**Research Article**

**A Secondary Analysis of the Types of Electronic Reminders and Use by Registered Nurses**

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**Abstract**

**Background:** Reminder systems have been implemented to address critical issues in patient care, such as improving quality and safety. Although the rate of reminder use has increased with the implementation of electronic health records (EHRs), registered nurses’ use of reminders remains a “black box.”

**Objectives:** The objective of this study was to examine the types of reminders and their frequency of use by acute care registered nurses.

**Methods:** A secondary data analysis was used in this study. The sample included 340 medical/surgical, progressive, and critical care registered nurses working in three different hospitals in the Midwestern United States. The Nursing Care Reminders Survey (NCRS) was used to assess reminder usage of nurses. Descriptive statistics, one-way ANOVAs, and independent *t*-tests were used to determine study outcomes.

**Results:** More than 90% of the nurses in the study reported they used reminders “occasionally” to “frequently” and expressed those reminders are helpful in their daily practice. The mean number of nursing care reminders used by nurses was 6.2. Seven different reminders, including a paper list of reminders based on EHR, nursing care orders in EHR, nursing care activities in EHR, a list of reminders in EHR, computerized provider order entry, documentation in EHR, and pop-up alerts in EHR, were consistently used by the nurses. In addition, it was found that there were differences in reminder use according to types of nursing units (medical/surgical, progressive care, and critical care), hospitals, and EHR system used.

**Conclusions:** Nurses utilize a myriad of types of reminders in their daily practice, which is problematic, as it is not efficient and may result in missed information, leading to potential errors. System vendors should consider including clinicians in the design and development of these systems. Well-designed reminders are needed by healthcare providers in order to provide efficient patient care and improve quality and safety.

**Abbreviated Abstract**

The study's purpose was to examine the types of reminders and their frequency of use by 340 acute care registered nurses in three hospitals. The nurses in the study reported they used an average of 6.7 reminders “occasionally” to “frequently”.

**Keywords:** Administration;Alerting; Clinical decision support; Electronic health records and systems; Maintenance; Nurse; Use

**Abbreviations**

ANOVA: Analysis of variance

BSN : Bachelor of science in nursing

CDSS : Clinical decision support system

CPOE : Computerized provider order entry

HER : Electronic health record

ONC : Office of the National Coordinator for Health Information Technology

HIT : Healthcare information technology

RNs : Registered nurses

NCRS : Nursing Care Reminder Survey

**Background and Significance**

The nation’s healthcare systems have rapidly adopted complex healthcare information technology (HIT) systems in the past two decades to provide quality, safe, and efficient patient care [1,2]. The functions in these systems, such as nursing documentation and clinical decision support remain inefficient and have been found to be a burden on documentation of patient care. Therefore, it is pertinent to examine some of the existing gaps in knowledge regarding the impact of clinical decision support systems (CDSSs) on nursing practice, particularly the types of reminders nurses use in clinical practice. Healthcare organizations are beginning to leverage the data that is captured and contained in these systems to offer real-time or near-real-time feedback to clinical providers and organizational leaders. The change is significant, as organizations and care givers have traditionally relied on historical data to make critical clinical and organizational decisions based on data that may no longer be relevant.

A popular solution to deliver reminders has been through electronic health record (EHR)-integrated CDSSs that utilize real-time data to offer reminders and/or alerts relating to patient care. Reminders and alerts are increasingly being implemented to address myriad issues in patient care as well as comply with external regulatory requirements. The promise of reminders and alerts to address these issues is significant; however, using these reminders to positively augment clinician behavior is an even greater challenge. In order for this to happen, reminders must be intelligently designed so that they are useful and not a burden on clinicians. Thus, understanding how registered nurses interact with reminders in the EHR is essential to developing solutions to ensure the goal of these tools remains intact and is realized.

A growing body of thought and research indicates that these benefits are partially offset by detracting factors [3] as the presence of electronic reminders and CDSS input has been shown to alter workflows and create new types of errors and issues. Zheng and colleagues [4] performed a meta-analysis on literature pertaining to unintended consequences related to HIT systems. They identified a wide range of unintended effects, such as technical errors in deleting or calculation of medication, increased or new work for healthcare providers, and poor workflow issues. Additionally, Coiera and colleagues [5] summarized the occurrence of unintended negative consequences of HIT systems into two areas: errors in entering and retrieving data and errors in the communication and coordination process. Despite the concerns about negative consequences of implementing HIT systems, there are some studies that reported improved mitigation of negative impacts of HIT systems or positive impacts. Borycki and colleagues [6] reported that there has been much effort to mitigate and eliminate technology-induced errors in healthcare settings. In addition, HIT systems containing alerts and reminders have demonstrated effectiveness in identifying and reducing certain causes of medical errors, such as misdiagnosis, treatment complications, and medication errors [7].

Increased implementation and usage of EHRs have led to significant changes in the workflow of caregivers [8,9]. Modern EHRs allow healthcare providers and patients to store, process, and share large volumes of administrative and healthcare data electronically [10]. The transition to electronic systems has been paired with a gradual shift away from traditional reminder systems (e.g., paper notes and checklists) in favor of automated reminders and alerts embedded within the EHR. A promising feature of modern EHRs is the ability to analyze voluminous, assorted, disorganized health data and obtain meaningful insights through analytical and decision-making tools [11]. The EHRs analyze the data and report unexpected or abnormal conditions back to healthcare providers through real-time alerts or reminders [12,13]. One of the primary methods to deliver reminders has been through EHR-integrated CDSSs that utilize real-time data to offer reminders and/or alerts relating to patient care. The CDSS is a fundamental EHR feature that supports healthcare providers in making more informed decisions at the point of care [14,15]. Modern CDSSs are embedded within EHRs and can generate evidence-based, time-sensitive, patient-centered, and contextually relevant clinical recommendations to support healthcare providers’ clinical reasoning and decision-making [16-19].

A patient care reminder is defined as any application or section of the EHR or other system that reminds the healthcare provider to perform needed care [20]. The different applications within the EHR then often serve as an alternative form of reminders. The reminders are present in numerous formats in EHRs, such as pop-up alerts, worklists, checklists, order lists, structured documentation, and data transcribed from the EHR. Some of these reminders are actively triggered through the CDSS, but many are passive in their effect in providing information to healthcare providers. Although modern CDSSs are available and have been found to have a positive impact on patient health outcomes and quality of care, they are not designed well and are not used to their fullest potential, which leaves healthcare providers searching the EHR for necessary data [21-23].

**Objectives**

The objective of this secondary analysis is to analyze the types of reminders that acute care registered nurses encounter and how often they are used in practice. The research questions are as follows:

What are the most common electronic reminders that acute-care registered nurses use in practice?

Are there meaningful differences in reminder usage among different types of nursing units (e.g., medical/surgical, progressive care, and critical care)?

Are there meaningful differences in reminder usage between different hospitals?

Are there meaningful differences in reminder usage between EHR used?

Implications for registered nurses, nurse leaders, and nursing informatics specialists will also be discussed.

**Methods**

The design, setting, sample, instruments, and procedures are described in detail in our previous publications [1,20]. A summary of the methods are described below.

**Design, Setting, & Sample**

The design of this study is a secondary analysis of reminder usage data from two previous descriptive cross-sectional correlational studies that examined the relationship between reminders and missed nursing care [1,20]. The samples were composed of medical/surgical, progressive care, and critical care registered nurses (RNs) working in three large teaching hospitals in the Midwestern United States. Hospital 1 is suburban, has achieved Magnet status, and uses EHR 1, and hospitals 2 and 3 are urban, are non-Magnet, use EHR 2, and are part of the same health system.

**Measures**

The Nursing Care Reminders Survey (NCRS) was used to collect data regarding nurses’ self-reported reminder usage. The NCRS contains 13 items regarding nurses’ usage of reminders; 10 items are about specific types of reminders, 1 item is an open-ended “other” item, and 2 items regard helpfulness and frequency of reminder usage ((Table 1) for example items). There are two versions of the NCRS; the original was used in Study 1 and contained 9 specific types of reminders. Prior to Study 2, the NCRS was revised to remove question 9 (Table 1), which was redundant, and to add question 11 (Table 1). Detailed information regarding the survey construction can be found in our previous publication [20]. The NCRS has established face and content validity [20]. Reliability was measured using Cronbach’s *a* and ranged from .70 to .84 in the two previous studies [1,20].

|  |  |
| --- | --- |
|   | Hospital |
| How frequently do you utilize the following types of nursing care reminders to assist you in completing nursing care activities? | 1n = 165 | 2n = 120–123 | 3n = 50–52 |
| 1. A paper list of reminders based on what is in the EHR | 70.0 (115) | 67.5 (83) | 62.7 (32) |
| 2. Print out a list of care activities that serves as a reminder | 36.6 (60) | 37.1 (39) | 19.6 (10) |
| 3. Electronic nursing care orders that serve as a reminder | 84.2 (139)  | 92.7 (114) | 94.2 (49) |
| 4. List of nursing care activities in plan of care that serves as a reminder | 63.0 (104)  | 71.3 (87) | 71.2 (37) |
| 5. Electronic list of reminders (e.g., task list, documentation checklist, documentation form, work queue, work list) | 68.5 (113) | 91.0 (112) | 92.2 (47) |
| 6. Electronic list of reminders not in the EHR | 33.3 (55) | 36.9 (45) | 27.5 (24) |
| 7. Computerized provider order entry (CPOE) list that serves as a reminder | 67.9 (112) | 68.3 (84) | 68.6 (35) |
| 8. Electronic documentation in the EHR that serves as a reminder | 77.6 (128) | 82.9 (102) | 78.0 (39) |
| 9. Electronic checklist for documenting care that serves as a reminder | 54.5 (90) | N/A | N/A |
| 10. Alert of reminder message pop-ups in the EHR | 63.0 (104) | 79.7 (98) | 71.2 (37) |
| 11. Text page reminders | N/A | 29.8 (36) | 18.0 (9) |
| 12. How frequently do you utilize nursing care reminders to assist you in completing nursing care activities?  | 83.0 (137) | 92.6 (112) | 96.2 (50) |
| 13. How helpful do you find the electronic nursing care reminders? | 83.6 (138) | 94.2 (113) | 96.0 (48)  |
| Notes: EHR = electronic health record; N/A = not applicable; \*Valid percentages presented in table; Ranges in sub-samples are due to the fact that respondents were not required to answer every question on the survey.  |

**Table 1:** Nursing Care Reminders Survey: Percentage\* (Frequency) of Occasionally to Always by Hospital (N = 335–340).

**Procedures**

The survey was delivered electronically in the first study and via paper and pencil in the second. Data were analyzed using SPSS 25.0 (SPSS Inc., Chicago, IL) and included calculating frequencies, percentages, one-way ANOVAs, and independent sample *t*-tests to answer the research questions.

**Results**

**Sample**

The sample consisted of *N* = 340 nurses from three hospitals, *n* = 165, 123, and 52. Most of the RNs reported having a baccalaureate in nursing (BSN) degree (45%, *n* = 151), were women (83%, *n* = 281), were between the ages of 25 and 34 (39%, *n* = 133), worked on a medical and/or surgical unit (53%, *n* = 181), and worked more than 30 hours per week (94%, *n* = 317).

**Reminder Types and Usage**

More than 90% (range, 83.0% to 96%) of the nurses in the three hospitals indicated they used reminders “occasionally” to “frequently,” and more than 90% (range, 83.6% to 96%) found reminders occasionally to always helpful. The mean number of nursing care reminders used by nurses was 6.2. The type of electronic nursing care reminders used by nurses varied. A mean percentage of the three hospitals was calculated for each question on the NCRS, and a cut-point of 60% or greater was established to delineate the most used reminders (Table 1). At the 60% cut-point, there were seven reminders that were consistently used by the nurses. They included a paper list of reminders based on EHR (*M* = 61.7%), nursing care orders in EHR (*M* = 90.4%), nursing care activities in EHR (*M* = 68.5%), a list of reminders in EHR (*M* = 83.9 %), computerized provider order entry (*M* = 68.3%), documentation in EHR (*M* = 79.5%), and pop-up alerts in EHR (*M* = 71.3%). The least used reminders were a printed list of care activities from the EHR (*M* = 31.9%), a list of electronic reminders not in EHR (*M* = 32.6%), an electronic list for documenting care (*M* = 54.9%), and text page reminders (*M* = 23.9%).

**Meaningful Differences Between Types of Nursing Units**

A one-way ANOVA to identify the differences in use of reminders between different nursing units (medical/surgical, progressive care, and critical care) was conducted (Table 2). There were four statistically significant differences in the scores between critical care and medical/surgical nursing units: (1) a paper list of reminders based on what is in the EHR (*F* = 7.97, *p* < .001), which critical care units used more frequently; (2) a print out of a list of care activities that serve as a reminder (*F* = 5.14, *p* = .006), which medical/surgical units used more frequently; (3) an electronic list of reminders not in the EHR (*F* = 3.99, *p* = .019), which critical care units used more frequently; and (4) and electronic checklist for documenting (*F* = 10.57, *p* < .001), which medical/surgical units used more frequently. In addition, there was one statistically significant difference in scores between progressive care and medical/surgical nursing units: an electronic checklist for documenting (*F* = 10.57, *p* < .001), which medical/surgical units used more frequently.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Nursing Care Reminder Survey | *Critical Care (a) (n = 53–122)* | Progressive (b) (n = 15–38) | *Medical Surgical (c)* *(n = 87–180)* | Variance | Post Hoc Comparisons (Bonferroni) |
|  | M | *SD* | M | SD | M | SD | F | *P* |  |
| 1. A paper list of reminders based on what is in the EHR | 2.93 | 1.4 | 3.47 | 1.35 | 3.58 | 1.41 | 7.97 | <.001\* | a–c |
| 2. Print out a list of care activities that serves as a reminder | 1.92 | 1.09 | 2 | 1.12 | 2.36 | 1.34 | 5.14 | .006\* | a–c |
| 3. Electronic nursing care orders that serve as a reminder | 3.87 | 1.14 | 3.92 | 1.19 | 4.04 | 1.11 | 0.853 | 0.427 |  |
| 4. List of nursing care activities in plan of care that serves as a reminder | 3.06 | 1.34 | 2.89 | 1.37 | 3.31 | 1.33 | 2.27 | 0.105 |  |
| 5. Electronic list of reminders (e.g., task list, documentation checklist, documentation form, work queue, work list) | 3.61 | 1.37 | 3.26 | 1.35 | 3.81 | 1.28 | 2.96 | 0.053 |  |
| 6. Electronic list of reminders not in the EHR | 1.93 | 1.17 | 2.08 | 1.34 | 2.35 | 1.35 | 3.99 | .019\* | a–c |
| 7. Computerized provider order entry (CPOE) list that serves as a reminder | 3.13 | 1.46 | 3 | 1.54 | 3.3 | 1.39 | 0.94 | 0.39 |  |
| 8. Electronic documentation in the EHR that serves as a reminder | 3.44 | 1.27 | 3.45 | 1.47 | 3.6 | 1.16 | 0.73 | 0.482 |  |
| 9. Electronic checklist for documenting care that serves as a reminder | 2.42 | 1.28 | 1.83 | 1.11 | 3.12 | 1.42 | 10.57 | <.001\* | a–c, b–c |
| 10. Alert of reminder message pop-ups in the EHR | 3.11 | 1.48 | 3.24 | 1.46 | 3.51 | 1.45 | 2.77 | 0.064 |  |
| 11.Text page reminders | 1.84 | 1.32 | 2.53 | 1.64 | 1.86 | 1.26 | 1.82 | 0.165 |  |
| 12. How frequently do you utilize nursing care reminders to assist you in completing nursing care activities? | 3.72 | 1.11 | 3.89 | 1.06 | 4.01 | 0.98 | 2.83 | 0.06 |  |
| 13. How helpful do you find the electronic nursing care reminders? | 3.74 | 1.09 | 3.87 | 1.14 | 3.93 | 1.07 | 1.18 | 0.31 |  |
| Notes: EHR = electronic health record; \*p < .01; ranges in sub-samples are due to the fact that respondents were not required to answer every question on the survey. |

**Table 2:** Meaningful differences between types of nursing units according to a one-way ANOVA results (N = 165–340).

**Meaningful Differences Between Hospitals**

A one-way ANOVA to identify the differences in use of reminders between different hospitals was conducted (Table 3). The results from the ANOVA indicated there were three reminders that were significantly different between the three hospitals (Table 3): (1) electronic nursing care orders in the EHR that serve as a reminder (*F* = 9.49, *p* < .001), which hospitals 2 and 3 used more frequently; (2) electronic list of reminders in EHR (*F* = 34.38, *p* < .001), which hospitals 2 and 3 used more frequently; and (3) alert of reminder message pop-ups in the EHR (*F* = 10.48, *p* < .001), which hospital 2 used more frequently.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Hospital 1 (a)(EHR 1)(n = 165) | Hospital 2 (b)(EHR 2)(n = 120–123) | Hospital (c)(EHR 2)(n = 50–52) | Variance |  | Post HocComparisons |
| Nursing Care Reminder Survey | *M* | SD | *M* | SD | *M* | SD | *F* | *p* | (Bonferroni) |
| 1. A paper list of reminders based on what is in the EHR | 3.45 | 1.42 | 3.22 | 1.39 | 3.24 | 1.53 | 1.11 | 0.331 |  |
| 2. Print out a list of care activities that serves as a reminder | 2.3 | 1.3 | 2.12 | 1.21 | 1.82 | 1.09 | 2.96 | 0.053 |  |
| 3. Electronic nursing care orders that serve as a reminder | 3.7 | 1.22 | 4.24 | 0.98 | 4.17 | 0.99 | 9.49 | <.001\* | a–b, a–c |
| 4. List of nursing care activities in plan of care that serves as a reminder | 3 | 1.3 | 3.31 | 1.37 | 3.17 | 1.34 | 2.76 | 0.065 |  |
| 5. Electronic list of reminders (e.g., task list, documentation checklist, documentation form, work queue, work list) | 3.12 | 1.38 | 4.2 | 1.02 | 4.22 | 1.05 | 34.38 | <.001\* | a–b, b–c |
| 6. Electronic list of reminders not in the EHR | 2.18 | 1.3 | 2.25 | 1.34 | 1.92 | 1.18 | 1.15 | 0.319 |  |
| 7. Computerized provider order entry (CPOE) list that serves as a reminder | 3.16 | 1.41 | 3.2 | 1.43 | 3.35 | 1.52 | 0.34 | 0.712 |  |
| 8. Electronic documentation in the EHR that serves as a reminder | 3.37 | 1.25 | 3.7 | 1.21 | 3.62 | 1.24 | 2.69 | 0.069 |  |
| 9. Electronic checklist for documenting care that serves as reminder | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |  |
| 10. Alert of reminder message pop-ups in the EHR | 2.98 | 1.48 | 3.75 | 1.33 | 3.5 | 1.5 | 10.48 | <.001\* | a–b |
| 11. Text page reminders | N/A | N/A | 2.02 | 1.4 | 1.66 | 1.1 | 2.58 | 0.11 |  |
| 12. How frequently do you utilize nursing care reminders to assist you in completing nursing care activities? | 3.68 | 1.13 | 4.07 | 0.92 | 4.15 | 0.87 | 7.2 | .001\* | a–b, a–c |
| 13. How helpful do you find the electronic nursing care reminders? | 3.57 | 1.17 | 4.15 | 0.91 | 4.08 | 0.94 | 11.93 | <.001 | a–b, a–c |
| Notes: EHR = electronic health record; N/A = not applicable; Question 11 compared between hospitals 2 and 3; \*p < .01; ranges in sub-samples are due to the fact that respondents were not required to answer every question on the survey. |

**Table 3:** One-way ANOVA results of meaningful differences between hospitals according (N = 171–340).

**Meaningful Differences Between EHR Systems**

Differences based on EHR used by the hospitals were calculated by combining hospitals 2 and 3 into one group (EHR 2) and conducting an independent samples *t*-test. The justification was that hospitals 2 and 3 were part of the same health system and used the same EHR and that combining samples would increase the power of the analysis. The results from the *t*-test indicated there were five reminders that were significantly different between the EHR 1 and EHR 2: (1) electronic nursing care orders in the EHR that serve as a reminder (*t* = –4.35, *p* < .001); (2) a list of nursing care activities in the plan of care that serves as a reminder (*t* = –2.34, *p* = .020); (3) an electronic list of reminders in EHR (e.g., task list documentation checklist, documentation from, work queue, work list) (*t* = –8.30, *p* < .001); (4) and electronic documentation in the EHR that serves as a reminder (*t* = –2.29, *p* = 0.23); and (5) an alert or reminder message pop-ups in the EHR (*t* = –4.46, *p* < .001). The EHR 2 hospital mean usage scores for these reminders were significantly higher than the EHR 1 hospital mean usage scores (Table 4).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | EHR 1(N = 165) | EHR 2(N = 170–175) | 95% CI |  |  |  |
| Score | *M* | *SD* | *M* | *SD* | *LL* | *UL* | *t* | *df* | *p* |
| 1. A paper list of reminders based on what is in the EHR | 3.45 | 1.42 | 3.22 | 1.43 | –0.07 | 0.54 | 1.49 | 337 | 0.137 |
| 2. Print out of a list of care activities that serve as a reminder | 2.3 | 1.3 | 2.03 | 1.18 | 0 | 0.53 | 1.95 | 337 | 0.052 |
| 3. Electronic nursing care orders in the EHR that serve as a reminder | 3.7 | 1.22 | 4.22 | 0.98 | –0.76 | –0.29 | –4.35 | 338 | <.001\* |
| 4. List of nursing care activities in that plan of care that serves as a reminder | 3 | 1.3 | 3.34 | 1.36 | –0.62 | –0.06 | –2.34 | 337 | .020\* |
| 5. Electronic list of reminders in EHR (e.g., task list, documentation checklist, documentation from, work queue, work list) | 3.12 | 1.38 | 4.21 | 1.02 | –1.35 | –0.83 | –8.30 | 337 | <.001\* |
| 6. Electronic list of reminders not in the EHR | 2.18 | 1.3 | 2.15 | 1.3 | –0.25 | 0.31 | 0.22 | 336 | 0.824 |
| 7. Computerized provider order entry (CPOE) list that serves as a reminder | 3.16 | 1.41 | 3.25 | 1.46 | –0.39 | 0.22 | –0.54 | 337 | 0.592 |
| 8. Electronic documentation in the EHR that serves as a reminder | 3.37 | 1.25 | 3.68 | 1.22 | –0.57 | –0.04 | –2.29 | 336 | .023\* |
| 9. Electronic checklist for documenting care that serves as a reminder | 2.72 | 1.41 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 10. Alert or reminder message pop-ups in the EHR | 2.98 | 1.48 | 3.67 | 1.39 | –1.00 | –0.39 | –4.46 | 338 | <.001\* |
| 11.Text page reminders | N/A | N/A | 1.91 | 1.33 | N/A | N/A | N/A | N/A | N/A |
| 12. How frequently do you utilize nursing care reminders to assist you in completing nursing care activities? | 3.68 | 1.13 | 4.1 | 0.91 | –0.64 | –0.20 | –3.77 | 336 | <.001\* |
| 13. How helpful do you find the electronic nursing care reminders? | 3.57 | 1.17 | 4.13 | 0.92 | –0.79 | –0.33 | –4.88 | 333 | <.001\* |
| *Notes*: EHR = electronic health record; N/A = not applicable; CI = confidence interval; LL = lower limit; UL = upper limit; \**p* < .05; ranges in sub-samples are due to the fact that respondents were not required to answer every question on the survey. |

**Table 4:** Independent T-test results of meaningful differences of electronic health record used according to hospitals (N = 340).

**Discussion**

**Reminder Types and Usage**

The findings from this secondary analysis have allowed us to answer the research questions posed. First, *what are the most common electronic reminders that acute-care registered nurses use in practice?* The findings support that many nurses use electronic reminders from EHRs and that nurses generally view electronic reminders as useful in their practice. The results support our previous work [1,19,20] that nurses may have an increased use of reminders if they believe healthcare information technology benefits their practice.

As noted in the findings, there are seven types of reminders that nurses frequently use in their practice. These include various functions or applications in the EHR and some non-EHR-based reminders that were not intended to be used as reminders. This finding is interesting and significant for several reasons. Nurses are using multiple types of reminders in their practice that were not designed to be reminders at relatively high rates. This may be an indication that searching and using data in the EHR for clinical decision-making is not an efficient process and may possibly lead to errors. This is significant because data that is pertinent to clinical decision-making may be missed.

Another expected finding is that many nurses still use paper lists that they prepare on their own as reminders. This is consistent with findings from other studies that have shown that nurses prefer to use written “Brains” or report sheets [24]. Blaz and collegues [24,25] found that nurses’ need for paper persisted even in the presence of well-structured, customized, and flexible digital patient summaries. A systematic review of 14 handoff tools commonly used by nurses was found to have little or no incorporation of information from the HER [26]. Staggers and colleagues [27] reported that most participants preferred to use personal paper forms for handoffs. This is consistent with our findings, as nurses indicated that they rarely used a hard-copy (printed) list of reminders. This suggests that nurses may not find the checklists and reminders generated by EHR systems to be suitable for their workflow. EHRs with more user-configurable reminder options could lead to higher user acceptance and utilization.

An implication of these findings is that HIT developers and informatics specialists consider applying systems design principles to alert and reminder systems. Increased end-user and stakeholder involvement in the development and configuration process can aid vendors and health IT specialists in improving the efficiency and efficacy of alerts and reminders [17,28]. In addition, it has been suggested that tailored alerts improve their specificity and sensitivity and can reduce many nuisance alerts [29]. Adding an alert-filtering function in the EHR may reduce alert fatigue by allowing the clinician to filter non-essential alerts and highlighting crucial alerts [28].

**Meaningful Differences Between Types of Nursing Units, Hospitals, and EHR Systems**

The findings related to determining if there are meaningful differences among types of nursing units, hospitals, and EHR systems were just as interesting as the types and use of reminders used by nurses. The three questions posed were: (1) *Are there meaningful differences in reminder usage among different types of nursing units (e.g., medical/surgical, progressive care, and critical care)?* (2) *Are there meaningful differences in reminder usage between different hospitals?* and (3) *Are there meaningful differences in reminder usage between EHRs used?*

There were four differences in reminder use among types of nursing units (medical/surgical, progressive care, and critical care); critical care nurses tended to use a paper list of reminders based on what was in the EHR and an electronic checklist of reminders not in the EHR more frequently than medical/surgical nurses. On the other hand, medical/surgical nurses tended to use a printed list of care activities and an electronic checklist for documenting care more frequently than progressive care and critical care nurses.

There were three differences in reminder use among the three hospitals. Hospitals 2 and 3 tended to use electronic nursing care orders, electronic lists of reminders, and reminder message pop-ups more frequently than hospital 1. There were five differences in reminder use based on EHR used. The EHR 2 hospitals tended to use electronic nursing care orders, lists of nursing care activities, electronic lists of reminders in EHR, electronic documenting in EHR, and pop-up alerts more frequently than the EHR 1 hospital.

Overall, there were differences found between types of nursing units, hospitals, and the EHR system used, but the mean differences tended to be small and likely not clinically significant. Most differences were noted between medical surgical units and critical care units and between the types of EHR used. These findings are not surprising considering that workflows are quite different between nursing units, hospitals and EHRs, which may necessitate the nurse to use different types of reminders to provide care [8]. An implication of these results is that reminders may not be “one-size fits all” and may require customization across hospitals and units for the reminders to be effective. As indicated previously, including end-users in the design and development of reminders is one strategy to address this issue [17].

**Limitations**

The limitations of this study include small sample sizes, sample bias, length of time between data collection, data only collected in three hospitals, and possible covariates. The sample sizes for each study were low, which was addressed by determining sample size a priori using power analysis [1,20,22]. Sample bias might have been an issue, as this was a convenience sample and self-selection may have occurred. The length of time between when the two sampling periods occurred is also a limitation that should be taken into consideration when evaluating the results. Although there were few meaningful differences between hospitals examined, the data was only collected in three hospitals and caution should be used in generalizing these findings. Finally, the results could be influenced by variables other than unit type, hospital, or EHR used. Due to these limitations, these results need to be interpreted with caution.

**Future Research**

Future research on the topic of electronic reminders is still needed. While the results of our study show consistency with existing research, there is a need for similar research on a larger scale and in more diverse clinical settings. Additional research is needed in order to draw conclusions about best practices in EHR reminder design.

**Conclusions**

The body of research on the benefits of EHRs, the risks associated with transitioning away from traditional reminder systems, and the solutions to correct poorly designed reminder systems is still in an early stage. Placing an increased priority on the unique workflow and needs of healthcare workers could enable HIT developers to create more consistent and thorough frameworks for effective reminder configuration and design in EHRs. Healthcare vendors and health informatics specialists who develop and implement EHRs need to seriously consider involving end users in the design, development, and implementation process. An additional recommendation is the application of systems design principles in order to present healthcare workers only with alerts and reminders that they will find contextually relevant and important. The effective design and implementation of EHR systems and reminders can greatly benefit caregivers and patients alike by carefully considering the right patient, right caregiver, right alert, right format, and right context of electronic alerts [30,31].

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**Conflict of Interest**

The authors declare that they have no conflicts of interest in the research.

**Human Subjects Protections**

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