TABLE 1. SUMMARY OF STUDIES RELATED TO NURSES' USER EXPERIENCE WITH THE EHR

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Bristol AA, Nibbelink CW, Gephart SM, Carrington JM [33] (2018)	To describe nurses' positive deviance when working with the EHR	144 (from the original study)	Qualitative; Qualitative Descriptive (secondary analysis); Triangle method	Varied(Medical/Surgical, ICU, Float, Ambulatory, Other Settings)	Five themes emerged from content analysis including user support after implementation, mixed perception of user satisfaction: nurses valued EHR when it fit their workflow, but felt EHRs lacked nursing input into EHR designs. Reported positive feelings about increased access to information, but described increased work effort in attempt to complete tasks. Nurses felt they were sometimes forced to make a decision between technology and patient care. Limits: Questions asked at the end of quantitative survey (issues with completing survey and response bias).
Byrne MD, Fong H, Danks JK [38] (2018)	To examine patterns of adoption of EHR and effect on clinical documentation and patient care among perinathesia nurses	1352 peri-anesthesia nurses	Quantitative; Descriptive Survey	Peri-anesthesia	Adoption rate of EHR was 93.5% among respondents. About 64% reported that they were spending less time with their patients due to EHR documentation demands. Although they had greater access to information, respondents felt less satisfied (66%) and efficient (56%).
Campion TR, Jr., Waitman LR, Lorenzi NM, May AK, Gadd CS [29] (2011)	Evaluate performance of an intensive insulin therapy using an EHR	30 ICU nurses; 49 hours of observation	Qualitative; Ethnography; Observation/ Interviews	Inpatient – intensive care unit (SICU and TICU at Vanderbilt University Hospital)	Identified barriers and facilitators of clinical decision support system use specifically for intensive insulin therapy. There was workload tradeoff between documentation and patient care. Nurses reported spending considerable time and effort back charting to take care of patients first causing double documentation. Nurses also described inaccurate user interface design and persistent use of paper.

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Colligan L, Potts HW, Finn CT, Sinkin RA [31] (2015)	To measure the changes in cognitive workload among nurses while performing EHR tasks	74 pediatric RNs	Quantitative; Longitudinal study (four-time series – baseline, first shift, fifth shift, tenth shift post go-live, and 4 months after go-live; NASA-TLX	Inpatient Pediatric (331-bed Children's Hospital with an academic tertiary care system)	Increased cognitive workload during early implementation of EHR but decreased at various rates. Computer attitudes, skills, and age to be significant predictors but only computer skills independently predicted outcome. Limitations: pediatric nurses; one commercial EHR system; no control
Collins SA, Fred M, Wilcox L, Vawdrey DK [32] (2012)	To examine nurses' use and perceived clinical significance of optional comments within EHR flowsheets	201 patients used for analysis; 5 nurses (for interviews)	Mixed method Sub-content analysis and semi-structure interviews	Inpatient	EHR flowsheets were suboptimal in relaying the "big picture"; consequently, nurses utilized workarounds such as the use of optional comment fields to communicate contextual relationships. Recommendation is to design EHRs where nurses do not have to change screens, and add visualization tools to convey temporal relationships.
Cornell P, Riordan M, Herrin-Griffith D [39] (2010)	To measure impact of a technology upgrade on nurse workflow (frequency and duration of nursing activities)	49 pre; 76 post (two different hospitals)	Quantitative; Observational study	Inpatient – Medical surgical units	Electronic information retrieval, charting, and navigation were one of the most frequent activities for nursing accounting to 19% of their time. Nurses also switched frequently from activity to activity. Study found that there was no significant difference between pre-and post-implementation on direct care and communication (18.9 to 29.1% of total time). Strength: randomly selected, two-group design

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Despins LA, Wakefield BJ [27] (2018)	To describe EMR's role of ICU nurses' determination of patients' deterioration	18 ICU RNs	Qualitative; Secondary analysis of a qualitative study	Inpatient – adult specialty ICU units (medical, cardiology, surgical/trauma/ burn, and neuroscience)	Two overall themes emerged in helping nurses detect patient deterioration: patient norms and EMR design. One of the sub-themes was that the EMR was not user-friendly and often nurses engaged with workarounds like using paper notes for recording information (e.g., during handoff). Nurses also felt that EHR was unreliable due to discrepancies received verbally by other clinicians. Recommendation is to have information visualization to support work and information flow.
Dudding KM, Gephart SM, Carrington JM [18] (2018)	To explore unintended consequences among neonatal nurses	42 NICU RNs (original study 144 RNs)	Quantitative; Secondary analysis from a descriptive cross-sectional correlational study; CG-UCE-Q Halbesleben (workaround tool) RPPE Scale	Inpatient NICU	Interruptions was the most common unintended consequences followed by high workload, changed workload, altered communication patterns, and reliance on the EHR for decision making. Workarounds were done in order to follow protocol, but when technology, equipment, and EHR was not a good fit, shortcuts were taken to take care of patients. Limitations: Generalizability
Gaudet CA [19] (2016)	To describe nurse-patient interactions with the use of the EHR	14 RNs (24 observations)	Qualitative; Micro-ethnography; Passive Participant observations, Semi- structured interviews	Inpatient (3 nursing units requiring cardiac monitoring)	Three themes surfaced related to nurse-patient interaction with the EHR: interruptions, game of tags, machine-like interactions. Interruptions were related to of data entry, data retrieval, data review, and other non-EHR related activities. Stationary computers may interrupt overall clinical workflow due to back-and-forth movement. Nurses still used paper to bridge communication gap or to accommodate the missing feature in the EHR to what was needed.

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Gephart S, Bristol AA, Dye JL, Finley BA, Carrington JM [17] (2016)	To investigate frequency and characteristics of nurses' experience with unintended consequences and determine psychometric adequacy of CG-UCE-Q	144 RNs	Quantitative; Cross-sectional exploratory, descriptive design (correlational); CG-UCE-Q RPPE Scale	Varies (Medical/Surgical, ICU, Float, Ambulatory, Other Settings)	Increased workload, interruptions, altered workflow, and duplicate data entry were the most frequent unintended consequences that nurses experienced.
Guo J, Iribarren S, Kapsandoy S, Perri S, Staggers N [21] (2011)	To evaluate the usability of electronic medication administration record (eMAR)	4 evaluators (reviewed with 5 nurses, and an informatics director)	Qualitative Heuristic evaluation	Inpatient	Issues with effectiveness, efficiency, and satisfaction were reported with the system eMAR. For instance, most where nurses missed medications due to scrolling back and forth on the screen that may lead to patient safety issues. Visibility was also an issue (small icons or non-intuitive functions). Error violation also existed where data was not integrated with other modules.
Hendrich A, Chow MP, Skierczynski BA [36] (2008)	To investigate how medical-surgical nurses spend their time in a shift	767 RNs	Quantitative Time and motion study	Inpatient – 35 medical/surgical units	Documentation time composed of 27.5% of nurses' activities. There were three areas where efficiency in nursing care can be improved: documentation, medication administration and care coordination. Strengths: large sample size, random assignment

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Higgins LW, Shovel JA, Bilderback AL, et al. [40] (2017)	To describe nurses' clinical activity through observations, nurses' perception of time spent on tasks, and EHR time stamps.	4 inpatient units (79 RNs)	Quality Improvement; Triangulated data capture, Prospective observations automated response time measurement system time stamps (Cerner Lights On), Nurse and patient surveys	Inpatient – non-intensive care units (family medicine interventional cardiology, telemetry step=down and medical surgical/stroke/ oncology units)	There was a mismatch between nurses' perception of time spent charting in the EHR (26% of their time) over actual observation (only 11% of their time). There was also over-reporting of time spent in waste activities (15%) versus actual observation (4%). Wasteful activities included waiting, searching and gathering within the EHR. Limitations: Generalizability
Jones NT, Seckman C [30] (2018)	To describe usefulness, ease of use and satisfaction of using a clinical procedure flowsheet in a geriatric unit.	11 nurses (excluded CNAs)	Quantitative Descriptive survey	Geriatric Extended Care Unit	Perceived usefulness was 35.88 indicating usefulness of the electronic clinical procedure (CP) flowsheets. Perceived ease of use was 36.29 indicating ease of use, and overall satisfaction was 72.17 denoting good level of satisfaction and acceptance.
Kim MS, Shapiro JS, Genes N, et al [22] (2012)	To investigate usability gaps in the emergency department information system between two nurse groups (novice and expert)	171 ED nurses (n=108 expert, n=63 novice); 10 ED nurses (for qualitative analysis)	Quantitative Usability testing Video analysis, SUS	Acute care – Emergency Department	No difference was found between the two groups in % task success rate (accuracy of task). Expert nurses had substantial difference in time on task completion (84s-85s compared to 133s to 163s), fewer mouse clicks and slightly shorter mouse movements. Expert nurses also reported excellent usability compared to novice nurses who reported it to be marginal to unacceptable. Usability concerns included dense and scattered data entry, lack to auto population, and non-functional data entry requirements. Limitations: Not generalizable, focused in one setting and one ED information system.

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Kohle-Ersher A, Chatterjee P, Osmanbeyoglu HU, Hochheiser H, Bartos C [24] (2012)	To evaluate barriers nurses/nurse aid/clinical tech encounter for point-of-care documentation	15 RNs (first survey); 16 RNs (second survey) (sample does not include CNAs and clinical techs	Qualitative study; Content analysis Documentation interview and workflow questions	Inpatient - Telemetry	The first survey revealed common themes as to the barriers in point of care documentation including location of in-room computer, perceived computer reliability, privacy concerns, and patient perception. The second survey rated documentation as the lowest priority among all nursing activities suggesting charting was not perceived as something that affects timely medical and nursing care.
Lambooij MS, Drewes HW, Koster F [41] (2017)	To examine the differences between doctors and nurses' use of the EMR and its impact to perceived q0ality of the data.	914 (n = 512 nurses)	Quantitative Questionnaire Structural Equation Modeling	Not mentioned	Nurses reported success of EMR implementation (i.e., it was easy to use) if there was authentic leadership (B = 0.13, .e. = 0.07), support from IT department (B = 0.37, s.e. = 0.06), and bottom-up communication (0.16, s.e. = 0.05. EMR was easier to use when culture was less open (B = −0.21, s.e. = 0.11) but innovative (B = 0.23, s.e. = 0.10).
McBride S, Tietze M, Hanley MA [34] (2017)	To describe relationship between health setting characteristics, nurse characteristics, CIS characteristics with nurse satisfaction?	1177 RNs, APRNS, LVNs (Texas state)	Quantitative (+ Content Analysis; Descriptive exploratory and Content Analysis Clinical Information System Implementation Evaluation Scale, Demographic Survey, and Meaningful Use Maturity-Sensitive Index	Varies (Acute care, ambulatory/ episodic care, and long-term care units)	Overall, study showed nurses were satisfied with the EHR. Compared to rural or urban settings, nurses in rural areas were less likely to be satisfied with EHRs (44%). Nurse characteristics (compute literacy) did not show any significant difference. Working nights, evenings, and rotating shift were more satisfied compared to days (p = .039). Nurses with 6 – 10 years' experience were also more likely to be satisfied. Age was also a factor in satisfaction.

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Sockolow PS, Rogers M, Bowles KH, Hand KE, George J [28] (2014)	To develop empirical data on nurses usage of nursing information systems and identify barriers and facilitators of EHR adoption for nurse leaders	12 RNs	Qualitative; Content Analysis; Think-aloud protocol, follow-up interviews	Inpatient – Medical or Surgical unit (three hospital health system)	Thematic analysis of EHR adoption included hardware issues, software usability (where screen flow did not sufficiently match the clinical workflow, issues with too many pages scrolling, difficulty of finding desired guideline), functionality deficits (inability to summarize patient's story), documentation completeness and quality (copy forward issues), overall satisfaction with nursing information system (NIS), poor interdisciplinary communication, patient rapport, training, and patient outcome. Nurses expressed not wanting to revert back to paper. Limitations: lack of generalizability
Stevenson JE, Nilsson G [20] (2012)	To describe nurses' perception of using EHR in everyday practice linked to patient safety in an acute setting	21 RNs	Qualitative design Content analysis Focus group interviews (Sweden)	Inpatient care – medical, surgical, orthopedic, stroke units	Issues with determining which part of the EHR should data be documented (e.g., physiological observations) due to several different locations. Certain functionalities were also available but nurses were not aware on how to use it (e.g., templates). Nurses reported advantage in simultaneous access to the EHR. Nurses agreed that going back to paper was not an option. However, the complexity of accessing needed information was an issue creating workarounds.
Stevenson JE, Israelsson J, Nilsson G, Petersson G, Bath PA [23] (2018)	To identify and describe workarounds related to vital signs documentation	15 nurses, total of 62 hours of observation (Sweden)	Qualitative; Observational study; Semi-structured interviews, observations	Inpatient (Cardiac ICU, High dependency unit, infection ward and ED)	Workarounds specifically paper documentation and verbal discussion persisted despite EHR implementation to ensure patient safety. Technology factors also contributed such as the inability to take a device into the room to document vital signs. Cultural and organizational factors also contributed to user experience. Limitations: one setting, one EHR system
Walker-Czyz A [42] (2016)	To measure impact of EHR on quality of nursing care (i.e., falls, VAP, CLABSI, CAUTI, nursing	1437 RNs	Quantitative; Retrospective analysis (interrupted time series)	Inpatient – Urban hospital (10 medical surgical units and 2 critical care units)	Study showed a statistically significant decline in falls ($p = .02$), CLABSI ($p < .01$), but no changes in HAPU, VAP after implementing an electronic evidence-based documentation tool to nursing workflow. No significant changes in hours per patient day ($p = 3.48$) and overtime ($p = .03$).

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
	hours) and nursing satisfaction (turnover rates)				Strength: Large data set
Ward MM, Vartak S, Schwichtenberg T, Wakefield DS [35] (2011)	To examine impact of CIS implementation of nurses' workflow and patient care	705 nurses (pre: 354, post: 203, 6months: 148)	Quantitative; Correlational research; I-SEE survey	Inpatient (Midwestern rural referral hospital) Variable units	EHR did not decrease perception of provider-patient communication, inter-provider communication, work life, quality of care, and patient care processes. Worsen perception: amount of time documenting, recording diagnosis, amount of time spent directly with patients. Perceptions were more positive with nurses with previous experience with the EHR, and less positive for more clinical work experience.
Yee T, Needleman J, Pearson M, Parkerton P, Parkerton M, Wolstein J [37] (2012)	To investigate nurses' time spent in documentation as it relates to use of electronic charting	105 inpatient units (55 hospitals)	Quantitative; Cross-sectional analysis using time and motion study	Inpatient – variable units	Nurses spent approximately 19% of their time documenting whether or not they are using an EMR or electronic notes. The rest were spent in other categories of care. Limitations: self-report, small sample size
Yeung MS, Lapinsky SE, Granton JT, Doran DM, Cafazzo JA [25] (2012)	To characterize vital signs collection and documentation to inform strategies for improving workflow design	24 RNs at three hospitals in a general medicine unit	Mixed Method; Qualitative Ethnography plus time and motion study	Inpatient General Medicine	Amount of time spent at patient's bedside was greater with electronic documentation (M = 116 minutes, SD = 89 minutes) compared to paper documentation (M = 79 minutes, SD = 39 minutes, p = 0.02). Statistically significant difference for vital signs documentation with EHR vs paper. Interaction between technology, clinical workflows and environment design factors need to be considered to minimize unintended consequences. Accessibility of devices to document vital signs or any electronic documentation was a barrier.

Author(s); (Year)	Purpose, aims, hypothesis	Sample	Study Design Method Instruments	Setting	Results
Zadvinskis IM, Garvey Smith J, Yen PY [26] (2018)	To understand longitudinal nurses' perception of health information technology	19 RNs (30 interviews)	Qualitative; Phenomenology	Inpatient – Medical surgical units	Nurses reported negative experience with equipment devices related to the EHR due to noise, scanning, power loss, lengthy logins, and accessibility. Nurses also expressed that documentation was very time consuming, albeit comprehensive. Organizational factors such as awareness of the rationale about design changes in the EHR impacted nurses' perception and experience with the EHR. Collaboration and teamwork was central in the positive experience of EHR usage. Nurses were initially dissatisfied with the EHR nine-months post-implementation, but satisfaction perception changed after 18 months.

LEGEND OF ABBREVIATIONS:

CAUTI: Community Acquired Urinary Tract Infection
CG-UCE-Q: Carrington Gephart-Unintended Consequences of the EHR-Questionnaire
CIS: Clinical Information System
CLABSI: Central Line-Associated Blood Stream Infection
CNA: Certified Nurse Assistant
CP: Clinical Procedure
ED: Emergency Department
EHR: Electronic Health Record
eMAR: Electronic Medication Administration Record
EMR: Electronic Medical Record
ICU: Intensive Care Unit
IT: Information Technology
M: Mean
NASA-TLX: NASA-Task Load Index
NIS: Nursing Information System
RN: Registered Nurse
SD: Standard Deviation
SICU: Surgical Intensive Care Unit
SUS: System Usability Scale
TICU: Trauma Intensive Care Unit
VAP: Ventilator Associated Pneumonia