

Improving Management of Test Results that Return After Hospital Discharge

Principal Investigator

Martin C. Were

Team Members

William M. Tierney, MD

Project Time Period: September 30, 2009 through May 31, 2014

Federal Project Officer: Kay Anderson

Grant Number: 5K08HS018539

Received support from the Agency for Healthcare Research and Quality

Structured Abstract

Purpose: Evaluate the role of Health Information technology in improving the communication and management of tests with pending results at the time of hospital discharge.

Methods: We developed, implemented and evaluated the impact of a computerized tool to automatically identify tests with pending results at hospital discharge and assist in communicating these pending tests to follow up providers through the hospital discharge summary. We also modified an existing clinical-messaging program used within a health information exchange to enable automatic delivery of test results returning after hospital discharge to designated follow-up providers. The impacts of these interventions were evaluated using randomized studies and survey methodologies.

Results: Health Information technologies can play a significant role in improving the identification and communication through discharge summaries of tests with pending results at the time of a patient's hospital discharge. These technologies can also improve management of test results once they return.

Key Words: Transitions of Care, Health Information Technology, Test Result Management, Health Information Exchange.

Purpose

Nearly half of patients discharged from the hospital with pending test results experience medical errors related to missed tests. These errors occur because pending tests are often not communicated to the follow-up provider, and systems to manage results are usually suboptimal. As the main mode of inpatient-to-outpatient communication, and a complement to direct provider interaction, discharge summaries remain highly inadequate at documenting tests with pending results at discharge. Studies show that only 12% of discharge summaries mention pending tests, and those which do contain inaccuracies and inadequacies. Outpatient providers report being unaware of up to 60% of results that require a change in patient management, and are dissatisfied with existing systems to follow results.

While the problem of communicating and managing tests with pending results at discharge is well-recognized, little has been done to implement and evaluate interventions to improve existing systems. Without effective interventions, medical errors will persist (despite well-motivated providers) and patient safety will continue to be compromised. My long-term goal is to develop and evaluate Health Information Technology (IT) interventions to improve the quality of care and patient safety. The objective of this K08 grant application was to create, implement, and evaluate IT-based interventions to improve management of tests with pending results at hospital discharge. The central hypothesis underlying this work is that IT-based approaches will allow providers to have the right information at the right time to make the right decisions. The rationale behind this research is the recognition that informatics-based interventions have the potential to improve patient safety by reducing errors related to missed tests.

To test my central hypothesis and achieve the overall research objectives, I completed the following specific aims:

Aim 1: Develop and implement a computerized tool which automatically identifies tests with pending results at hospital discharge, and assists in incorporating these tests into the discharge summary.

In year one, we developed a tool, based on a stable Computerized Provider Order Entry (CPOE) system, which queries the electronic medical record and displays tests with pending results to the provider preparing the discharge summary. The provider was able to then choose the pending tests to incorporate into the discharge summary through the CPOE interface. A copy of the pending tests was also be printed and given to the patient to take to his/her outpatient appointments.

Aim 2: Evaluate the impact of this tool on accuracy with which pending tests are documented in discharge summaries.

To evaluate the tool described above, we used before-and-after time series studies to tease out the specific effects of this tool on adequacy and accuracy with which tests with pending results are documented in the discharge summary. We also surveyed providers regarding who the responsible provider to manage pending tests should be.

Aim 3: Modify an existing clinical-messaging program to enable automatic delivery of returning results for pending tests to the designated outpatient follow-up providers.

Researchers at Regenstrief have developed a clinical messaging system called Docs4Docs® which serves more than 10,000 providers in Central Indiana. The system currently delivers results of tests to the ordering provider both electronically or via fax. We modified Docs4Docs® to deliver returning results for pending tests to the inpatient and outpatient follow-up providers.

Aim 4: Evaluate how the automatic delivery of test results impacts follow-up providers' actions and attitudes.

Using a tested methodology, chart reviewers rated each test result on whether the result required a change in patient management. By querying patients' electronic medical records and paper charts, we determined if (and when) the appropriate actions were taken in response to each test result.

In addition, we surveyed inpatient and outpatient providers to assess their attitudes towards their systems for managing test results returning after hospital discharge. The survey also assessed the specifically attitudes towards automatic delivery of test results.

I accomplished the above aims with the mentorship of an internationally-recognized advisory panel of medical informaticians and health services researchers from the Regenstrief Institute. I used this project to achieve the following career award goals: (a) acquire additional skills in developing and implementing IT solutions to address healthcare problems (Aims 1&3); (b) enhance my research expertise in the study design, implementation, and critical evaluation of health IT interventions (Aims 2&4); and (c) establish the foundation for a larger randomized trial to evaluate the impact of the above interventions on error-rates related to missed tests and on patient outcomes.

Scope

The overall goal of this research project was to critically evaluate health information technology (IT) interventions aimed at improving management of tests with pending results at hospital discharge. The first health IT tool helped inform inpatient providers of preparing a discharge summary of tests ordered in the hospital which had pending results at the time of hospital discharge. These could then be communicated to outpatient providers as part of the patient's discharge summary. The second health IT tool automatically delivered results of tests returning after hospital discharge to designated follow-up providers. We built these tools using infrastructure in our hospital Computerized Provider Order Entry (CPOE) system and our regional Health Information Exchange (HIE).

To evaluate the tools, we used a combination of randomized controlled studies, before-and after time series studies, and surveys to tease out the specific effects of each technology on processes of care. Outcomes of interest included: (a) adequacy and accuracy with which tests with pending results are documented in discharge summaries; (b) usability of the tool to help incorporate pending tests into the discharge summary; (c) impact of automatically delivering results to actions taken by providers; and (d) follow-up providers' attitudes regarding automatic delivery of test results that return after hospital discharge. Our research covered a period of just over four and a half years.

We conducted this work at Wishard Memorial Hospital (WMH). WMH was a 353-bed, urban, tax-supported, public hospital on the campus of Indiana University School of Medicine. It has now been rebuilt in a different location and renamed Eskenazi Health). At WMH, nine inpatient General Internal Medicine Hospitalist Services (GIMHS) provided care for admitted adult medicine patients. Three kinds of GIMHS teams existed, namely: (a) five traditional academic teams composed of an attending physician, a resident (year two and above of training), two interns, and a variable number of medical students; (b) two teams composed of a staff physician and an intern; and (c) two teams staffed exclusively by a hospitalist staff physician. As the county hospital, WMH primarily supported a low income, minority and uninsured population, and as such, our evaluation touched on priority populations for AHRQ.

WMH was served by the Regenstrief Medical Record System (RMRS),¹ and the Gopher CPOE.² At this Institution, all inpatient orders and discharge summaries were entered electronically via Gopher. Order details, admission and discharge information, and all test results were stored in real-time in the statewide Indiana Network for Patient Care (INPC)³ database, which served the regional HIE.⁴ This HIE is used by most outpatient providers in central Indiana for delivery of test results.

Methods

Aim 1: Develop and implement a computerized tool which automatically identifies tests with pending results at hospital discharge, and assists in incorporating these tests into the discharge summary.

During the first year of the project, I oversaw programming (in java programming language) of a processor that allowed incorporation of pending tests into the electronically-prepared discharge summaries. We programmed Gopher to send an HL7 trigger-message (ADT^A03 discharge trigger message) to our processor when a discharging provider chose to sign (and hence finalize) the electronic discharge summary. On receiving this trigger message, our

processor - called the 'Pending Test Processor (PTP)' - identified tests with pending results by querying the INPC Electronic Medical Record (EMR) database.

To determine tests with pending results at discharge, we queried three INPC tables, namely: the '*Inpatient Admissions File*' which contains information about admission and discharge times; the '*Orders File*' which contains order times and details; and the '*Results File*' which contains result times and details for all types of results. In these queries, tests with pending results at hospital discharge are defined as those "ordered during the admission but which have no final result (in the '*Results File*') at the time the discharge summary is finalized". All our queries were programmed using the Structured Query Language (SQL).

The tests identified through the queries as having pending results were delivered back to Gopher using a web-service. The Gopher computer interface displayed these tests (arranged by test battery) to the discharging provider, who was able to select the pending tests she/he wanted to be mentioned in the discharge summary. We did not automatically populate the discharge summary with all pending tests identified through the queries because (a) we wanted the inpatient provider to proactively identify tests she/he wanted the outpatient provider to be notified about; and (b) the automatically generated list of pending tests frequently contains some that have little chance of changing outpatient management.

In addition to selecting pending tests to be incorporated into the summary, the discharging provider entered names of the providers who were responsible for following up the results that are pending. Provider information was either entered as free-text or chosen from a drop-down menu containing information of all providers who have had encounters with the patient during the admission or in the outpatient setting. The selected pending tests and the follow-up provider information was incorporated into the discharge summary. The discharge summaries were available to outpatient providers through the electronic health record system, and also through routine delivery mechanisms used by the hospital.

The system developed was tested to our satisfaction, and eventually transferred to the production system. We organized formal information and training sessions for the Medicine Attending Physicians, the residents, and the nurses so as to familiarize them with the new tool. When we activated the PTP tool, we had three consecutive days with a Gopher 'Message of the day' which alerted alert all providers about the new functionality. In addition, medicine residents and students beginning their rotation at Wishard Hospital were educated each month about the new function in Gopher at their introductory meeting with the chief resident. There was continuous technical support and ongoing assistance to the providers by our technical team. Providers also had round-the-clock support that already existed for users of RMRS and Gopher. We turned on the PTP function only for the GIMHS teams during the evaluation period by taking advantage of Gopher's inbuilt functionality which allows access to different parts of the system to be set for specific teams.

Limitations:

- Providers may have wanted to update an already finalized discharge summary: We ensured that providers were able to edit, update, and delete pending tests to be incorporated into the discharge summary. At the final activation of the discharge summary, any new changes in result status were updated, and discharging providers were made aware of those results that have returned.
- Discharging provider may have wanted to know who the follow-up provider was: We operated under the criteria that tests mentioned as pending should be followed by a provider. In cases where no follow-up provider was identified using the mechanisms

described, we automatically designated the discharging provider as the follow-up provider.

- Discharge summary is not available: In some rare cases, patients may have been inadvertently discharged before the discharge summary was finalized (e.g. in cases where patient leaves against medical advice). In these cases, the patient would have unfortunately not received a list of tests with pending results.
- Patient dies in the hospital or is discharged to hospice: We decided to leave it to the discharging provider to decide whether to incorporate any tests with pending results into the summary for patients who die during the admission or those who are discharged to hospice.
- Tests show up as pending using our processor, but the results have actually been seen by the discharging provider: There may have been cases where results were available to the provider well before they made it to the EMR. We educated providers on why these tests might show up on the displayed list of pending tests, and have default choices selected for these tests not to be incorporated into the summary. The final decision on what to incorporate was left to the discharging provider.

Aim 2: Evaluate the impact of the PTP tool on the accuracy with which pending tests are documented in discharge summaries.

During year two and three of the award, we evaluated the impact of the PTP tool described in Aim 1 on documentation of tests with pending results into discharge summaries. The goals of this study were to determine: (a) the follow-up patterns of patients discharged from two large hospitals in central Indiana, and (b) the potential role of a regional health information exchange (RHIE) in improving identification of the providers with whom these patients follow-up with post-discharge. The evaluation was done using a randomized three-arm methodology.

We also employed methods we previously used in retrospective analyses⁵ to determine percentages of pending tests mentioned for the intervention and control groups of the PTP tool. With help from data managers at Regenstrief Institute, we queried INPC data to identify patients who (a) were discharged from the GIMHS at WMH and (b) who had pending test results at the time of discharge.

Discharge summaries for all the study patients (before and after implementation) were reviewed independently by three chart reviewers. The three reviewers independently abstracted all tests mentioned as having pending results in the discharge summary. Inter-rater reliability was calculated. If there were disagreements between the reviewers, the reviewers discussed the case to achieve consensus. The tests mentioned as pending in the discharge summaries were compared against tests which are truly pending as determined by queries of the patient's EMR. Proportions of documented pending tests were compared between the pre-implementation and post-implementation periods.

Additionally, the three reviewers independently analyzed each test result that returned for the study patients within a three-month period after discharge to determine if any of the results required a change in patient management – i.e. whether results were actionable. The reviewers used an algorithm modified from Roy et al.⁶ The reviewers used their clinical judgment, the discharge summary, and data contained in the patient's record to determine whether the test result was actionable. A result was considered actionable if it called for a change in management of the patient by requiring “a new treatment or diagnostic test (or repeat testing), modification or discontinuation of a treatment or diagnostic test, scheduling of an earlier follow-up appointment, or referral of the patient to another physician or specialist”.⁶

Reviewers rated the test result as “actionable” and “not actionable”. Inter-rater reliability was calculated, and a consensus about “actionable” tests was reached where there were disagreements. The percentage of “actionable” tests that were documented in the discharge summaries as having pending results were compared between the study arms. Further statistical analysis to control for potential confounders in our results are ongoing.

Limitations: Determination of whether a test was actionable or not involved some degree of reviewer judgment; discharging providers might have paid more attention to pending tests simply because of the intervention; there might have been differences in practices among survey responders and non-responders; and the findings might not be easily generalizable because the study was conducted at one institution using only the medicine team, and few hospitals have the CPOE and HIE infrastructure that is available at WMH and Regenstrief.

Aim 3: Modify an existing clinical-messaging program to enable automatic delivery of returning results pending at discharge to the designated outpatient follow-up provider.

As outlined in Aim 1, we created a processor that determines tests with pending results at discharge and helps incorporate them into the discharge summary. We stored all tests selected for inclusion into the discharge summary, and information about follow-up providers in a table called *‘Pending Tests at Discharge’*.

During the 2nd-4th years of this project, I oversaw programming to augment the PTP Processor. The new functionality allowed the PTP tool to do several things, namely: (a) Query the INPC appointment database to see if any new providers or clinics were scheduled to see a patient, and incorporate any new provider or clinic information into the *‘Pending Tests at Discharge’* table (b) Query the Docs4Docs® provider database (maintained by Regenstrief Institute) to determine whether follow-up providers and clinics contained in the *‘Pending Tests at Discharge’* table were signed up to receive messages through Docs4Docs®. (c) Monitor all results flowing into INPC (usually as HL7 messages) and detect those belonging to tests that were identified as pending in the discharge summaries (i.e. contained in the *‘Pending Tests at Discharge’* table).

If a returning result belonged to a test which had been mentioned by the discharging provider as one to be delivered to the follow-up provider, the PTP processor generated a new HL7 message with details of the test result but with the follow-up providers’ information and clinics incorporated in the section where the test result should be delivered (PV1 section of the HL7 message). The follow-up providers were derived from the updated list of providers contained in the *‘Pending Tests at Discharge’* table. Results for providers and clinics signed up to receive test results through Docs4Docs® were delivered through this mechanism.

The major enhancement of the PTP tool allowed for automatic delivery of results to a provider other than the ordering provider.

We tested automatic delivery of pending tests using an account we already had with Docs4Docs®. Before the actual implementation happened, we sent a Docs4Docs® message to all providers who use Docs4Docs® informing them that they would start receiving results for tests ordered in the hospital whose results return after the patient is discharged.

Limitations: Despite Docs4Docs® serving over 10,000 providers, there was always the possibility that a follow-up provider will not be signed up to receive messages through this

system. Unlike mailing of discharge summaries, mailing returning test results is not part of the current hospital workflow. Future enhancements of our system will implement methods to print and mail results to providers who cannot get results through Docs4Docs®. For this study, we only focused on providers who could receive results via Docs4Docs®.

Aim 4: Evaluate how the automatic delivery of test results impacts follow-up providers' actions and attitudes.

We evaluated the impact of the automatic delivery of returning results which were pending at hospital discharge.

We tested the impact of the clinical messaging function by randomizing returning test results to be delivered automatically to the follow-up providers using DOCS4DOCS® as soon as the result was available. The randomized study lasted from 11-12-12 through 3-19-13.

For the study, we determined which of the returning results in the study were thought to require some actions, and whether there were any differences in actions taken. We used the same method described in Aim 2 to determine if a test result required a change in patient management (i.e. 'actionable'). Three reviewers analyzed all results in the study and rated them as "actionable" or "not actionable" – these reviewers used the discharge summary, other notes for the patient, historical laboratories, and their clinical judgment. Inter-rater reliability was calculated, and consensus on ratings reached. For each result rated as "actionable", the reviewers outlined the action needed, and the time-frame with which the action should be taken.

About six months after the delivery of a result, we queried the INPC database to determine if the action outlined by our reviewers were taken by the follow-up providers. If the action was taken, we recorded the time it was done. The INPC database contains most outpatient orders, results, drug dispensing history, and appointment data for most outpatient practices in central Indiana and especially for those in the Wishard Health Services system. Researchers and data managers at Regenstrief Institute have many years of experience querying INPC data to derive most of this information.⁷⁻¹⁰ In addition to INPC queries, we reviewed electronic outpatient notes, and the patient's paper charts. Our data analyst analyzed each test and the gathered data to determine whether an action was taken or not.

At the end of the evaluation period, we surveyed all inpatient and outpatient providers in the study to assess their attitude on existing systems for managing results returning after a patient was discharged from WMH. We emailed the surveys to providers who received results delivered automatically. Repeat mailings to non-respondents were sent after the initial mailing. Responses were analyzed anonymously. We received survey results from 30 inpatient and 15 outpatient providers.

The main outcome of interest for the randomized study was whether an actionable test has led to an appropriate action by any follow-up provider after the hospital discharge. We are planning to conduct analyses to compare the proportion of actionable tests with appropriate follow-up action between the intervention and control groups using each outcome as an independent binary outcome in a multiple logistic regression model in which the primary predictor of interest is the intervention vs. control. Other covariates to be included will control for effects of patient characteristics (age, sex, race, insurance status), length of hospitalization, time it took for result to return. Physician characteristics will not be included because one actionable test result could go to multiple physicians. We also assessed provider attitudes towards the system for managing test results pending at hospital discharge, and specifically attitudes on automatic delivery of results. Analysis for these results are still underway.

Limitations: We had no way of tracking what happened to a result once it was delivered; providers who signed up to Docs4Docs® may have been systematically different from those who did not sign up to use the system; survey responders may have been systematically different from those who did not respond; physician-reviewers and the data analyst were not blinded, and some degree of judgment was involved in interpreting whether a test result was actionable or not, and what action was taken on the result; we calculated interrater reliability, and adjudicate differences; even though INPC receives a lot of patient information, some information may have been missing especially for patients who are not from central Indianapolis – we focused specifically on patients within the Wishard Healthcare system as we know how to access almost all the data about these patients; our findings might not be easily generalizable because of the advanced clinical messaging and HIE infrastructure we have, and because the study was conducted in a single setting – we aim to advance the field of science, and outline new potential uses of health IT and HIE in improving care. Though our work may not be generalizable at the moment, the emerging HIEs around the country and the National Health Information Network promise to make it easy to adopt interventions like the one in our study. Members of Indiana HIE should be able to implement the tools developed because we use the INPC infrastructure which contains data from these institutions.

Results

During Year 2, we conducted a survey of both inpatient and outpatient providers regarding who the responsible provider to manage pending tests should be. We found that opinions varied widely based on the physician's role (resident vs. attending), the amount of time spent in inpatient vs. outpatient care, and the characteristics of the pending test result. Respondents tended to disagree with statements that assigned responsibility to them in a way that would increase their workload. In addition, respondents felt that it would be best to develop a consensus policy among inpatient and outpatient providers for determining who this provider should be.

Our study to evaluate the impact of simple enforcement of documentation of pending tests through a computerized order entry system revealed a modest but statistically significant increase in documentation (from 12% to 22%, $p=0.02$ for all pending tests, and from 0% to 50%, $p<0.001$ for tests with eventual actionable results). This work pointed to the need to facilitate identification and documentation of pending tests to further improve management of these tests.

During Year 4, we conducted a survey to evaluate the impact of automatic delivery of results returning after hospital discharge to the inpatient ($n=30$) and outpatient ($n=15$) follow-up providers. We found that many of the inpatient providers ($n=14$) who responded believe that the "tests with pending results" field on the discharge summary impacts the quality of patient care that that it improves the quality of documenting tests with pending results into discharge summaries, and an even greater number of inpatient providers ($n=20$) believe this field should be included in the discharge summary template. Additionally, a number of the providers who received the results returning after hospital discharge through the Docs4Docs inbox felt the delivery of the results returning after hospital discharge improved quality of care, decreased errors in care, reduced time spent searching for results, and felt that the automatic delivery of results returning after hospital discharge via Docs4Docs should be continued.

Several additional analyses are underway and we have several manuscripts currently in preparation.

List of Publications and Products

Cadwallader J, Asirwa C, Xiaochun L, Kesterson J, Tierney WM, Were MC. Using Computerized Provider Order Entry to Enforce Documentation of Tests with Pending Results at Hospital Discharge. *Applied Clinical Informatics*. April 4; 2012: 3(2):154-63. (PMCID: PMC3613020).

Were MC, Gorbachev S, Cadwallader J, Kesterson J, Li X, Overhage JM, Friedlin J. Natural language processing to extract follow-up provider information from hospital discharge summaries. *AMIA Annu Symp Proc*. Nov 13; 2010: 872-6. (PMCID: 21347103).

Bibliography and References Cited

1. McDonald CJ, Overhage JM, Tierney WM, Dexter PR, Martin DK, Suico JG, et al. The Regenstrief Medical Record System: a quarter century experience. *Int J Med Inf*. 1999 Jun;54(3):225-53.
2. McDonald CJ, Tierney WM. The Medical Gopher--a microcomputer system to help find, organize and decide about patient data. *West J Med*. 1986 Dec;145(6):823-9.
3. McDonald CJ, Overhage JM, Barnes M, Schadow G, Blevins L, Dexter PR, et al. The Indiana network for patient care: a working local health information infrastructure. An example of a working infrastructure collaboration that links data from five health systems and hundreds of millions of entries. *Health Aff (Millwood)*. 2005 Sep-Oct;24(5):1214-20.
4. Overhage JM. Health information exchange: 'lex parsimoniae'. *Health Aff (Millwood)*. 2007 Sep-Oct;26(5):w595-7.
5. Were MC, Li X, Kesterson J, Cadwallader J, Asirwa C, Khan B, Rosenman MB. Adequacy of hospital discharge summaries in documenting tests with pending results and outpatient follow-up providers. *J Gen Intern Med*. 2009 Sep;24(9):1002-6.
6. Roy CL, Poon EG, Karson AS, et al. Patient safety concerns arising from test results that return after hospital discharge. *Ann Intern Med*. 2005 Jul 19;143(2):121-8.
7. Mahon BE, Rosenman MB, Kleiman MB. Maternal and infant use of erythromycin and other macrolide antibiotics as risk factors for infantile hypertrophic pyloric stenosis. *J Pediatr*. 2001 Sep;139(3):380-4.
8. Kho AN, Lemmon L, Commiskey M, Wilson SJ, McDonald CJ. Use of a regional health information exchange to detect crossover of patients with MRSA between urban hospitals. *J Am Med Inform Assoc*. 2008 Mar-Apr;15(2):212-6.
9. Biondich PG, Downs SM, Carroll AE, et al. Shortcomings in infant iron deficiency screening methods. *Pediatrics*. 2006 Feb;117(2):290-4.
10. Simonaitis L, Belsito A, Overhage JM. Aggregation of pharmacy dispensing data into a unified patient medication history. *AMIA Annu Symp Proc*. 2008:1135.