

Grant Final Report

Grant ID: 5R01HS015084

Value of Technology to Transfer Discharge Information

Inclusive Dates: 09/01/04 – 08/31/07

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Submitted to:

The Agency for Healthcare Research and Quality (AHRQ)

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Abstract

Purpose: The objective was to measure effects of a discharge software application of computerized physician order entry (CPOE).

Scope: Discharge communication between inpatient and outpatient physicians is error-prone. Adverse events result from poor discharge communication. The value of discharge software to improve clinically relevant outcomes is unknown. We studied discharge software at a teaching hospital. Participants were internal medicine hospitalist physicians and patients who had high probability of readmission.

Methods: The design was cluster-randomized, controlled, with discharging hospitalist as unit of randomization and with allocation concealment. The intervention was discharge software with CPOE versus usual care (handwritten) discharge. Follow-up was 6 months. Database abstraction and blinded interviews assessed patient readmissions, emergency department visits, and adverse events after discharge. Un-blinded interviews or questionnaires measured patient and physician perceptions of discharge.

Results: Hospitalists (n=70) discharged 631 patients to home. When comparing patients assigned to discharge software or usual care, there was no difference in hospital readmission (37.0% vs. 37.8%), emergency department visits (35.4% vs. 40.6%), or adverse events (7.3% vs. 7.3%). Discharge software patients and their outpatient physicians had better perceptions of discharge. Hospitalist users of discharge software reported more effort but no difference in satisfaction with usual care.

Key Words: continuity of patient care, electronic discharge summary, hospital information systems, hospitalists, medical records systems-computerized, medication reconciliation, patient care transitions, patient discharge, health care surveys, patient satisfaction

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Final Report

Purpose

The study objective was to assess the benefit of discharge software when used to discharge patients at high risk for repeat admission. The discharge software was health information technology that utilized computerized physician order entry (CPOE). After an application of discharge software versus handwritten, usual care discharge, we compared the rates of hospital readmission, emergency department visits, and post-discharge adverse events due to medical management. We also compared the discharge interventions from the perspectives of the patient, the discharging hospitalist, the pharmacist, and the outpatient primary care physician.

Scope

Background and Context

The transition from hospital to home is a high-risk period in a patient's illness.(1,2) Poor communication between healthcare providers at hospital discharge is common and contributes to adverse events affecting patients after discharge.(1,3) Medication errors are unintended consequences of inadequate discharge communication processes. Among elderly patients, 64% had at least one medicine not ordered by the discharging physician, 73% of patients failed to use at least one medicine as directed, and 32% of drugs ordered at discharge went unused by the patient.(4) Poor communication also occurs between healthcare providers and patients. Ineffective communication of the discharge plan to the patient has been associated with adverse events after discharge.(5-7)

Discharge communication between the discharging physician and the outpatient physician sometimes fails because hospital processes rely on dictated discharge summaries.(3) The discharge summary is available to the primary care physician at only 8.2% of initial post-hospital visits.(8) No discharge summary was available for any post-hospital visit for 68.4% of patients.(8) Previous investigations found several reasons for failure to communicate via discharge summary. Failure to generate a discharge summary occurred for 20% of post-hospital visits.(8) For 50.8% of patients, the discharge summary was never sent to the follow-up physician.(8) Systematic review reveals the discharge summary is an inefficient and error-prone process for communicating between the discharging physician and outpatient primary care physician.(3)

Is there a Role for Health Information Technology in the Discharge Process? One potential solution to poor discharge communication is health information technology. For our study, we defined discharge software as health information technology designed to 1) facilitate communication of timely, complete, accurate, and legible patient care information among providers and to patients, 2) concurrently capture information useful in quality assurance and

quality improvement activities, and 3) provide simple “just-in-time” prompts and educational resources to physicians, nurses, and patients during the discharge process. Discharge software applies computerized physician order entry (CPOE). By definition, CPOE is a computer-based system that automates direct entry of orders by physicians and ensures standardized, legible, and complete orders.(9) The benefits of CPOE have been tested in other inpatient settings.(9,10) It is logical to consider software applications with CPOE for discharge interventions.(11)

How Might Discharge Software Improve Patient Outcomes? Applications with CPOE decrease medication errors 55-81% and eliminate medication errors due to illegible prescriptions and transcription errors.(9, 12) Discharge software could prompt physicians to enter post-hospital appointment dates. When patients receive a written follow-up appointment during the discharge process, they are more likely to arrive for the appointment.(13) Discharge software could assist discharging physicians to reconcile admission medications with in-hospital changes and with discharge prescriptions. Interventions with medication reconciliation improve concordance between discharge prescriptions and community pharmacy patient profiles and reduce medication errors and adverse events.(14, 15) Discharge software could generate written drug information for patients automatically. The presence of such information improves patient satisfaction and may improve outcomes.(7) While using discharge software, physicians could receive decision support to prompt orders for other indicated interventions like vaccines and aspirin.(16) There are several mechanisms that might explain the potential benefit of discharge software with CPOE.(11)

What Are the Results of Other Studies of Discharge Health Information Technology? Most previous studies have been descriptive or observational. Measured outcomes have included physician satisfaction.(17, 18) Randomized, clinical trials of discharge health information technology report benefits in quality and timeliness of discharge summaries. (<http://www.ahrq.gov/clinic/ptsafety/chap42b.htm#42.3>) There are no randomized, controlled clinical trials with clinically relevant outcomes that have demonstrated a benefit of discharge health information technology.

Setting

To measure the effects of discharge software with CPOE, we performed a clinical trial in a 730-bed, tertiary care, teaching hospital in Central Illinois. The Peoria Institutional Review Board approved the protocol for human research.

Participants

Study participants were internal medicine hospitalist physicians and their patients. Hospitalists and patients enrolled between November 2004 and January 2007. Eligible hospitalists were resident or attending physicians who discharged patients from the general internal medicine service. We excluded hospitalists if their assignment duration was less than two months with the general internal medicine service. Hospitalists with brief assignments were unlikely to accrue sufficient numbers of patients to fill their clusters. After hospitalists gave consent, trained research coordinators screened patients, applied inclusion and exclusion criteria, and obtained informed consent. Research personnel identified all consecutive adult inpatients

who were discharged to home. Patients were eligible to enroll only once in the trial. Patient inclusion required a probability of repeat admission (*Pra*) score greater than or equal to 0.40.(19, 20) The research coordinators calculated the *Pra* within 2 days before discharge from the index hospitalization. The *Pra* score came from a logistic model of age, gender, prior hospitalizations, prior doctor visits, self-rated health status, informal caregiver, and comorbid coronary heart disease and diabetes mellitus.(19, 20) We designed exclusion criteria to produce patient groups with homogenous risk for readmission. For example, we excluded patients if the discharge destination was a nursing home, another acute care hospital, or an inpatient rehabilitation unit. Another example was hospice candidacy. Patients were excluded if life expectancy was less than 6 months as estimated by the hospitalist. Another rationale for exclusion related to the logic of the discharge intervention. If the outpatient primary care physician treated the patient during the index hospitalization, then there was no perceived barrier in physician-to-physician communication and the patient was excluded. Other exclusion criteria pertained if the patient could not participate in outcome ascertainment. For example, we excluded patients for lack of telephone, absence of English or Spanish language skills, or residence outside Central Illinois. Cognitive impairment was a conditional exclusion criterion. We defined cognitive impairment as a score less than 9 on the 10-point clock test.(21) Patients with cognitive impairment could participate only with consent from their legally authorized representative. In addition, we enrolled patients with cognitive impairment only if a proxy spent at least 3 hours daily with the patient and the proxy agreed to answer post discharge interviews.

Methods

Study Design

The trial design was a cluster randomized, controlled trial with blinded outcome assessment. Follow up occurred until 6 months after discharge from index hospitalization. The rationale for our clustered design was to correct the influence of potentially correlated outcomes measured at the patient level. Our rationale also followed the recommendation for cluster designs from a systematic review of discharge interventions.(6) We applied our research intervention at the hospitalist level and measured major outcomes at the patient level. It was not feasible to mask the treatment assignment from the hospitalist or the patient. To minimize the influence of correlated measures, we designed the discharging hospitalist as the unit of randomization. Hospitalists were assigned to discharge software or usual care discharge.

Intervention

The research intervention was a CPOE software application that facilitated communication at the time of hospital discharge. A description of the discharge software intervention was published.(11) In summary, the software helped inpatient physicians transfer timely, complete, and legible information to outpatient physicians, pharmacists, and patients. The software design incorporated principles of CPOE with basic levels of clinical decision support. Features included required fields, pick lists, standard drug doses, alerts, reminders, and online reference

information. Hospitalists used the software on or before the day of discharge to generate four discharge documents. The first document was a personalized letter to the outpatient physician to communicate pertinent features of the hospitalization. Information included discharge diagnoses with codes for International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM). The letter detailed information about changes to the patient's previous medication regimen, diet and activity instructions, patient education materials provided, and follow-up appointments and studies. Because the program prompted the discharging physician to complete all pertinent fields, the theoretical benefit was more complete communication with the outpatient physician. Correspondence was generated in real-time and then downloaded from a server for transmission to the patient's outpatient provider by facsimile. Second, the software printed legible prescriptions along with specific information for the dispensing pharmacist about changes and deletions to the patient's previous regimen. Third, the software generated a summary of instructions for patients including follow-up appointments and studies. The software automatically supplied addresses and telephone numbers for follow-up appointments. Fourth, the software printed a legible discharge order including all aforementioned information.

The control intervention was the usual care discharge process.(11) When performing usual care, physicians and nurses completed handwritten discharge forms on or before the day of discharge. The forms contained blanks for discharge diagnoses, discharge medications, medication instructions, post discharge activities and restrictions, post discharge diet, post discharge diagnostic and therapeutic interventions, and appointments. Patients received a copy of the handwritten discharge instructions on the day of discharge. Ward clerks were expected to send copies of the completed handwritten discharge forms to outpatient primary care physicians via facsimile transmission. Patients were given handwritten copies of the forms, one page of which also included medication instructions and prescriptions. Further details about the usual care intervention and the standard care available to both treatment groups were published.(11)

Randomization

Hospitalists underwent random allocation to discharge software or usual care discharge process. The randomization ratio was 1:1 and the block size was 2. There was no stratification or matching. The unit of randomization was the hospitalist who performed the discharge process. The random allocation was concealed. An investigator who was not involved with hospitalist recruitment generated the randomization sequence with a computerized random number generator. The randomization list was maintained in a secure location. Another investigator who was unaware of the next random assignment performed the hospitalist recruitment and informed consent. After confirming eligibility and obtaining informed consent from hospitalists, the blinded investigator requested the next random assignment from the custodian of the randomization list. Hospitalists subsequently used their randomly assigned process when discharging their patients who enrolled in the study. After random allocation, it was not possible to conceal the test or control intervention from the hospitalists or their patients.

All hospitalists received training on the usual care discharge process. Hospitalists assigned to discharge software completed additional training via multimedia demonstration with one-on-one coaching as needed. Hospitalists assigned to usual care did not receive training on the discharge software and were blocked from using the software. After informed consent, patients were passive recipients of the research intervention performed by their discharging hospitalist. Patients received the research intervention on the day of discharge from the index hospitalization.

Measures with Data Sources and Collection

The baseline assessment of patient characteristics occurred during the index hospitalization. Trained data abstractors recorded baseline patient demographic data plus variables to calculate the probability for repeat admission: age, gender, race, diabetes mellitus, and coronary heart disease. Patients or proxies provided the number of hospital admissions and doctor visits during the year before the index hospital admission. We recorded the availability of an informal caregiver in response to the question, “Is there a friend, relative or neighbor who would take care of you for a few days, if necessary?” Patients rated their health status on the following scale: poor, fair, good, very good, and excellent. Patients or their proxies completed the SF-36 questionnaire (Version 2, Medical Outcomes Trust, Boston, Massachusetts) to assess overall physical functioning and mental health.(22) We recorded covariates as potential risk factors for readmission: heart failure, and number of previous emergency department visits. Before discharge, patients received a logbook to record post-discharge symptoms, hospitalizations, and emergency department visits.

The primary study outcome was the proportion of patients readmitted at least once within 6 months after the index hospitalization. Readmission was for any reason and included observation and full admission status. Outcome assessment occurred at the patient level. We obtained readmissions and emergency department visits from six hospitals in Central Illinois where study patients were likely to seek care. We validated the primary outcome with patient interviews. Six months after discharge from the index hospitalization, research personnel performed telephone interviews with patients or proxies. Interviewers were blind to intervention assignment. While following a script, interviewers instructed patients to avoid mentioning the discharge process. Interviewers asked patients to consult their logbooks while answering questions. Interviewers recorded admissions to hospitals and visits to emergency departments that did not result in hospital admission.

A secondary outcome was the proportion of patients who experienced an adverse event related to medical management within one month after discharge. The process for adverse event ascertainment was described previously.(1,23) In summary, one internal medicine physician performed telephone interviews with the patient or proxy. The interviewer was blind to treatment assignment. To avoid missing responses, the interviewer made up to 20 attempts to contact the respondent between 20 and 40 days after discharge from the index hospitalization. The interviewer asked the respondent to consult the patient logbook while answering questions. If the interviewee responded “yes” to any symptom question, then the interviewer recorded date, time, location, drug information, treatment, and resolution. The interviewer recorded health service utilization: hospital readmissions, outpatient doctor visits, and emergency department visits. Another physician who was blind to treatment assignment compiled a case summary from interview data and information abstracted from the electronic medical record. Two additional internal medicine physicians who were blind to intervention assignment adjudicated each case summary separately. Adverse events were counted only when adjudicators agreed that medical management probably or definitely caused the event. The initial rating by each adjudicator entered a Kappa test to assess the level of agreement beyond chance. Kappa was 0.52 and our interpretation was moderate-to-good agreement beyond chance.(24) When initial adjudications were discordant, then adjudicators met to achieve consensus. If consensus failed, then a third physician adjudicator was available to break ties. Primary adjudicators met and resolved all discrepancies so a third adjudicator was not required. The adjudicators scored the severity of the

adverse event. The severity scale values were serious laboratory abnormality only, one day of symptoms, several days of symptoms, nonpermanent disability, permanent disability, or death. The adjudicators also scored the adverse event as preventable (yes/no) and ameliorable (yes/no).

One of the secondary outcomes was the patient perception of preparation for discharge. One week after discharge, trained research personnel conducted telephone interviews with patients or their proxies. Interviewers read items from the PREPARED questionnaire.(25) We validated a scale from the PREPARED items. The scale validation manuscript is in press. Briefly, the scale assessed three principle components of patient preparedness for discharge: Self Care Information for Medications and Activities, Equipment and Services, and Confidence. High scale values reflected high perceptions of discharge preparedness from the patient perspective. The scale demonstrated internal consistency, construct validity, and predictive validity.

Another secondary outcome was patient satisfaction with information about discharge medications. One week after discharge, telephone interviewers read items from the Satisfaction with Information about Medicines Scale (SIMS).(26) The derivation and validity of the SIMS have been described extensively elsewhere.(26) In summary, patients with high total SIMS scores had high satisfaction with the amount of medication information they received. SIMS demonstrated internal consistency, test-retest reliability, and criterion related validity.(26)

One of the secondary outcomes was the quality of hospital discharge from the outpatient physician perspective. During the index hospitalization, patients designated an outpatient primary care physician to receive discharge reports and results of diagnostic tests. Ten days after discharge, research personnel mailed the Physician-PREPARED questionnaire to the designated outpatient primary care practitioner. Karen Grimmer-Somers, PhD, and her colleagues at the University of South Australia developed the Physician-PREPARED questionnaire. We requested one Physician-PREPARED questionnaire for each enrolled patient so the outcome assessment was at the patient level. Primary care physicians were not blind to intervention assignment because they received the output of discharge software or usual care discharge. In collaboration with Dr. Grimmer-Somers, we validated a scale for the Physician-PREPARED items and we submitted the manuscript for peer-review and publication. High scale values reflected high perceptions of discharge quality from the community physician perspective. The Physician-PREPARED scale demonstrated internal consistency and construct validity. The principal components of the scale were adequacy and timeliness.

We measured the satisfaction of hospitalists who used the discharge software and the usual care discharge. After hospitalists participated in the trial for 6 months, they rated their assigned discharge process on Likert scales. The first question was, “On a scale of 1 to 10, indicate your satisfaction with your portion of the discharge process.” The scale anchors were 1 for “very dissatisfied” and 10 for “very satisfied.” The second question was, “On a scale of 1 to 10, indicate the effort to complete your portion of the discharge process. For the second question, the scale anchors were 1 for “very difficult” and 10 for “very easy.”

Both the discharge software and the usual care process produced a discharge prescription. We assessed the satisfaction of the retail pharmacist who filled the discharge prescription. During the baseline assessment, research personnel asked patients to identify their usual pharmacy. On the day after discharge, research personnel sent a questionnaire to the retail pharmacy identified by the patient. The questionnaire had a Likert scale and one other item. The first item was, “On a scale of 1 to 10, indicate your satisfaction with the discharge prescription.” The scale anchors were 1 for “very dissatisfied” and 10 for “very satisfied.” The

second item was, “I needed to clarify the discharge prescription with the prescriber (check one: yes, no).”

Statistical Methods

We estimated a sample size of 275 patients in each of two study groups would show a 13% difference in readmissions with 95% certainty and 80% power under various assumptions regarding intra-cluster correlation. The sample size calculator was nQuery (Statistical Solutions, Saugus, Massachusetts).

For analysis of outcome variables, we utilized the principle of intention-to-treat. The outcomes reported by hospitalists were unaffected by the cluster assumption so we analyzed results with Chi-square procedure or t-test. For outcomes assessed at the patient level, we used generalized estimating equations that corrected for clustering by hospitalist. The primary outcome was at least one readmission within 6 months. For the primary outcome, we used generalized estimating equations that corrected for clustering by hospitalist and adjusted for covariates that predicted readmission. We screened baseline variables for their correlation with readmission. The initial variable with the highest correlation and p value less than 0.05 entered the general estimating equation. After the initial variable was entered, subsequent variables were evaluated using partial correlations that controlled for variables entered previously. At each step, we entered the variable with the highest partial correlation and p value less than 0.05. The analyses were performed with SPSS PC (Version 15.0.1, SPSS Inc, Chicago, Illinois).

Results

We screened 127 physicians who were general internal medicine hospitalists. Seventy hospitalists consented and received random allocation to discharge software (n = 35) or usual care (n = 35). We excluded 57 hospitalists. The most common reason for hospitalist exclusion applied to resident physicians who had short duration assignments to internal medicine wards. We followed 631 patients who gave informed consent. During follow-up, a small proportion of patients died, 3% (20/631). Hospital records were available for deceased patients and they were included in the analysis. A small proportion of patients withdrew consent or left the trial for other reasons, 6% (41/631). Protocol deviations were rare, 0.5% (3/631). Three patients erroneously received usual care discharge from hospitalists assigned to discharge software. All 631 patients were included in the intention-to-treat analysis. The baseline characteristics of randomly assigned hospitalists and their patients revealed the treatment groups were comparable.

Principal Findings

The primary study outcome evaluated readmission. Within 6 months after discharge from the index hospitalization, 37.0% (117/316) of discharge software patients and 37.8% (119/315) of usual care patients had at least one readmission. The mean time to first readmission was 142.9 days for the discharge software patients and 142.7 days for usual care patients. Generalized estimating equations accounted for potential clustering of readmissions within

hospitalists and adjusted for baseline characteristics that predicted readmission: previous hospitalizations, previous emergency department visits, heart failure, and physical function. In adjusted analyses, the parameter estimate coefficient for the treatment variable was negligible. After treatment with discharge software versus usual care, there was no significant difference between patient groups for readmission or time to first readmission.

We evaluated emergency department visits that were unrelated to readmission as secondary outcomes. Within 6 months after discharge from the index hospitalization, 35.4% (112/316) of discharge software patients and 40.6% (128/315) of usual care patients had at least one emergency department visit. The mean time to first emergency visit was 149.9 days for the discharge software patients and 140.9 days for usual care patients. Generalized estimating equations accounted for potential clustering of emergency visits within hospitalists and revealed a negligible parameter estimate for the treatment variable coefficient. All analyses confirmed there was no significant difference between discharge software and usual care for post-discharge emergency department visits.

Post-discharge adverse events were secondary outcomes. Within one month after discharge, 7.3% (23/316) of discharge software patients and 7.3% (23/315) of usual care patients had at least one adverse event probably or definitely related to medical management. Generalized estimating equations accounted for potential clustering of adverse events within hospitalists and confirmed a negligible parameter estimate for the treatment variable coefficient.

The patient's perception of discharge preparedness was a secondary outcome. When interviewed one week after hospital discharge, patient mean (SD) scores for discharge preparedness were 17.7 (4.1) in the discharge software group and 17.2 (4.0) in the usual care group. In generalized estimating equations that accounted for potential clustering within hospitalists, the parameter estimate for the treatment variable coefficient was small but significant ($p = 0.042$). Patients in the discharge software group had slightly better perceptions of their discharge preparedness.

Another secondary outcome was the patient's satisfaction with information about discharge medications. One week after discharge, patient mean (SD) scores for satisfaction were 12.3 (4.8) in the discharge software group and 12.1 (4.6) in the usual care group. Generalized estimating equations confirmed the insignificant coefficient for the treatment variable.

We assessed the outpatient physician perception of the discharge. We mailed questionnaires 10 days after discharge to outpatient physicians designated by patients. On a scale that measured outpatient physician perceptions of the hospital discharge, the mean (SD) scores were 17.2 (3.8) for the discharge software group and 16.5 (3.9) for the usual care group. High scores reflected high perceptions of discharge quality. The small mean difference in favor of discharge software was significant and confirmed by the significant parameter estimate from generalized estimating equations ($p = 0.027$).

We compared the satisfaction of hospitalists who used the discharge software and the usual care discharge. After using their assigned discharge process for at least 6 months, the mean (SD) satisfaction was 7.3 (1.5) for discharge software users and 7.9 (1.4) for usual care hospitalists ($p = 0.111$). The discharge software users found the mean effort, 6.5 (2.0), was more difficult than the usual care physicians, 7.9 (2.1). Even though hospitalists found the discharge software significantly more difficult ($p = 0.011$), they did not report a difference in their satisfaction between the two discharge treatments.

We compared the satisfaction of retail pharmacists with the discharge prescription produced by the discharge software versus handwritten usual care. We received responses from 168

unique pharmacies that returned a range of 1 to 39 questionnaires per pharmacy. Pharmacies returned a questionnaire for only 45% (286/631) of patients. For 116 patients, the questionnaire was blank because the pharmacist could not associate a prescription with the discharge. For the remaining questionnaires, the response rate for each item was low. The pharmacist answered the satisfaction item for 27% (84/316) of patients in the discharge software group and 26% (83/315) of patients in the usual care group. The mean (SD) satisfaction was 8.5 (2.1) for pharmacists who filled prescriptions from the discharge software versus 8.0 (2.3) for pharmacists who filled usual care prescriptions (difference = -0.43, 95% CI = -1.11 to 0.25, $p = 0.214$). The pharmacist answered the clarification item for 20% (63/316) of patients in the discharge software group and 21% (65/315) of patients in the usual care group. The proportion of pharmacists who had to clarify the prescription with the hospitalist was not significantly lower for prescriptions from the discharge software, 13% (8/63), versus usual care prescriptions, 17% (11/65), $p = 0.621$.

Discussion

We performed a cluster-randomized clinical trial to measure the effects of discharge software versus usual care discharge. The discharge software in our study incorporated ASTM's Continuity of Care Record (CCR) standards.(27) The CCR is a patient health summary standard with widespread support from medical and specialty organizations. The CCR was developed "to organize and make transportable a set of basic patient information consisting of the most relevant and timely facts about a patient's condition."(28) The rationale for the CCR was the need for continuity of care from one provider or practitioner to any other practitioner. Our discharge software had the same rationale as the CCR and included a subset of the clinical content specified by the CCR. Like the CCR, our discharge software produced concise reports, and emphasized a brief, post-discharge, care plan.(28) Since we included clinical data elements recommended by the CCR, we hypothesized our discharge software would produce clinically relevant improvements in our study patients.

Our discharge software also implemented elements of high quality discharge planning and communication endorsed by the National Quality Forum and systematic reviews. (http://qualityforum.org/pdf/reports/safe_practices/txsppublic.pdf) (3) For example, the discharge software produced a legible, typed, discharge plan for the patient or caregiver with medication instructions, follow-up tests, studies, and appointments. The discharge software generated a discharge summary for the outpatient primary care physician and other clinicians who provided post-discharge care. Users of the software were required to reconcile pre-admission medication lists with discharge prescriptions. The discharge software compiled data for purposes of benchmarking, measurement, and continuous quality improvement. Again, we thought our implementation of elements endorsed by the National Quality Forum would lead to improved patient outcomes.

Our discharge software intervention did not improve readmissions, emergency department visits, or adverse events after discharge. What are potential explanations? Output from our discharge software went to community physicians via facsimile transmission with back-up copies via standard post. Our distribution method responded to several realities. The vast majority of community physicians in our area did not have access to interoperable electronic medical records or secured email. In addition, electronic transmittal of prescriptions was not commonplace. Potential delays imposed by our distribution method may have contributed to our findings. Despite the limited technology available to primary physicians in our study, they

perceived communication generated by the software to be an improvement over the handwritten process. Our results confirm previous studies in which physicians preferred computer-generated discharge summaries and summaries in standardized formats.(29, 30)

Our research intervention did not reduce adverse events. Medication errors and adverse drug events account for a significant proportion of the adverse events after hospital discharge.(23) Medication reconciliation was a component of both software-assisted discharge and usual care in our study. For example, our usual care discharge process required completion of a form that specified which medications were new prescriptions, which medications taken on admission were to be discontinued, which were to be continued with changes in dose or frequency, and which were to be continued without change. Required medication reconciliation in both groups, by its known effect on preventable adverse drug events, may have reduced the event rates in both groups.(15) This possibility is supported by the low rate of adverse events observed in our study compared with others.(1)

What Are the Implications of our Study Results for Patients? Patients had slightly better perceptions of their preparedness when their hospitalist used discharge software. Their perceptions were unrelated to satisfaction with medication information. Our results apply to a population of adults of all ages with high risk for readmission. The results may not generalize to children, surgical patients, or people with low risk for readmission. We designed the discharge intervention to benefit patients at risk for poor, post-discharge outcomes. It is logical to assume that patients with low risk might have no capacity to benefit from our software or any other discharge intervention. All of the patients in our study were discharged to home. The exclusion of other discharge destinations helped us to enroll a cohort with homogenous risk for readmission. However, the exclusion criteria did not allow us to generalize our results to patients discharged to nursing homes, inpatient rehabilitation units, or other acute care facilities.

What Are the Implications of our Study Results for Hospitalists? The research intervention in our trial was a stand-alone software application. The discharge software was not integrated with the hospital electronic medical record. Consequently, hospitalist users had to re-enter patient demographic data and prescription data that already existed in the electronic record. Data re-entry may have caused hospitalists to attribute greater effort to the discharge software. If modules within the discharge software used pre-populated data from the electronic record, then hospitalists could shift their work from data entry to data verification and possibly mitigate their perceived effort.

An important practical issue is whether physicians will readily adopt new information technologies. Our study demonstrated that physicians successfully accommodated discharge software into their clinical workflow. Despite the perception of increased effort, hospitalists did not report significant differences in their overall satisfaction with the software-assisted discharge process when compared to handwritten usual care.

What Are the Implications of our Study Results for Hospital Administrators? We demonstrated a discharge intervention that caused small improvements in perceptions of patients and their outpatient physicians with neutral effects on readmissions, emergency department visits, and adverse events. To the hospital administrator, the perceptions of patients and community physicians may be valuable. Our study did not attempt to quantify an economic value for these perceptions. Hospital administrators may wish to design discharge processes that comply with

recommendations of the National Quality Forum. Our discharge software demonstrated a practical application of these recommendations. The strengths and limitations of our discharge intervention may guide future attempts to implement National Quality Forum recommendations.

What are the Implications of our Study Results for Developers and Vendors of Electronic Health Records? In our study, hospitalists incorporated discharge software with CPOE into their clinical workflow without deterioration in their satisfaction. Software engineers may wish to consider features of our discharge software as a starting point for further development. When designing discharge functions, developers should consider medication reconciliation and the standards of the Continuity of Care Record.⁽²⁷⁾ Developers may wish to explore options for data transmission to community physicians: secure email, automated fax servers, and direct digital file transfer. Future studies should test the acceptability of discharge functions incorporated within electronic health records with robust clinical decision support.

What are the Implications of our Study Results for Retail Pharmacists? Pharmacist-related outcomes were not different in the discharge software and usual care groups. For both groups, pharmacists gave high satisfaction scores for discharge prescriptions. Our results should be interpreted with caution because of the large amount of missing data from pharmacists.

Conclusions

A discharge software application with CPOE improved perceptions of the hospital discharge process for patients and their outpatient physicians. When compared to handwritten discharge process, the improvements were small in magnitude. Discharge software did not affect patient readmissions, emergency department visits, or adverse events after discharge. Hospitalist users of the discharge software reported more effort but otherwise no difference in their satisfaction with the discharge process.

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