Pending Studies at Hospital Discharge: A Pre-post Analysis of an Electronic Medical Record Tool to Improve Communication at Hospital Discharge

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BACKGROUND: Achieving safe transitions of care at hospital discharge requires accurate and timely communication. Both the presence of and follow-up plan for diagnostic studies that are pending at hospital discharge are expected to be accurately conveyed during these transitions, but this remains a challenge.

OBJECTIVE: To determine the prevalence, characteristics, and communication of studies pending at hospital discharge before and after the implementation of an electronic medical record (EMR) tool that automatically generates a list of pending studies.

DESIGN: Pre-post analysis.

PATIENTS: 260 consecutive patients discharged from inpatient general medicine services from July to August 2013.

INTERVENTION: Development of an EMR-based tool that automatically generates a list of studies pending at discharge.

MAIN MEASURES: The main outcomes were prevalence and characteristics of pending studies and communication of studies pending at hospital discharge. We also surveyed internal medicine house staff on their attitudes about communication of pending studies.

KEY RESULTS: Pre-intervention, 70 % of patients had at least one pending study at discharge, but only 18 % of these were communicated in the discharge summary. Most studies were microbiology cultures (68 %), laboratory studies (16 %), or microbiology serologies (10 %). The majority of study results were ultimately normal (83 %), but 9 % were newly abnormal. Post-intervention, communication of studies pending increased to 43 % ($p<0.001$).

CONCLUSIONS: Most patients are discharged from the hospital with pending studies, but in usual practice, the presence of these studies has rarely been communicated to outpatient providers in the discharge summary. Communication significantly increased with the implementation of an EMR-based tool that automatically generated a list of pending studies from the EMR and allowed users to import this list into the discharge summary. This is the first study to our knowledge to introduce an automated EMR-based tool to communicate pending studies.

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INTRODUCTION

Achieving safe transitions of care at discharge from the hospital to the ambulatory care setting requires accurate and timely communication. Communication failures during these care transitions can lead to medication errors, duplication of diagnostic testing, delays in diagnosis and treatment, and increased rates of rehospitalization.[1–10] The discharge summary is the primary method of communication at hospital discharge.[5,11] There is widespread agreement that the discharge summary should communicate both the presence of and follow-up plan for diagnostic studies that are pending at hospital discharge.[5,12–15] However, only 12–16 % of pending studies are communicated in discharge summaries.[16–18] This is problematic, as previous authors have shown that 41 % of medical patients are discharged with at least one pending study, and 43 % of the results of these studies were eventually abnormal.[19]

Despite the need for quality improvement in this area, many of the efforts aimed at improving safety in transitions of care have focused on communication and care coordination without specifically addressing pending studies.[3,20] Unfortunately, these communication challenges are likely to become more difficult for several reasons: greater incentives for shorter lengths of hospital stay, inpatient care increasingly delivered by hospitalists rather than primary care physicians, and more hand-offs in the inpatient setting due to restrictions on house staff work hours.[14,15,21–23] To our knowledge, only one previous study has attempted quality improvement in this area, by prompting the discharging provider to manually list pending studies using a discharge order set.[18] However, this method is prone to error, as discharging inpatient physicians are often unaware of studies that have been ordered or for which results are still pending.[19]

We responded to this challenge by utilizing the electronic medical record (EMR) to create a tool that automatically generated a list of studies pending at discharge. We conducted a quality improvement study at our academic teaching hospital to better understand (1) the frequency at which patients were discharged from the inpatient general medicine service with pending studies as well as the characteristics of these studies, and (2) the quality of communication of pending studies in the discharge summary before and after the implementation of this EMR-based tool.

METHODS

Design Overview

We conducted a prospective quality-improvement study on the general medicine inpatient wards at an academic tertiary care hospital. We conducted a pre-post analysis of communication at discharge regarding pending studies before and after the introduction of an EMR-based tool that automatically generated a list of pending studies and which could be imported into the discharge summary.

Setting and Participants

Our study was conducted at a 613-bed academic tertiary care hospital located in Stanford, California, that both serves the local community and is a regional referral center for patients with complex medical needs.[24] At our institution, the general medicine inpatient services comprise an attending physician, one junior or senior resident, two interns, and one or two medical students, one of whom may be a sub-intern. The attending physician is typically a full-time hospitalist, although a minority are sub-specialists who attend on the general medicine wards for several weeks per year. The discharge summary is generally written by the discharging intern or resident and is finalized and signed by the attending physician. All house staff use computer-based charting rather than dictation to complete discharge summaries. A discharge summary note template is available that automatically imports patient information from the EMR and also allows modification and free-text entry. Our institution uses the EpicCare electronic medical record system (Epic Systems Corporation, Verona, WI) as our EMR system, which is a comprehensive medical record that incorporates both inpatient and outpatient notes, computerized physician order entry, and laboratory and radiology studies. This study was exempted from review by the Stanford IRB.

Data Collection

Data were gathered by EMR chart review from all consecutive patients discharged from the general medicine wards during a period of one month from July to August 2013. The intervention was introduced on August 9, 2013. Patients were excluded from the study if they died during the hospitalization, were discharged on hospice care, were transferred to another primary service in the hospital (such as psychiatry or surgery) or to another acute care hospital, or left against medical advice. Patients who were readmitted during the study period were included separately for each hospitalization. Patients discharged to subacute care facilities were included.

Intervention

Through our EMR, we created a programmed tool that automatically retrieved a list of pending laboratory, microbiology, and pathology studies. Studies were considered pending if the status of the study was not final, including studies that had a preliminary result or were still in process. We implemented our intervention by making the EMR tool available to all physicians to be used at their discretion, including in the discharge summary. Our house staff were informed and educated about the EMR tool through a combination of verbal announcements, demonstrations at teaching conferences, small group tutorials, and e-mail notifications.

Frequency of Patients Discharged with Pending Studies, Study Categories, and Study Results

To determine the frequency of patients discharged with pending studies, all charts were reviewed within 24 hours of discharge for the presence of pending studies, which was assessed by automatic data-gathering from the EMR and verified by manual review. Studies were considered pending if the status of the study was not final, including studies that had a preliminary result or were still in process. Studies were categorized as microbiology cultures, microbiology serologies, laboratory studies, pathology studies, or radiology studies.

To determine study results, charts were reviewed until all results of pending studies were finalized. The final result of each pending study was categorized as normal, newly abnormal, or abnormal as previously known. The category of newly abnormal was chosen to study as these results would be expected to involve a change in management. The institution normal range was used to determine whether a result was normal or abnormal. A physician reviewer (MK) used clinical judgment to determine whether an abnormal result was newly abnormal or previously known to be abnormal by comparison with both previous results since hospital admission and the discharge summary narrative. Any ambiguities were resolved upon discussion with the discharging attending physician. To preserve patient safety, all newly abnormal results were directly communicated to the discharging inpatient physicians.

Communication of Pending Studies

To determine communication of pending studies, the aforementioned process was undertaken to first determine the presence of pending studies. Charts were then reviewed regularly until the discharge summary was completed and finalized by the attending physician. A physician reviewer (MK) reviewed the discharge summary for documentation of each pending study, including in list format or in narrative text. A study was considered to be communicated as pending if the discharge summary documented that the study was pending, not finalized, outstanding, in process, or needed follow-up. Clinical judgment was used to classify any ambiguities.

Survey of Internal Medicine House Staff

We surveyed internal medicine house staff on their awareness of, communication of, and attitudes towards responsibility of studies pending at hospital discharge. Questions regarding opinions on the discharge process were scored on a 100-point Likert scale, with 0 indicating "never" and 100 indicating "always" for questions regarding frequency, and with 0 indicating "low" and 100 indicating "high" for questions regarding awareness. The survey was distributed through a house staff Listserv, with an e-mail reminder sent one week after the initial e-mail. Data were collected using Qualtrics software (Qualtrics, Provo, UT).

Statistical Analysis

Categorical variables and proportions were analyzed using the χ^2 test.

RESULTS

Frequency of Patients Discharged with Pending Studies, Study Categories, Study Results

There were no statistical differences between pre- and post-intervention data for frequency of patients discharged with pending studies (p=0.34) or study results (p=0.29); study categories were significantly different (p=0.04). Table 1 illustrates pre- and post-intervention frequency, category, and results of pending studies. Pre-intervention (n=108), 70 % of patients discharged from the general medicine wards had one or more studies pending at discharge (mean: 2.1, range: 0–13; Table 1). Post-intervention (n=152), 76 % of patients were discharged with at least one pending study (mean: 2.3, range: 0–20; Table 1). Table 2 demonstrates examples of pending studies. Table 3 lists the most common pending laboratory and microbiology serology studies with their expected turnaround time and whether they are run in-house or sent out to reference laboratories; these 16 studies represent 42 % of pending studies in these categories.

Pre-intervention, 9 % of the final results of the pending studies were newly abnormal, with 83 % normal and 8 % abnormal but previously known (see Table 1). Post-intervention, 13 % of studies generated newly abnormal results, with 78 % of results normal and 9 % abnormal but previously known. There was no statistical difference in the study results comparing pre- and post-intervention (p=0.29, see Table 1). Table 2 demonstrates examples of newly abnormal results. Pathology studies and laboratory tests were more commonly newly abnormal (36–50 % and 22–26 %, respectively), while microbiology cultures and serologies were more likely to have normal results (89 % and 75–91 %, respectively) (see Table 4).

Communication of Pending Studies

Pre-intervention, only 18 % of pending studies were communicated in the discharge summary. On average, 2.5 studies per patient were not communicated. Only 7.6 % of discharge summaries communicated all of the pending studies for an individual patient in the pre-intervention period.

After the implementation of our EMR tool, communication of pending studies increased from 18 % to 43 % (p <0.001). Post-intervention, discharge summaries communicating all pending studies for an individual patient increased from 7.6 % to 26 % (p=0.002). The EMR tool was used in 30 % of the discharge summaries for patients with pending studies. A subgroup analysis was performed comparing communication of pending studies between discharge summaries that used the EMR tool and those that did not. Of discharge summaries that used the EMR tool, 74 % communicated all studies pending at discharge, compared to 6 % of discharge summaries that did not use the EMR tool (p<0.001).

Survey of House Staff

Seventy-nine of 111 house staff and sub-interns (71 % response rate) completed our survey. On average, they rated their frequency of communication of pending studies at 64.9 (scale: 0 indicating "never" and 100 indicating "always") and awareness of pending studies at 62.4 (scale: 0 indicating "low" and 100 indicating "high"). The majority of house staff (81 %) considered the outpatient primary care physician responsible for following up on pending studies at discharge, but house staff also considered the discharging intern (43 %), resident (34 %), and outpatient specialist (39 %) responsible. Only 29 % of house staff considered discharging attending physicians responsible for follow-up on pending studies. Almost half (48 %) of house staff physicians reported having a system

Table 1. Comparison of frequency, category, and result of pending studies, pre- and post-intervention

	Pre-intervention	Post-intervention	p value
Frequency of pending studies			p=0.34
Number of patients	108	152	
Patients discharged with at least one pending study	76 (70 %)	115 (76 %)	
Total number of pending studies (mean/patient)	227 (2.1/patient)	353 (2.3/patient)	
Study category			p=0.04
Microbiology cultures	155 (68 %)	207 (59 %)	
Microbiology serologies	24 (11 %)	34 (10 %)	
Laboratory studies	36 (16 %)	72 (20 %)	
Radiology studies	6 (3 %)	26 (7 %)	
Pathology studies	6 (3 %)	14 (4 %)	
Study result (%)			p=0.29
Normal	185 (83 %)	274 (78 %)	
Abnormal, previously known	18 (8 %)	31 (9 %)	
Newly abnormal	21 (9 %)	47 (13 %)	

for follow-up of pending studies, and many commented that this consisted of a handwritten list.

DISCUSSION

We found that a surprisingly high percentage (70 %) of our general medicine patients were discharged from the hospital with at least one pending study, which contrasts with prior studies showing this to be 41 %.[19] While it is possible that our institution is an outlier, we suspect that the discrepancy can be explained by systems changes. The previous study was conducted in 2004; in the interim decade, length of hospital stay has shortened and house staff work hours have become more restricted, leading to an increased number of handoffs.[14,15,19,21–23,25] While the average length of stay for hospitalized medical patients has shortened to less than four days, we found that many pending studies were cultures without finalized results or tests with turn-around time of five days or more (see Table 3).[25] To our knowledge, we are the first to reexamine the prevalence of pending studies in this new environment. This observed marked increase in the number of patients discharged from the hospital with pending studies highlights the importance of accurate communication of these studies and their follow-up plans.

We also showed that availability of an EMR tool that automatically imported a list of pending studies significantly increased the communication of studies that were pending at hospital discharge. Prior to our intervention, only 18 % of

Table 2. Representative examples of pending studies and newly abnormal results

Category	Example of pending studies	Example of newly abnormal results
Laboratory studies	• Methylmalonic acid, serum • Anti-nuclear antibody • Testosterone, total • Antiphospholipid antibody panel • Niacin • Celiac disease screen	• 25-hydroxy vitamin D level of 9 ng/mL • p-ANCA positive • Thiamine level of 2 nmol/L • Proteinase 3 antibody positive
Microbiology cultures	• Blood culture • AFB culture, respiratory • CSF culture • Fungal culture • Stool ova and parasites	• Wound culture growing methicillin-resistant *Staphylococcus aureus* • Blood culture growing *Salmonella typhii* • Urine culture growing vancomycin-resistant *Enterococcus*
Microbiology serologies	• Histoplasma antigen, urine • HIV-1 RNA quantitative PCR • Cocci complement fixation • Syphilis treponemal screen • QuantiFERON	• Hepatitis C viral RNA of 1,770,000 IU/mL • *Helicobacter pylori* antibody-positive • Detected West Nile IgM antibody in CSF • Dengue fever antibody positive
Pathology studies	• Breast biopsy • Colon biopsy • Stomach biopsy • Peritoneal fluid cytology • Pancreatic cytology	• Colon biopsy showing invasive adenocarcinoma • Atypical pancreatic cells on fine-needle aspiration • Colon biopsy showing active colitis with crypt abscesses
Radiology studies	• CT chest • MRI knee • US renal artery • Gastric emptying study • Chest X-ray	• Delayed gastric emptying on gastric emptying study • CT chest revealing pulmonary nodules • X-ray esophagram showing esophageal dysmotility

Table 3. Turn-around time and send-out status of common pending laboratory and microbiology serology studies

Study name	Category	Turnaround Time[33]	In-house or Send-out[33]	Days run[33]	Batched status[33]
ANCA	Laboratory study	6 days	In-house	Monday-Saturday	Not batched
Anti-nuclear antibody	Laboratory study	5 days	In-house	Monday–Friday	Not batched
Cocci complement fixation	Microbiology serology	7–14 days	Send-out	NA	NA
Cocci immunodiffusion	Microbiology serology	7–14 days	Send-out	NA	NA
Dengue fever antibody	Microbiology serology	5–7 days	Send-out	NA	NA
Elastase, stool	Laboratory study	9 days	Send-out	NA	NA
Factor V Leiden	Laboratory study	7–14 days	In-house	Weekly	Batched
Helicobacter pylori antibody	Microbiology serology	5–7 days	In-house	Wednesday	Batched
Helicobacter pylori antigen	Microbiology serology	5–7 days	In-house	Thursday	Batched
Niacin	Laboratory study	3–9 days	Send-out	NA	NA
QuantiFERON test for latent tuberculosis	Microbiology serology	3–6 days	In-house	Tuesday-Sunday	Not batched
Syphilis treponemal screen	Microbiology serology	1–3 days	In-house	Monday, Wednesday, Friday	Batched
Thiamine	Laboratory study	4 days	In-house	Monday–Friday	Not batched
Urine protein immunofixation electrophoresis	Laboratory study	7 days	In-house	Monday, Tuesday, Wednesday, Friday	Batched
25-hydroxy-vitamin D	Laboratory study	7 days	In-house	Monday–Friday	Not batched

pending studies were communicated in the discharge summary, similar to previous studies.[17,18] With the introduction of our EMR-based tool, communication increased from 18 % to 43 %.

Despite the availability of this tool, however, fewer than half of pending studies were communicated in discharge summaries. We hypothesize that one of the main barriers to communication was a lack of standardized practices of work in the discharge process.[8,11] Despite an enthusiastic response to the availability of the EMR tool, only 30 % of discharge summaries actually utilized it. Our EMR tool required manual importation by users into the discharge summary note, and a busy physician or one without a standard practice of writing discharge summaries may forget to include the EMR tool.

In response, we have modified the discharge summary template so that it now contains this tool. We believe that pre-populating the discharge summary with a list of pending studies will both enhance communication to outpatient providers and prompt the discharging physician to contextualize each pending study in the discharge summary narrative. In addition, our EMR tool did not automatically retrieve pending radiology studies, and we have subsequently programmed a second EMR tool that can accomplish this. We also plan to include turn-around time and send-out status for all studies at the time of ordering, which may prompt providers to order fewer studies with long turn-around times. Finally, we have created a standard discharge process that includes beginning discharge summary notes at the time that the discharge order is signed, thus pre-populating the discharge summary template in real time to include an accurate list of pending studies as well as discharge medications and appointments.

To our knowledge, the only other study that attempted to improve communication of pending studies relied on prompting the discharging physician to manually list pending studies via a discharge order set; following this intervention, only 22 % of studies were communicated.[18] Our EMR-based tool has important advantages because it automatically generates a list of pending studies from the EMR rather than relying on human memory. This is especially important, as our survey found that house staff vastly overestimate their communication of pending studies, and previous studies have shown that discharging physicians are often unaware of which studies have been ordered and which results are still pending.[19]

Table 4. Result of pending study by category

	Newly abnormal		Abnormal, previously known		Normal	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Laboratory test	8 (22 %)	19 (26 %)	0 (0 %)	2 (3 %)	28 (78 %)	51 (71 %)
Microbiology culture	5 (3 %)	13 (6 %)	12 (8 %)	10 (5 %)	138 (89 %)	184 (89 %)
Microbiology serology	3 (13 %)	3 (9 %)	3 (13 %)	0 (0 %)	18 (75 %)	31 (91 %)
Pathology	3 (50 %)	5 (36 %)	1 (17 %)	4 (29 %)	2 (33 %)	5 (36 %)
Radiology	2 (33 %)	7 (27 %)	1 (33 %)	15 (58 %)	2 (33 %)	4 (15 %)
Overall	21 (9 %)	47 (13 %)	18 (8 %)	31 (9 %)	188 (83 %)	275 (78 %)

Given the frequency at which patients are discharged with pending studies, designating responsibility for follow-up is critical. Our survey showed that house staff consider multiple agents responsible for following up pending studies. The legal responsibility for follow-up of studies and communication of results to the patient and/or outpatient providers falls on the inpatient attending physician.[26] However, in practice, it is essential for both the discharging and outpatient physicians to be aware of the results of pending studies. This is particularly important for results that are newly abnormal or require a change in management, which were 9–13 % of those included in our study.

Achieving further gains in patient safety in this area will require improved management systems to facilitate appropriate follow-up of pending results. Our survey showed that many house staff do not have a systematic approach for result follow-up. While many institutions have systems that notify physicians of "critical" values, including microbiology cultures, these may fail to capture other results that may warrant action in certain clinical situations but not in others. This is especially concerning, as our study showed that microbiology results were very likely to have normal results, compared to pathology, in which half of the results were newly abnormal. Previous studies, primarily investigating follow-up of studies in the outpatient setting, have shown that without results management systems in place, abnormal results can be missed or overlooked, leading to delays in care.[27–30] Few institutions have implemented standardized systems to help physicians manage studies that are pending at discharge, and those that have established such systems have noted poor adoption or have raised concerns regarding "alert fatigue."[31,32] Future studies are needed to develop reliable systems for follow-up of pending studies.

Our study has several limitations. First, data were gathered from only one academic institution, limiting generalizability. The sample size was small, and the data were gathered from a limited time period, which may have been an outlier. We did not randomize patients and cannot exclude the possibility that the pre- and post-intervention groups differed in characteristics such as severity of illness or length of stay. In addition, we used written discharge summaries as a proxy for communication, although it is possible that other means of communication, such as e-mail, telephone call, or in-person discussion, were used. Finally, our institution uses a sophisticated EMR that was capable of generating a list of pending studies at discharge, a process that may not be available to institutions with other EMR systems.

There are several future directions for ongoing quality improvement work in this area. Determination and designation of the provider(s) responsible for following up and acting on pending studies at discharge are critical to maintaining patient safety, and the creation of results management systems is necessary to support this work. This work can also inform inpatient ordering behavior, particularly for studies that are likely to be pending at discharge and thus unlikely to change inpatient management. Finally, while we hypothesize that communication of pending results improves patient safety and quality of care while reducing the waste and cost of duplicate testing, we would like to study patient-centered outcomes such as timeliness of diagnosis.

CONCLUSIONS

Most patients are discharged from the hospital with pending studies, but in usual practice, the presence of these studies is rarely communicated to outpatient providers in the discharge summary. We are the first to show that communication was significantly increased with the implementation of an EMR-based tool that automatically generated a list of pending studies from the EMR and allowed users to import this list into the discharge summary. EMR-based tools can enhance the transition of care between inpatient and outpatient setting by improving communication, but standardized practices of work incorporating such tools into routine practice and results management systems to facilitate result follow-up are necessary.

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Conflicts of Interest: *The authors each declare that they have no conflicts of interest.*

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