Grant Final Report

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Virtual Continuity and its Impact on Complex Hospitalized Patients' Care

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Structured Abstract

Purpose: To examine the effects of hospital to primary care provider (PCP) automated communication tools, including computerized discharge medication reconciliation, on hospital discharge medication errors and 30-day patient outcomes.

Scope: Hospitalized patients are increasingly cared by hospitalists, heightening the importance of communication between hospitals and primary care providers (PCPs) to prevent medical errors and improve quality of care. For these same goals, medication reconciliation is recommended at all patient care transitions, but hospitals and electronic medical record (EMR) venders have struggled to meet this mandate.

Methods: We performed a pre-post study of automated PCP communication and patient safety tools, including computerized discharge medication reconciliation, examining their effects on hospitalized complex medical patients ($\geqslant$2 comorbid conditions, $\geqslant$5 chronic medications) at a single center. The primary outcome was discharge medication errors. Secondary outcomes were 30-day rehospitalization, emergency department visit, and PCP visit rates. Medication errors were retrospectively ascertained by 2 reviewing pharmacists.

Results: In 835 hospitalizations (422 pre-intervention, 392 post-intervention); 560 (317 pre- and 243 post-intervention) had medication variances that were reviewed by both pharmacists. Discharge medications errors decreased post-intervention (13% vs. 18%, $p<0.001$, adjusted for age, gender, insurance, comorbidity, and number of medications). Clinically important errors, with the potential for serious or life-threatening harm, were rare and not significantly different between study periods. Thirty-day patient outcomes were not significantly different between study periods after adjustment. Post-hoc analyses found associations of female gender with more frequent and hospital length of stay with less frequent errors.

Key Words: medical error; hospitalization; medication reconciliation

Final Report

Methods and Results

Communication between physicians caring for hospitalized patients and those patients' primary care providers (PCPs) is often suboptimal, leading to diminished health care quality and safety (1, 2). Hospital-based information systems can improve communication by automating information transfer between hospital physicians and PCPs. MedTrak, the information system used by the University of Pittsburgh Medical Center (UPMC), at the start of the project notified PCPs when patients are admitted and discharged from the hospital. We proposed to enhance MedTrak by automating it to promptly communicate critical clinical information to the patient's PCP from the time of admission through discharge and thereafter via a series of mechanisms that we termed virtual continuity. The AHRQ Ambulatory Safety and Quality program has highlighted "integration of patient information across transitions of care" as a focal point for improving quality of care. As we envisioned it, virtual continuity is innovative, providing an automated real-time notification and alert system as patients undergo transitions in care and allows PCPs to obtain current electronic medical records (EMR) and communicate with hospital physicians from a remote location.

Throughout the project period, we faced challenges that forced changes in our research plan.

Throughout this report, for each aim, we will outline our original research plan, the challenges faced by that plan, the modifications made to the research plan in response to those challenges, and then summarize the results of the research.

Specific Aim 1

Augment the present system of PCP notification, through the development and use of electronic medical record links, to allow virtual continuity for the PCP.

Our original plan to fulfill this aim has to implement the virtual continuity intervention in an iterative fashion working in concert with the UPMC Office of Physician Relations (OPR) and its head, Dr. Robert Schwartz. Unfortunately, Dr. Schwartz left UPMC in 2009 and, without his leadership and support, our implementation plans were forced to change. Through the first year of our funding period, we met frequently with OPR and other health IT personnel, but it became clear that we needed to scale back our plans for the virtual continuity intervention. In addition, our hope for limiting any intervention to a randomized group of PCPs was not tenable. Rather than a series of email communications with web links to access patient data and to facilitate communication with hospitalist physicians, our intervention evolved to a series of global initiatives to improve communication with PCPs whose patients were hospitalized at UPMC Presbyterian.

These interventions included improved, more reliable email communications to PCPs regarding: patient hospital admission, transfers to critical care units, hospital discharge, and post hospitalization care planning. These interventions were informed by a modified Delphi expert panel survey we performed as part of this project, which was published in the journal Family

Medicine and will be described further below (3). Other communication tools put into place were enhanced reporting to PCPs of tests performed during a hospitalization whose results were not available until after discharge. Finally, a comprehensive and mandatory computer-based discharge medication reconciliation system was put into place, with that information supplied to both patients and PCPs.

Our Delphi survey arose as a result of the research group's discussions with the health IT group, since it was unclear what information PCPs wanted to hear about their hospitalized patients, when they wanted to receive it, and in what format (email, fax, phone, etc.). Based on this uncertainty, we developed a questionnaire, drawing candidate items from the published literature on hospital/PCP communication, communication on medication changes made during hospitalizations, and post hospitalization care planning (1, 4-8). Our intent was to include a broad range of information items that PCPs might find valuable in the continuing care of their patients, from which our PCP expert panel could choose the most valuable items.

To seek a consensus on what information items PCPs would find most useful, we used an internet-based two-round modified Delphi survey of PCPs considered experts in internal medicine and family medicine. The Delphi methodology is a structured group interaction, involving ''rounds'' of opinion collection and feedback, that has been shown to provide accurate and reliable assessments of clinical or informational parameters by facilitating a group consensus (9). Experts were invited via email and, once they accepted, were emailed a link to the survey web site. They were asked to rate their agreement with survey items on a 5-point Likert scale and, on the first round of the survey, could suggest additional items. The study was completed in March-April 2010.

Once the round 1 survey was completed, 95% confidence intervals for each item were calculated. Items were accepted, rejected, or deemed equivocal based on consensus agreement, disagreement, or neither being found. Equivocal items were included in the round 2 survey, along with the panelist's own response and average scores for all panelists.

Results are shown in Table 1 (next 2 pages), depicting items that were accepted by consensus. In round 1, 41.6% (37 of 89) items were accepted by consensus and 1 was rejected (receiving daily progress notes. Of the 51 remaining items included in the Round 2 survey, 6 were accepted by consensus. The experts preferred notification on admission and discharge, without much contact otherwise, except for notification of medical crises. At the start of the hospital stay, they wanted emergency department visit data (physician documentation, laboratories, radiology, and medications), notification of admitting diagnoses, and consultants' evaluation data. PCPs wanted a brief description of the hospital course, discharge medication and medication reconciliation data, key hospitalization findings, a list of pending tests and their eventual results, and follow-up plans.

Table 1. Information primary care physicians favored receiving from hospitals*

Pre-admission status	**Mean**	**95% CI**
Be notified of the patient's ED visit	4.4	4.0 – 4.8
Receive physician documentation from the ED visit	4.7	4.4 – 5.0
Receive consultant physician evaluation	4.4	4.0 – 4.8
Receive ED medications discharged on	4.7	4.4 – 5.0
Receive ED laboratory study results and pending results	4.5	4.1 – 4.9
Receive ED radiology studies and reports	4.6	4.3 – 4.9
Receive ED diagnostic studies (other) and reports	4.6	4.3 – 4.9
Receive discharge instructions from the ED visit†	4.6	4.2 – 5.0
Admission-related information (data generated within the first 24 hours of admission)		
Be notified of the patient's admitting diagnosis(es)	4.4	4.0 – 4.8
Receive consultant evaluation†	4.4	4.0 – 4.8
Change in Status information (occurring any time after admission)		
Be notified of medical crises (e.g. cardiac arrest, respiratory failure)	4.6	4.3 – 4.9
Discharge-related information (defined as information sent on the day of discharge)		
Receive presenting problem	4.6	4.3 – 4.9
Receive key findings and test results	4.8	4.6 – 5.1
Receive discharge diagnosis(es)	4.7	4.3 – 5.1
Receive discharge medications	4.9	4.7 – 5.1
Receive comparison of discharge medications with admission medications (i.e. medication reconciliation)†	4.8	4.4 – 5.1
Receive list of changes in dosage and/or frequency in previous prescribed medications and rationale for changes	4.6	4.3 – 4.9
Receive list of medications started during the hospitalization including rationale for prescribing†	4.8	4.4 – 5.1
Receive list of medications discontinued during the hospitalization and rationale for discontinuing	4.6	4.3 – 4.9
Receive pending laboratory and tests	4.6	4.2 – 5.0
Receive follow-up plan	4.8	4.5 – 5.0
Receive recommendations of subspecialty consultants	4.7	4.3 – 5.1
Information included in/with a discharge summary		
Receive discharge diagnosis(es)	4.9	4.7 – 5.1
Receive name/contact information of the discharging physician†	4.6	4.2 – 5.0
Receive brief hospital course†	4.8	4.4 – 5.1
Receive lab results	4.7	4.4 – 5.0
Receive major procedures/treatments performed	4.9	4.7 – 5.1
Receive results of procedures	4.5	4.2 – 4.8
Receive responses to treatments	4.5	4.1 – 4.9
Receive recommendations of subspecialty consultants	4.8	4.6 – 5.1
Receive discharge medications	4.9	4.7 – 5.1
Receive comparison of discharge medications with admission medications	4.6	4.3 – 4.9
Receive reasons for changes and indications for newly prescribed medications	4.5	4.2 – 4.8
Receive drug allergies; adverse drug reactions	4.7	4.4 – 5.0
Receive patient's functional status at discharge	4.6	4.3 – 4.9

Information included in/with a discharge summary	Mean	95% CI
Receive patient's cognitive status at discharge	4.6	4.3 – 4.9
Receive resuscitation / code status and other end-of-life issues	4.8	4.4 – 5.1
Receive pending laboratories and tests	4.8	4.4 – 5.1
Receive follow-up plan	4.9	4.7 – 5.1
Receive future appointments, procedures, and laboratory studies	4.7	4.4 – 5.0
Post discharge (defined as information generated following discharge)		
Receive results of pending laboratory studies	4.8	4.4 – 5.1
Receive results of pending radiology studies	4.8	4.6 – 5.1
Receive results of pending diagnostic studies	4.8	4.6 – 5.1

† Panel consensus was not reached until Round 2 of the Delphi study
* Means based on 5-point Likert scale with 1 = strongly disagree and 5 = strongly agree

PCPs came to no consensus regarding their preferred mode of receiving hospital information (Table 2). E-mail was most favored, with fax being the next most favored; regular mail was least favored.

Table 2. Primary care provider preferences for communication with the hospital*

Communication Preferences	Mean	95% CI
Communications from the hospital should be via email	4.2	3.4 – 5.0
Communications from the hospital should be via fax	3.4	2.7 – 4.1
Communications from the hospital should be via pager	3.0	2.5 – 3.5
Communications from the hospital should be via phone	2.9	2.3 – 3.5
Communications from the hospital should be via regular mail	2.3	1.7 – 3.0
Communications from the hospital should be routed through my office staff	3.1	2.4 – 3.8

* Means based on 5-point Likert scale with 1 = strongly disagree and 5 = strongly agree
CI = confidence interval

We found that PCPs wanted information at the start and finish of hospital stays, in a concise and focused format, concentrating on key findings, medication reconciliation, and follow-up plans. Our findings were largely consistent with published recommendations for improved hospital discharge care transitions and prior surveys of PCPs regarding communications from hospitals (10). Trends toward preferring email communications were not previously reported, but could be expected to continue and strengthen in the future. PCPs were also interested in receiving information about their patients' emergency department visits, an area where present systems are frequently inadequate (11, 12). Finally, hospitalists will likely be an enduring component of medical care, so incorporating communication with hospitalists and hospitals into the workflow of PCPs will be an important to their practices. Whether modern communication systems can efficiently and effectively transmit information that PCPs find valuable, and which improve patient care, requires further study.

Specific Aim 2

In a cluster randomized trial, measure differences in patient care safety and quality between PCPs receiving virtual continuity vs. usual communication by comparing discharge medication errors, follow-up visit frequency, hospital readmissions, and emergency department visits, using information from the PCPs' patients with complex medical problems (age ≥65, ≥2 comorbid conditions, and ≥5 medications) hospitalized during the study period.

In our original proposal, we planned a randomized trial with primary care providers (PCPs) as the unit of randomization. After a long series of discussions among project investigators, it was recognized that a better and more feasible design was a pre-post study. In the typical hospital system environment, new health IT features are generally rolled out in a hospital-wide fashion, not selectively to certain groups of physicians. A pre-post design more realistically captures how health IT changes affect physicians as a group, making findings from such a study more generalizable to other hospital settings.

In a pre-post research design, physicians serve as their own controls, allowing better demonstration of how physicians might change behavior and practice as a result of virtual continuity, since data are collected on all participating physicians both with and without the intervention. A randomized trial would not allow observation of this change over time within physician groups since different physicians would be in the intervention and control groups. In addition, as it had been planned, our randomized trial needed to recruit a broad range of PCPs, many of whom admit only 1-2 patients to our hospitals per year, making it more difficult to discern differences within an individual physician's practice that might occur due to the intervention. Moving to a pre-post design allowed us to choose PCPs who refer larger numbers of patients to the hospital who will get a larger "dose" of the intervention and thus increase the likelihood of behavior change among those physicians.

The major reason we originally planned a cluster-randomized trial was to minimize selection bias. As the project progressed, we felt that an RCT was not necessary to control selection bias. We included the same physicians (admitting at least 5 patients per year) pre- and post-intervention and all their patients were eligible for the intervention during the post-intervention period. Finally, we had concerns about possible contamination effects with a randomized trial. A pre-post design alleviates this concern. Overall, the research team felt that a pre-post research design was the best approach to assess the impact of rolling out our intervention. It mimics real world roll-out of health IT in most settings and provides the data needed to determine whether the same physicians made changes in their practice and whether they and their patients benefit from the IT intervention.

More challenges came in the area of patient recruitment for the project. We originally hoped to obtain consent from patients so that we could maintain contact with them for follow-up data. However, despite numerous efforts to improve patient recruitment to meet study goals, including expanding eligibility criteria and implementing several recommended strategies to improve subject recruitment, we found that hospitalized patients were difficult to contact in the hospital, due to frequently being occupied by testing or other health care processes and short hospital length of stay. In addition, they would frequently decline to participate. Eventually, continuing difficulties with patient recruitment, despite multiple efforts, led us to rethink our research plan and seek to collect project data solely from the electronic medical record. Through the University

of Pittsburgh IRB, we obtained a HIPAA waiver and a waiver of informed consent that permitted us to use the electronic medical record to collect the necessary data on pre- and post-intervention patients on our primary outcome, discharge medication errors, and on the secondary outcomes, 30 day rates of rehospitalization, emergency department (ED) visits, and PCP follow-up visits.

In the project, the pre-intervention period was defined as from April 1, 2009 through October 7, 2010. This end date was chosen based on the first of the new automated UPMC PCP communication initiatives (the My UPMC Safe Discharge Report, a more complete summary of a patient's hospital discharge findings reported electronically and automatically at patient discharge to PCPs) being rolled out on October 8, 2010. Other PCP communication initiatives were rolled out over the subsequent several months to improve admission, critical illness notification, testing result, and discharge communication. These efforts culminated in the launching of a mandatory computer-based discharge medication reconciliation procedure, with reports given to the patient and sent to the PCP. This medication reconciliation system was launched on August 22, 2011; this became the start of our post-intervention period, which ended December 6, 2012.

Subjects were included if they were admitted to the UPMC Presbyterian General Medicine, Geriatrics, Cardiology, or Surgery inpatient services; were cared for by PCPs who use the UPMC Epic ambulatory care EMR; were 18 years of age or older; were currently receiving 5 or more medications; and had 2 or more comorbid conditions present, defined using the Elixhauser comorbidity system. They were excluded if they were admitted to critical care units, admitted from skilled nursing facilities, had dementia, or were organ transplant recipients.

Medication errors were ascertained using a 2-stage process (13). During the first stage, trained research personnel created a case summary of each patient's medications, which included a list of the participant's preadmission medications, medications prior to discharge, and discharge medications. Preadmission medications were obtained by examining the EMR data on a patient's current medications at the time of their last health care encounter prior to the index hospitalization. Medications received during the hospitalization and discharge medications were obtained by EMR following hospital discharge. Discharge medications were defined as medications listed in the written discharge medication instructions. Medication omissions and commissions were then identified by comparing preadmission medications, medications prior to discharge, and discharge medications. Any differences will be considered discharge medication variances. These medication variances were specified on the case summary.

During the second stage, two trained pharmacists independently reviewed medication variances. The pharmacists reviewed the EMR to identify the need for additions or removal of medications from the patient's outpatient medication regimen. Medication variances not considered changes in required medications due to the patient's hospital course or disease status were classified as medication errors. Medication errors were classified as clinically important if they had the potential to cause any of the following: death, permanent or temporary disability, prolonged hospital stay, readmission, or the need for additional treatment or monitoring to protect the patient from harm (14). Discrepancies between pharmacists were resolved by consensus. Data for secondary outcomes: 30-day readmission, emergency department visits, and PCP return visits, were obtained through EMR review.

All comparisons between the pre-intervention and post-intervention periods were performed using Kruskal-Wallis and chi-square tests. To control for pertinent covariates and potential confounders, multivariable logistic regression was performed. Factors were included in the multivariable mixed effects model if they were found to be significantly associated with the

outcome variable (unintended medication variances) at $P<0.20$ or to be considered potentially clinically significant. Patients were included in the mixed effects model as a random effect and individual patient characteristics were included as fixed effects.

Most factors did not differ between the study periods (Table 3). There was a significant difference for insurance coverage between the pre-intervention and post-intervention periods, with patients hospitalized during the post-intervention period being more likely to have employer/commercial insurance. The modified Elixhauser comorbidity index score (15) was also slightly lower in the post-intervention period. The frequency of unintended medication variances (medication errors) was found to be lower during the post-intervention period.

Table 3. Characteristics and Outcomes of Virtual Continuity Participants by Study Period

	Pre-intervention n=317	**Post-intervention n=243**	***P* value**
Demographic Characteristics			
Age (years), median (IQR)	63 (53 – 76)	63 (54 – 73)	0.43
Sex (%)			0.20
Male	139 (44)	93 (38)	
Female	178 (56)	150 (62)	
Race (%)			0.44
White	216 (68)	151 (62)	
Black	96 (30)	86 (35)	
Native American/Alaskan Native	1 (0.3)	1 (0.4)	
Asian	3 (1)	4 (2)	
Hispanic	1 (0.3)	0 (0)	
Missing	0 (0)	1 (0.4)	
Insurance (%)			<0.001
Private	96 (30)	193 (79)	
Public	215 (68)	50 (21)	
Uninsured	4 (1)	0 (0)	
No documentation	2 (1)	0 (0)	
Clinical Characteristics			
Number of comorbidities (%)			<0.001
0	9 (3)	4 (2)	
1	62 (20)	75 (31)	
2	118 (37)	106 (44)	
3	83 (26)	47 (19)	
4	32 (10)	10 (4)	
5	12 (4)	1 (0.4)	
6	1 (0.3)	0 (0)	
Modified Elixhauser comorbidity index, median (IQR)	5 (3 – 11)	3 (0 – 5)	<0.001
Hospital length of stay (days), median (IQR)	3 (2 – 4)	2 (2 – 4)	0.54
Number of medications, median (IQR)	11 (8 – 15)	8 (6 – 10)	<0.001

	Pre-intervention n=317	Post-intervention n=243	*P* value
Number of medications (%)			<0.001
5-9	107 (34)	165 (68)	
10-14	126 (40)	61 (25)	
15-19	62 (20)	14 (6)	
20-24	15 (5)	3 (1)	
25-29	6 (2)	0 (0)	
30	1 (0.3)	0 (0)	
Medication Variance			
Medication variance (%)			<0.001
None	1,836 (53)	1,650 (58)	
Medically indicated variance	1,009 (29)	814 (29)	
Medication error	645 (18)	359 (13)	
Clinically important medication error	9 (1.4)	11 (3.1)	0.10
30-day Follow-up			
Attended PCP follow-up appointment (%)	148 (47)	109 (45)	0.04
Emergency department visit (%)	81 (26)	49 (20)	0.16
Admitted (%)	58 (18)	41 (17)	0.74
Died (%)	0 (0)	0 (0)	--

Differences in medication errors remained statistically significant on multivariable analysis (Table 4) adjusting for age, sex, and modified Elixhauser comorbidity index score. The significant differences between PCP follow-up visits and emergency department visits at 30 days, as depicted in Table 3, were no longer significant after adjustment. No significant differences were seen between groups in clinically important medication errors or in 30-day readmission or death rates.

Table 4. Multivariable Mixed Effects Model of the Effect of Virtual Continuity on Unintended Medication Variances (Medication Errors)

	Odds ratio	95% confidence interval	*P* value
Unadjusted	0.63	0.51 – 0.77	<0.001
Adjusted for age, sex, and insurance	0.54	0.43 – 0.69	<0.001
Adjusted for age, sex, insurance, and comorbidity score	0.52	0.41 – 0.67	<0.001
Adjusted for age, sex, insurance, comorbidity score, and number of medications	0.57	0.44 – 0.74	<0.001

In summary, in this aim we strove to demonstrate that a series of hospital-based interventions to facilitate communication between hospitals and PCPs, in the context of a PCP's patient being admitted to the hospital, cared for by another physician, and discharged back to the PCP's care,

would improve patient care quality and safety. For the reasons outlined, the original research plan was substantially altered to a pre-post study using, for the most part, EMR data. Statistically significant decreases in medication errors, in both unadjusted and adjusted analyses, were demonstrated when comparing the pre- and post-intervention periods. Clinically significant medication errors were rare and not significantly different between groups. Thirty-day patient outcomes were not significantly different between groups after adjustment.

Specific Aim 3

Evaluate the impact of virtual continuity by comparing, between PCP intervention groups, PCPs' frequency and timeliness of receiving information, PCPs' perception of information exchange adequacy and usefulness, and their patients' satisfaction with care and with the information they have received.

Unfortunately, due to the challenges outlined in Specific Aim 2, Aim 3 had to be abandoned. The absence of a randomized trial precluded any consideration of comparing differences in PCPs experiences with and without the intervention, and the retrospective nature of our pre-intervention data collection precluded any comparison of PCP experience pre- and post-intervention. For patient follow-up data required for fulfill this aim, the HIPAA and informed consent waiver forbade any patient contact; data gathering was limited to elements that could be obtained from the EMR. Thus, patient satisfaction data, which could only be collected through contacting patients, was not available.

Conclusions

Our work, despite many challenges, made contributions in 2 areas pertinent to hospital to PCP communication and patient care quality. In Specific Aim 1, we used a Delphi expert panel of PCPs to inform the development of hospital to PCP communication tools (3). We learned that PCPs have definite preferences regarding the type of information they wanted to receive and when they wanted to receive it. PCPs preferences regarding the specific items they felt most valuable to receive and the receipt of emergency department visit data had not been well characterized previously. In addition, physician preference for communication mode shifting toward email vs. fax or phone was unsurprising but not previously documented.

From the patient care quality standpoint, we showed that discharge medication errors, our primary outcome, were significantly decreased by a set of automated communication tools designed to update PCPs on their hospitalized patients while under the care of a hospital physician. Unfortunately, we cannot distinguish which component(s) were critical to this result. It could be argued that the automated mandatory medication reconciliation process at patient discharge was the key component in decreasing discharge medication errors, and that the PCP communication occurring after this process could not affect this outcome. If this is the case, demonstration that a software-based medication reconciliation process successfully reduces medication errors is still valuable finding.

We did not find differences in clinically important medication errors or in patient outcomes. Interestingly, our clinically important medication error rates were much lower than typically reported in both the pre- and post-intervention periods (14). It is not clear why our rates were so low. We used a commonly definition for these errors (14), and well-described format for finding them (13). Low and unchanged medication error rates suggest that patient outcomes would be no different with or without the intervention, which is what we found.

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List of Publications and Products

1. Smith KJ, Clark S, Kapoor WN, Handler SM. Information primary care physicians want to receive about their hospitalized patients. *Fam Med*. 2012; 44: 425-430.

2. Smith KJ, Handler SM, Kapoor WN, Reddy V, Clark S. Automated communication tools and computer-based medication reconciliation to decrease hospital discharge medication errors: a quasi-experimental study. In preparation.