ORIGINAL RESEARCH

Effect of a Systems Intervention on the Quality and Safety of Patient Handoffs in an Internal Medicine Residency Program

Kelly L. Graham, MD^{1,4}, Edward R. Marcantonio, MD, SM^{1,2}, Grace C. Huang, MD^{1,3}, Julius Yang, MD, PhD¹, Roger B. Davis, ScD¹, and C. Christopher Smith, MD¹

¹Division of General Medicine and Primary Care, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA; ²Division of Gerontology, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA; ³Carl J. Shapiro Institute for Education and Research at Harvard Medical School and Beth Israel Deaconess Medical Center, Boston, MA, USA; ⁴Harvard Medical School Fellowship in General Internal Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA.

BACKGROUND: Poor quality handoffs have been identified as a major patient safety issue.

In residency programs, problematic handoffs may be an unintended consequence of duty-hour restrictions, and key data are frequently omitted from written handoffs because of the lack of standardization of content.

OBJECTIVE: Determine whether an intervention that facilitates face-to-face communication supported by an electronic template improves the quality and safety of handoffs.

DESIGN: Before-after trial.

PARTICIPANTS: Thirty-nine interns providing night-time coverage over 132 intern shifts, representing ~9,200 handoffs.

INTERVENTIONS: Two interventions were implemented serially—an alteration of the shift model to facilitate face-to-face verbal communication between the primary and nighttime covering physicians and an electronic template for the day-to-night handoff.

MEASUREMENTS: Overall satisfaction and handoff quality were measured using a survey tool administered at the end of each intern shift. Written handoff quality, specifically the documentation of key components, was also assessed before and after the template intervention by study investigators. Interns used the survey tool to report patient safety events related to poor quality handoffs, which were validated by study investigators.

RESULTS: In adjusted analyses comparing intern cohorts with similar levels of training, overall satisfaction with the new handoff processes improved significantly ($p < 0.001$) post intervention. Verbal handoff quality (4/10 measures) and written handoff quality (5/6 measures) also improved significantly. Study investigators also found significant improvement in documentation of key components in the written handoff. Interns reported significantly fewer reported data omissions ($p = 0.001$) and a non-significant reduction in near misses ($p = 0.056$), but no significant difference in adverse events ($p = 0.41$) post intervention.

CONCLUSIONS: Redesign of shift models common in residency programs to minimize the number of handoffs and facilitate face-to-face communication, along with implementation of electronic handoff templates, improves the quality of handoffs in a learning environment.

KEY WORDS: hand-off; transitions in care; patient safety; quality improvement; graduate medical education; systems-based practice; communication; continuity of care.

J Gen Intern Med 28(8):986–93

DOI: 10.1007/s11606-013-2391-7

© Society of General Internal Medicine 2013

Transfers of responsibility for patient care between physicians, known as handoffs, are ubiquitous in the era of duty-hour restrictions for physicians-in-training. When the Accreditation Council for Graduate Medical Education enacted duty hours restrictions for physicians-in-training in 2003, handoffs increased by about 40 %; the average 5-day inpatient stay is now associated with approximately 15 handoffs.¹ Handoffs have been recognized as a significant source of patient harm. The Joint Commission found that communication failures were the root cause of up to 60 % of adverse events,² and it is likely that handoffs represent vulnerable times for communication failures. Other studies have demonstrated a link between problematic handoffs with patient safety events³ and increases in healthcare utilization.⁴ These concerns have led governing bodies, including the World Health Organization, The Joint Commission, and the Institute of Medicine to set an international agenda to standardize, improve, and provide education around handoffs.⁵

Several studies have identified flaws in the handoff process and potential targets for intervention. Findings include: (1) problematic shift models common to residency programs in the US undermine direct physician communication and increase the number of handoffs, reducing the quality of the verbal handoff^{6–9}; (2) written handoffs are wrought with variability and content omissions⁷; (3)

Electronic supplementary material The online version of this article (doi:10.1007/s11606-013-2391-7) contains supplementary material, which is available to authorized users.

Published online April 18, 2013

electronic templates can mitigate handoff problems.^{10,11} The aforementioned research has led to several recommendations for interventions to improve handoffs.^{1,2,5,6,12–14} The few published intervention studies have not examined patient safety events as outcomes, leading experts to question the utility of standardization of handoffs as a patient safety initiative.¹⁵ Additionally, despite several studies evaluating written handoff templates and educational workshops, we are not aware of any studies examining the effect of more system-wide interventions to address the problematic shift models that are common in the era of duty hours restrictions.

We aim to evaluate a systems-level intervention on the structural framework in which handoffs occur. Our outcomes include patient safety events, physician-rated handoff quality, and standardized reviews of handoff content. We hypothesized that by altering the shift model to eliminate additional handoffs and facilitate face-to-face verbal communication between the primary and cross-covering physicians, and providing an electronic template to standardize written handoff content, handoff quality, physician satisfaction, and patient safety would improve.

METHODS

Setting

We studied the handoff process from the primary day teams to the nighttime coverage teams in an internal medicine residency program. Nighttime coverage is provided by two interns, who provide cross-coverage for the entire teaching service (excluding ICU patients) during 2-week rotations. These interns receive almost all of the day-to-night handoffs in the residency program, with each intern receiving between 60 and 90 patient handoffs from 14 physicians at the start of each shift.

Study Design and Intervention

We used a before/after design to measure the effect of our intervention on pre-specified outcomes. Two separate interventions were implemented serially during academic year 2009–2010 across the entire residency program. The interventions were based on an extensive review of the handoff literature across numerous industries and an informal survey of handoff recipients at our institution.^{1,6,7,9,13,16–18} The interventions were additive, such that the second intervention occurred with the first in place.

At baseline, the day-to-night handoff was a “double handoff,” whereby the primary physicians handed off to an intermediary physician, so that they could leave the hospital earlier and preserve duty hour limits. A second handoff occurs between the intermediary and nighttime coverage physician when the night shift began (Appendix Figure 1A,

available online). The written handoff used a simple free text box linked to each of the patients in the hospital’s clinical information system, with no structure for content (Fig. 1a).

The first intervention occurred in November 2009 and altered the shift model to facilitate face-to-face verbal communication between the primary and nighttime coverage physicians. By asking the night float teams to arrive 1.5 h earlier, at 5:30 p.m., and requiring the primary teams to remain in the hospital until their arrival, the intermediary handoff was removed (Appendix Figure 1B, available online).

The second intervention occurred in March 2010 and was designed to improve the content of the written handoff. The study investigators (KG, JY) created an electronic template for the handoff that linked to the hospital’s clinical information system and provided cues for appropriate content, including a summary assessment of the patient, past medical history, current medication list, active problems, current clinical status at the time of handoff, “contingency planning” where the primary team provided anticipatory guidance for events that were likely to occur overnight, and a task list to be completed during the overnight shift (Fig. 1b).

Evaluation

All eligible interns providing nighttime coverage during the study period were asked to complete a paper survey designed to assess the outcomes of interest at the end of each shift. Participants met with a study investigator at the start of each 2-week rotation, at which time they were invited to participate and oriented to the survey tool. There were no exclusion criteria. All interns agreed to participate.

To monitor the impact of each intervention on our outcomes, we collected data over four time periods (Fig. 2). Of note, period 4 served as a comparison group to period 1, in that both groups were at a similar level of training; however, period 4 interns had both interventions in place.

Ethical Issues

The Institutional Review Board of Beth Israel Deaconess Medical Center approved the protocol as exempt from further review as a quality improvement project. Participation by individual physicians was voluntary and kept anonymous.

Outcomes and Analysis

Survey-Based Outcomes. The paper survey included one question to assess overall satisfaction with handoff

a

[Notes:](#)

[Provider Order Entry](#)
[View WebOMR](#)

Allergies: Penicillins
Insurance: No insurance

[To Do:](#) [Dt:](#) [Tm:](#)

[To Do:](#) [Dt:](#) [Tm:](#)

b

[Notes:](#)

[Provider Order Entry](#)
[View WebOMR](#)

Allergies: Penicillins
Insurance: No insurance

[Summary Assessment:](#)

[Past Medical History:](#)

[Current Clinical Status:](#)

[Active Issues:](#)

[Contingencies:](#)

[Tasks:](#)

Figure 1 The written sign-out template before (a) and after (b) the electronic template intervention. Displayed here is the electronic documentation system, which links to the provider order entry system and the hospital's online medical record (webOMR); see the upper right corner of a and b for the location of these links. The larger text boxes featured at the top of a and b are where the teams keep their admission history and physicals for the patient, and the smaller text boxes at the bottom are where the teams document their written sign-outs. Before the intervention, the template was very simple, with the subheading "To do" for each text box. After the intervention, the template subheadings are specific, directing learners about what type of information should be documented in the sign-out.

communication, ten questions to assess verbal handoff quality, and six questions to assess written handoff quality. Answers were on a 5-point scale of behavior frequency (almost never, rarely, sometimes, usually, almost always). To assess the effect of our intervention on overall satisfaction and handoff quality, we compared the results

from periods 1 and 4 to avoid confounding by clinical experience. We fit regression models with generalized estimating equations (GEE) methods to account for correlated data, as the interns were surveyed multiple times. To control for confounding, we screened all variables included on the survey that differed significantly

Figure 2 Timing of data collection periods and interventions over two academic years.

between the groups (gender, categorical status, handoff training prior to residency) and included those that changed the effect estimate $>20\%$ in our model. All statistical analyses were performed using SAS version 9.2 (Cary, NC) and STATA (STATA Corp. LP, College Station, TX).

Review of Written Handoffs. To isolate the effect of the electronic template intervention and to minimize the subjectivity embedded in the survey responses, a study investigator (KG) directly reviewed the content of written handoffs. We randomly selected 200 written patient handoffs, half of which were collected before (period 2) and half after (period 3) the electronic template intervention (Fig. 2). We scored these written handoffs for adherence with what we had determined to be “best practices” for written handoff content as determined by consensus of local educational and quality improvement experts and an extensive review of the literature. A separate investigator (EM) blinded to the study period scored a 10% random sample of the written handoffs to ensure that the initial adherence assessment was not biased; to blind this review, headings were removed from the period 3 handoffs and only content was reviewed. We calculated the percentage of handoffs containing each of these five components before and after the intervention, and assessed for significant change in the “before-after” periods using a regression model with a GEE to account for clustering within interns.

Patient Safety Events. At the start of each nightfloat rotation, as interns were recruited into the study, each group met individually with a study investigator for a tutorial on how

to recognize data omissions, near misses, and adverse events. Definitions and case examples were included on the survey tool as reminders. Interns were asked to report all data omissions, near misses, or adverse events related to poor quality handoffs after each shift, and to describe the events. All reported events were analyzed independently by three study investigators (KG, GH, CS) unblinded to the collection periods to determine (1) if the events were related to a poor quality handoff and (2) the correct event classification. Where there was disagreement, a meeting was held to reach consensus. In addition, a separate investigator (EM) blinded to the time period re-classified the events along the same parameters. To assess the effect of our intervention on patient safety, similar to the aforementioned analysis of survey-based outcomes, we compared results from periods 1 and 4 by fitting the data to an exact Poisson regression model, which enabled us to perform the analysis despite problems with non-convergence, as zero events were reported in the final collection period.

RESULTS

Intern Characteristics

A total of 39 interns were surveyed over 132 intern shifts, representing approximately 9,200 individual patient handoffs. The average age of the respondents was 27.6 years, and 51% were female. Eighty-eight percent of respondents reported receiving no training on handoffs

before residency, and 97 % believed that handoffs were an important part of patient care. Table 1 displays the intern characteristics by period. Examining periods 1 and 4, which are the primary periods for our analysis, intern age, handoff training during residency, and attitudes toward the importance of handoffs were similar. There were more females, categorical interns, and interns reporting that they had received handoff training prior to residency in period 1 vs. 4.

Survey Results

Post intervention interns (period 4 vs. 1) reported better overall satisfaction with the handoff process than interns without any interventions (Table 2). Before the interventions, interns on average reported “fair” overall satisfaction with handoff communication. After the intervention, interns were equally likely to report “good” or “excellent” overall satisfaction with handoff communication ($p<0.001$).

Post intervention (period 4 vs. 1) interns reported higher quality verbal handoffs than interns without any interventions (Table 2). In adjusted analyses, interns were significantly more likely to report meeting face to face with the outgoing doctor ($p=0.002$), to have the outgoing doctor’s full attention ($p<0.001$), to state that the outgoing doctor was better able to explain why specific tasks were assigned ($p=0.002$), and to report that there was more time for follow-up questions ($p=0.004$). However, several quality measures were not improved by our intervention (Table 2).

Post intervention interns (period 4 vs. 1) reported higher quality written handoffs than interns without any interventions (Table 2). In adjusted analyses, interns reported that

written handoffs more clearly listed tasks to be completed ($p<0.001$), had more complete and succinct case summaries ($p=0.009$), more clearly identified clinical priorities for patients ($p<0.001$), had more anticipatory guidance should patients become clinically unstable ($p<0.001$), and had less frequent data omissions ($p<0.001$). In summary, comparing periods 1 and 4, overall satisfaction with handoffs, four of ten verbal handoff quality measures and five of six written handoff quality measures improved.

While our primary statistical analysis was performed using data from periods 1 and 4, overall physician satisfaction and physician-rated handoff quality steadily improved, with declines in reported data omissions, near misses, and adverse during periods 2 and 3.

Assessment of Written Handoffs

In addition to the intern handoff survey, we evaluated the content quality of written handoffs before and after the electronic template intervention using a scoring system conducted during collection periods 2 and 3 (before and after the written handoff intervention). We found a high level of agreement between the study investigators that scored the written handoffs in real time and the second blinded assessment (kappa = 0.95). Post intervention interns (period 3 vs. 2) were more likely to adhere to best practices for written hand-off content (Table 3), including being more likely to document an active problem list ($p<0.001$), provide contextual information on the patient’s current clinical status ($p<0.001$), and include anticipatory guidance for potential clinical issues that may have arisen during the shift ($p<0.001$).

Table 1. Baseline Characteristics of Interns for Each Data Collection Period

	Period 1*	Period 2	Period 3	Period 4
Age				
Mean (SD), years	26.9 (1.6)	28.9 (1.8)	27.0 (1.4)	27.2 (1.1)
Gender				
% Female	68	67	39	33
Categorical vs. preliminary†				
% Categorical	94	80	88	63
Handoff training				
% Reporting training prior to residency	38	28	3	0
% Reporting training during internship	89	80	75	91
Attitudes				
% Agreeing handoffs are important for patient care	100	100	97	100

***See Figure 2 for details about timing of collection periods, number of interns, shifts, and handoffs evaluated

**†Categorical interns stay for a full internal medicine residency; preliminary interns spend 1 year in internal medicine and then proceed to other specialties

Patient Safety Events

We found a high level of agreement between the three study investigators who rated the patient safety events in real time and a fourth blinded investigator (kappa = 0.78 for adverse events, 0.96 for near misses, and 0.76 for data omissions). Disagreements between blinded and unblinded assessments were resolved at a consensus meeting. These consensus ratings showed that interns reported significantly fewer data omissions ($p=0.001$) and a non-significant reduction in near misses ($p=0.056$), but no significant difference in adverse events ($p=0.41$) post intervention (Table 4).

DISCUSSION

In this before/after trial evaluating approximately 9,200 patient handoffs within a large urban teaching hospital, an intervention focused on handoff systems eliminated a

Table 2. Change in Overall Satisfaction and Perceived Handoff Quality Before and After the Intervention Based on Intern Survey Responses

Survey question**	Period 1 mean (SD)	Period 4 mean (SD)	P value *
Overall satisfaction			
Overall, the communication I received during handoff was	2.4 (0.49)	3.5 (0.62)	<0.001 [†]
Verbal handoff quality			
I met face to face with the outgoing intern to discuss the sign-outs	3.9 (0.80)	4.9 (0.23)	0.002 [‡]
The sign-out happened in a place that allowed for minimal interruption and distractions	3.9 (0.99)	4.5 (0.23)	0.85 [§]
During the sign-out I had the outgoing intern's full attention	4.3 (0.59)	5.0 (0)	<0.001 [†]
The outgoing intern explained why tasks were assigned	3.5 (0.68)	4.3 (0.73)	0.002 [‡]
During sign-out, the outgoing intern and I discussed the sickest patients first	2.1 (0.90)	2.6 (0.68)	0.39
I had enough time to ask the outgoing intern additional questions	2.0 (0.95)	3.2 (1.2)	0.004 [†]
The outgoing intern used vague terms that made it difficult for me to understand the patient's clinical status	3.1 (0.95)	2.7 (0.81)	0.48 [§]
For the sickest patients, the outgoing resident and I went to the bedside for the sign-out	1.0 (0)	1.2 (0.71)	0.14 [¶]
During the sign-out, I felt comfortable bringing up issues the outgoing intern did not address	3.9 (1.0)	4.8 (0.42)	0.34 [#]
The outgoing intern assessed my understanding of each patient or task	2.7 (1.1)	3.0 (0.96)	0.35 [§]
Written handoff quality			
The paper sign-out clearly listed and prioritized tasks that needed to be completed for each handoff	3.5 (0.72)	4.8 (0.42)	<0.001 [†]
The written case summary was complete and succinct	3.0 (0.83)	4.3 (0.67)	0.009 [‡]
The outgoing intern clearly identified the clinical priorities for the patients	3.2 (0.67)	4.4 (0.61)	<0.001 [†]
I received guidance on actions to take if a particular issue arose during my shift	3.3 (0.58)	4.6 (0.61)	<0.001 [†]
By the end of my shift, I discovered elements missing from the sign-out (history, tasks, data) that would have helped me provide more effective care	3.7 (0.81)	2.3 (0.82)	<0.001 [‡]
By the end of my shift, I discovered that I received excessive information during the sign-out, which hindered my ability to provide effective care	2.7 (0.98)	2.2 (1.12)	0.68 [¶]

**P values for change in mean score were derived using a regression model with a generalized estimating equation using the score as the dependent variable and the period (1 vs. 4) as the independent variable of interest. To control for confounding, we screened all variables included on the survey that differed significantly between the groups (gender, categorical status, handoff training prior to residency) and included those in our model that changed the effect estimate > 20 %

**† No adjustment necessary

**‡ Adjusted for training

**§ Adjusted for training, categorical status, and gender

**|| Adjusted for gender

**¶ Adjusted for gender and categorical status

**# Adjusted for training and gender

*** Response scale is as follows: almost always (5), usually (4), sometimes (3), rarely (2), almost never (1)

problematic shift model to facilitate face-to-face verbal communication and provided an electronic, evidence-based template to ensure appropriate written content. We found a significant improvement in physician satisfaction, physician-reported quality of handoff processes, documentation of key elements in the written handoff, and reduced data omissions. Our study fills an important gap in the literature on handoffs by addressing problematic shift models common to residency programs and studying resultant

patient safety outcomes. The systematic components we implemented are broadly applicable to residency programs.

The “double handoff” (Appendix Figure 1A, available online) exemplifies a problematic handoff system. This shift model has been identified in several other studies^{2,7} and is likely common in residency programs across the US as a mechanism to reduce duty hours.⁸ Prior studies have shown that this practice is associated with critical data omissions, particularly in the verbal handoff. Horwitz and colleagues found that the intermediary physician is less likely to provide information about patients' current clinical condition or provide anticipatory guidance about problems that may arise overnight, and 22 % of the information in the second handoff was either misclassified or omitted completely.⁷ In another study, interns frequently identified the double handoff as a source of critical content omissions and disruptions in work flow.² Our study eliminated this problematic handoff system and our evaluation demonstrated improved outcomes.

Horwitz and colleagues⁷ also evaluated the written handoff and found that less than one third contained minimum requirements for content. Our baseline assessment supports these findings, as our pre-intervention interns reported critical data omissions that interfered with patient care on 59 % of night float shifts, and our detailed analysis

Table 3. Change in Written Handoff Content After an Electronic Template Intervention Based on Investigator Review of Sign-out Documents

Handoff content evaluated	Pre-intervention	Post-intervention	P value*
Summary assessment	87 %	90 %	0.58
Past medical history	90 %	100 %	†
Active problem list	74 %	96 %	<0.001
Current clinical status	46 %	96 %	<0.001
Anticipatory guidance	53 %	86 %	<0.001

***P values for significant change in inclusion of content elements were based on regression models using generalized estimating equations to adjust for clustering within interns

**†A p value could not be obtained because of non-convergence, as all sign-outs during the post-intervention period included a summary assessment

Table 4. Reported Patient Safety Events over the Course of the Study based on Intern Survey Responses

	Number of events				IRR (95%CI)*†	P value *
	Period 1 (39 shifts represented)	Period 2 (43 shifts represented)	Period 3 (31 shifts represented)	Period 4 (19 shifts represented)		
Critical data omissions (no. events)	23	24	8	0	0 (0, 0.34)	0.001
Near misses (no. events)	9	4	1	0	0 (0, 1.04)	0.056
Adverse events (no. events)	4	4	1	0	0 (0, 3.11)	0.41

***Effect estimates and p values represent a comparison between collection periods 1 and 4. P values are derived using exact Poisson regression

**†IRR Incident rate ratio

of written handoff content confirmed that key data elements were frequently missing pre-intervention. A structured handoff template substantially improved the quality and content of handoffs, particularly in documentation of real-time clinical status and anticipatory guidance.

It is important to understand the limitations of a systems intervention as opposed to a physician-centered educational approach. Our intervention was successful at producing improvement in facilitated behaviors rather than behaviors that reflect clinical training and experience. For example, our intervention effectively facilitated direct verbal communication, with significant improvement on the survey question: "I met face-to-face with the outgoing doctor." However, the intervention was less effective at improving behaviors such as "The outgoing doctor and I discussed the sickest patient first" or "The outgoing physician used vague language," which may be more indicative of clinical experience. These examples illustrate the continued importance of educational workshops and performance feedback for training physicians on handoff skills in addition to systems-based approaches such as ours.

There are unique challenges in implementing a systems-level change in a residency program. Both of our interventions created standard work in areas characterized by a fair amount of physician discretion and practice variation. We met regularly with housestaff to inform them of upcoming changes to their workflow and hear their valued feedback during the study and shared our results with them at the conclusion. This approach kept our process inclusive and user-focused, while enhancing the safety culture of the residency program.

The available literature on the relationship between handoffs and patient safety is limited. One study found that the condition of cross coverage was associated with preventable adverse events.¹⁹ A follow-up study by this author demonstrated a loss of this association when an electronic template for handoffs was introduced.²⁰ Previous observational studies have linked problematic handoffs with patient safety events—specifically adverse events, near misses, and duplicative care.³ We are unaware of previous studies that have evaluated the effect of a handoff intervention on patient safety events. Our study was able to show a significant reduction in data omissions and a non-

significant reduction in near misses after a handoff intervention.

Our study has several important implications for both faculty clinical practice and residency training programs. Hospital medicine and residency programs share similar handoff structures; as such, both will need to assess the potential consequences of their shift models and written sign-out methods. Further study of the effect of such interventions with hospitalists is warranted. By developing creative solutions that preserve direct physician communication, it is possible to limit duty hours while still facilitating safe handoff practices. Our study suggests that both verbal and written handoffs are, though not universal among residency programs,⁸ important to patient safety.

Our study has some limitations. We employed a before/after study design, rather than a randomized controlled trial. However, because our study took place within a training program, the threat of contamination was too great with randomization. To address the potential effect of other ongoing quality improvement interventions at the hospital, we limited the length of the study phases to 3 months. To avoid confounding by clinical experience, we used periods 1 and 4 for our primary comparisons. While our study was technically unblinded, we compared separate intern years and used blinded validation studies for assessment of our outcomes. Our analysis of patient safety events was likely underpowered. Moreover, there is a risk of reporting bias in period 4 due to generally improved satisfaction with the handoff process. While prospective evaluation of patient safety events through medical record review would have been superior, we had over 9,000 handoffs represented, and such a review was beyond the scope of our study. Moreover, it would be difficult to attribute such events to poor handoffs as such an assessment is dependent on the involved physician. We were unable to use chart review to verify whether the sign-out content was accurate as such analysis was beyond the scope of our study. Medical record review would have potentially led to interns underreporting for fear of repercussions to themselves or their colleagues. Because our outcomes were dependent on the involved physicians' judgment, we felt anonymity was critical to accuracy. Finally, it should be noted that the interns in periods 1 and 4 differed significantly with respect to gender,

categorical status, and handoff training. We adjusted our analysis for these factors accordingly.

In summary, we found that an intervention aimed at facilitating safe handoff practices, by reducing the number of sequential handoffs, enabling direct face-to-face communication, and providing a template to ensure appropriate written content, improved perceived verbal and written handoff quality, improved documentation of key handoff components, and reduced content omissions. Our findings suggest that shift models that impose double handoffs should be re-designed to promote face-to-face verbal communication between the primary team and the cross-covering team and that hospitals should leverage their information technology departments to create embedded electronic systems to facilitate high quality content for the written handoff.

Funders: Dr. Graham is supported by a Health Resources and Services Administration training grant (T32 HP12706). Dr. Marcantonio is supported by a Midcareer Investigator Award in Patient-Oriented Research from the National Institute on Aging (K24 AG035075). This work was also conducted with support from Harvard Catalyst (NIH Award #UL1 RR 025758) and financial contributions from Harvard University and its affiliated academic health care centers. None of the aforementioned funding sources had a role in the design, conduct, collection, analysis, or interpretation of the data or in the preparation, review or approval of the manuscript.

This work was presented at the New England Regional SGIM conference as an oral abstract on March 8, 2013.

Conflicts of Interest: No authors report any conflicts of interest.

Corresponding Author: Kelly L. Graham, MD; Harvard Medical School Fellowship in General Internal Medicine, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Office CO-210, Boston, MA 02215, USA (e-mail: kgraham@bidmc.harvard.edu).

REFERENCES

1. Vidyarthi AR, Arora V, Schnipper JL, Wall SD, Wachter RM. Managing discontinuity in academic medical centers: strategies for a safe and effective resident sign-out. *J Hosp Med.* 2006;1(4):257-66.
2. Arora V, Johnson J, Lovinger D, Humphrey HJ, Meltzer DO. Communication failures in patient sign-out and suggestions for improvement: a critical incident analysis. *Qual Saf Health Care.* 2005;14(6):401-7.
3. Horwitz LI, Moin T, Krumholz HM, Wang L, Bradley EH. Consequences of inadequate sign-out for patient care. *Arch Intern Med.* 2008;168(16):1755-60.
4. Lofgren RP, Gottlieb D, Williams RA, Rich EC. Post-call transfer of resident responsibility: its effect on patient care. *J Gen Intern Med.* 1990;5(6):501-5.
5. Johnson JK, Arora VM. Improving clinical handovers: creating local solutions for a global problem. *Qual Saf Health Care.* 2009;18(4):244-5.
6. Arora VM, Johnson JK, Meltzer DO, Humphrey HJ. A theoretical framework and competency-based approach to improving handoffs. *Qual Saf Health Care.* 2008;17(1):11-4.
7. Horwitz LI, Moin T, Krumholz HM, Wang L, Bradley EH. What are covering doctors told about their patients? Analysis of sign-out among internal medicine house staff. *Qual Saf Health Care.* 2009;18(4):248-55.
8. Horwitz LI, Krumholz HM, Green ML, Huot SJ. Transfers of patient care between house staff on internal medicine wards: a national survey. *Arch Intern Med.* 2006;166(11):1173-7.
9. Philibert I. Use of strategies from high-reliability organisations to the patient hand-off by resident physicians: practical implications. *Qual Saf Health Care.* 2009;18(4):261-6.
10. Wayne JD, Tyagi R, Reinhardt G, Rooney D, Makoul G, Chopra S, et al. Simple standardized patient handoff system that increases accuracy and completeness. *J Surg Educ.* 2008;65(6):476-85.
11. Van Eaton EG, Horvath KD, Lober WB, Rossini AJ, Pellegrini CA. A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours. *J Am Coll Surg.* 2005;200(4):538-45.
12. Horwitz LI, Moin T, Green ML. Development and implementation of an oral sign-out skills curriculum. *J Gen Intern Med.* 2007;22(10):1470-4.
13. Arora V, Johnson J. A model for building a standardized hand-off protocol. *Jt Comm J Qual Patient Saf.* 2006;32(11):646-55.
14. Solet DJ, Norvell JM, Rutan GH, Frankel RM. Lost in translation: challenges and opportunities in physician-to-physician communication during patient handoffs. *Acad Med.* 2005;80(12):1094-9.
15. Cohen MD, Hilligoss PB. The published literature on handoffs in hospitals: deficiencies identified in an extensive review. *Qual Saf Health Care.* 2010;19(6):493-7.
16. Patterson ES, Wears RL. Patient handoffs: standardized and reliable measurement tools remain elusive. *Jt Comm J Qual Patient Saf.* 2010;36(2):52-61.
17. Patterson ES, Roth EM, Woods DD, Chow R, Gomes JO. Handoff strategies in settings with high consequences for failure: lessons for health care operations. *Int J Qual Health Care.* 2004;16(2):125-32.
18. Jeffcott SA, Evans SM, Cameron PA, Chin GS, Ibrahim JE. Improving measurement in clinical handover. *Qual Saf Health Care.* 2009;18(4):272-7.
19. Petersen LA, Brennan TA, O'Neil AC, Cook EF, Lee TH. Does housestaff discontinuity of care increase the risk for preventable adverse events? *Ann Intern Med.* 1994;121(11):866-72.
20. Petersen LA, Orav EJ, Teich JM, O'Neil AC, Brennan TA. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. *Jt Comm J Qual Improv.* 1998;24(2):77-87.