Journal of HOSPITAL MEDICINE www.journalofhospitalmedicine.com

REVIEWS

Review of Computerized Physician Handoff Tools for Improving the Quality of Patient Care

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BACKGROUND: Computerized physician handoff tools (CHTs) are designed to allow distributed access and synchronous archiving of patient information via Internet protocols. However, their impact on the quality of physician handoff, patient care, and physician work efficiency have not been extensively analyzed.

METHODS: We searched MEDLINE, PUBMED, EMBASE, CINAHL, the Cochrane database for systematic reviews, and the Cochrane central register for clinical trials, from January 1960 to December 2011. We selected all articles that reported randomized controlled trials, controlled clinical trials, controlled before–after studies, and quasi-experimental studies of the use of CHTs for physician handoff for hospitalized patients. Relevant studies were evaluated independently for their eligibility for inclusion by 2 individuals in a 2-stage process.

RESULTS: The literature search identified 1026 citations of which 6 satisfied the inclusion criteria. One study was a randomized controlled trial, whereas 5 were controlled before–after studies. Two studies showed that using CHTs reduced adverse events and missing patients. Three studies demonstrated improved overall quality of handoff after CHT implementation. One study suggested that CHTs could potentially enhance work efficiency and continuity of care during physician handoff. Conflicting impacts on consistency of handoff were found in 2 studies.

CONCLUSIONS: The evidence that CHTs improve physician handoff and quality of hospitalized patient care is limited. CHT may improve the efficiency of physician work, reduce adverse events, and increase the completeness of physician handoffs. However, further evaluation using rigorous study designs is needed. *Journal of Hospital Medicine* 2013;8:456–463 © 2012 Society of Hospital Medicine

Physician handoff is a common and essential component of daily patient care that includes transfer of important clinical patient information and accountability of patient care. Thus, high-quality physician handoffs are crucial to ensure patient safety and continuity of patient care, especially with the new resident work hour restriction in North America.[1,2] As such, healthcare organizations including the World Health Organization[3] have issued specific goals and organizational challenges to "improve the effectiveness and coordination of communication among the care/service providers and with the recipients of care/service across the continuum" in healthcare.[4,5]

It has been well-documented that physician handoffs in hospital settings are often unstructured and not standardized, which leads to medical errors and jeopardizes patient safety.[2,6–12] This lack of standardization of physician handoff for hospitalized patients occurs in every major in-hospital service and affects trainees and staff.[2,6,7,9,10,12,13] It has been demonstrated in healthcare and in other domains that a standardized handoff protocol that involves both verbal communication and written handoff documents is likely to be an effective method of handoff to decrease miscommunication and associated errors.[14–17] Computerized physician handoff tools (CHTs) have been increasingly deployed to address these challenges and have quickly gained popularity among physicians for documenting patient information during physician handoff for hospitalized patients.[18] CHTs can be an complementary part of electronic medical record (EMR) systems, but not a substitute since their focus is to deliver concise and essential information vital for patient care during interfaces of patient care.

Two recent systematic reviews have examined information technology (IT) systems to promote the handoff process in healthcare.[17,19] However, to our knowledge, there has not been a systematic review of the potential role of CHT in physician handoff and quality of patient care for hospitalized patients. We therefore conducted a systematic review to examine the current evidence for CHTs in physician handoff for hospitalized patients, focusing specifically on potential effects on continuity of patient care, physician work efficiency, quality of handoffs, and patient outcomes.

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Additional Supporting Information may be found in the online version of this article.

Received: March 12, 2012; **Revised:** August 27, 2012; **Accepted:** September 19, 2012
2012 Society of Hospital Medicine DOI 10.1002/jhm.1988
Published online in Wiley Online Library (Wileyonlinelibrary.com).

METHODS

Criteria for Considering Eligible Studies

We included randomized controlled trials, controlled clinical trial, quasi-experimental studies, and controlled before–after studies that evaluated CHTs during physician handoff of hospitalized patients. Studies needed to report patient outcomes (adverse events, missing patients at rounds, or in-hospital mortality), physician work efficiency, quality of handoff (accuracy, consistency, or completeness), continuity of care, or physician satisfaction. Articles that met all these inclusion criteria were considered to be eligible for the review. We excluded review articles, commentaries, case reports, and retrospective studies.

Search Strategy

CHTs were defined as computer-based platforms, designed specifically for the purpose of physician handoff, to allow distributed access and synchronous archiving of patient information via Internet protocols (ie, electronic tool to allow physician data access and data entry for handoff from different computers at multiple locations within the authorized hospitals or clinics). A search strategy was developed based on a MEDLINE search format combined with our inclusion criteria and with this definition of CHTs. We used search terms related to physician communication and information technology, and relevant Medical Subjects Headings, which include handover, handoff, signoff, sign-over, off-duty, post-call, computerized, Web-based, communication tool. The databases, including MEDLINE, PUBMED, EMBASE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane database for systematic reviews, and the Cochrane CENTRAL register of controlled trials, were initially searched from 1985 to December 2011 in all languages. The Cochrane Collaboration filter for controlled interventional studies was used to select the above-mentioned interventional trial designs. In addition, the first 2 authors hand searched the references of included articles and relevant systematic reviews.

Screening for Eligible Studies

All articles identified in the database searches described above were included for screening in 2 stages. First, 2 reviewers (P.L., S.A.) independently reviewed the title and abstracts of the identified articles for eligibility. The articles selected in the first stage of screening were then further assessed by a full-text review independently by the 2 reviewers. Any discrepancy was resolved by consensus or by involvement of a third reviewer (C.T.).

Data Abstraction and Analysis

Data abstraction from selected studies was conducted independently by 3 authors based on a predefined template. All discrepancies in this stage were resolved by consensus among the 3 authors. For each study, we analyzed study design, data collection, intervention, main outcomes, and components of physician handoffs in the study. Due to heterogeneity of study outcomes, measures used, and results, a meta-analysis was not performed. Study outcomes, which included adverse events, missing patients at rounds, time spent on rounding patient, accuracy, consistency or completeness of handoff information, and continuity of care, were summarized.

RESULTS

Study Selection

A total of 1026 citations were identified in the initial search, of which 1006 studies did not evaluate CHT and were excluded by title and abstract screening. Of the 20 studies evaluated further by full-text review, 5 were selected for the final analysis. One additional study was identified by hand searching references. The kappa score of inter-reviewer agreement on article selection in the first stage of screening was 0.7, and for the second stage of article selection, kappa was 1.0. The reasons for exclusion in the second selection step are presented in Figure 1.

Study Characteristics

Of the 6 studies identified, 1 study was a randomized controlled trial[20] and the other 5 were controlled before–after studies.[21–25] All studies were conducted in teaching hospitals in English-speaking high-income countries. All were single-center studies, except the study by Van Eaton et[20] that involved 2 centers. All the studies investigated physician handoffs conducted by trainees. Two studies included staff physicians.[22,24] Van Eaton et al's study included general medical, general surgical, and subspecialty surgical services.[20] The other 5 studies assessed physician handoffs in family medicine,[25] internal medicine services,[21,23] a surgical service,[22] and a neonatal intensive care unit.[24] The study by Van Eaton et al[20] enrolled the largest study population. The intervention or observation phase ranged from 1 month[20] to 6 months[24] (Table 1).

CHT Characteristics

Three CHTs were standalone applications designed specifically for physician handoffs.[20,22,25] The other 3 CHTs were add-on functions to existing hospital Electric Medical Record (EMR) systems.[21,23,24] All CHTs except one[25] interfaced with existing EMR systems, allowing for variable degrees of data transfer depending on CHT design and the functionalities of the EMR systems. CHT users were actively involved in designing and modifying the CHTs in most of the studies.[20,21,23,25] The characteristics of the CHTs were summarized in Table 2.

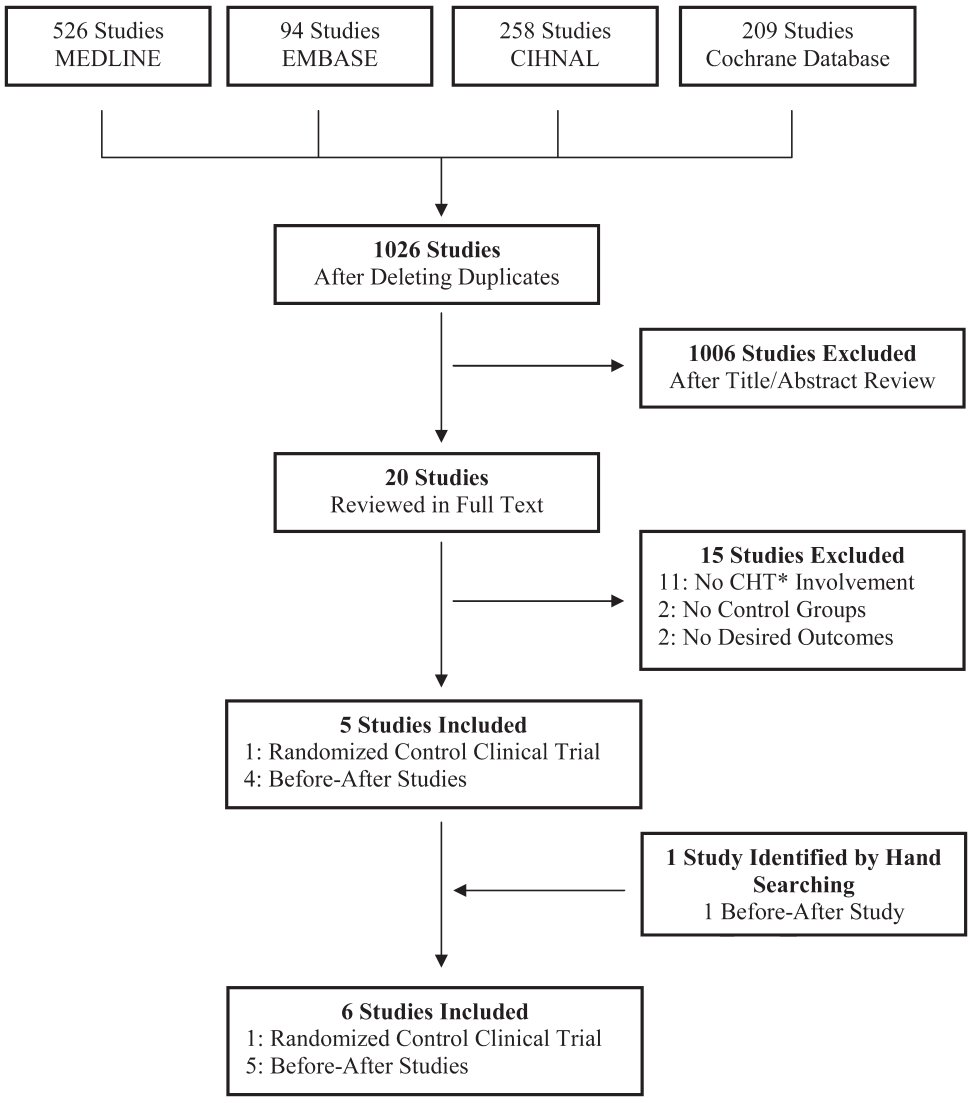

FIG. 1. Flow chart of study inclusion.

CHT's Impact on Adverse Events

The impact of CHTs on preventable adverse events was evaluated in a single study by Peterson et al.[21] The authors defined an adverse event as an injury due to medical treatment which prolonged hospital stay or produced disability at discharge in the study. Preventability was determined by using a 6-point scale and assessed independently by 3 reviewers. Fewer adverse events were found after implementation of CHTs (2.38% vs 3.94%, $P < 0.001$). They also reported nonsignificant reductions in preventable adverse events (1.23% vs 1.72%, $P < 0.1$) with implementation of the CHT, and preventable adverse events during cross-coverage (0.24% vs 0.38%, $P > 0.10$). The odds ratio for a patient experiencing a preventable adverse event during cross-coverage compared to non–cross-coverage time was reduced from 5.2 (95% confidence interval [CI], 1.5–18.2) to 1.5 (95% CI, 0.2–9.0) following implementation of the CHT (Table 3).

CHT's Impact on Physician Work Efficiency

Van Eaton et al's study examined the effect of CHTs on physician work efficiency.[20] Improved physician work efficiency was found following implementation of CHT. Self-reported time spent on hand-copying patient information was reduced by 50%, while the portion of time spent on seeing patients during pre-rounding increased. Similarly, self-reported time spent on each patient during rounding (routine patient assessment by the primary team) was decreased by 1.5 minutes. Overall, resident physicians subjectively reported an average time saving of 45 minutes daily for junior residents and 30 minutes for senior residents, and 81% of residents reported finishing their

TABLE 1. Study Characteristics Included in the Review

Study	Design	Setting	Target Services	Intervention Group	Control Group	Data Collection and Validation
Ram and Block[25] (1992)	Before–after study	150-bed urban hospital in USA	Family MedicineResidents (N = 7)	Patient no. not reported1 mo of interventionNo CHT training prior to the intervention reported	Patient no. not reportedTraditional handoff note (on index card or previous list)Components of handoff note not reported	QuestionnaireNo data validation
Peterson et al[21] (1998)	Before–after study	720-bed tertiary care hospital in USA	All Internal MedicineServicesResidents (N = 99)	3747 patients4 mo of intervention8 wk of run-in period	1874 patientsHandwritten handoffComponents of handoff note not reported	Self-report using e-mail, report card, in personchart review for unreported adverse events in 250 samples
Van Eaton et al[20] (2005)	Randomized cross-over trial	450-bed tertiary care hospital and a 368-bed trauma center in USA	General Medicine, General Surgery, and Subspecialties TraumaResidents (N = 7 teams)	8018 patients14 wk of randomized crossover period6 wk of run-in period	7569 patientsIndividual written lists, cards, a team-developed computer-generated spreadsheetComponents of handoff note not reported	Telephone interview and anonymous online surveyNo validation of data
Cheah et al[22] (2005)	Before–sfter atudy	A 400-bed regional teaching hospital in Australia	General SurgeryRegistrars and Residents (N = 7–14)	Patient no. not reported3 mo of observation period (for weekend coverage only)No CHT training prior to the intervention reported	Patient no. not reportedNo description of pre-intervention handoff method reported	In-person interview and surveyNo validation of data
Flanagan et al[23] (2009)	Before–sfter atudy	Tertiary care hospital in USA	Internal Medicine, Medical Intensive Care UnitFirst-year Residents(N = 35)	1264 patient handoff forms1 mo of observationOrientation session and 1 cross-over shift of run-in period	Patient no. not reportedNo description of pre-CHT implementation handoff method reported	In-person interview and surveyNo validation of data
Palma et al[24] (2011)	Before–after study	304-bed quaternary care women and children hospital in USA	NICUAttendings, Residents, Nursing staffs (N = 46–52)	Patient no. not reported6 mo of intervention of NICU handoff toolInstruction document by e-mail and informal instructional session	Patient no. not reportedA Microsoft-based standalone handoff tool or EMR integrated Medical/Surgical handoff toolComponents of handoff note not reported	Online surveyNo validation of data

Abbreviations: CHT, computerized physician handoff tool; EMR, electronic medical record; NICU, neonatal intensive care unit.

TABLE 2. Characteristics of CHTs

Study	CHT Design	EMR Interface	Physician Daily Progress Note	Participants' Role in CHT Design	Components of CHT	Components That Require Manual Input
Ram and Block[25] (1992)	Standalone application	No interface	Paper-based	Designing	Patient demographicsMedicationsDiagnosisProblem listsComment line	All the information
Peterson et al[21] (1998)	A part of existing EMR	Bi-directional interface	Paper-based	Designing	Patient demographicsCurrent medicationAllergyCode statusRecent lab valueA problem listA ''to do'' list	A problem listA ''to do'' list
Van Eaton et al[20] (2005)	Standalone application	Uni-directional interface (data input from hospital IT system)	Electronic-based	Designing and modifying	Patient demographics DiagnosisMedicationAllergyVital signsLab and investigationA problem listA ''to do'' list	DiagnosisMedicationA problem listA ''to do'' list
Cheah et al[22] (2005)	Standalone application	Uni-directional interface (data input from hospital IT system)	Electronic-based	No	Patient demographics DiagnosisLength of stayRecent investigationsFree-text note(Not standardized)	Free-text note
Flanagan et al[23] (2009)	A part of existing EMR	Uni-directional interface (data input from hospital IT system)	Electronic-based	Evaluating and modifying	Patient demographics MedicationAllergyLab and investigationPhysician daily noteFree-text note (not standardized)	Free-text note (may contain assessment, a problem list, venous access, short-term concerns and long-term plan, and follow-up tasks)
Palma et al[24] (2011)	A part of existing EMR	Uni-directional interface (data input from hospital IT system)	Paper-based	No	Patient demographics Lab and measurementFree-text note (not standardized)	Free-text note (including patient description, active medical issues, ongoing care and a ''to do'' list)

Abbreviations: CHT, computerized physician handoff tool; EMR, electronic medical record; IT, information technology.

TABLE 3. Description of Study Outcomes and Recommendations for CHT

Study	Outcomes of Interest	Results	Implication for CHT Design and Use
Ram and Block[25] (1992)	Physician satisfactionImportance and accessibility of clinical information	Improved physician satisfactionHandoff documentation more legible, more consistent, and more comprehensiveInformation required to be typed in by residents and not up-to-date	The most important data for handoff: a ''to do'' list and code statusA CHT interfaced with hospital IT system, and in a format that can focus on physician needs
Petersen et al[21] (1998)	Adverse event ratePreventable adverse events rate	Fewer adverse events (2.38% vs 3.94%, $P < 0.001$)Fewer preventable adverse events (1.23% vs 1.72%, $P < 0.1$)Few preventable adverse events during cross-coverage (0.24% vs 0.38%, $P > 0.10$)Lower OR of preventable adverse events during cross-coverage (1.5; 95% CI 0.2–9.0 vs 5.2; 95% CI 1.5–8.2)	Active involvement in the design of CHT by house staff likely contributes to high participation and CHT use rate in the study
Van Eaton et al[20] (2005)	No. of patients missed on roundsPerception on continuity of care quality and workflow efficiencyDaily self-reported pre-rounding and rounding times and tasks	Reduced the no. of patients missed on rounds (2.5 patients/team/mo) ($P = 0.0001$)Spent 40% more time with patients at pre-roundsReduced time on team rounds by 1.5 min per patientReduced time on manual copying at pre-rounding by 50%Improved handoff qualityImproved continuity of careNo reduction of overall pre-rounding time	The largest benefit from CHTs varies between clinical services, from more time assessing patients before rounds in Internal Medicine to reduced backtracking and locating patients in Surgery
Cheah et al[22] (2005)	Completeness and usefulness of handoff informationDesirability of electronic handoff system	Identified information set for handoffFree text entry in CHT often deficient in particular patient informationConcerns of the completeness and consistency of information delivered in CHT	CHT needs to be linked to hospital information system
Flanagan et al[23] (2009)	Common data elements of interest extracted during physician handoffMissing data required during handoffPhysicians' perception of CHT	Additional important information needed that not included during handoff in 25% cases	Code status, relevant lab data, short-term concerns, a problem list, and a ''if-then'' list should be included in CHT templateA standard form reduces variability of handoff information
Palma et al[24] (2011)	Accuracy of handoff informationHealthcare provider satisfaction	Improved perceived accuracy of handoff information (91% vs 78%, $P < 0.01$)Improved satisfaction with handoff process (71% vs 35%, $P < 0.01$)Improved satisfaction with handoff documents (98% vs 91%, $P < 0.01$)More time spent on updating handoff information (16–20 min vs 11–15 min, $P = 0.03$)	A discipline-specific handoff tool results in perceived handoff accuracy and satisfactionA more efficient handoff tool can be achieved by more extensive data transfer from hospital IT system

Abbreviations: CHT, computerized physician handoff tool; IT, information technology.

work sooner when using CHTs. Although no data were reported in the pre-CHT period described in the study by Cheah et al, they indicated that work efficiency was felt to be improved because all physicians could locate their patients quickly and were pleased to be able to check patients' lab results in the CHT.[22] Conversely, Palma et al and Ram and Block reported perceived increased work load with CHTs by users due to time spent updating handoff information.[24,25]

CHT's Impact on Quality of Physician Handoff

Overall quality of physician handoff and completeness of the handoff document was improved in 3 studies.[20,24,25] Flanagan et al reported that patient identifiers and medications were extracted most of the time.[23] However, there were concerns regarding consistency,[22] completeness[22,23] of information provided during physician handoff using CHTs. Palma et al's and Ram and Block's studies[24,25] commented on the accuracy of patient information communicated during physician handoff. While Ram and Block's study suggested that it may be poorer during the intervention period,[25] Palma et al's study found improved perceived accuracy of handoff information postimplementation of a CHT (98% vs 91%, $P < 0.01$).[24]

CHT's Impact on Continuity of Patient Care

Using CHTs was associated with a decreased number of patients missed on rounds after handoff (new admitted patients who were not assessed by the primary team in the morning rounds because cross-covering physicians did not inform the primary team) in Van Eaton et al's study.[20] On the other hand, Cheah et al[22] reported that documented handoffs after physicians returned to duty occurred on 50% of patients who had experienced important clinical events on weekends.

DISCUSSION

Our systematic review identified 6 controlled studies of CHT. Outcome parameters reported in these studies included quality of the handoff (including completeness, accuracy, and consistency), physician time management, continuity of care, adverse events, and missed patients. Our results suggest that while CHT are a promising tool, further evaluation using rigorous study methodologies is needed. These findings are somewhat surprising given increasing popularity of CHTs in daily patient care.[19,24,26–28] This might be due to the fact that IT adoption and use in healthcare is still in a phase of relative infancy,[29] and that the success of adopting IT systems in healthcare depends on various factors.[30]

Roles of CHT in Physician Handoff for Hospitalized Patients

Our study indicates that CHT can potentially improve continuity of patient care by reducing the number of

''missing'' patients during rounds following handoff,[20] and similarly improve patient safety by decreasing adverse events and preventable adverse events.[21] Of note, users reported that they were able to spend more time with patients during pre-rounding[20] which will likely enhance quality and continuity of patient care. However, it is unclear whether these improvements translate into better patient outcomes. Although Peterson et al attempted to minimize the risk of bias by using anonymous reporting and blinding participants to the timing of data collection,[21] adverse events during the intervention period could have been underestimated due to surveillance bias or decreased self-reporting. Nevertheless, the results suggest that CHTs may have affected quality of patient care in a positive manner from included studies.

The findings from our review also point to a positive impact of CHT on physician work efficiency. Specifically, residents spent less time rounding on patients after handoff and finished their work sooner after introduction of the intervention.[20] Several other published studies on CHT also indicated potential benefits on work efficiency and/or patient safety,[31,33–35] although they did not meet the inclusion criteria for our study (prespecified outcomes not reported,[31,35] or study design[33–35]). In the studies in which the majority of handoff information was manually typed in the CHT, the work load was perceived to be increased with CHT implementation.[24,25] On the other hand, the study conducted by Van Eaton et al demonstrated that a CHT that had broad integration with the hospital main IT system, and could automatically transfer important patient information such as medication, medical problems, recent investigation, and vital signs into CHT, quickly gained popularity among residents and staff due to its user-friendly features.[20] This integration can also potentially reduce miscommunication and associated medical errors during physician handoff. Palma et al's study reported higher perceived workload due to manual entry of patient data.[24] Although the CHT used in their study was developed within their existing EMR system, large amounts of information needed to be manually imputed, and thus increased time spent on updating handoff information. This information included patient demographics, active medical issues, a ''''to do'' list, and on-going issues,[24] some of which could be imputed automatically with better CHT design. It is also possible that users spent more time in updating the handoff because they were able to deliver more information using a CHT.[24] However, this may allow cross-covering physicians to spend less time on looking for patient information from other sources and thus actually decrease workload during cross-coverage. Although there are numerous factors that could affect physician work efficiency when using a new IT system,[30] it was felt that a well-designed and easy-to-use CHT that is integrated with the hospital information system can improve physician productivity.

The role of CHT in improving quality of handoff is less clear. Three studies[20,24,25] found an overall improvement in the quality of handoff after implementation of CHT, such that the handoff information was more complete and more consistent. On the other hand, physicians were concerned about the comprehensiveness of physician handoff after implementation of CHT in 2 studies.[22,23] In Ram and Block's study,[25] physicians relied heavily on an unstructured free-text entry system to deliver the majority of patient information that physicians thought to be important. In Flanagan et al's study,[23] resident physicians had to search for alternative sources, such as patient charts and electronic order systems, to obtain vital information in many cases in spite of a structured CHT. As a result, the information available was often not sufficient to help on-call physicians make patient care decisions.[23]

Implication of CHT Design and Use

It has been demonstrated in many non-healthcare domains,[15,36,37] as well as nursing care,[38] that a standardized handoff protocol is vital to decrease medical errors and improve patient safety. In our review, we found that physicians generally reported being satisfied with the accuracy of handoff information and the overall handoff when using standardized CHTs interfaced with hospital IT systems. This suggests, as recommended by Flanagan et al,[23] Palma et al,[24] and Ram and Block[25] that CHTs be developed with a standardized protocol and wide integration into hospital IT systems.

In order to achieve this goal, key patient information necessary for patient care need to be communicated during physician handoff. As hospitals consist of a wide range of disciplines and specialties with varying cultures and focuses of patient information, it is likely difficult to develop a single ''panacea'' CHT template for all the in-hospital services.[1] This may be even particularly relevant when developing CHTs for different hospital services. However, some patient information appears to be universally important for physician handoff for inpatient care. Key elements, such as patient demographics, diagnosis, outstanding investigation results, code status, a ''problem'' list, and a ''to do'' list, were noted to be consistently present in the CHTs that were evaluated in our review (Table 2). Other studies have also demonstrated that information items such as a ''to do'' list, outstanding investigation results, and patients' code status were regarded as the most important information during physician handoff.[1,2,17,23,39,40] Based on these findings, a potential solution for CHT standardization would be to develop a core CHT which includes the universally important components of physician handoff identified in this review, and provides options for adding well-categorized service-specific information as needed (eg, type and date of surgical procedures for

surgical patients). It also appears that active involvement of physicians in CHT design and modification facilitates successful implementation of CHT, as demonstrated in Van Eaton et al's and Peterson et al's studies.[20,21]

It is difficult to recommend metrics for CHT evaluation based on the limited literature identified in our review. However, it appears to be reasonable to consider integration into existing IT system, "user friendly" features, impact on quality of handoff documents, work efficiency, and processes and outcomes of patient care when assessing CHTs.

Limitations

There are several limitations in the studies included in our review. None of the studies were multi-centered. The majority of the included studies had a before–after design.[21–25] Some studies did not have user training or a "run in" period to ensure familiarity of CHTs by users.[22,24,25] None of the studies described the key components of handoff in the control groups, or used quality control measurements for user familiarity with the CHTs. Furthermore, outcomes reported by the studies were heterogeneous, subjective, based on participant self-report, and not independently validated.

Our review also has also several limitations. First, in spite of a comprehensive search effort, it is possible that we failed to identify all relevant articles. However, this is unlikely, given that we searched multiple databases and performed hand searches of all references identified from the included articles, as well as content-related previously published systematic reviews. Second, we were not able to perform a meta-analysis, given the heterogeneity seen in outcomes assessed across studies, measures applied, and results presented.

CONCLUSIONS AND IMPLICATIONS FOR PRACTICE

Although the current literature suggests that implementation of CHTs is likely to improve physician work efficiency, satisfaction, and quality of patient care during physician handoff for hospitalized patients, the evidence supporting these potential benefits is limited. Furthermore, it is unknown what impacts CHTs may have on clinical outcomes, such as hospital length of stay and mortality. Further studies with larger sample size, multiple center involvement, and more objective patient outcome measurements are therefore needed to evaluate the roles of CHTs in physician handoff and improving the quality of patient care.

In the absence of larger studies evaluating major clinical outcomes, such as length of stay and mortality, hospitals considering innovations in the domain of computerized platforms for physician handoffs will need to consider the pros and cons of immediate system implementation on the basis of the evidence presented here versus waiting until there is more evidence from more definitive studies. In addition, our study suggests that organizations engage physicians during CHT design and develop a standardized CHT protocol that is interfaced with hospital IT systems and includes key components of handoff information, but provides flexibility to meet service-specific needs. The evidence summarized here, while far from definitive for major outcomes, is nonetheless rather positive for the general benefits of CHT–an impetus for careful design, implementation, and modification, whenever and wherever possible. Any such system implementations should, however, incorporate an evaluative component so that the evidence-base surrounding CHT can be enhanced.

Disclosure: Nothing to report.

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