



State of the Science of Dimensions of Nurses' User Experience When Using an Electronic Health Record

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This integrative review synthesized relevant studies in the last decade associated to nurses' experience with the electronic health record using Robert and Lesage's dimensions of User Experience: functional, physical, perceptual, cognitive, psychological, and social. A comprehensive search was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidance across four electronic databases. We included articles if they were specific to nurses' electronic health record experience and workflow, published between January 2008 and June 2018, and available in English. The search resulted in 793 records with 26 articles included in the final analysis. Articles ranged from quantitative, qualitative, mixed-methods, and quality improvement studies. Across studies, the suboptimal design of the electronic health record affected the functional experience of nurses, often resulting in interruptions. The navigational design contributed to nurses' perceptual experience leading to many workarounds and workflow mismatches. Most of the studies reported overall satisfaction with the electronic health record that represented the psychological dimension of nurses' experience. Communication barriers due to the use of the electronic health record prevented nurses from having meaningful interaction with other clinicians and patients. Although nurses reported substandard user experience, many stated that reverting to a linear paper-based system was not an option.

KEY WORDS: Electronic health records, Nursing, User-computer interface, User experience, Workflow

Technology has become a catalyst in nursing knowledge generation, influencing nurses' clinical activities. As technology evolves and continues to be a substantial part of nursing, cultivating technological tools for data management and processing can foster

the ontological foundation of nursing in understanding the person, health, and environment that anchors nursing practice. One such tool is the electronic health record (EHR), which has changed the landscape of how nursing knowledge is acquired, generated, and used. Consequently, nursing praxis is shifting as the EHR continues to shape the future of healthcare.¹

BACKGROUND

The EHR is now widely used by healthcare organizations and providers, which was a change from the traditional linear paper-based systems. The increase in EHR use was in part due the passage of the Health Information Technology for Economic and Clinical Health Act, which provided incentives for the use and adoption of EHRs.² Although there has been pronounced progress since the advent of early versions of EHRs, clinicians such as nurses still face numerous issues, such as increased workload, documentation burden, difficult use, alert fatigue, loss of situational awareness, interruptions, and dissatisfaction.

In the United States, nurses make up the largest segment of healthcare workers, with approximately 2.9 million registered nursing jobs filled as of December 2016.³ Healthcare organizations maximize the use of the EHR to support nursing process for better clinical decision making.⁴ With the sheer number of nurses in healthcare and the ubiquitous presence of technology, it is critical to study how the EHR affects nurses' daily workflow and emphasize the redesign of EHRs that match nurses' workflow. It is also important to understand how data, information, and knowledge within the EHR are managed and processed. The purpose of this integrative review is to describe the state of the science, as derived from a synthesis of relevant studies of nursing experience with the EHR from the last decade across Robert and Lesage's⁵ dimensions of User Experience (UX). We explored the impact of the EHR on nursing workflow by categorizing nurses' experience to functional, physical, perceptual, cognitive, psychological, and social user experience dimensions.

Workflow

Workflow, sometimes called work process, is the execution of a chain of tasks, activities, and interactions in a prescribed

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sequence for information processing.^{6,7} Many of today's health information technologies, like EHRs, were conceived from a computer science characterization of a workflow.⁷ In this characterization, a hierarchy exists such that data are valued less than information, information is less than knowledge, and information processing is isolated from the workflow. This isolationist view of workflow and human-computer design has plagued the meaningful adoption of the EHR, leading to unfavorable UX.⁸

Robert and Lesage's User Experience Dimensions

User experience is the overall sense-making or experience of a user as a result of continuous interaction with a system, task, organization, and situation within a specific workflow.⁵ The UX moves beyond usability which incorporates several factors including functional, physical, cognitive, perceptual, and social dimensions. User experience encompasses usefulness, usability, findability, valuableness, desirability, ease of use, aesthetics, reliability, and accessibility. A gap exists in research on the impact of the EHR on nurses' UX and the difference in medical versus nursing workflow, which warrants further investigation.⁹

Robert and Lesage⁵ emphasize the importance of evaluating the different layers of user experience that include functional/physical, sensory, cognitive, and psychological levels. The *functional dimension* refers to the user's awareness of the usage of a system to achieve extrinsic or intrinsic goals. It answers the question of how well the system serves its purpose.⁵ The *physical dimension* refers to the effort exerted by the user, dealing with postures, movements, and coordination when using a system.⁵ The *perceptual dimension* refers mostly to the "look and feel" of a system, including sound, surfaces, and smoothness of the interaction.⁵ Essential to making sense of an experience, the *cognitive dimension* refers to the interaction of a user with a system by learning, evaluating, and understanding, which allows user progress and knowledge gain.⁵ The *psychological dimension* pertains to the mood, attitudes, opinions, and motivation of a user while interacting with a system.⁵ The *social dimension* is when a user relates to other people through the interaction with the system.⁵

Unintended Consequences

The unintended consequences of the EHR often result from a mismatch between the user workflow and system design.¹⁰ There is a misalignment when performing a task in the EHR due to variations in the task, technology, or user characteristics. In a systematic review of unintended consequences of the EHR, nurses reported that their frustrations in the use of the EHR were due to constant changes in workflow, difficulty accessing information for clinical decision making, the creation of workarounds, communication or system problems, navigation, and usability issues.¹⁰ Other unintended consequences of the EHR included unavailability of complete

clinical information at the point of care, information overload, and the focus on documentation to inform quality measurement versus workflow to support patient interactions.¹¹ When there is a mismatch between user expectations and system design, unintended consequences occur.

The consequences of technology innovation are not always desirable, anticipated, or direct.¹² Critical to any technology implementation such as the EHR is the understanding of three intrinsic elements of innovation: *form*, *function*, and *meaning*. The *form* is the physical, observable characteristics of an innovation; *function* is the contribution of the innovation to the individual and the organization; *meaning* is the subconscious perception of the stakeholders regarding the innovation.¹²

As technology designers can readily predict form and function, they often neglect meaning when designing a system.⁷ When designing systems, it is crucial that we consider not only the obvious human factors such as efficiency, effectiveness, and satisfaction but also the meaning (ie, the UX) the innovation holds for the users. The UX is about making the experience more meaningful and valuable. As Oettinger¹³ wrote,

The very first requisite (of nursing)—a practical belief that the greatest likeness among humans is their difference—is not simple to achieve. The unspoken lesson of the autopsy room, the anatomy class, and the chemistry laboratory may build up the insidious biological impression of the body as a predictable entity... It is no small wonder that "normal" and "alike" become confused.... (pp1224–1225)

Oettinger's message acknowledged that everyone, however they may appear alike, is unique and different.¹⁴ It raises the question of what effects the task, technology, individual, and organizational characteristics of a system implementation have on nurses' workflow. Exploring nurses' user experience in *form*, *function*, and *meaning* and how these dimensions affect the UX as represented in Robert and Lesage's dimensions are the core concepts we used in this integrative review.

METHOD

We conducted a systematic search using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)¹⁵ to identify articles published between January 2008 and June 2018. Database selection included the Cumulative Index of Nursing and Allied Health Literature (CINAHL), PsycINFO, Ovid MEDLINE, and PubMed. Search terms were informed by the primary research question, "What is the current state of the science in nurses' workflow as related to their use of the EHR and its impact on nursing experience?" The goal was to identify relevant studies characterizing nurses' experience with the EHR and its influence on their workflow.

The key Boolean search terms used were (electronic health record or EHR or electronic medical record or EMR) AND (workflow or work process or navigation or user experience) AND (nursing or nurse or nurs).

Results from the review of literature were screened first by title and abstract and then by full text. Reference lists of publications were checked for any additional studies. Inclusion criteria were articles written in English, quantitative and qualitative studies, and conference proceedings. Exclusion criteria were book reviews, non-English studies, letters to the editor, commentaries, dissertations, magazines, and any studies on bedside technology (eg, a physiological monitor), mobile devices, telemedicine, personal health records, mHealth, nursing education, and physician-centric articles. We also excluded articles published before January 2008 and after June 2018. Studies with a combination of physicians and nurses as participants were considered initially and later excluded after full-text review if the sample and results focused primarily on physicians.

Results were coded via Directed Content Analysis to identify, analyze, and present themes across the included studies.¹⁶ Codes were derived a priori from Robert and Lesage's six dimensions of UX to explain the data.⁵ The first author read and re-read the studies, noting initial ideas and themes, and then findings were categorized based on the six UX dimensions. The second author reviewed the included studies and agreed with the findings obtained by the first author.

RESULTS

The electronic search conducted in June 2018 yielded a total of 793 potentially relevant articles. Of these, 781 records were identified through database searches, and 12 additional records were identified from other sources (ie, manual searches through reference lists in the included articles). We removed 12 records as they appeared more than once from the database search. We screened the titles and/or abstracts of the remaining articles and excluded 690 articles as these studies were not relevant to the research question.

We thoroughly reviewed the remaining 91 records. After full text reviews, we excluded 65 articles which focused on implementation design, order sets or protocol orders, systematic reviews, and study participants were mostly physicians or advanced practitioners. A total of 26 articles were addressed in this integrative review. The articles included studies that examined nurses' workflow while using the EHR, UX with the EHR, and measured outcomes around unintended consequences, performance, workflow disruption, adoption, workload, nursing care, satisfaction, and time spent in the EHR. Figure 1 depicts the flow of article selection for this paper using the PRISMA diagram.¹⁴

General Trends

Across the 26 articles, 13 (50%) were quantitative studies, 10 (38%) were qualitative studies, two (8%) were mixed methods, and one (4%) was a quality improvement report. Study locations were heterogeneous, ranging from inpatient to ambulatory and long-term care settings. The majority of the studies were performed

in an acute care environment (86%). Studies conducted in acute care settings covered a wide range of departments from general medicine to neonatal intensive care units (NICUs). The predominant study setting was a medical/surgical nursing unit (28%). A majority of the studies were performed in the United States, except for two which were conducted in Sweden.

The preponderance of the studies focused on the impact of the EHR on the human-technology interface, workarounds, documentation time, interruptions, and satisfaction. See the Supplemental Table (Supplemental Digital Content 1, <http://links.lww.com/CIN/A63>) for a summary of the articles included in the review. Using directed content analysis, we inductively derived patterns of nurses' UX based on Robert and Lesage dimensions of UX (eg, functional, physical, perceptual, cognitive, psychological, and social).⁵

Functional Dimension

The dominant theme that emerged from nurses' functional experience of the EHR was related to interruptions produced by suboptimal functionality within the EHR. Interruptions triggered a breakdown in workflow, affecting information transfer and nurses' overall UX.

In a study examining EHR-related unintended consequences among nurses (N = 144), interruptions during documentation occurred more than once a shift.¹⁷ In a secondary analysis of NICU respondents (N = 44), they reported interruptions as one of the most frequent adverse outcomes of the EHR.¹⁸ Neonatal nurses described at least one interruption per shift during a critical time (ie, documentation), which the researchers estimated translated to 4160 to 6240 interruptions in a year. In a micro-ethnography study of 14 nurses, the prevalent interruptions that nurses experienced were related to data entry, retrieval, and review.¹⁹ The result of the interruptions due to redundant documentation and increased workload hampered the attainment of nurses' extrinsic or intrinsic goals such as the completion of nursing documentation.

Several other studies revealed substandard functional dimensions of UX. In a qualitative study (N = 21), inpatient nurses reported their unawareness of functions in the EHR such as the use of templates.²⁰ Similarly, in a heuristic evaluation of the EHR (N = 4), evaluators found "match violation" in the EHR function. Most nurses missed medications, a critical function of the nursing role, due to the need for continuous scrolling at the medication administration screen.²¹

One study highlighted the functional differences in nurses' experiences in the EHR based on individual characteristics. In examining the performance of nurses in the emergency department (n = 10), the authors found no statistically significant difference in the accuracy of task completion within the EHR between novice and expert nurses.²² However, expert nurses used fewer mouse clicks and had faster task completion and shorter mouse movements when using the

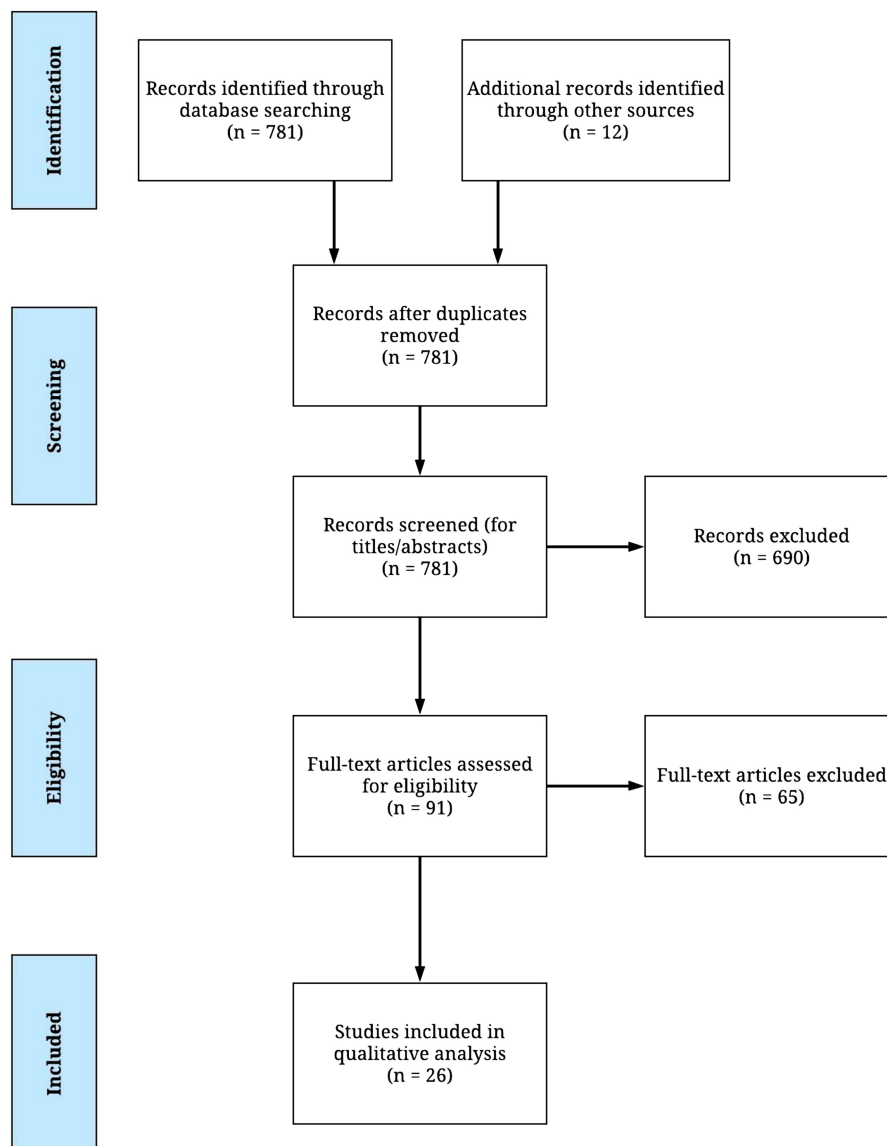


FIGURE 1. PRISMA 2009 flow diagram for selection of the studies.¹⁴ Used with permission.

EHR. Two studies found nonfunctional data entry requirements in the EHR. That is, nurses reported the difficulty in entering and finding patient information due to conflicting or differing areas in the EHR to document.^{20,22}

Physical Dimension

The themes that emerged within this dimension included issues related to (1) use and accessibility of computers inside the patient's room and (2) hardware. In an observational study (N = 15), nurses criticized the excessive clicking, weak readability of data, and suboptimal physical function of the EHR, which impeded workflow.²³ In two other studies, stationary computers and in-room computers interrupted the overall clinical workflow of nurses, heightened privacy concerns, and reduced

computer reliability.^{19,24} The lack of designated devices for nurses to complete electronic documentation and their accessibility posed a barrier for nurses' use of the EHR.²⁵ Nurses also reported negative experiences with the use of equipment due to noise, power loss, unreliable devices, computer locations, lengthy logins, and scanning issues.^{24,26}

Perceptual Dimension

The most common theme in this dimension was the human-computer interface (HCI). The HCI issues experienced by nurses constituted navigational concerns, lack of perceived usefulness, and difficulty of use. In two different qualitative studies, nurses reported their perception of the quality of the EHR's interface.^{27,28} Nurses stated that their perceptions

were related to usability issues, lack of customization, the unreliability of the systems, and the presence of data silos (ie, the same data do not populate the same data fields on other screens). Nurses explained that these experiences prevented EHR adoption and, in some cases, the ability to detect patient deterioration status. In a grounded theory study evaluating the use of an intensive insulin therapy using an EHR ($N = 30$), nurses reported that inaccurate interface design might have led to incorrect medication therapy overrides.²⁹ In contrast, a descriptive survey study ($N = 11$) reported nurses' positive experience with the EHR.³⁰ The authors found that nurses reported positive perceived usefulness and ease of use when using an electronic flowsheet, leading to overall satisfaction with the EHR.³⁰

Cognitive Dimension

In the studies reviewed, cognitive dimension pertained mostly to the workload experienced by nurses and the workarounds that developed as a result of the use of the EHR.

Several studies reported changes in nurses' workload postimplementation of the EHR. For instance, in a quantitative longitudinal study ($N = 74$), nurses experienced an increase in cognitive workload in the early implementation phases of the EHR.³¹ Their cognitive workload, however, decreased at various rates after 10 postimplementation shifts. This change in cognitive workload was predicted by factors such as computer attitude, skills, and age. Conversely, two studies reported that nurses experienced an increased workload almost weekly with the use of the EHR.^{17,18}

Despite the promise of increased efficiency when implementing the EHR, many workarounds emerged and were described across studies. A common workaround was the use of paper artifacts, including the use of paper scraps, sticky notes and pocket notebooks.^{19,20,23,27} In two studies,^{18,24} nurses preferred hand-written notes to find information readily during hand-off. Nurses stated that they used paper workarounds due to (1) usability (ie, more accessible to write on paper); (2) proximity of devices; (3) frequency of documentation episodes (eg, every 15 minutes); (4) patient safety; (5) need to support workflow processes; and (6) accessibility.²³

Another workaround was the use of unstructured, free-text fields in the EHR. In a mixed-method study³² ($N = 201$) and a qualitative study²⁸ ($N = 12$) examining the use of optional comments in the EHR, nurses reported the inability of EHRs to paint the patient's story or the "big picture" as rationale for using free-text fields. To compensate, nurses used comment fields to communicate contextual information entering critical elements about the patient.^{28,32}

When patient safety was in jeopardy, nurses resorted to workarounds to continue patient care and circumvent EHR design flaws. A workaround was described in a study on positive deviance where nurses performed atypical actions

during difficult situations to support safe patient care.³³ In documenting vital signs, nurses created workarounds such as the use of paper to safeguard patient safety and ensure a frictionless workflow.²³ Additionally, NICU nurses' reasoning to use workarounds was to follow policies and procedures to ensure continuity of patient care.¹⁸

Psychological Dimension

Nurse satisfaction and documentation time are measures of the psychological dimension of nurses' experience with the EHR. In a study examining positive deviance when using the EHR ($N = 144$), nurses reported mixed satisfaction with the EHR; frustration surfaced if technology designers or administrators did not consider nurse input in the workflow design.³³ At the same time, nurses expressed enthusiasm when the EHR helped incorporate knowledge into practice.

In a statewide descriptive exploratory study in Texas of 1177 nurses on the relationship of EHR with satisfaction, nurses were widely satisfied with the EHR.³⁴ Positive perception and satisfaction with the EHR were associated with 6 to 10 years of nursing experience and working nights, evenings, and rotating shifts.³⁴ In another study of 705 nurses, previous EHR experience contributed to a more positive experience; however, nurses with more clinical experience reported less satisfaction.³⁵

In another qualitative study of 12 medical-surgical nurses, they were unanimously satisfied with the EHR and preferred electronic documentation over paper documentation.²⁸ In another study, although nurses reported initial dissatisfaction 3 to 9 months postimplementation due to equipment and documentation requirements, dissatisfaction receded after 18 months of usage.²⁶

Inconsistency of results emerged from the literature review regarding EHR documentation time demands. Several studies showed an increase in time spent documenting in the EHR, while other studies demonstrated no significant differences. For instance, in a time and motion study of 767 nurses, almost one-third (28%) of time was spent documenting.³⁶ In contrast, in another cross-sectional analysis of a time and motion study ($N = 105$), nurses reported that only 19% of time was spent documenting, while 80% was spent in other nursing care.³⁷ These wide percentage ranges depict the inconsistency of nurses' experience of how much time is actually spent using the EHR, perhaps relating to different EHRs or versions.

When compared to paper recording, one study found a statistically significant increase in the time needed for vital signs documentation in the EHR (mean [SD], 116 [89] minutes) versus paper (mean [SD], 79 [39]; $P = .02$).²⁵ In another survey study ($N = 1352$), perianesthesia nurses reported devoting approximately 64% less time to patient care; 56% reported being less efficient due to EHR documentation demands.³⁸ Similarly, in a correlational study of 705

participants, the amount of time nurses spent documenting in the EHR and the decreased time spent with patients contributed to a poor perception of experience with the EHR.³⁵ In evaluating the performance of a clinical decision support (CDS) tool within the EHR, nurses reported spending substantial time and effort using the CDS due to back-charting and double documentation.²⁹

In contrast, in a two-group observational study measuring the frequency and duration of nursing activities, there was no significant difference in the time spent in direct care pre- and post-EHR implementation.³⁹ Additionally, in a mixed-method study (N = 79), nurses reported that 26% of their time was spent documenting in the EHR.⁴⁰ Upon observation, only 11% of nurses' overall time was actually spent documenting and 4% was allocated in "wasteful activities." The authors concluded that nurses tend to over-report time spent in the EHR.

Social Dimension

In the studies reviewed, social dimension was reflected in communication changes among clinicians and between patients. In two studies, nurses reported altered communication due to the EHR, resulting in poor interdisciplinary communication that eventually affected patient rapport.^{10,28} In contrast, three studies found the EHR did not decrease the perception of provider-patient communication and interdisciplinary communication.^{28,35,39}

Organizational culture also played a role in nurses' social dimension experience with the EHR. The success of EHR implementation was related to authentic leadership, support from technology departments, innovative but less open culture, and "bottom-up" communication.⁴¹ In two studies, nurses described their reliance on unit collaboration and teamwork as a byproduct of everyday experiences with the EHR.^{26,28} Additionally, in a study that measured patient quality outcomes, EHR usage led to a significant decline in falls, urinary tract infection, and bloodstream infections.⁴² Another study also showed the protective relationship of a strong professional practice environment that was associated with fewer unintended consequences of the EHR.¹⁷

SUMMARY OF THE RESEARCH

This article classified nurses' experience with the EHR related to their workflow across multiple dimensions of UX to present the state of the science in this field. Although reported as unidimensional categories, these dimensions are interrelated and a dimension may represent multiple themes. Across studies, the suboptimal design of the EHR affected the functional experience of nurses, often obstructing their extrinsic or intrinsic goals for using the EHR. Interruptions were reported as common occurrences by nurses and were regularly related to redundant data entry and increased workload that affected documentation experience. Nurses' unawareness of available functions in the EHR such as the

use of templates also resulted in interruptions and workarounds. Although nursing experience partially accounted for differences with clicks, movements, and time to complete tasks within the EHR, experience did not affect the accuracy of task completion.

Differences in navigational patterns and exertion of physical effort among nurses also made a difference in their experience. Such challenges included data readability and hardware reliability contributing to negative user experience. The EHR's navigational design affected nurses' perceptual experience, leading to many workarounds, workflow mismatches, and patient safety concerns. The workflow mismatches, that is, the discrepancies between nurses' behavior and workflow versus what is designed within the EHR, have caused unfavorable and unintended outcomes in the EHR.⁴³ These mismatches were due to the lack of the ability to customize EHR screens and the presence of data silos.

There were inconsistent results in nurses' experience with the EHR related to workload. Workarounds were also common such as using paper artifacts and free-text fields. Nurses resorted to workarounds when there were concerns with patient safety or when they needed to accomplish tasks due to existing policies or procedures.

Satisfaction with the EHR was another shared theme that measured nurses' psychological UX dimension. Most of the studies reported overall satisfaction with the EHR which is contrary to many anecdotal stories from the field. In a 2018 survey of more than 7400 nurses, 44% reported dissatisfaction and 69% stated EHRs are disruptive to nursing productivity.⁴⁴ Many of the dissatisfaction expressed by nurses were due to various factors including equipment issues and documentation requirements.

There were also discrepancies in studies that measured time spent within the EHR. Some studies reported as low as 8% of shift time spent in the EHR. Other studies have found that nurses spent 26% of their time documenting in the EHR. Although there were discrepancies in time spent, the perception of many nurses was the EHR created more or new additional work. The use of the EHR has led to the perception of increased documentation time and less direct patient care.

Some nurses also indicated that the introduction of the EHR diminished communication between clinicians. The EHR resulted in communication barriers preventing nurses from establishing meaningful interaction and rapport not only with other clinicians but also with their patients. However, positive and supportive organizational culture contributed to nurses' positive social experience when using the EHR. These experiences resulted in stronger teamwork and collaboration, and improved quality outcomes. Nurses have also stated that although many have experienced unintended consequences, reverting to a linear paper-based system was not an option.

IMPLICATIONS FOR FUTURE RESEARCH

Themes identified in this review reflect the same trends shown in a systematic review conducted by Zheng et al⁴⁵ on the associated impact of EHRs on physicians. However, unlike studies quantifying the impact of the EHR on physicians' clinical workflow by using data mining techniques, many of the nursing studies were designed as observational, descriptive, survey, time-and-motion studies, or qualitative in nature.^{46–50} These studies were informative but posed methodological issues such as subjective judgment, limited generalizability, and conflicting results. One example was the discrepancies reported in satisfaction, time spent, and workload across studies. These discrepancies highlight the paradox Zheng et al⁴⁶ described between qualitative and quantitative EHR workflow studies. The availability of big data in the EHR, such as data audit trails, can be used to further understand nurses' workflow in the EHR. Using data mining techniques and computational ethnography to supplement existing workflow analyses tools would build nursing science related to UX in nursing.

Data visualization is also an essential component in improving nurses' user experience within the EHR. In many of the studies, nurses reported unreliability of data during hand-offs due to verbal discrepancies and the inability to see patients' big picture through texts. Data visualization can present patient data in a more meaningful, digestible, and understandable manner. Visualization can reduce the time needed to interpret data and increase the ability to see patterns and trends and could greatly enhance the nursing science evidence base on this topic.

It is crucial to represent nurses' experience with the EHR through a new set of interrelated concepts and statements to better examine this phenomenon. Using theory synthesis to summarize relevant research findings on UX to present multiple and complex relationships will support the examination of the antecedents and outcomes of UX. A UX conceptual framework can be leveraged to describe the impact of EHR on nursing's workflow systematically. Questions such as what is the relationship of navigation patterns to satisfaction, workload, and time spent need to be clarified, and studies are under way.

We owe nurses a more robust understanding and perceptiveness of the workflow patterns that are involved when we introduce technologies such as EHRs that disrupt existing clinical workflow. In turn, we can then develop action plans to support nurses so they can continue to provide quality care to patients without the burden of technology interruptions. Prominent nursing theorists have argued that nursing action occurs within a caring commitment by understanding the meaning of a person's situation and recognizing patterns to plan specific actions, a critical issue to address and one that could pave the path to UX improvement.

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