The Effect of the Electronic Health Record on **Interprofessional Practice: A Systematic Review**

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Abstract **Background** Interprofessional practice and teamwork are critical components to patient care in a complex hospital environment. The implementation of electronic health records (EHRs) in the hospital environment has brought major change to clinical practice for clinicians which could impact interprofessional practice.

> **Objectives** The aim of the study is to identify, describe, and evaluate studies on the effect of an EHR or modification/enhancement to an EHR on interprofessional practice in a hospital setting.

> Methods Seven databases were searched including PubMed, Scopus, Web of Science, CINAHL, Cochrane, EMBASE, and ACM Digital Library until November 2021. Subject heading and title/abstract searches were undertaken for three search concepts: "interprofessional" and "electronic health records" and "hospital, personnel." No date limits were applied. The search generated 5,400 publications and after duplicates were removed, 3,255 remained for title/abstract screening. Seventeen studies met the inclusion criteria and were included in this review. Risk of bias was quantified using the Quality Assessment Tool for Studies with Diverse Designs. A narrative synthesis of the findings was completed based on type of intervention and outcome measures which

Keywords

- electronic health records
- interdisciplinary teams
- interprofessional practice
- hospitals

included: communication, coordination, collaboration, and teamwork. **Results** The majority of publications were observational studies and of low research quality. Most studies reported on outcomes of communication and coordination, with few studies investigating collaboration or teamwork. Studies investigating the EHR demonstrated mostly negative or no effects on interprofessional practice (23/31 outcomes; 74%) in comparison to studies investigating EHR enhancements which showed more positive results (20/28 outcomes; 71%). Common concepts identified

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throughout the studies demonstrated mixed results: sharing of information, visibility of information, closed-loop feedback, decision support, and workflow disruption. **Conclusion** There were mixed effects of the EHR and EHR enhancements on all outcomes of interprofessional practice, however, EHR enhancements demonstrated more positive effects than the EHR alone. Few EHR studies investigated the effect on teamwork and collaboration.

Background and Significance

The past decade has seen widespread adoption of digital health technologies aiming to enable safer, high quality, more equitable and sustainable health care while also improving patient and clinician experience.¹ A major example of digital health technology in the clinical setting is the implementation of the electronic health record (EHR), often synonymous with the term electronic medical records (EMRs).² This computerization of medical records has had a major impact on the way clinicians work, communicate, and support patient's goals of care.³

Interprofessional practice has been highlighted as a promising area to improve patient experience, integrated care, and efficiency of health services.^{4–11} However, definitions of interprofessional practice have been inconsistent and ambiguous within the literature.⁷ The framework by Xyrichis et al¹² has been used in this review to define interprofessional practice as four key interprofessional activities: teamwork, collaboration, coordination, and networking. As interprofessional networking is a recent concept and not commonly described within the context of interprofessional practice literature, we have replaced this term with communication. Communication is an essential element of teamwork underpinned by the relational coordination theory, where effective coordination of work tasks and work relationships is reliant on effective communication.^{13–15}

The premise of interprofessional practice is to create high performing teams that collaborate on patient care to improve health outcomes and health care integration.¹¹ It is recommended to "strengthen health systems and improve health outcomes."^{11,16} Common interventions to improve interprofessional practice involve training and education, structured checklists or communication tools, and the design of work environments.^{17,18} Despite widespread agreements on its importance, research to date has been hampered by heterogenous outcome measures and small sample sizes, leading to inconclusive evidence to support improved quality of patient care.¹⁸ More rigorous studies are required.¹⁹

The hospital environment is a busy and complex setting and often multiple health professionals are involved in a patient's care. Effective communication amongst clinicians is essential, with communication breakdowns as one of the key preventable aspects of health care that can be mitigated via team training and team performance.^{8,20} The delivery of high quality patient care relies on the ability of interdisciplinary teams to work together to achieve patient goals and improve patient outcomes.^{4,6,8,16,21–24} Each discipline involved in a patient's care is mutually dependent on the other.^{21,23,25}

An interesting and pervasive consequence of the EHR is its change to communication and interprofessional practice amongst clinicians. As digital aspects of health care have increased, face to face communication amongst professions has decreased.^{26–29} Health professionals were used to gathering around the paper chart for documentation which allowed informal and unplanned communication amongst team members.³⁰ Now, data can be accessed from any place at any time, providing convenience, however, also resulting in team separateness.^{31,32} It is reported that some clinicians feel the EHR creates an "illusion of communication" through extensive documentation, however, their clinical notes are not read by other clinicians and therefore not acted upon.³³

Despite the challenges presented, leveraging the EHR to support key activities of interprofessional practice such as communication and collaboration appears to be expanding.³⁴ "Customization" or modifications of EHRs such as dashboards or clinical decision support systems enhance the potential of EHRs to improve clinical care.³⁵ Studies investigating EHR enhancements (e.g., secure messaging systems) have demonstrated benefits such as enhanced communication, reduce cognitive workload, and improved clinician performance.³⁶ However, uptake of these enhancements remains challenging.^{35–37}

The motivation for this study is that few studies to date have focused on the impact of the EHR on interprofessional teams. In addition to limited knowledge on this topic, studies that have been completed provide a piecemeal view, that is, investigating effects of the EHR on one discipline only such as doctors or nurses, or focusing on one element of interprofessional practice such as coordination of patient care.^{26,27,34,38-44} The EHR has the potential to improve interprofessional practice, however, conflicting results are found within the literature, with disconnected teams and "information overload."³²

Objectives

The objective of this review was to identify, describe, and evaluate studies on the effect of an EHR, or enhancement to an EHR on interprofessional practice in an inpatient hospital setting.

Methods

This systematic review has been conducted using the PRISMA guidelines⁴⁵ and was registered in PROSPERO on May 07, 2021 (CRD42021247103).

Information Sources and Search Strategy

Databases searched include PubMed, EMBASE, CINAHL, Cochrane, Scopus, Web of Science, and ACM Digital Library. Included study designs were randomized controlled trials, non-randomized controlled trials, controlled before–after studies, observational studies, mixed methods, and qualitative study designs. Subject heading and title/abstract searches were undertaken for the search concepts: "interprofessional" AND "electronic health records" AND "hospital, personnel."

An academic librarian assisted in the search strategy string to extract relevant publications related to outcomes of interprofessional practice in using an EHR system or enhancement to an EHR in an inpatient hospital setting. Initially, databases were searched up to the 12^{th} of March 2021. No publication date limit was applied as the timing of implementation of EHRs internationally varies widely. Reference lists were hand searched to identify further relevant publications. The search strategy was then reapplied to all databases from the 12^{th} of March to November 1^{st} , 2021 to capture the most recent publications. Reverse snowballing via Google Scholar was used to identify more recent articles that cited relevant studies. The search strategy is available in **~ Appendix A**.

Study Eligibility Criteria

Eligible studies included were those conducted in an inpatient hospital setting with the main intervention as the EHR or modification/enhancement to the EHR. Outcome measures reported on teamwork, communication, coordination, collaboration, or staff perceptions of these. Studies involving patient-specific outcomes were excluded. The study selection criteria are outline in **-Table 1**.

Study Selection

Search results were exported to EndNote where duplicates were removed. A two-stage review system was used: stage

one involved two independent reviewers (S.T.R., I.C.M.R.) screening the title and abstracts of publications against the inclusion criteria. Conflicts were resolved by discussion and consensus voting. Stage two involved two independent reviewers (S.T.R., S.G.B.) reviewing the remaining publications in full-text. Again, conflicts were discussed and resolved between the two reviewers. The Covidence program was used to screen articles and data extraction was performed manually using a template outlining study demographics, population and setting, methods, participants, intervention groups, outcomes, and results.

Quality Assessment

The Quality Assessment Tool for Studies with Diverse Designs (QATSDD) was used to determine risk of bias.⁴⁶ Two reviewers (S.T.R., I.C.M.R.) independently used the tool for each of the included publications. As the publications were spread across quantitative (n=7), qualitative (n=5), and mixed methods (n=5) study designs, the QATSDD was deemed most suitable. Reviewers score 16 items on a scale of 0 to 3; 14 of the criteria are applicable to quantitative/ qualitative study designs. Reviewers then count the scores and calculate a percentage based on the total number scored (out of 42 for quantitative/qualitative study designs). Higher scores indicate higher quality research.

Reporting and Analysis

Due to the heterogeneity of interventions described, outcome measures used, and the observational nature of the study designs, a meta-analysis was not possible. We have provided a narrative synthesis of the findings structured around the type of intervention (EHR or EHR enhancement) and classification of outcome investigated (e.g., communication, coordination, collaboration, teamwork). The effect of the EHR or EHR enhancement was categorized into positive,

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	Inclusion criteria
Population	Interdisciplinary, i.e., involving two or more professions (e.g., medical, nursing, allied health, IT)
	Inpatient setting within a hospital using EHR
Intervention of Interest	Effect of an inpatient EHR or EHR enhancement on interprofessional practice
Comparison	Routine care, i.e., prior to implementation/use of EHR or enhancement or paper-based record
Outcome measure	Outcomes can be any measure of:
	 Teamwork Collaboration Coordination Communication Staff perception of communication/teamwork/coordination
Study design	RCTs, non-RCTs, before-after studies, observational studies, qualitative studies Excluded: opinion pieces, unpublished studies, conference abstracts
Publication date	No limit
Language	English

 Table 1
 Systematic review inclusion criteria

Abbreviations: EHR, electronic health record; IT, information technology; RCT, randomized controlled trial.

negative, or neutral/no effect for each outcome measure reported in the studies (**- Appendix B**). Studies could include one or more of the outcome measures within the same classification group (i.e., a study may measure communication in a variety of ways) therefore reporting of both positive and negative results was possible for each outcome. Inductive analysis by one researcher was performed on all publications to gain further insight into reasons for positive or negative results.

Results

Overall, the database searches generated 5,400 publications, with 3,255 remaining after duplicates were removed. The majority of publications (n = 3,090, **Fig. 1**) were excluded as the EHR was not the main intervention or the publication did not examine the impact of the EHR on interprofessional practice outcomes. Based on title/abstract screening, 164 publications were selected for full text review with one additional paper identified through hand searching; 148 were excluded. A total of 17 publications met the inclusion criteria and were analyzed. **Fig. 1** illustrates the combined search strategy results and reasons for exclusion.

- Table 2 outlines key study characteristics. The 17 publications that met the inclusion criteria consisted of five non-randomized pre-post studies⁴⁷⁻⁵¹ and 12 observational

studies.^{43,52–62} Of the 17 studies, only six were considered at a low risk of bias^{43,47,52,53,57,60} (- Appendix C). One study by Rogers⁵¹ reported results that were inconclusive, therefore these results are presented in - Table 2, although excluded from the narrative synthesis. Interprofessional practice was assessed mostly via observation and/or interview data (n = 10). Of the studies using only a survey as their measurement tool (n = 4), few survey questions related directly to our study aim therefore results were analyzed based only on related questions (ranging from one to four questions). The majority of studies (n = 10) involved two interprofessional disciplines, e.g., medicine and nursing compared with greater than two types of interprofessional disciplines (n = 7). Medicine and nursing were the most frequent disciplines participating in the studies.

Of the 17 publications, 47% investigated the EHR and 53% investigated the effect of an EHR enhancement. Studies investigating the EHR found some positive effects on interprofessional practice (8/31 outcomes; 26%), although most showed no effect (14/31 outcomes; 45%). EHR enhancements demonstrated a more positive trend on outcomes (20/28 outcomes, 71%), with positive findings distributed across communication, coordination, collaboration, and teamwork (**Table 3**). Studies on the EHR ranged from publication in the year 2003 to 2016 and studies on EHR enhancements were published in 2006 to 2021.



Fig. 1 Search strategy results flowchart.

udy quality ,TSDD ^a	%	%	8	%
conclusions Str. QA	$\begin{array}{llllllllllllllllllllllllllllllllllll$	f information 79 zre 2.65; range is showed /quite a lot" /quite a lot" ization for each ization for each izage 0–6); ved "not at all/a ived primarily dical and NPs, s and the s.	with CPOE 83 9 (more changed (more of various IT with laboratory ordination as :essible in a	ere ordered by 45 staff to d-loop feedback sks marked as heir requested asks eventually asks eventually armedical fron.
Significant results/	Fewer questions (R usual =10.6 (6.9), <i>I</i> fewer incorrect rest using RRT (RRT =0. usual = 0.6 [1.3], <i>p</i> differences for miss differences for miss between the two to [0.9], usual = 0.6 [C Quality of interactiv communication war the RRT with fewer through questions, incorrect responses	Improved sharing o with care team (scc 0–6); 70% response moderate amount Low effect on orgar patient (score 1.79 58% responses shov little." The LCIM was perce positive by PICU mu both for themselve patients and familie	Improved legibility Medical and nursin, communication poo as a result of CPOE interdependent). Lack of integration systems (e.g., CPOE results) reduced co information not acc single place.	Majority of tasks w nurses for medical complete (97.1%) A high level of close with 77.4% of all ta completed within t timeframe and all timeframe and all timeframe adopti platform for nursin platform for nursin clinical communica
Effect (+/ -/ \sim)	+ Positive effect on communication	+ Positive effect on communication ~ No effect on coordination	 + Positive effect on communication - Negative effect on coordination 	+ Positive effect on communication
Outcome measure	Communication: Clinical content discussed Questions raised Breakdowns in interactive communication	Perceived usefulness Perceived ease of use User satisfaction	Staff perspectives of success factors for implementing CPOE	Usage: type of task, urgency of task, requestor role, and time to completion
Intervention	EHRE: EHR integrated Rounding Report Tool (RRT) Comparator: Microsoft Word fillable rounding tool (usual tool)	EHRE: Large Customizable Interactive Monitor (LCIM) in each patient room; data updated from EHR; view only	EHR: Computerized Physician Order Entry (CPOE) "a process that allows direct entering of medical orders"	EHRE: ETM system allows requesting and resolution of nonurgent tasks between all clinicians
Population and setting	Twenty-seven participants (medical and pharmacy) across two teams participated in 169 patients rounds at an academic medical center.	Thirty-six participants: 19 medical and 27 nurse practitioners (NPs) in the pediatric intensive care unit (PICU)	Participant observations, focus groups and interviews across three hospital facilities: 72 clinicians (unspecified) Eight IT staff Seven administrators	Usage audit of all users of the Electronic Task Management (ETM) system in a pediatric hospital
Study design	Prospective, non- randomized pre-post study design	Cross sectional concurrent mixed methods study design	Multisite qualitative study design	Retrospective cross sectional study design
Author/ Year/ Country	Abraham et al 2019 United States ⁴⁷	Asan et al 2018 United States ⁵²	Ash et al 2003 United States ⁵³	Cheng and South 2020 Australia ⁵⁴

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Study quality QATSDD ^a	5 5 8	844	88 %
Significant results/conclusions	 82.8% agreed that the microblog allowed transparent conversation that all care team members can view. Barriers were the availability of other messaging modalities (e.g., pagers, email, texting), poor awareness of the system, and inability to communicate with outform in the system. 49.4% of messages discussed care coordination; 27.2% of messages discussed care team collaboration; 65.5% respondents stated that the application was useful for improving plan of care concordance. 	Positive: system prompts prevented clinicians from forgetting to input important information. Mixed: physicians were unsure if nurses were taking patients histories accurately. Negative: interprofessional communication time increased. Positive: unclear responsibility for inputting the data and coordination of care.	Medical: Clarity of the importance of assigned work tasks and responsibility for tasks significantly improved while mental workload reduced with use of EHR compared with paper. Nursing: No difference in clarity about plan of care for nursing of the patient or for the medical treatment of the patient and no change in mental workload. Reduction in missing pieces of information (0.90 with paper records and only 0.17 with EHR compared with paper.
Effect (+/ -/ \sim)	+/- Mixed effects on communication + Positive effect on coordination	+/- Mixed effects on communication +/- Mixed effects on coordination	 + Positive effect on coordination (medical). ~ No effect on coordination (nursing) + General positive effect on coordination
Outcome measure	Usage and messaging activity Useful features and barriers	Usage/uptake of CIS by staff Staff perceptions of CIS	Mental workload Missing pieces of information Importance assigned to tasks Responsibility for tasks.
Intervention	EHRE: "Microblog" messaging platform to view, contribute, and communicate plans of care via a single forum and synchronization with EHR	EHRE: Colposcopy Information System (CIS), cumulative electronic note on patient history, examination, treatment plans to view on one screen	EHR: Electronic patient record trial in an acute stroke unit for 5 d Comparator: paper- based records
Population and setting	Usage audit of all users of the microblog in a medical intensive care unit and 2 non-critical care units and participant survey: 7 nursing 1 care coordinator	Usage audit (non- identifiable data) in a colposcopy clinic in large teaching hospital and 24 participant interviews: eight medical 10 nursing six IT	Observation and survey of medical and nursing staff in an acute stroke unit who attend team conferences, ward rounds, and nursing handovers.
Study design	Observational study design	Prospective mixed methods case study design	Mixed methods pre- post intervention
Author/ Year/ Country	Dalal et al 2017 USA ⁵⁵	Goldman et al 2012 Canada ⁵⁶	Hertzum and Simonsen 2008 Denmark ⁴⁸

Table 2 (Continued)

Study quality QATSDD ^a	2%	67%	45% 2	36%
Significant results/conclusions	"Communication of information from the clinical pathway during shift report (patient hand-off)" 34% increase (28% paper $n = 29$ to 62% electronic $n = 21$). "Documentation by ancillary staff on the pathway" 31% increase (60% paper $n = 15$ to 91% electronic n = 23). "The clinical pathway allows for a multidisciplinary approach to patient care" 24% increase (71% paper $n = 34$ to 95% electronic n = 22).	Of 199 respondents specific to hospital setting ($n = 143$ medical, n = 56 nursing), 62.1% of medical and 72% of nursing staff agreed that the EHR supports collaboration and information exchange between clinicians in the same services.	Physical setup of the EHR (group formation, non-verbal behavior, access to patient data, and reaction to patient data) decreased interaction or openness of discussion, resulting in staff having less understanding of the patient goals. The easy access to information that the EHR provided did not encourage the usual trading of information that stimulates multidisciplinary interaction.	Three main areas of dissatisfaction in information flow: IT system, communication, and coordination. The IT system was perceived to have a negative impact on communication and coordination. 75% medical and 50% nursing staff believe the information flow in the EHR needs to be improved.
Effect (+/ -/ \sim)	+ Positive effect on communication + Positive effect on teamwork	 + Positive effect on collaboration + Positive effect on communication 	-Negative effect on communication and collaboration ~ No effect when strategies to mitigate were implemented	 Negative effect on communication √- No effect or negative effect on coordination
Outcome measure	Staff perceptions Documentation	Clinician perceptions on usability, technical quality, ease of use, benefits, collaboration	Interaction between members of a multidisciplinary team during ward rounds	Workflow issues impacting on efficiency and satisfaction (tasks, activities, and barriers)
Intervention	EHRE: Computerized clinical care pathway Comparator: paper- based care plan	EHR: Electronic health record	EHR: Electronic patient record (Metavision)	EHR: Electronic health record
Population and setting	Pre-post survey of nursing and ancillary staff (PT, pharmacy, nutrition, respiratory the rapy, case management, social work) in a 28-bed medical-surgical department	Participant survey of 297 medical and nursing staff from both hospital and primary care	Participant observation and video analysis of ward rounds in ICU: medical, nursing and allied health including pharmacy, dietetics and physiotherapy. Participant interviews of 7 medical and nursing staff	Participant survey of 4 medical and 16 nursing staff in a pediatric intensive care unit (PICU)
Study design	Pre post pilot study	Observational study	Qualitative observational pre-post study	Mixed methods observational study
Author/ Year/ Country	Hyde and Murphy 2012 USA ⁴⁹	Lloyd et al 2021 Australia ⁵⁷	Morrison et al 2008 UK ⁵⁰	Munoz et al 2014 USA ⁵⁸

(Continued)

	Study design	Population and setting	Intervention	Outcome measure	Effect (+/ -/ \sim)	Significant results/conclusions	Study quality QATSDD ^a
	Ethnographic qualitative research design	Participant observation: medical, nursing and medical assistants in a hospital emergency department (ED) Participant interviews: medical and nursing leadership	EHRE: eSignout (electronic handoff tool) for automatic signout information and patient transfer from ED to medical ward	Social elements of clinical and organizational interactions of the key stakeholders with eSignout	 + Positive effect on coordination + Positive effect on communication + Positive effect on collaboration + Positive effect on tearwork 	eSignout largely replaced verbal communication for handoffs leading to reduced disruption to workflows. When verbal communications were required, they were relevant, patient-centered, and succinct. eSignout allowed staff to gain a more coherent picture of the patient, improving communication and care for patients. Teamwork and collaboration improved through increased mutual respect and a shared understanding of clinician's respective time pressures	45%
	Pre-post study design	Documentation audit; comparing medical and nursing documentation pre and post implementation in an acute hospital setting	EHRE: Electronic tool to identify, communicate and document Present On Admission (POA) Pressure Ulcers (PrUs)	Communication and documentation of POA PrUs	~ No effect on communication	The implementation of the electronic prompt did not contribute to the improvement in the communication process between the admitting physicians and the clinical nurses because the improvement in POA PrUs rates occurred before the EHR prompt intervention.	29%
	Qualitative study design	29 participants: clinicians and information technology professionals from six regions chosen as national leaders in HIT	EHR: Health Information Technology (HIT) specifically focused on EHR	Care coordination: patient level, provider level and systems level	+ Positive effect on coordination (patient level) ~/- No effect/ negative effect on coordination (provider level) +/- Mixed effect on coordination (system level)	Positive uses of HIT to "assess patients' needs and goals," "monitor, follow-up and respond to change" and some examples of HIT to "support patients' self- management goals." HIT was occasionally used in "establishing accountability" and "communication" however, processes were inefficient and had a negative impact on information transfer due to lack of interoperability.	79%
wollow	Cross sectional observational pilot study	Participant survey of 19 nurses on a general medical acute care unit	EHRE: Electronic sign- out tool	Communication between nursing and medical staff	 + Positive effect on communication + Positive effect on coordination 	Communication between medical and nursing staff improved—score 4.6 (where 5 greatly improved and 1 worsened). Coordination improved by nurses' access to the sign-out tool allowing development of an accurate daily nursing plan of care – score 4.3.	29%

Table 2 (Continued)

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Study quality QATSDD ^a	81% 2	52%
Significant results/conclusions	34% of communication mediated by the EHR resulted in a workaround: 6/44 workarounds Participants intentionally stopped using the system as it impeded workflow; 30/44 workarounds participants deliberately compromised their work pattems to adopt pathways allowed by the system. Senior medical staff were more likely to display a heightened awareness of the interprofessional effects of workarounds compared with junior staff.	Staff perceptions of communication were not affected with implementation of the EHR: "Communication between medical and hospital staff is adequate to meet patient care needs" Baseline 4.7 (1.2): Pre-implementation 4.6 (1.0): post implementation 4.6
Effect (+/ -/ \sim)	~/- No effect/ negative effect on communication ~/- No effect/ negative effect on collaboration	~ No effect on communication
Outcome measure	Interprofessional communication strategy	Perception of communication and information flow
Intervention	EHR: Electronic patient records	EHR: Clinical information system of EHR and CPOE
Population and setting	Participant observation of 9 medical and 62 nursing staff in one ward of a pediatric hospital Interviews: 9 medical and 11 nursing staff	840 participant surveys: 48 medical 341 nursing 451 other clinical across 7 hospitals
Study design	Qualitative study	Prospective, nonexperimental evaluation study
Author/ Year/ Country	Varpio et al 2009 Canada ⁴³	Ward et al 2012 USA ⁶²

Abbreviations: EHR, electronic health record; EHRE, electronic health record enhancement. ^aAuthors of the QATSDD tool suggest that scores >60% are considered at low risk of bias.⁴⁶

	Total studies n (%)	Effect	Overall outcomes f (%)	Outcome of communication f (%)	Outcome of coordination f (%)	Outcome of collaboration f (%)	Outcome of teamwork f (%)
EHR	8 (47)	Positive	8 (26)	2 (13)	5 (42)	1 (25)	0
		Negative	9 (29)	4 (27)	4 (33)	1 (25)	0
		No effect	14 (45)	9 (60)	3 (25)	2 (50)	0
EHRE	9 (53)	Positive	20 (71)	13 (68)	3 (60)	2 (100)	2 (100)
		Negative	5 (18)	4 (21)	1 (20)	0	0
		No effect	3 (11)	2 (11)	1 (20)	0	0
Total	17		59	34	17	6	2

 Table 3 Effect of the intervention on interprofessional practice outcomes

Abbreviations: EHR, electronic health record; EHRE, electronic health record enhancement; f, frequency of outcome; n, number of studies.

Communication was the most studied outcome measure for both EHR and EHR enhancements (f=34; 58%). The majority of EHR studies showed no effect on communication (f=9; 60%) in comparison to studies investigating EHR enhancements demonstrating positive effects on communication (f=13; 68%). Coordination of care was mainly studied amongst EHRs. There were mixed effects of the impact on coordination amongst teams with both the EHR and EHR enhancements. Few studies investigated the specific outcomes of collaboration or teamwork.

EHR enhancements included a variety of intervention tools that were incorporated into the EHR (as described in **-Table 2**). Three of the EHR enhancement tools were designed specifically for interprofessional communication, for example, communicating outstanding tasks, discussing plans of care for patients, and highlighting patient priorities to team members.^{54,55,61} Five of the EHR enhancement tools were more focused on sharing patient information, for example, computerized care plans or automated templates for documentation or handover.47,49,52,56,59 Studies often reported mixed findings, for example, Dalal et al⁵⁵ investigated a microblog messaging platform which demonstrated improved team communication, coordination, and collaboration through improved visibility of information by all team members, however, negative impacts to communication through the inability to use this system with clinicians outside the hospital environment.

Despite mixed results, most outcome measures evaluated the impact of the EHR/ EHR enhancement on communication and coordination. Common concepts were noted for both positive and negative results: (1) sharing of information, (2) visibility of information, (3) closed-loop feedback, (4) decision support, and (5) workflow disruptions.

Sharing of Information

There were mixed findings reported on the ability to share information in studies investigating an EHR. In a recent Australian survey of clinicians using an EHR, 62.1% of doctors and 72% of nursing staff in hospitals across Australia agreed upon EHRs supporting collaboration and information exchange between clinicians in the same services.⁵⁷ Converse-

ly, a study conducted in the United Kingdom in 2014 reported that the IT system (EHR) was perceived to have a negative impact on communication and coordination.⁵⁸ Furthermore, a U.S. study of nine critical access hospitals in North Iowa showed no effect of a new EHR on communication between hospital staff before and after implementation, with relatively high rates of clinician satisfaction regarding communication and information transfer with both paper-based records and EHRs.⁶²

Publications that reported on EHR enhancements found more positive benefits associated with the ability to share information. In a study investigating a customizable touchscreen monitor and display (LCIM), which receives data from the EHR, 70% of doctors and nurse practitioners stated that the LCIM monitor improved sharing of information with the care team.⁵² The ability for the EHR to share information amongst professions was also demonstrated through an electronic sign-out tool intervention.⁶¹ Although this tool was initially used by doctors to handover salient clinical information during medical shift changes, the ability for nursing staff to use this tool in their own clinical practice improved information exchange and communication across professions.⁶¹

Visibility of Information

Multiple studies described the value of team members being able to view the communication and interactions of other professions via the EHR.^{52,55,56,58} Sixty percent of doctors and nurse practitioners viewing the LCIM⁵² felt this tool was useful in their ward rounds in the pediatric intensive care unit setting and aided in their clinical work. Similarly, survey responses evaluating a "microblog" messaging platform showed that 82.8% of interdisciplinary team members agreed that a valuable feature of the platform was the "transparent conversation that all team members can view."⁵⁵ In contrast, the study by Morrison et al describes the struggle for health professionals to adequately display the clinical information when engaging in an ICU ward round. Physical set up of the health care team around the EHR system during ward rounds impacted the ability to view and therefore interact with discussions about the patient, i.e., the study suggests a physical change to formation of the team around the EHR in a horseshoe format to allow all members of the team to see the EHR data as well as each other.⁵⁰

Closed-Loop Feedback

Studies within this review described the benefit of closedloop feedback via the EHR supporting interprofessional practice. In an electronic task management intervention by Cheng and South,⁵⁴ the authors reported a high level of "closed-loop feedback," as once a requested task is completed by a clinician, a message is sent back to the requestor.⁵⁴ A read-receipt functionality was also a key component within the study by Dalal et al⁵⁵ where a "microblog" messaging platform allowed visualization of when messages were read and by whom. When asynchronous communication via the EHR occurs, this visual representation of messages being received is an important aspect for allowing team members to coordinate and collaborate on patient care. However, some studies demonstrated how closed-loop feedback did not work optimally within the EHR due to confusion around who is responsible for each aspect of patient care represented in the EHR.48,58

Decision Support

EHR systems can provide real-time decision support for clinicians through automated prompts, messages, and forcing functions.^{56,60} As described in Ash et al⁵³ investigating a computerized physician order entry (CPOE) in the EHR, communication among doctors, nurses and pharmacists has changed and "caused everybody to become more interdependent." Positive effects of an EHR enhancement on providing prompting and decision support were also seen in the study by Goldman et al,⁵⁶ investigating a Colposcopy Information System (CIS), an electronic note that allows health professionals to view a flow sheet of cumulative data and patient history on one screen.⁵⁶ However, in their study investigating to what extent Health Information Technology (HIT) is involved in care coordination, Samal et al⁶⁰ concludes that despite its potential, there is a low utilization of HIT to impact care coordination at the patient level.

Workflow Disruption

Mixed results were seen regarding disruptions to clinical workflow. Clinicians using an EHR integrated Rounding Report Tool (RRT), which automatically collects and organizes clinical information from the EHR, experienced less interruptions to workflow through lower requirements in seeking clarifying information.⁴⁷ Benefit has been reported from capacity for asynchronous clinical handover through an electronic sign out system, with minimization of workflow disruption due to automatic transfer of information through the EHR.^{59,61} However, one study in this review exploring communication between doctors and nurses using an EHR showed the common use of "workarounds" ("informal temporary practices for handling exceptions to normal workflow").^{43,63} In a study by Varpio et al⁴³ the authors showed that 34% of communication facilitated by an EHR resulted in a workaround demonstrating workflow disruptions.⁴³

Discussion

This systematic review included 17 publications on the effect of the EHR or EHR enhancement on interprofessional practice. The majority of studies evaluated outcomes of communication^{43,47–50,52–62} and coordination.^{48,52,55,56,58–60} Fewer studies reported on the effect on the EHR/EHR enhancement on collaboration^{43,50,53,55,57,59} or teamwork.^{49,59} Overall, there were mixed findings on the effect of the EHR/EHR enhancement on interprofessional practice with both positive and negative impacts evident for sharing of information, visibility of information, closedloop feedback, decision support and workflow disruption. EHR enhancements demonstrated a more positive trend for its impact on communication amongst interprofessional teams.

From EHR to EHR Enhancements

Results showed that evaluation of EHR enhancements are more common in the literature in the past 5 years. This may indicate that implementation and adoption of EHRs are becoming more universal and now, modifications and adaptations to EHRs are taking place to address unintended consequences, described as "unpredictable, emergent problems" as a result of EHR use.⁶⁴ Unintended consequences of the EHR on interprofessional practice are evident throughout this systematic review, with increased workflow disruptions, negative impacts of sharing of information within teams, and insufficient use of the EHR to feedback clinical information between professions.43,58,60 Interestingly, these negative impacts were not demonstrated in the studies investigating enhancements to the EHR. This may be due to EHR enhancements being specifically designed to mitigate these negative effects. Customization of EHRs (e.g., enhancements) have provided some solutions for operational and technical factors that impact clinical communication; however, these are often in response to issues or problems faced. Within this review, EHR enhancements appear to be designed specifically to fix a problem (reactive) rather than to accommodate the goals of the organization or end-users (proactive). However, there is also the possibility that these negative effects were understudied in the EHR enhancement publications.

Interprofessional Practice and the EHR

Studies in this review show mixed findings on the impact of the EHR to provide enhanced clarity of patient care.^{48,56} Hertzum and Simonsen⁴⁸ studied the effect of the EHR on clinical activity and results indicated that the EHR enhances clarity of the patient care plan as well as clarity around the responsibility of tasks by clinicians. Conversely, in the study by Goldman et al⁵⁶ on the CIS, it was unclear who was responsible for inputting data which negatively impacted coordination of care. This phenomena has been previously reported in a primary care setting investigating the impact of the EHR on coordination of patient care.³⁹ The authors describe that when teams with a high level of cohesion utilize the EHR, there is greater agreement on patient goals of care and improved clarity about the responsibilities of patient care.³⁹ It is possible that clinicians working in more cohesive teams may see greater benefits of improved care coordination with an EHR, possibly due to better procedures regarding data retrieval and documentation as well as more shared learning.³⁹

Greater communication and coordination of work via EHRs may enhance efficiency, however, interprofessional practice encompasses many additional aspects beyond sharing of information and feedback of information. The particular activities associated with interprofessional practice are underpinned by enabling values of teamwork such as trust, interdependence, and mutual respect.^{8,10,14,30} One approach to describing teamwork is from the viewpoint of shared goals, shared knowledge, and mutual respect, that is, acting with a greater regard for the "whole," higher level systems thinking and respecting individual contributions to achieve the desired outcome.¹⁴ Teams that are described as "high performing teams" demonstrate improved quality and efficiency of care.^{65,66} With increased use of EHRs to communicate and coordinate clinical tasks, face to face interaction amongst clinicians decreases and there is a risk of health care teams losing the essential elements of teamwork. The loss of the important constructs of teamwork such as shared identity and mutual respect could negate the productivity achieved through EHR enhancements.

Digital health technology has changed the way clinicians work with each other. One of the key findings of this study is that targeted enhancements to an EHR have the capability of promoting enhanced communication and coordination of patient care. The COVID-19 pandemic has impacted care by enforcing virtual ward rounds, remote patient assessments, social distancing, and virtual team meetings. This has in turn impacted the nature of team functioning and interprofessional practice in the clinical setting.⁶⁷ Asynchronous communication and coordination of care via the EHR have been used widely in response to COVID-19 challenges and may have altered staff perceptions regarding the value of the EHR for such uses. For example, users may place a higher value on comprehensive clinical documentation or EHR messaging systems when they are less able to exchange clinical information through face-to-face meetings or handover. The adjustments to interprofessional practice in the COVID-19 era have been necessary short-term measures to protect the health of both staff and patients, however, long-term impacts to health care teams and ultimately patient care are yet to be determined.

Future Considerations

Ultimately, the goal of health care lies within the quadruple aim of achieving optimal patient outcomes, patient satisfaction, and clinician satisfaction at a reduced cost.⁶⁸ The revision from the triple aim to the quadruple aim of health care proposed the additional important element of clinician satisfaction.⁶⁹ This was considered essential as the effective-ness of health care organizations relies on their workforce, which Sikka et al⁶⁹ describes as "an engaged and productive workforce." The key to clinician engagement is finding joy and meaning in work and many studies have lamented the

growing increase of clinician burnout, especially evident throughout the digital transformation of health care and throughout the COVID-19 pandemic.⁷⁰⁻⁷³ Evidence shows that teamwork plays an important role in reducing clinician burnout and promoting clinician well-being,^{65,71,74-76} in addition to achieving optimal patient outcomes,^{6,77-79} patient satisfaction,⁸⁰ and efficiency⁸¹ in line with the "quadruple aim" of health care.⁶⁹ As the use of EHRs becomes more ubiquitous in daily clinical practice, the link between teamwork and clinician satisfaction cannot be overlooked.

The inconsistency and ambiguity of definitions of interprofessional practice in the literature has made it challenging to identify the overall impact of the EHR on interprofessional practice.^{12,82} There is a need for hospital environments to evaluate where efficiency can be achieved through use of EHRs and where face-to-face teamwork is essential to achieve integrated care. We cannot simply substitute the interaction of teams from face-to-face to digital, and there is a need to consider the context in which interprofessional tasks are performed. Where clinical work is more complex, time constrained and interdependent, the notion of teamwork seems more important, and EHR enhancements may not be the answer to improving interprofessional practice in this case. Future studies should aim to utilize a common definition of interprofessional practice with agreed upon outcome measures and rigorous study designs.¹⁸

Limitations

Limitations of this study include the heterogeneity of outcome measures and study designs and therefore inability for meta-analysis of results. Additionally, as definitions of interprofessional practice in the literature are still ambiguous, our search terms may not encompass all available studies on this topic. Our study aimed to integrate the effect of an EHR on interprofessional components such as communication, coordination, collaboration, and teamwork. This viewpoint reflects the complex nature of teams within a hospital environment and the complexity of implementation of digital health interventions. However, in this review, not all studies incorporated whole interdisciplinary teams; interprofessional practice was mainly studied amongst the medicine and nursing professions with only few studies including the viewpoints of allied health practitioners in addition.^{49,50,53–55,62} Therefore, studies within this review may not represent a true interdisciplinary depiction of teams within a clinical setting. In selecting publications for inclusion within the systematic review, the EHR was required to be the main intervention. There is a possibility that studies investigating process enhancements of an EHR have been published, however, not directly described as a result of the EHR resulting in selection bias, however, dual screening and the broad search terms reduce this potential. Additionally, when critically evaluating study quality and coding of publications, some subjectivity of results were inevitable. Results and constructs gathered from this study were based on heterogenous outcome measures and relatively small sample sizes.^{48,49,51,59,61} The majority of publications in this study were observational and of poor research quality.

Conclusion

Interprofessional practice is widely considered an essential element of high quality patient care,^{6,25} yet research remains limited into the effect of the EHR on the way interprofessional teams function. Our study demonstrates mixed findings on the impact of the EHR/EHR enhancements on aspects of interprofessional practice including communication, coordination, collaboration, and teamwork. EHR enhancements showed more positive results in the ability to communicate (sharing of information, visibility of information, closed-loop feedback) and coordinate (decision support and reduced workflow disruptions) patient care. The impact of the EHR/EHR enhancements on other components of interprofessional practice such as collaboration and teamwork remains understudied.

Clinical Relevance Statement

This systematic review summarizes existing research into how the EHR and EHR enhancements impact interprofessional practice in the hospital environment. Clinicians should be encouraged to use digital health technologies such as the EHR to their advantage in communicating and coordinating patient care. Findings from this review demonstrate that the EHR can be used to promote interprofessional practice, however, continuing to encourage elements of teamwork through face to face interactions remains important in a digitally evolving environment.

Multiple Choice Questions

- 1. The most commonly studied areas of interprofessional practice in the context of the Electronic Health Record (EHR) include?
 - a. Communication and teamwork.
 - b. Communication and coordination.
 - c. Communication, coordination, collaboration, and teamwork.
 - d. Coordination and teamwork.

Correct Answer: The correct answer is option b. This study shows that the effects of the EHR and/or EHR enhancements have been more frequently studied within the areas of communication and coordination. Few studies within this review have demonstrated the use of EHR/EHR enhancement to promote interprofessional collaboration or teamwork.

- 2. EHR and EHR enhancements have impacted interprofessional practice in what way?
 - a. Positive impact on interprofessional practice.
 - b. Negative impact on interprofessional practice.
 - c. Both positive and negative impact on interprofessional practice.
 - d. No impact on interprofessional practice.

Correct Answer: The answer is option c. This review demonstrated mixed findings on the impact of interpro-

fessional practice in the areas of sharing of information, visibility of information, real time feedback, decision support, and reduced disruption to clinical workflows.

Protection of Human and Animal Subjects

No human subjects were involved in this study.

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Conflict of Interest

None declared.

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Appendix

Terms translated to other databases		
Concept 1	Concept 2	Concept 3
"Electronic health records" [MESH] OR "Electronic Health Records" [tiab] OR "Electronic Medical Records" [tiab] OR "Electronic Health Record"" [tiab] OR "Electronic Medical Record"" [tiab] OR "Computerised Health Record"" [tiab] OR "Computerised Medical Record"" [tiab] OR "Computerized Health Record"" [tiab] OR "Computerized Medical Record"" [tiab] OR "EHR" [tiab]	"Interprofessional relations" [MESH] OR "interdisciplinary communication" [MESH] OR "Inter-professional" [tiab] OR "Interprofessional" [tiab] OR "Interdisciplinary" [tiab] OR "Inter- disciplinary" [tiab] OR "Multi-disciplinary" [tiab] OR "Multidisciplinary" [tiab] OR "collaboration" [tiab] OR "communication" [tiab] OR "teamwork" [tiab] OR "Interprofessional collaborative practice"	"Personnel, hospital" [MESH] OR "Acute" [tiab] OR "inpatient" [tiab] OR "ward"" [tiab]

Intervention	EHR or enhancement	Author/ Year	Outcome 1 (communication)	Outcome 2 (coordination)	Outcome 3 (collaboration)	Outcome 4 (teamwork)
EHR-integrated rounding report tool (RRT)	Enhancement	Abraham et al 2019	+ + 2			
Large customizable interactive monitor (LCIM)	Enhancement	Asan et al 2018	+	ζ		
Computerized physician order entry (CPOE)	EHR	Ash et al 2003	+	1		
Electronic Task Management (ETM) system	Enhancement	Cheng and South 2020	+ + 2			
"Microblog" messaging platform	Enhancement	Dalal et al 2017	++111	+	+	
Colposcopy Information System (CIS)	Enhancement	Goldman et al 2012	+ + 1	1		
Electronic Patient Record (EPR)	EHR	Hertzum and Simonsen 2008		+ + 2		
Computerized Clinical Care Pathway	Enhancement	Hyde and Murphy 2012	+ +			+
Electronic Medical Record (EMR)	EHR	Lloyd et al 2021	+		+	
Electronic Medical Record (EMR)	EHR	Morrison et al 2008	2 2		2	
IT/ EHR	EHR	Munoz et al 2014	1 2	1 1		
eSignout (electronic handover tool)	Enhancement	Nelson et al 2017	+	+	+	+
EHR prompt for present on admission (POA) Pressure Ulcers	Enhancement	Rogers et al 2013	Results excluded as inconclusive			
Health Information Technology (HIT)	EHR	Samal et al 2016	2	+++ 1		
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Intervention	EHR or enhancement	Author/ Year	Outcome 1 (communication)	Outcome 2 (coordination)	Outcome 3 (collaboration)	Outcome 4 (teamwork)
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Electronic signout incorporated into EHR	Enhancement	Sidlow and Katz-Sidlow 2006	+	+		
Electronic Patient Records (EPR)	EHR	Varpio et al 2009	I		I	
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Clinical Information System (CIS)	EHR	Ward et al 2012	Z			
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Ward et al 2012	22	52		2	2	3	0	2	2	2	2	-	-	1	2	1	-	0	2
Varpio et al 2009	34	81		3	3	3	3	2	я	3	2	1	1	3	3	3	3	0	0
Sidlow and Katz-Sidlow 2006	12	29		0	1	2	0	1	1	0	2	-	0	I	1	0	I	2	1
Samal et al 2016	33	79		2	3	3	2	-	3	2	3	1	I	2	3	2	2	2	m
Rogers et al 2013	12	29		0	2	3	0	1	1	1	0	0	2	1	1	0	I	0	-
Nelson et al 2017	19	45		0	3	2	0	1	3	1	1	I	1	2	2	2	0	0	2
Munoz et al 2014	15	36		0	1	3	1	2	1	1	1	0	-	2	1	0	0	0	-
Morrison et al 2008	19	45		3	2	2	0	1	1	3	1	1	1	2	0	2	1	1	0
Lloyd et al 2021	28	67		1	1	3	0	1	3	3	3	e	2	1	2	2	1	1	e
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and F 2008 N	0,	2		0	-	-	1	-	-	-	0	-	0		0	-	-	-	0
Hertzum s Simonsen	23	48		0	3	3	0	1	£	2	2	1	m	1	1	1	0	0	2
Goldman et al 2012	21	44		0	3	3	1	2	e	1	2	0	-	2	2	0	0	0	-
Dalal et al 2017	23	55		0	2	3	0	2	1	2	1	2	2	1	3	1	I	1	e
Cheng and South 2020	19	45		0	3	2	0	3	2	0	2	0	2	1	3	0	I	0	2
Ash et al 2003	35	83		3	3	3	2	2	ε	3	2	1	1	ĸ	3	3	3	0	2
Asan et al 2018	38	79		0	£	3	0	£	£	3	2	m	m	ñ	3	3	£	0	e
Abraham et al 2019	33	69		0	3	3	0	2	ε	1	3	2	£	2	3	3	e	0	2
Study ID (Author, Year)	Total score	%	Criteria	Explicit theoretical framework	Statement of aims/objectives in main body of report	Clear description of research setting	Evidence of sample size considered in terms of analysis	Representative sample target group of reasonable size	Description of procedure for data collection	Rationale for choice of data collection tool(s)	Detailed recruitment data	Statistical assessment of reliability and validity of measurement tool(s) (Quantitative only)	Fit between stated research question and method of data collection (Quantitative only)	Fit between research question and format and content of data collection tool (Qualitative only)	Fit between research question and method of analysis	Good justification for analytic method selected	Assessment of reliability of analytic process (Qualitative only)	Evidence of user involvement in design	Strengths and limitations critically discussed