document a patient fall Survey and tested, using the NIS in crafted scenarios	*Recommendations for NIS change* (from authors): Bedside placement, design feedback, flow sheet design, functionality, and careful implementation including educating nurses and physicians on NIS use	No validity testing for coding besides common coding schemes; tested using scenarios, not real patients

Abbreviations: COPE, computerized provider order entry; EHR, electronic health record; NIS, Nursing Information System; QUAL, qualitative; QUANT, quantitative; RN, registered nurse; WA, work-around.

documentation and interviewed 5 nurses, using a semistructured format. The text data were collected from the EHR for 201 patients who experienced cardiac arrest, with data focus on oxygen level, blood glucose, and blood pressure. Clarification of EHR documentation was captured in 350 optional comment fields. Most comments were related to nursing interventions and the resulting communication with other health care professionals. Qualitative themes identified through content analysis included nurses' perceptions of the benefit of using the optional comment field to (1) justify their care for legal purposes, (2) simplify EHR use, (3) ensure patient safety, and (4) improve team communication (if and when physicians read the note). Recommendations for EHR flow sheet redesign included making it possible to document a clinical episode without changing screens, supporting electronic notification of abnormal measurements by the nurse to other health care team members, and relating multiple sheets as a methodology for presenting a single story linking abnormal assessment, nursing intervention, and patient response.

In 2012, Stevenson and Nilsson[26] explored nurses' perceptions of patient safety when using the EHR as part of daily practice in a general ward setting. Focus group interviews were conducted with 21 nurses who had used the EHR system for a year. Using content analysis, one category emerged, "documentation in everyday practice," which had 3 facets related to documentation of vital signs, patient overview, and management of the medication module. When EHR documentation was redundant and duplicative, nurses reported that it led to confusion and added to their mental workload to find information they needed.

Complex EHR design made it difficult to navigate and resulted in missed information (eg, unclear medication changes). It was easy to make mistakes (eg, logging medication on the wrong day or time). Nurses' perceived EHR benefits included its capability to (1) present a collective record that was accessible to all health care providers, (2) support data permanence (eg, patient allergies),

(3) increase legibility and readability, and (4) reduce paper shuffling. Collectively, nurses agreed that the EHR was better than paper. Yet, nurses felt disempowered and described being excluded from decision-making discussions about the EHR. They expressed feeling that their opinions were not taken seriously when they offered their recommendations for record improvement.

In 2014, Sockolow et al[24] assessed the impact of a Nursing Information System (NIS) and subsequent health care outcomes associated with NISs. The NIS is an application within the EHR that provides nurses with access to evidence-based guidelines to plan and inform patient care decisions. Twelve randomly selected nurses were interviewed. The interview included scenario-based testing where they were asked to "think aloud" in response to questions about the EHR when they were documenting a patient's fall. Content analysis was used to assess the interview transcripts for the simulation. Thematic analysis identified the positive and negative aspects of NIS usability. While generally satisfied with the completeness of documentation, availability of reminders, access to quick medication information, and the ability to document at the bedside, nurses were neutral about NIS charting functionality and its support of team communication. Dissatisfaction was noted about the frequency of interruptions they experienced when documenting at the bedside, a lack of ability to provide feedback on the NIS design, and poor flow sheet design, hindering their ability to construct a clear clinical picture about what was going on with the patient. Design factors that could influence patient safety included poor usability, the need to copy patient information, time lags between orders, lack of physician assessment of documentation in the nursing information system, missing information, need for duplicative documentation, and inadequate training during implementation. The authors recommended that nurse administrators advocate for improved training and implementation support when implementing NISs on their unit.

While all studies used qualitative research methods to identify nurses' perspective, approaches varied among researchers. Schoville[25] combined interviews and observation of nurses' workflow following implementation of an EHR application. Carrington and Effken[8] used semistructured interviews and content analysis to identify the emergent categories and themes. Stevenson and Nilsson[26] organized nurse participants into focus groups. Collins et al[27] used mixed methods within the qualitative domain including interviews and text (from the EHR). Sockolow et al[24] also used interviews but in the context of simulation or scenario-based testing.

DISCUSSION

The articles included in this systematic review represent the current state of the science on nurses' experiences with unintended consequences while using EHRs. Five articles were identified. All used a qualitative component, and 1 used a mixed-methods design. Of the 5, only 1 addressed a theoretical framework for the study, using information theory to define constructs and interpret the meaning of results.[8] Remaining authors did not specify the theory that guided their research. However, it is likely that each was informed by human factors principles that inform the design and improvement of the user-technology interface, which in this case is the nurse-EHR interface.

Implications for research

The state of the science studying nurses' experience with EHR-related unintended consequences is supported by qualitative, text-intensive data collection approaches. It is underdeveloped, compared with the number of studies focused on physician experience. The use of qualitative methods for these pioneering studies was effective and appropriate. Over time, nurse informaticists have employed more sophisticated qualitative methods, perhaps attempting to gain a "real" sense of the unintended consequences

using the EHR from a "hands-on" approach to measurement.

Quantitative approaches could make measurement of UC-EHRs efficient for EHR implementers, including nurse administrators, and inform development and testing of interventions to avoid them. Studies are needed to describe the incidence, prevalence, and impact of nurse experience of UC-EHRs. The theoretical and qualitative work that has been completed sets the stage for continuation of a more focused line of study using quantitative methods. A validated measure to quickly assess UC-EHRs to tailor mitigation strategies is needed for avoidance of unintended consequences. Halbesleben et al[23] developed a tool to measure nursing barriers and work-arounds, but the full extent of EHR-related unintended consequences is not captured. The tool's focus is not on barriers, and work-arounds related mostly to the EHR.[23] As a general tool focused on work-arounds, its 20 items have demonstrated reliability and validity as tested with 460 nurses. To assess for the incidence of job crafting or work-around activity, nurse administrators could use the tool to assess EHR or other work impacts. However, a specific tool that addresses EHR-related unintended consequences is still needed.

Implications for practice

Results from this systematic literature review suggest that nurses face changes in workflow, inconsistent accessibility of information, and flow sheet design mismatches to their work. In addition, EHRs do not appear to alter the practice of other clinicians choosing not to read the patient information captured in nurse documentation. To minimize the impact of UC-EHRs, the authors recommend 4 major strategies.

The first is to anticipate changes in workflow, barriers, and work-arounds. Nurse administrators can then plan strong advocacy for nurses during all stages of the EHR implementation from build, test, and rollout to adoption. The second is to ensure that nurses from all care areas are represented in the system decision making. These nursing representatives must effectively communicate nursing needs while anticipating unintended consequences (barriers, work-arounds, alterations in workflow, altered communication across professions, and power shifting) and voice a plan to colleagues to address them in advance. The third strategy is for nurse administrators to be aware and involved during the implementation process so that they can advocate for nursing while minimizing as many of the known UC-EHRs as possible. For example, during the build process, nurse leaders should work with the full nursing team to analyze the current workflow and support education for the anticipated new workflow postimplementation. They should support the education process during system testing so that nurses can provide input while learning the system. Nurse administrators can also support the "super user" model, where nurses in all care areas become the unit "expert" on use of the system. These individuals serve as the frontline "leads" for questions, issues, and support during EHR education and implementation. Finally, during the maintenance and evaluation stages, nursing administrators should create and support an environment where nurses can freely communicate unanticipated and unintended consequences while suggesting their navigation.

CONCLUSION

Our purpose was to systematically search the informatics literature in order to summarize the state of the science around nurse experience with EHR-related unintended consequences. We also sought information on how nurses approach barriers and use of work-arounds when UC-EHRs occur. We did not distinguish or limit our search by focusing only on the EHR but included applications that nurses use directly in the care of their acute care patients. Two articles were included in our search that focused on the applications of CPOE[25] and NIS.[24] The findings revealed many of the same unintended consequences reported in studies that focused on the EHR: workflow timing, communication, system problems, a learning

curve during implementation, patient safety, documentation interruptions, nurse satisfaction, functionality, and efficiency. Increasing vigilance while planning for the unexpected (ie, the unintended consequences of EHRs) may be the ounce of prevention that leads to long-term EHR implementation success, ultimately supporting patient safety. Without careful attention to UC-EHRs, the promise of EHRs will not be achieved.

REFERENCES

1. Geisler BP, Schuur JD, Pallin DJ. Estimates of electronic medical records in U.S. emergency departments. *PLoS One*. 2010;5(2):e9274. doi:10.1371/journal.pone.0009274.
2. Kaplan B, Harris-Salamone KD. Health IT success and failure: recommendations from literature and an AMIA workshop. *J Am Med Inform Assoc.* 2009; 16(3):291-299.
3. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. *J Am Med Inform Assoc*. 2004;11:104-112. doi:10.1197/jamia.M1471.
4. Ash JS, Sittig DF, Campbell EM, Guappone KP, Dykstra RH. Some unintended consequences of clinical decision support systems. *AMIA Annu Symp Proc.* 2007;2007:26-30.
5. Campbell EM, Guappone KP, Sittig DF, Dykstra RH, Ash JS. Computerized provider order entry adoption: implications for clinical workflow. *J Gen Intern Med.* 2009;24(1):21-26. doi:10.1007/s11606-008-0857-9.
6. Staton R, Bautista A, Harwell J, Jensen L, Minister A, Roller S. Computerized provider order entry awareness for nursing: unintended consequences and remediation plan. *Comput Inform Nurs.* 2013;31(9):401-405.
7. Carrington JM, Effken JA. Modeling electronic documentation as a communication system. *AMIA Annu Symp Proc*. 2007:890.
8. Carrington JM, Effken JA. Strengths and limitations of the electronic health record for documenting clinical events. *Comput Inform Nurs.* 2011;29(6):360-367. doi:10.1097/NCN.0b013e3181fc4139.
9. Silverman DC. The electronic medical record system: health care marvel or morass? *Physician Exec*. 1998;24(3):26-30.
10. Ash JS, Sittig DF, Campbell E, Guappone K, Dykstra RH. An unintended consequence of CPOE implementation: shifts in power, control, and autonomy. *AMIA Annu Symp Proc*. 2006;2006:11-15.
11. Ash JS, Sittig DF, Dykstra R, Campbell E, Guappone K. Exploring the unintended consequences of computerized physician order entry. *Stud Health Technol Inform.* 2007;129(pt 1):198-202.
12. Ash JS, Sittig DF, Dykstra R, Campbell E, Guappone K. The unintended consequences of computerized provider order entry: findings from a mixed methods exploration. *Int J Med Inform.* 2009;78(suppl 1):S69-S76.
13. Ash JS, Sittig DF, Poon EG, Guappone K, Campbell E, Dykstra RH. The extent and importance of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc.* 2007;14(4):415-423.
14. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. In reply to: "e-Iatrogenesis: the most critical consequence of CPOE and other HIT." *J Am Med Inform Assoc.* 2007;14:389. doi:10.1197/jamia .M2385.
15. Campbell EM, Sittig DF, Guappone KP, Dykstra RH, Ash JS. Overdependence on technology: an unintended adverse consequence of computerized provider order entry. *AMIA Annu Symp Proc*. 2007;2007:94-98.
16. Dowding D, Mitchell N, Randell R, Foster R, Lattimer V, Thompson C. Nurses' use of computerised clinical decision support systems: a case site analysis. *J Clin Nurs.* 2009;18(8):1159-1167.
17. Iqbal T, Oldfield EC III. Electronic medical records: unintended consequences of a duplicitous default setting. *Infect Control Hosp Epidemiol.* 2010;31(11):1198-1199.
18. Landman AB, Takhar SS, Wang SL, et al. The hazard of software updates to clinical workstations: a natural experiment. *J Am Med Inform Assoc.* 2013;20(e1):e187-e190.
19. Love JS, Wright A, Simon SR, et al. Are physicians' perceptions of healthcare quality and practice satisfaction affected by errors associated with electronic health record use? *J Am Med Inform Assoc.* 2012;19(4):610-614.
20. Dixon-Woods M, Redwood S, Leslie M, Minion J, Martin GP, Coleman JJ. Improving quality and safety of care using "technovigilance": an ethnographic case study of secondary use of data from an electronic prescribing and decision support system. *Milbank Q.* 2013;91(3):424-454. doi:10.1111/1468-0009 .12021.
21. Murray EL, Samuel MC, Brodsky J, et al. *Neisseria gonorrhoeae* outbreak: unintended consequences of electronic medical records and using an out-of-state laboratory-California, July 2009-February 2010. *Sex Transm Dis.* 2013;40(7):556-558. doi:10.1097/OLQ.0b013e3182927c8c.
22. Smith SW, Koppel R. Healthcare information technology's relativity problems: a typology of how patients' physical reality, clinicians' mental models, and healthcare information technology

differ. *J Am Med Inform Assoc.* 2014;21(1):117-131. doi:10.1136/amiajnl-2012-001419.

23. Halbesleben JR, Rathert C, Bennett SF. Measuring nursing workarounds: tests of the reliability and validity of a tool. *J Nurs Adm.* 2013;43(1):50-55. doi:10.1097/NNA.0b013e31827860ff.
24. Sockolow PS, Rogers M, Bowles KH, Hand KE, George J. Challenges and facilitators to nurse use of a guideline-based nursing information system: recommendations for nurse executives. *Appl Nurs Res.* 2014;27(1):25-32.
25. Schoville RR. Work-arounds and artifacts during transition to a computer physician order entry: what they are and what they mean. *J Nurs Care Qual.* 2009;24(4):316-324.
26. Stevenson JE, Nilsson G. Nurses' perceptions of an electronic patient record from a patient safety perspective: a qualitative study. *J Adv Nurs.* 2012;68(3):667-676.
27. Collins SA, Fred M, Wilcox L, Vawdrey DK. Workarounds used by nurses to overcome design constraints of electronic health records. *Nurs Inform.* 2012;2012:93.