Six Sigma Methodology and Postoperative Information Reporting: A Multidisciplinary Quality Improvement Study With Interrupted Time-Series Regression

Aalap C. Shah, MD, [*,†] Andrew R. Herstein [*], Katherine T. Flynn-O'Brien [‡], Daniel C. Oh [¶], Anna H. Xue [¶] and, Meghan R. Flanagan, MD, MPH [‡,§]

[*]Department of Anesthesiology and Pain Medicine, University of Washington Medical Center, Seattle, Washington; [†]Independent Practice in Los Angeles, California; [‡]Department of Surgery, University of Washington Medical Center, Seattle, Washington; [¶]University of Washington School of Medicine, Seattle, Washington; and [§]Department of Surgery, University of Washington Medical Center, Seattle, Washington

OBJECTIVE: The postoperative handover is often compromised by reporting inconsistencies between different specialties. We describe a multidisciplinary quality improvement initiative to improve postoperative information reporting.

DESIGN: A quality improvement project with interrupted time-series data collection was undertaken in the postanesthesia care unit between January 2015 and August 2015. We utilized Six Sigma methodology to engage multispecialty stakeholders in identifying deficiencies in the existing postoperative handover process in January 2015. A standardized handover process including a checklist and electronic handover note was implemented within a postanesthesia care unit in June 2015. Direct observations of handovers were conducted to determine reporting accuracy, handover duration, and specialty representative attendance. Segmented linear and logistic regression analyses were used for interrupted time-series data.

SETTING: Single postanesthesia care unit at an academic tertiary referral center.

PARTICIPANTS: Physician trainees in anesthesia (n = 82) and surgical subspecialties (n = 139), certified registered nurse anesthetists (n = 57), and recovery room registered nurses (n = 139).

RESULTS: Cumulative handover scores increased by 18.3 points in the postimplementation period (n = 70) when compared to preimplementation handovers (n = 69), a finding which remained statistically significant after adjusting for preintervention time trends (difference 16 points; 95% confidence intervals 3-31; p = 0.021). No statistically significant difference in handover duration was seen between cohorts (6.8 minutes vs 6.1 minutes, difference 0.5 minutes; 95% confidence intervals −2.8 to 3.7; p = 0.78). Three years postimplementation, there was consistent use of a modified electronic handover note and surgical subspecialty attendance during handover.

CONCLUSIONS: A standardized handover process was associated with improved information reporting among different surgical disciplines without significantly lengthening handover duration. (J Surg Ed 76:1048−1067. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Continuous quality improvement, Six Sigma, Postoperative handover, Information reporting

COMPETENCIES: Interpersonal and Communication Skills, Systems-Based Practice, Professionalism, Patient Care

Correspondence: Inquiries to Aalap C. Shah, MD, University of Washington Medical Center, 1959 NE Pacific Street, Box 356540, West Hollywood, CA 90069; fax: 1-(310)-423-0387; e-mail: aalap.c.shah@gmail.com

Funding/Support: The University of Washington Housestaff Quality and Safety Committee (HQSC) funded the materials and staff necessary for the collection management and analysis of the data.

This report was previously presented, in part, at the 2017 American Society of Anesthesiologists meeting on October 21, 2017, in Boston, Massachusetts.

  1931-7204/$30.00 https://doi.org/10.1016/j.jsurg.2018.12.010

INTRODUCTION

The postoperative transfer-of-care (TOC), or handover, is an interactive process that facilitates patient-specific information exchange between multidisciplinary providers to ensure the continuity and safety of patient care after the perioperative physicians have left the bedside. This handover typically follows a model in which members of the clinical care team provide a verbal report of the anesthetic and surgical course of the patient in the operating room (OR) to a nurse in the postanesthesia care unit (PACU). This process often occurs in an environment with incomplete teams, multiple distractions, and competing demands on the attention of each of the involved members.[1–4] These handovers may lack electronic documentation and can lead to omission of critical data that may be important for subsequent care providers. It is well recognized that incomplete or inaccurate information, repeated interruptions, and lack of anticipatory guidance impair handover quality and may contribute to adverse patient outcomes.[5–10]

The Joint Commission Center for Transforming Healthcare advocates the use of Robust Process Improvement tools to improve the quality and safety of healthcare delivery in different practice settings.[11] Lean and Six Sigma are quality improvement methodologies that have been gradually adopted into the healthcare arena over the past decade, including initiatives to optimize perioperative efficiency.[12,13] In an effort to improve the postoperative TOC, a resident-led multidisciplinary group at a high-volume, tertiary academic hospital participated in a year-long quality improvement curriculum and applied Six Sigma methodology to develop and implement a structured TOC process.[14] This endeavor included a paired visual checklist and electronic handover note and encouraged routine attendance of surgical subspecialty representatives, anesthesia, and PACU nursing personnel during the handover. We hypothesized that these changes would improve the reporting of patient and operation-specific data transfer without significantly increasing handover duration.

METHODS

This quality improvement project took place at Harborview Medical Center (HMC), a 413-bed tertiary-care hospital and level one trauma center within the University of Washington Medicine system. Over 16,000 operations are performed each year, of which approximately 8400 are elective cases with the remainder comprised of emergent and acute inpatient cases. The Human Subjects Division at the University of Washington determined this study was exempt from review by the Institutional Review Board. We utilized the Six Sigma Define, Measure, Analyze, Improve, and Control (DMAIC) methodology[15] to tailor our approach to this project and referenced the Standards for Quality Improvement Reporting Excellence guidelines (version 2.0) in composition of the manuscript.[16]

D: *Define*

Results from an institution-wide survey (HMC Culture of Patient Safety Survey[17]) regarding areas of improvement revealed inter-team communication as a frequently reported concern by physicians and healthcare staff members. In December 2014, a multidisciplinary team of physicians, certified registered nurse anesthetists (CRNAs) and PACU registered nurses (RNs) collaborated to identify deficits in the perioperative TOC process. This group included resident trainees within the University of Washington Housestaff Quality and Safety Committee involved in a year-long quality improvement curriculum, including a member with Six Sigma green belt qualification (A.S.). We utilized the Donabedian model[18] and a Supplier, Input, Process, Output, and Customer table to provide a conceptual framework of the processes and members contributing to an ideal postoperative TOC, including the completion of essential patient care-related tasks prior to the verbal handover. Furthermore, we utilized a process map (Fig. 1) and a cause-and-effect diagram (Appendix Fig. A) to understand the current workflow of healthcare provider activities around the time of TOC and identify competing tasks and processes (e.g., tasks unrelated to the postoperative patient) that would detract from TOC quality. At our institution, we identified stakeholders at administrative levels (e.g., HMC Surgical Council, PACU Nursing Supervisor) as well as chief resident trainees for the different surgical subspecialties represented at HMC.

All postoperative TOCs involving a dyad of healthcare practitioners (anesthesia and surgical subspecialty trainees, CRNAs, and PACU RN) and their patients were included in the assessment. Specifically, we considered dyads with elective postoperative patients who presented to the PACU prior to planned inpatient admission to the ward or intensive care unit (ICU). We excluded TOCs involving practitioners transferring postprocedural patients to the ambulatory surgery unit or ICU, as well as patients already admitted as an inpatient in the hospital.

M: *Measure*

The primary outcome measure was the frequency of accurate data transfer during the verbal handover (cumulative handover score, CHS), as determined by a comparison of data elements against the electronic health record (EHR) of the patient. Secondary outcome measures include the frequency of erroneous information reporting, total TOC

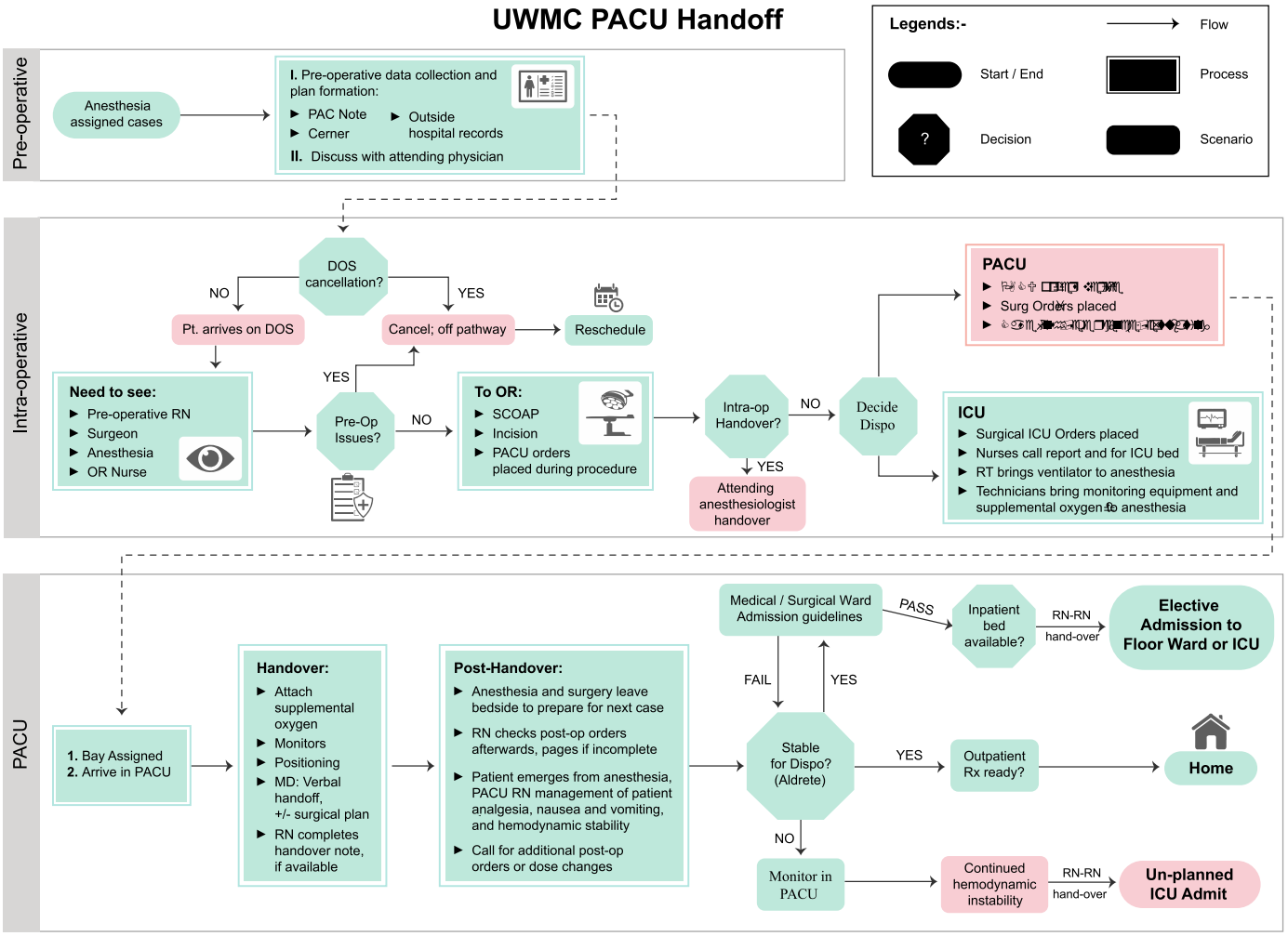


FIGURE 1. Perioperative process flow map (Harborview Medical Center, Seattle, Washington).
DOS, day of surgery; ICU, intensive care unit; MD, medical doctor (physician); PAC, preanesthesia clinic; PACU, postanesthesia care unit RN, registered nurse; Rx, medication; SCOAP, Surgical Clinical Outcomes Assessment Program.

duration, and surgical subspecialty representative attendance. A 5-question survey was distributed to PACU RN in January 2015 (preimplementation) and May 2018 (3 years postimplementation).

After a review of literature related to handovers and a consensus of the multidisciplinary team, a list of 32 data elements critical for an accurate and effective handoff was created and used to create the grading rubric for the TOC audit form. For 3 months prior to the phase-in period (preimplementation phase: January 20, 2015-March 8, 2015), 2 observers audited TOCs during scheduled shifts. All handovers occurring during an observer's shift were audited. Each of the 32 key data elements was recorded as being present or absent for each TOC, as well as staff members present, duration of handover and number and type of interruptions. Observers did not announce their presence, but stated their role if asked.

The EHR of the associated patient was reviewed to determine whether all of the 32 checklist items were appropriate for the particular handover, and whether the information provided was accurate. If an item was not applicable for a specific procedure, it was flagged as such, and was not scored as a missing data item. For each of the 32 checklist items, a score of "1" was granted if either an applicable item was appropriately mentioned and the information conveyed was accurate, or an inapplicable item was correctly omitted. A score of "0" was granted if an applicable item was incorrectly omitted or an inapplicable item was inappropriately reported. In addition to a score of "0," applicable items which were inaccurately reported (e.g., incorrect paralytic medication) were given an error notation ("E") and tallied for each item. CHS was calculated for each handover by dividing the sum of each individual item score (0-

32) by the total number of checklist items. Verbal handover duration was defined as the time in minutes required by the surgeon and anesthesia provider to verbally communicate the checklist information. Total TOC time was defined as the time in minutes elapsed between patient arrival in the PACU and the end of the verbal handover.

A: *Analyze*

Descriptive statistics were examined for the pre- and postintervention patient cohorts. A 2-tailed Fisher exact test was used to compare characteristics between groups, to compare the TOC process and frequencies of information transfer during the handover process before and after the intervention.

CHS, erroneous reporting, and TOC duration were compared pre- and postimplementation using a segmented logistic and linear regression analysis. This is a technique utilized with interrupted time-series data to separate the actual effect of the intervention from time trends in compliance that would have likely occurred without the intervention.[19] Analyses of the proportion outcomes were performed using segmented logistic regression models. A segmented linear regression model was utilized for CHS, TOC duration, and number of errors. The segmented regression models contained a factor for "treatment" (indicator of pre- vs postintervention), time over the follow-up (quarter), and another covariate indicating time elapsed postintervention (defined to be zero before the intervention). A statistically significant "time postintervention" coefficient would indicate evidence that the trend associated with calendar time had changed postintervention. Covariates adjusting for American Society of Anesthesiologists (ASA) class and number of interruptions were also included in the models. Because we allowed our time-trend effect estimates to vary pre- and postintervention, our estimated effects of intervention are not constant over time. We calculated estimates for the intervention effect (outcome postintervention compared to estimated level of the outcome assuming that no intervention had been implemented but preintervention time trend had continued) at 3 time points during the postimplementation phase.

A stratified subgroup analysis was conducted in the postimplementation cohort to determine if there were any differences in CHS comparing handovers with use of the checklist vs those that had no checklist use. Multivariable analyses were completed to evaluate the independent contribution of checklist use, surgeon attendance, and interruptions on the CHS. These covariates were chosen a priori based on the hypothesis that these variables were most likely to impact the handover score. All statistical analyses were performed with Stata version 12 (College Station, Texas).

I: *Improve*

A modified Delphi technique[20] was utilized to identify gaps in the current TOC process and determine the essential categories of information appropriate for inclusion into a checklist. (Appendix Fig. B) For the purposes of this approach, "experts" were defined as the chief resident trainees representing each surgical subspecialty residency training program that were involved in operative procedures at HMC. These individuals routinely communicate and work together closely with all involved members of the TOC, including anesthesia and surgical subspecialty trainees as well as PACU RNs, and serve as role models for resident trainees. Subspecialties were represented by a different number of experts. Of the 22 experts initially contacted, 19 provided consent and agreed to participate in the checklist evaluation process. We used electronic mail (e-mail) and Google Documents as the primary mode of communication with the expert panel and dissemination of information and surveys pertinent to checklist content reconciliation, respectively. Surveys regarding checklist iterations were distributed via 2 e-mail rounds in March 2015 (round 1). Weekly e-mail reminders were used to facilitate responses to the surveys at each stage. Responses to round 2 were used to modify the visual checklist (version 2; Appendix Fig. C) after a second meeting with the PACU RN leadership and the HMC Surgical Council. Subsequently, the checklist was laminated and placed in each patient bay (a) as a placard on the patient bedside table, and (b) on the wall above the patient bay and next to the PACU RN computer. In parallel with the development of the paper checklist (version 2), an electronic handover note (Appendix Fig. D1) was created and implemented within the EHR (Cerner Millennium Powerchart, North Kansas City, Missouri) in April 2015.

Next, we developed a standardized reporting process incorporating the visual checklist and electronic handover note as well as a structured reporting order similar to that of the OR-to-ICU TOC in the HMC ICU. The anesthesia provider, surgeon, and PACU were instructed to convene at the bedside upon arrival in the PACU. After reconnecting the patient to monitors and obtaining the first set of vital signs, surgical and anesthesia providers communicated key aspects of the medical history, intraoperative course, and plan for postoperative recovery. To encourage common reporting standards, surgical and anesthesia providers were asked to follow the paper checklist (recommended but not mandatory) while the PACU RN completed the electronic handover note (mandatory) to provide documentation of the handover. All team members were encouraged to stay at the bedside until the presentations were complete and all questions were addressed. A short video (Appendix Video A) demonstrating the ideal handoff process using both the

paper and electronic checklist was distributed to nursing, residents, fellows, and faculty via e-mail.

A 1-month phase-in period of the structured TOC process began on May 14, 2015. During the following 2 weeks, e-mail notifications, announcements at departmental academic conferences and face-to-face instruction by the group were provided to familiarize representatives of the perioperative team with the structured TOC process. Individual PACU RNs were voluntarily designated as "champions" and mentored other PACU RNs regarding use of the electronic handover note. Similar reminders and instructions on access and use of the electronic handover note, along with contact information for feedback and questions, were distributed to the HMC Department of Anesthesiology on a weekly basis. Postimplementation data collection continued until September 1, 2015.

C: Control

Responsibility regarding checklist iterations and feedback about the visual checklist was delegated to the PACU RN Supervisor. Surgical subspecialty representation was reinforced during monthly Surgical Council meetings, attended by the surgical attending chiefs representing each subspecialty. A study author (A.H.) provided encouragement for anesthesia representation and completion of the electronic checklist via monthly reminders to the Department of Anesthesiology. A revised version of the electronic checklist incorporating the elements of the visual checklist was instituted in December 2015 (Appendix Fig. D2), and the visual checklist was discontinued at this time. Feedback using subdomains from the Handoff CEX assessment[21] was elicited from e-mail and direct interviews of anesthesia and surgical subspecialty representatives, PACU RN Supervisor, and Surgical Council representatives between January 2018 and May 2018.

RESULTS

A total of 139 TOCs were audited in the pre- and postimplementation time periods (preimplementation, n = 69; postimplementation, n = 70). Each TOC was associated with (a) a PACU RN (n = 139), (b) a surgical subspecialty representative (n = 139), and (c) either an anesthesia resident trainee (n = 42 preimplementation, n = 40 postimplementation) or a CRNA (27 preimplementation, n = 30 postimplementation). Table 1 lists the patient and procedural characteristics. The mean age was 47 ± 15 years in the preimplementation cohort and 50 ± 19 years in the postimplementation cohort. Twenty-three females (38%) and 32 females (46%) were included in the preimplementation and postimplementation groups, respectively. In the preimplementation phase, 26 patients (38%) were of ASA class ≥3, compared with 29 patients (41%) after implementation. Orthopedic procedures were most common in both cohorts, followed by neurosurgical and general surgery procedures.

TABLE 1. Study Population Characteristics

	Preimplementation* (n = 69)	Postimplementation* (n = 70)
Demographics, *n* (%)		
Mean age, years (SD)	46.8 (15.2)	49.5 (19.2)
Male	43 (62)	38 (54)
ASA class, *n* (%)		
I	13 (19)	5 (7)
II	30 (44)	36 (51)
III	24 (35)	29 (41)
IV	2 (3)	0 (0.0)
Surgical subspecialty, *n* (%)		
General surgery	6 (89)	7 (10)
Neurologic surgery	21 (30)	6 (9)
Orthopedic surgery	28 (41)	42 (60)
Plastic surgery	5 (7)	0 (0)
Vascular surgery	3 (4)	7 (10)
Other†	6 (9)	8 (11)

ASA, American Society of Anesthesiologists; SD, standard deviation.
*Preintervention dates January 20, 2015 to March 18, 2015, postintervention dates May 14, 2015 to September 1, 2015.
†Surgical services with less than 5 cases.

Accuracy of Information Transfer

Based on the 32-item list created to evaluate information transfer, accuracy of information reporting for multiple reporting items was significantly higher in the postimplementation phase. (Appendix Table A) When comparing the CHS in the pre- and postimplementation groups, the mean score was significantly higher by 18.3 points (95% confidence intervals [CI] 15.4, 21.2). In a segmented regression analysis, mean CHS was significantly higher during the postintervention phase (difference 13 points; 95% CI 4, 22; p = 0.004) after adjustment for time trends, ASA class, and number of interruptions (Fig. 2). Erroneous reporting per TOC (Appendix Table B) was lower for multiple items in the postimplementation phase (adjusted difference −1.5 errors; 95% CI −2.7, −0.4; p = 0.010).

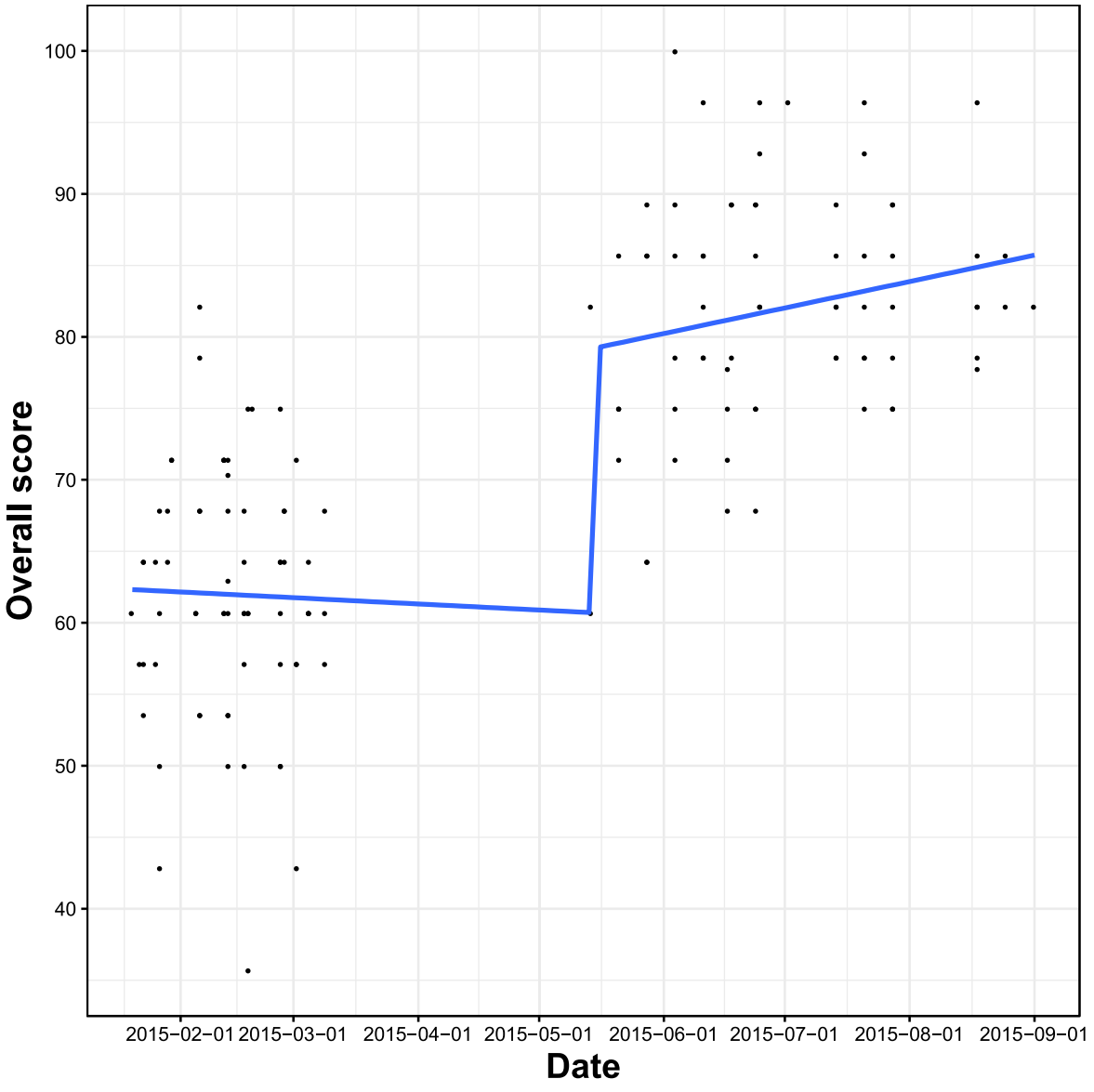


FIGURE 2. CHS with estimated pre- and postintervention trend lines. CHS, cumulative handover score.

During the postimplementation phase, 34 (49%) of the TOCs were conducted with the assistance of the visual checklist. A significantly higher mean CHS was seen when the checklist was utilized (unadjusted difference 7.6 points, 95% CI 4.0-11.3; $p < 0.001$), even when adjusting for number of interruptions and the presence of all team members (adjusted difference 7.5 points, 95% CI 4.0, 11.0; $p < 0.001$).

Attendance of Team Members

Surgical team participation was significantly greater during the postimplementation phase (84% vs 62%; $p = 0.003$; Table 2). There were a significantly greater proportion of TOCs with the presence of all 3 members at the initiation of the handover from 61% preimplementation to 79% postimplementation ($p = 0.020$), but no difference in the presence of all team members at the end of the handover (29% vs 36%; $p = 0.34$). There was no difference in mean number of interruptions per handover (1.0 vs 1.2; $p = 0.13$). Between handovers with and without attendance of the complete team at the end of the TOC, there was no significant difference in CHS (unadjusted difference: 2.0 points, 95% CI −2.5 to 6.5; $p = 0.383$).

TOC Duration

Time elapsed from arrival of the OR team in the PACU until the start of the verbal handover was significantly

TABLE 2. TOC and Attendance Pre- and Postimplementation of the Standardized Handover Intervention

	Preimplementation* (n = 69)	Postimplementation* (*n* = 70)	p Value
Attendance, *n* (%)			
PACU RN	68 (99)	69 (99)	0.99
Surgery representative	43 (62)	59 (84)	0.003‡
Anesthesia representative	69 (100)	70 (100)	–
All team members present at initiation of handover	42 (61)	55 (79)	0.020
All team members present at termination of handover	25 (36)	20 (29)	0.34
TOC metrics, mean (SD)			
Time until verbal handover (min)†	2.3 (2.4)	1.6 (1.1)	.003
Verbal handover duration (min)	3.9 (2.1)	5.3 (1.8)	< .001
Total TOC duration (min)	6.1 (3.2)	6.8 (2.3)	0.18‡
Number of interruptions	1.2 (0.9)	1.0 (0.6)	0.13

PACU, postanesthesia care unit; RN, registered nurse; SD, standard deviation; TOC, transfer-of-care.
*Preintervention dates January 20, 2015 to March 8, 2015, postintervention dates May 14, 2015 to September 1, 2015.
†Time to handover is calculated as the time elapsed between the patient arriving in the PACU and initiation of verbal handover.
‡Unadjusted p values.

less in the postimplementation cohort (p = 0.030; Table 2). The mean duration of the verbal handover was significantly greater during the postimplementation phase, but there was no statistically significant difference in the mean total TOC duration, even when controlling for time trends, ASA class, and number of interruptions (adjusted difference 0.5 minutes; 95% CI −2.8, 3.7; p = 0.782; Appendix Fig. E)

PACU RN Survey

Results from a PACU RN survey were collected from 32 RNs prior to the intervention (January 2015), and 11 RNs submitted completed surveys at the 3-year anniversary of the original intervention (May 2018). An average of 1.8 ± 1.3 calls and 1.4 ± 0.7 calls were reported by the January 2015 and the May 2018 responders, respectively (p = 0.34). Appendix Figure F illustrates the most common reasons for which a PACU RN initiated a call to the anesthesia or surgery teams for clarification.

PACU RNs reported having received a comprehensive postoperative management plan frequently (defined as "very often" or "often") in 9 of 11 responses (82%) during the May 2018 survey, and 17 of 32 responses (53%) during the January 2015 survey (p = 0.15). In comparing responses between the May 2018 and January 2015 surveys, RNs frequently received information regarding procedure-specific call triggers and a contact representative for order clarification in 27% vs 16% (p = 0.40) and in 82% vs 56% (p = 0.17) of responses, respectively.

DISCUSSION

Multidisciplinary quality improvement projects that are fostered through university-affiliated institutional housestaff programs have previously demonstrated success with regards to design, implementation, and efficiency with resource utilization.[22] Residents and fellows perform a large portion of the hands-on patient care in academic medical centers, receive a mandated educational experience in quality improvement[23] and are thus well suited to identify quality and patient safety issues.[24-30] Interdisciplinary transitions-of-care have long been the focus of healthcare and regulatory agencies,[29-31] and many studies have targeted problematic areas regarding the verbal handover process in the inpatient[32-35] and

postoperative setting.[7,36-39] Unlike other handovers throughout our institution, there was no structured process to assist with the postoperative patient TOC prior to our intervention. Using the Six Sigma DMAIC methodology, we demonstrated that a structured handover process with a physical and electronic checklist improves the accuracy of information transfer between OR and PACU team members.

The content-specific improvements demonstrated in the verbal handovers after implementation of a standardized handover process are noteworthy, with global improvements seen in both surgical and anesthetic information reporting. CHSs, representing the accuracy and thoroughness of the handover, were significantly improved even after adjustment for known confounders including number of interruptions and presence of all team members. Preimplementation data revealed significant opportunities for improvement, including the availability of a surgical service representative during the TOC, which occurred in only 62% of PACU handovers. These gaps clearly have significant implications for patient care, but could also negatively affect PACU throughput with nursing staff needing to contact surgical or anesthesia team members with questions. Similarly, deficient reporting of intraoperative postoperative nausea and vomiting prophylactic medication administration can lead to delays in treatment and contribute to longer PACU recovery time. However, a verbal discussion of these plans during TOC could have alerted the PACU RN to focus on these objectives earlier during the recovery of the patient. Certain preimplementation deficits can be rationalized based on provider and documentation workflow immediately after surgery. We garnered feedback during the modified Delphi process[20] regarding certain content deficiencies affecting TOC quality in order to better understand the reason behind these information omissions. For example, reporting of items such as diet and activity plans occurred during less than half of the handovers due to the assumption that these data would be present in a forthcoming postoperative note.

Checklist utilization during postimplementation TOC was independently associated with greater handover scores, demonstrating its pivotal role as a component of the structured TOC. In addition to standardizing information transfer, the structured handover process facilitates a shared mental model that occurs with checklist implementation whereby participants feel more comfortable clarifying unclear information.[40,41] Our study methodology is also unique in that we utilized the patient EHR to cross-verify the information reported in the TOC, thus identifying erroneous information. Although many studies report on interventions to improve the frequency of key information relayed to the receiver (e.g., PACU RN), few evaluate the information accuracy and incidence of erroneous reporting.[42–44] By comparing the information conveyed in the handoff with the electronic medical record, we were able to distinguish between appropriate vs inappropriate omission of information. The structured handover TOC was associated with decreased errors for individual items and the overall verbal handover process in the postimplementation phase.

Our standardized process was associated with an increase the average duration of the verbal handover, a valid concern held by all perioperative team members because of its perceived impact on OR turnover duration. Although we adjusted for a phase-in period, thematic feedback from the PACU RN team consistently mentioned lengthy documentation time for both junior and senior PACU RN personnel because of the electronic handover note. At our hospital, it is difficult to expedite this process as both the handover note and the anesthesia record are not integrated into the EHR, preventing direct information transfer and auto-completion of anesthetic and operative details in the handover note. Furthermore, the pre- and postimplementation handovers spanned 2 academic years, which may have been associated with increased anesthetic recovery time associated with newer trainees.[45] However, total TOC duration, defined as the time elapsed between patient arrival in the PACU and end of the verbal handover, was not significantly different as the period of time between patient arrival and verbal handover was significantly shorter postimplementation. Feedback from PACU RN team suggested that the standardized process encouraged more teamwork between the perioperative and nursing teams to situate the patient (e.g., attach monitors, position patient in the PACU bay) and initiate the verbal TOC in a timely manner. This finding corroborates published evidence that multidisciplinary huddles do not prolong TOC time and are unlikely to hamper efficiency with OR turnover.[46]

Despite educational efforts including a video depicting the ideal process, providers required repeated prompting by PACU RN staff to utilize the visual checklist during the postoperative verbal TOC, which was eventually discontinued and integrated into the EHR handover note. One barrier to utilization was the inaccessibility of the visual checklists, even with strategic placement on the wall and bedside table. Direct feedback provided to the PACU RN team suggested that the multiple surgical subspecialties involved in postoperative TOC at HMC made it difficult to consistently report every item on the surgeon section of the visual checklist. Furthermore, most RNs were focused on recording information from the verbal handover, either directly into the electronic handover note or indirectly via written notes, rather than supervising the structured TOC process while the handover was taking place. On the other hand, nursing staff commented on the organization of the TOC, finding the note easy to navigate and intuitive

for data entry. This finding is corroborated by the PACU RN survey findings demonstrating 100% compliance with the electronic handover note 3 years postimplementation. Although there was no significant change in the number of interruptions during the postimplementation phase, staff members reported that comments made between team members were focused on care for the patient at hand rather than other surgical patients under care of the reporting team. Next, consistent efforts have resulted in mandatory attendance of a surgical subspecialty representative, a result that has coincided with improved CHS during the postimplementation phase. However, surgeon presence for the entirety of the handover was not associated with improved CHS because other team member representatives (i.e., OR RN, anesthesia) were able to corroborate details or provide missing information to the PACU RN. On the other hand, surgeon presence during TOC may improve the anticipatory guidance and call parameter reporting, as gauged by a 3-question subsection of the PACU RN survey, although this finding did not reach statistical significance.

We recognize certain limitations in our study design, which is limited to 1 PACU at a single hospital and focusing on an unvalidated measure of handover accuracy (CHS). A prospective randomized trial with a control cohort could better account for contextual factors, such as seasonal variability due to trainee experience and other PACU workflow modifications. Furthermore, a control chart, or "p-chart," such as the individuals−moving range chart, would have allowed to track process stability and variation after data collection was completed. Thus, one would be able to identify the effect of any other PACU workflow modifications (e.g., construction of a PACU extension area) on outcome measures. Unfortunately and inevitably, several of the original members of the Housestaff Quality and Safety Committee subsequently graduated from the institution, thereby restricting continued data collection. Next, additional rounds in the modified Delphi process could have optimized the content and layout of the visual checklist prior to the implementation phase, and a greater PACU RN survey response could better discern about differences in postoperative calls for clarification. Finally, our study did not evaluate patient outcomes, including the incidence of sentinel patient safety events or other quality-of-care indicators such as timely medication administration, primarily because of the concurrent renovations in the Patient Safety Net system during the study time frame.

CONCLUSIONS

A structured OR-to-PACU TOC process improved information transfer without significantly lengthening total TOC time. Consistent representation of all perioperative team members and a modified electronic handover note incorporating pertinent elements of the original visual checklist are the current status quo at HMC. Although improved communication is intuitively worthwhile, it is a process measure that requires further investigation into the relationship preventable patient safety errors. Future studies could utilize larger datasets than ours to re-examine the relationship between handoff standardization, patient, and hospital outcomes. Nevertheless, structured handover protocols utilizing total quality improvement techniques such as the Six Sigma DMAIC methodology can be adopted by other hospitals as they are a well-accepted paradigm for quality improvement in surgery and anesthesia.

ACKNOWLEDGMENTS

We thank Thomas Varghese, MD, University of Utah, and the University of Washington Housestaff Quality and Safety Council for their consultation with project conception and design and mentorship through a longitudinal quality improvement curriculum, Ronald Meier, MD, and Michael Souter, MD, Harborview Medical Center, for facilitating discussions and garnering support with the Surgical Services Committee, Barbara Dewitt, RN, University of Washington, for the training of PACU RN staff and demonstrations of the new standardized transfer-of-care process throughout the course of the project, Elizabeth Visco CRNA, Harborview Medical Center, for administrative support and CRNA project champion, Earl Kurashige, RN, Harborview Medical Center, for his assistance in developing the electronic handover note, and Whitney Gould, Harborview Medical Center, for assistance with film production and distribution of a simulated postoperative patient handover via hospital networks.

Role of the Funder/Sponsor: The funding organization provided a longitudinal quality improvement program for members of the HQSC. However, the organization had no role in the conduct of the study, collection, management analysis, and interpretation of the data; preparation, review or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

1. Nagpal K, Arora S, Abboudi M, et al. Postoperative handover: problems, pitfalls, and prevention of error. *Ann Surg*. 2010;252:171–176.
2. Delrue KS. An Evidence-Based Evaluation of the Nursing Handover Process for Emergency Department Admissions. Dissertation submitted to the faculty of Grand Valley State University; 2013.

3. Staggers N, Blaz JW. Research on nursing handoffs for medical and surgical settings: an integrative review. *J Adv Nurs*. 2013;69:247–262.

4. Thomas MJ, Schultz TJ, Hannaford N, Runciman WB. Failures in transition: learning from incidents relating to clinical handover in acute care. *J Healthc Qual*. 2013;35:49–56.

5. Patterson ES, Wears RL. Patient handoffs: standardized and reliable measurement tools remain elusive. *Jt Comm J Qual Patient Saf*. 2010;36:52–61.

6. Salzwedel C, Mai V, Punke MA, Kluge S, Reuter DA. The effect of a checklist on the quality of patient handover from the operating room to the intensive care unit: A randomized controlled trial. *J Crit Care*. 2016;32:170–174.

7. Bittner EA, George E, Eikermann M, Schmidt U. Evaluation of the association between quality of handover and length of stay in the post anaesthesia care unit: a pilot study. *Anaesthesia*. 2012;67:548–549.

8. Breuer RK, Taicher B, Turner DA, Cheifetz IM, Rehder KJ. Standardizing postoperative PICU handovers improves handover metrics and patient outcomes. *Pediatr Crit Care Med*. 2015;16:256–263.

9. Nagpal K, Vats A, Ahmed K, et al. A systematic quantitative assessment of risks associated with poor communication in surgical care. *Arch Surg*. 2010;145:582–588.

10. Agarwal HS, Saville BR, Slayton JM, et al. Standardized postoperative handover process improves outcomes in the intensive care unit: a model for operational sustainability and improved team performance*. *Crit Care Med*. 2012;40:2109–2115.

11. Joint Commission Center for Transforming Healthcare. Robust Pprocess Iimprovement. 2013 Available at http://www.centerfortransforminghealthcare.org/about/rpi.aspx. (accessed January 10, 2017).

12. Bendell T. A review and comparison of Six Sigma and the Lean organization. *TQM Mag*. 2006;18:255–262.

13. Cima RR, Brown MJ, Hebl JR, et al. Surgical process improvement team, Mayo Clinic, Rochester. Use of Lean and Six Sigma methodology to improve operating room efficiency in a high-volume tertiary-care academic medical center. *J Am Coll Surg*. 2011;213:83–92.

14. Martin L, Joyner B. IHI Open School as a Framework for Resident Education in Safety and Quality. Institute for Healthcare Improvement; 2013. [cited 2013 Aug]. Available from: http://www.ihi.org/offerings/IHIOpenSchool/resources/Pages/UniversityOfWashingtonResidentEducation.aspx.

15. DelliFraine JL, Langabeer JR, Nembhard IM. Assessing the evidence of Six Sigma and Lean in the health care industry. *Q Manage Health Care*. 2010;19:211–225.

16. Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. *BMJ Qual Saf*. 2016;25:986–992.

17. Holden L. 2014 HMC culture of patient safety survey. UW Medicine Board Annual Patient Safety and Quality Committee Report to the UW Board of Regents. Accessed May 2015.

18. Donabedian A. Evaluating the quality of medical care. *Milbank Meml Fund Q*. 1966;44(3 suppl):166—206. Reprinted in Milbank Q. 2005;83(4):691—729.

19. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27:299–309.

20. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. *J Adv Nurs*. 2000;32:1008–1015.

21. Horwitz LI, Dombroski J, Murphy TE, Farnan JM, Johnson JK, Arora VM. Validation of a handoff assessment tool: the Handoff CEX. *J Clin Nurs*. 2013;22:1477–1486.

22. Dixon JL, Papaconstantinou HT, Erwin J.P. 3rd, McAllister RK, Berry T, Wehbe-Janek H. House Staff quality council: one institution's experience to integrate resident involvement in patient care improvement initiatives. *Ochsner J*. 2013;13:394–399.

23. Accreditation Council for Graduate Medical Education. Common program requirements. http://www.acgme.org/acWebsite/home/Common_Program_-Requirements_07012011.pdf. Accessed January 10, 2018.

24. Voss JD, May NB, Schorling JB, et al. Changing conversations: teaching safety and quality in residency training. *Acad Med*. 2008;83:1080–1087.

25. Alliance of Independent Academic Medical Centers. National initiative. Improving patient care through medical education: a national initiative of independent academic medical centers. 2013. http://www.aiamc.org/ni-phase-iii.php. Accessed January 10, 2018.

26. Stueven J, Sklar DP, Kaloostian P, et al. A resident-led institutional patient safety and quality improvement process. *Am J Med Qual*. 2012;27:369–376.

27. Fleischut PM, Faggiani SL, Evans AS, et al. 2011 John M. Eisenberg Patient Safety and Quality Awards. The effect of a novel Housestaff Quality Council on quality and patient safety. Innovation in patient safety and quality at the local level. *Jt Comm J Qual Patient Saf*. 2012;38:311–317.

28. HOUSE. Journal of the University of Washington Housestaff Quality and Safety Committee. 2nd ed. Golgotiu V, Staub M, Wu C, Editors. Seattle, Washington, 2016

29. Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academy Press; 2001. p. 45.

30. Joint Commission. National patient safety goals, 2006, critical access hospital and hospital national patient safety goals. http://www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals/06_npsg_cah.htm. Accessed December 24, 2014.

31. World Health Organization. The WHO collaborating centre on patient safety (solutions), the world alliance for patient safety and the commonwealth fund announce action on patient safety (High 5s) initiative. http://www.who.int/patientsafety/news/High_5_Release.pdf. Accessed December 10, 2017.

32. Wentworth L, Diggins J, Bartel D, Johnson M, Hale J, Gaines K. SBAR: electronic handoff tool for non-complicated procedural patients. *J Nurs Care Qual*. 2012;27:125–133.

33. Flanagan ME, Patterson ES, Frankel RM, Doebbeling BN. Evaluation of a physician informatics tool to improve patient handoffs. *J Am Med Inform Assoc*. 2009;16:509–515.

34. Collins SA, Stein DM, Vawdrey DK, Stetson PD, Bakken S. Content overlap in nurse and physician handoff artifacts and the potential role of electronic health records: a systematic review. *J Biomed Inform*. 2011;44:704–712.

35. Barnes SL, Campbell DA, Stockman KA, Wunderlink D. From theory to practice of electronic handover. *Aust Health Rev*. 2011;35:384–391.

36. Weinger MB, Slagle JM, Kuntz AH, et al. A multimodal intervention improves postanesthesia care unit handovers. *Anesth Analg*. 2015;121:957–971.

37. Starmer AJ, Spector ND, Srivastava R, et al. Changes in medical errors after implementation of a handoff program. *N Engl J Med*. 2014;371:1803–1812.

38. Petrovic MA, Martinez EA, Aboumatar H. Implementing a perioperative handoff tool to improve postprocedural patient transfers. *Jt Comm J Qual Patient Saf*. 2012;38:135–142.

39. van Rensen EL, Groen ES, Numan SC, et al. Multitasking during patient handover in the recovery room. *Anesth Analg*. 2012;115:1183–1187.

40. Borowitz SM, Waggoner-Fountain LA, Bass EJ, Sledd RM. Adequacy of information transferred at resident sign-out (in-hospital handover of care): a prospective survey. *Qual Saf Health Care*. 2008;17:6–10.

41. Shah AC, Oh DC, Xue AH, Lang JD, Nair BG. An electronic handoff tool to facilitate transfer of care from anesthesia to nursing in intensive care units. *Health Inf J*. 2016. 1460458216681180.

42. Sexton A, Chan C, Elliott M, Stuart J, Jayasuriya R, Crookes P. Nursing handovers: do we really need them? *J Nurs Manag*. 2004;12:37–42.

43. Palma JP, Sharek PJ, Longhurst CA. Impact of electronic medical record integration of a handoff tool on sign-out in a newborn intensive care unit. *J Perinatol*. 2011;31:311–317.

44. Flemming D, Hübner U. How to improve change of shift handovers and collaborative grounding and what role does the electronic patient record system play? Results of a systematic literature review. *Int J Med Inform*. 2013;82:580–592.

45. Nakata Y, Watanabe Y, Otake H, Nakamura T, Oiso G, Sawa T. Productivity change of surgeons in an academic year. *J Surg Educ*. 2015;72:128–134.

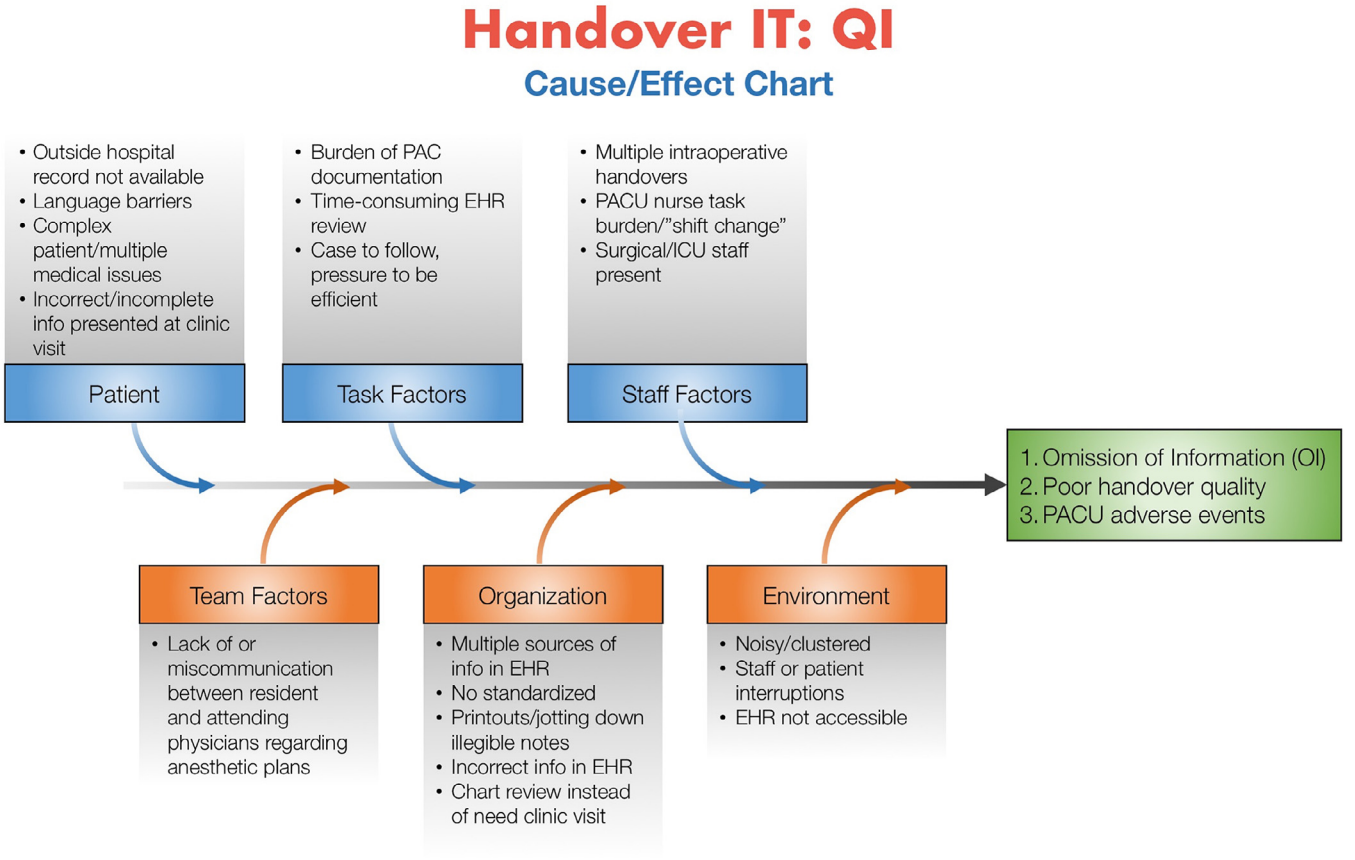
46. Weld LR, Stringer MT, Ebertowski JS, et al. TeamSTEPPS improves operating room efficiency and patient safety. *Am J Med Qual*. 2016;31:408–414.

SUPPLEMENTARY INFORMATION

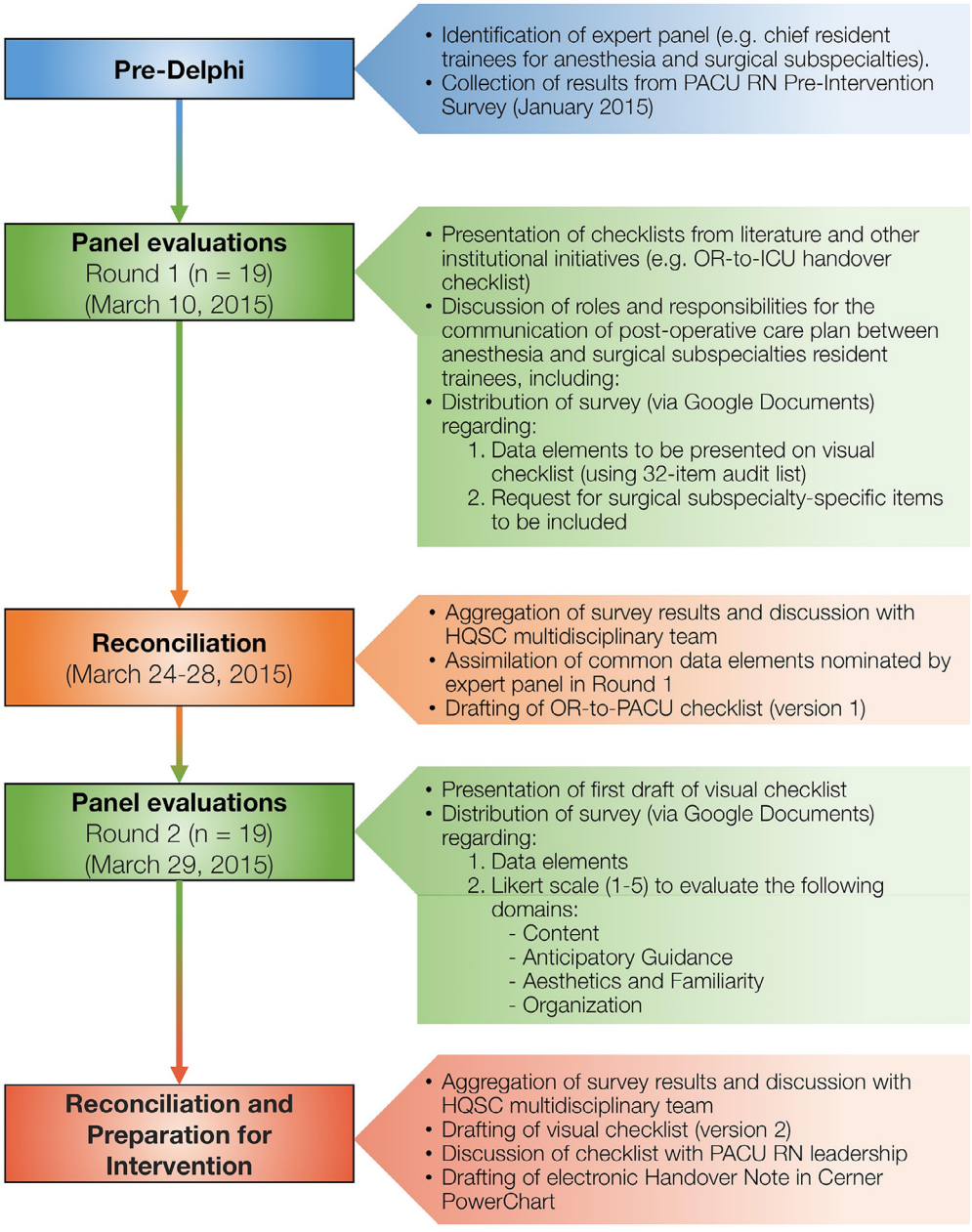
Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jsurg.2018.12.010.

APPENDICES

Figures A, B, C, D1, D2, E, F and Tables A and B.



APPENDIX FIGURE A. TOC environment: cause and effect diagram.
EHR, electronic health record; IT, information technology; PAC, preanesthesia clinic; PACU, postanesthesia care unit; QI, quality improvement; TOC, transfer-of-care.



APPENDIX FIGURE B. Modified Delphi method[3] for visual checklist creation and content curation.
HQSC, Housestaff Quality Safety Committee; ICU, intensive care unit; OR, operating room; RN, registered nurse.

Multidisciplinary OR to PACU Transition of Care Checklist

1 PACU Nurse

Introductions
Confirm patient with two identifiers
Confirm patient allergies

2 Surgeon

- Surgical course
  - Diagnosis
  - Procedure
  - Important intra-op events
- Post-operative management plan
  - Tubes, drains and dressings/wound care
  - Pain management – PRS (pain relief service), PCA
  - PACU studies needed
  - Service specific requests
- Call triggers and contact information
  - Confirm specific call/page triggers
  - Resident surgeon and surgical service
  - Attending surgeon
- Post-op family update – Has it been done?
- Patient disposition
- Orders in?

3 Anesthesia Provider

- Medical/surgical history
- Anesthetic course
  - Anesthetic
  - Intraoperative events
  - Medications
    - Neuromuscular blockers
    - Anti-emetics
    - Drips
    - Narcotics
    - Antibiotics
    - Specialty-specific
  - Ins/Outs
    - Fluids
    - EBL
    - Blood product
    - UOP
- Important labs
- Lines
  - CXR needed?
- Hemodynamic plan
- Call triggers and contact information
  - Confirm specific call/page triggers
  - Anesthesia provider
  - Attending surgeon
- Orders in?

4 PACU Nurse

- Ask for clarifications / questions

APPENDIX FIGURE C. OR-to-PACU visual checklist.
CXR, chest x-ray (radiograph); PACU, postanesthesia care unit; PCA, patient-controlled analgesia; PRS; Pain Relief Service; UOP, urine output.

'Anesthesia to PACU PostOp Hand-off' PowerNote Screen Print

Admission <Hide Structure> <Use Free Text>

Admit date and time:===
Admission RN:===
Anesthesia Team:===
Surgical Team:===
Surgical Procedure:===

Allergies <Hide Structure> <Use Free Text>

Allergies	<IMPORT Allergies> / <ADD/UPDATE Allergies>

History <Hide Structure> <Use Free Text>

History and pre-op medications:===

General Information <Hide Structure> <Use Free Text>

Anesthetic	General / Regional / MAC / OTHER
Airway	Mask/LMA / Intubated / Tracheostomy / OTHER
Regional	Spinal: Dermatome level:=== / Agent:=== Epidural: Dermatome level:=== / Agent:=== PNB:=== type: Agent:===
Medications	Muscle relaxant:=== / Muscle relaxant reversal:=== / Narcotics:=== / Narcotic reversal:=== / Sedatives:=== / Antiemetics:=== / Local:=== / OTHER Induction agent: Etomidate / Propofol / Ketamine / Methohexital / OTHER Antibiotics:===: Date/time OTHER: Date/time
Intra-operative fluids	Crystalloid:=== / Colloid:=== / Blood:=== / Urine:=== / OTHER EBL:===cc: None / Scant / Moderate / Severe / OTHER
Appearance upon arrival:===	
Intra-operative events:===	
OTHER	

APPENDIX FIGURE D1. OR-to-PACU electronic handover note, January 2015.

ADMISSION: <Hide Structure> <Use Free Text>

Admit date and time:===	
Reporting Surgical Provider:	Provider Look-Up / OTHER
Reporting Anesthesia Provider:	Provider Look-Up / OTHER

REPORT FROM SURGEON: <Hide Structure> <Use Free Text>

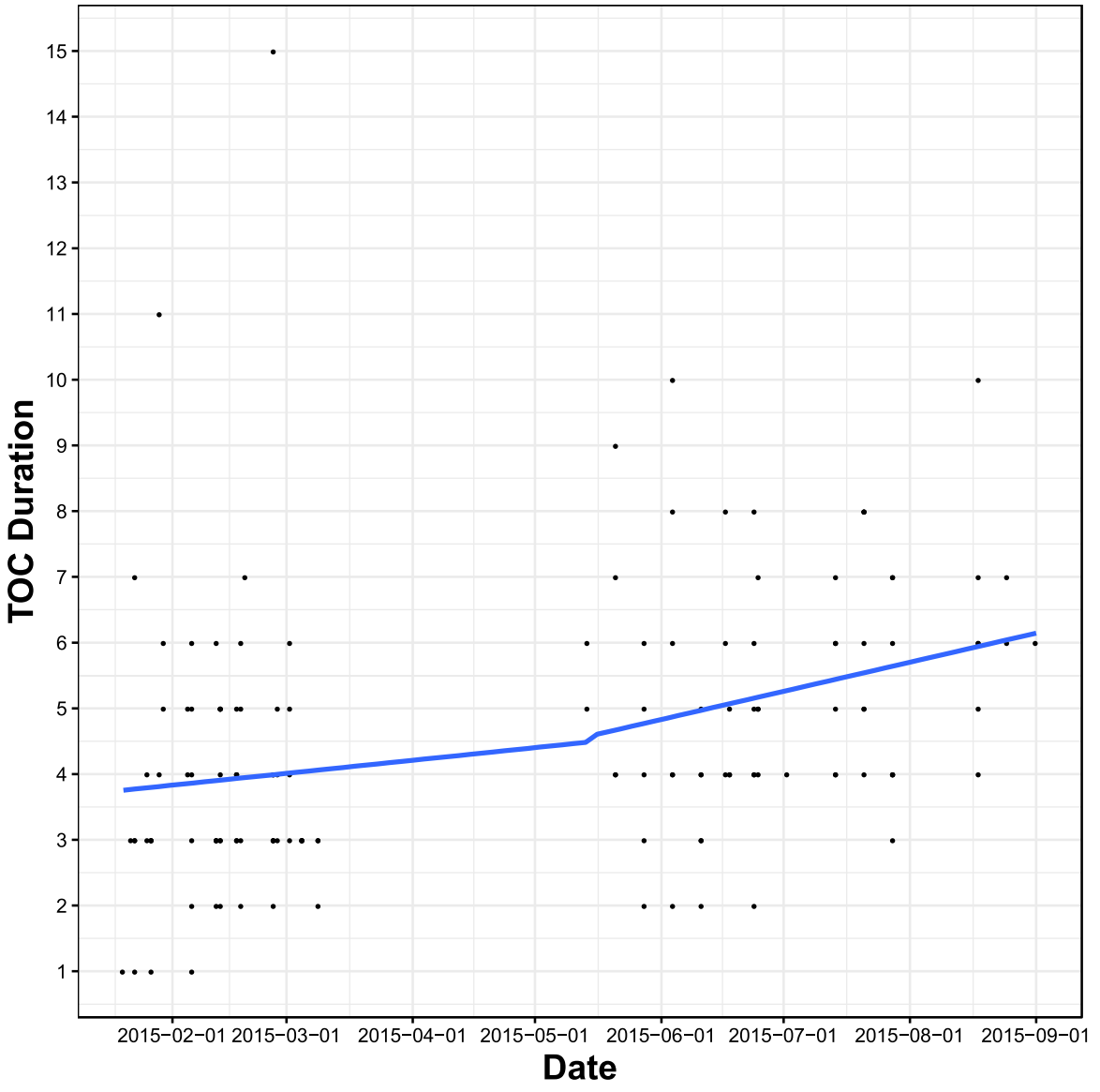
Surgical Diagnosis:	OTHER
Procedure/Surgery Type:	OTHER
Surgical service:	OTHER
Post Op Management	OTHER
Tubes/Drains/Dressings:	OTHER
Local at surgical site:	Yes / No
Surgical call triggers:	OTHER
Spine precautions	Yes / No / OTHER
Pathways:	Yes / No / OTHER
Post Op orders written?	Yes / No / OTHER
Family updated?	In person / By phone / OTHER

APPENDIX FIGURE D2. OR-to-PACU electronic handover note, December 2015 to present.

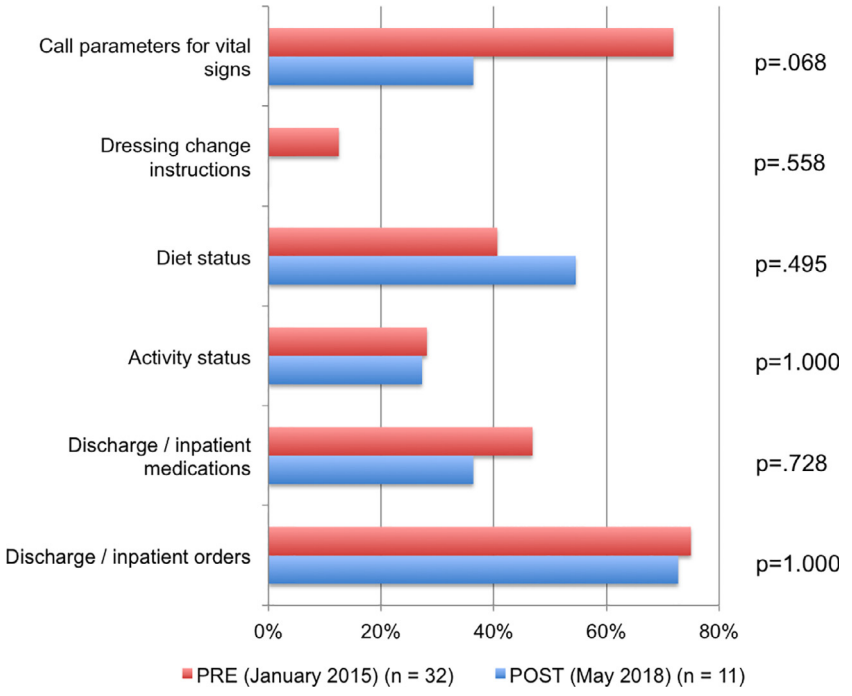
REPORT FROM ANESTHESIA PROVIDER: <Hide Structure> <Use Free Text>

Allergies:	<IMPORT Allergies> / <ADD/UPDATE Allergies>
Significant past medical history:	OTHER
Anesthetic	General / Regional / MAC / OTHER
Airway	LMA / Intubated / Tracheostomy / OTHER
Difficult intubation:	Yes / No / OTHER Glide scope: Yes / No
Medications	OTHER Sedatives: Midazolam===mg / OTHER Anesthetics: OTHER / Propofol: bolus / infusion / Ketamine: bolus / infusion / Dexmedetomidine: bolus / infusion Muscle relaxant: Yes / No / OTHER Sugamadex: Yes / No / OTHER Pain: Remifentanil / Fentanyl===mcg / Hydromorphone===mg / Morphine===mg / Demerol===mg / Methadone===mg / Ketorolac===mg / Ketamine===mg / OTHER / Acetaminophen===mg: last dose:=== / route:=== Antiemetics: Yes / No / OTHER Vasoactive agents: Yes / No / OTHER Antibiotics: Cefazolin===gm: last dose:=== / Clindamycin===mg: last dose:=== / Gentamycin===mg: last dose:=== / Levofloxacin===mg: last dose:=== / Metronidazole===mg: last dose:=== / Unasyn===gm: last dose:=== / Vancomycin===gm: last dose:=== / OTHER:===: ===gm / last dose:=== Glycemic control: Yes / No / OTHER / Orders written: yes / no Other Medications with dosage:===: OTHER Regional: Yes / No
Access	Arterial line / Central line / PICC line Left: 14 g / 16 g / 18 g / 20 g / 22 g / OTHER Right: 14 g / 16 g / 18 g / 20 g / 22 g / OTHER
Intra-op fluids	Crystalloids: Plasmalyte===ml / NS===ml / OTHER Blood Products: Yes / No
EBL:	===ml / OTHER
Urine output:	Foley===ml / Straight cath===ml / Bladder scan===ml / OTHER
Intra OP lab studies:	<ABG> / <HCT> / <K> / Latest Lab Results / OTHER
Anesthesia orders written?	Yes / No / OTHER
Intra op events:	Yes / No / OTHER
Personal belonging with pt at time of transfer from OR	Yes / No
OTHER	

APPENDIX FIGURE D2. Continued.



APPENDIX FIGURE E. Bi-weekly erroneous reporting frequency with estimated pre- and postintervention trend lines. TOC, transfer-of-care.



APPENDIX FIGURE F. PACU RN survey results: calls for clarification (January 2015 and May 2018).
Question: "If you had questions regarding patient care, what were they about?"
Percentages add to greater than 100% as nursing staff were able to check more than 1 answer.
PACU, postanesthesia care unit; RN, registered nurse.

APPENDIX TABLE A. Accurate Data Element Transfer Using the Postoperative OR-PACU Verbal Handover

	Preimplementation* (*n* = 69) *n* (%)	**Postimplementation* (*n* = 70) *n* (%)**	**OR (95% CI)**	**p Value**
Surgery				
Patient identification	42 (60.9)	47 (67.1)	1.3 (0.7-2.6)	0.44
Procedure description	69 (100)	67 (95.7)	–	0.10
Significant events	34 (50.0)	68 (97.1)	34.0 (7.7-150.0)	<0.001
Medical history	59 (85.5)	64 (91.4)	1.8 (0.6-5.3)	0.31
Diet	41 (59.4)	63 (90.0)	6.2 (2.5-15.4)	<0.001
Activity	31 (44.9)	50 (71.4)	3.1 (1.5-6.2)	<0.001
Antibiotic plan	25 (36.2)	36 (51.4)	1.9 (1.0-3.7)	0.06
Foley	44 (63.8)	44 (62.9)	1.0 (0.5-1.9)	0.57
DVT prophylaxis	24 (34.8)	24 (34.3)	1.0 (0.5-2.0)	1.00
Drains/wound care	34 (49.3)	65 (92.9)	13.4 (4.8-37.3)	<0.001
Call triggers	53 (76.8)	70 (100.0)	–	<0.001
Disposition	36 (52.2)	50 (71.4)	2.3 (1.1-4.6)	0.040
Anesthesia				
Significant events	28 (41.8)	66 (95.7)	30.6 (8.7-107.5)	<0.001
Airway	36 (52.2)	63 (90.0)	8.3 (3.3-20.6)	<0.001
Anesthesia type	66 (95.7)	68 (97.1)	1.6 (0.3-9.6)	0.63
Induction agent	64 (92.8)	64 (94.1)	0.8 (0.2-2.9)	0.77
Nausea/emesis prophylaxis	33 (47.8)	56 (80.0)	4.4 (2.1-9.3)	<0.001
Vasopressor agent	32 (46.4)	51 (72.9)	3.1 (1.5-6.3)	0.001
Antibiotic administered	57 (82.6)	65 (92.9)	2.7 (0.9-8.2)	0.07
Time of last antibiotic dose	23 (33.3)	59 (84.3)	10.7 (4.8-24.2)	<0.001
Pain medication	67 (97.1)	69 (98.6)	2.1 (0.2-23.3)	0.55
Paralytic agent	58 (84.0)	61 (87.1)	1.3 (0.5-3.3)	0.75

(continued)

APPENDIX TABLE A (*CONTINUED*)

	Preimplementation* (*n* = 69) *n* (%)	Postimplementation* (*n* = 70) *n* (%)	OR (95% CI)	p Value
Time of last paralytic dose	21 (30.4)	25 (35.7)	1.3 (0.6-2.6)	0.50
Paralytic reversal	45 (65.2)	53 (75.7)	1.7 (0.8-3.5)	0.06
Special medications	31 (44.9)	56 (80.0)	4.9 (2.3-10.4)	<0.001
Blood products	66 (95.7)	68 (97.1)	1.6 (0.3-9.6)	0.83
Fluids	63 (91.3)	64 (91.4)	1.0 (0.3-3.3)	0.57
EBL	52 (75.4)	68 (97.1)	11.1 (2.5-50.3)	<0.001
Urine output	47 (68.1)	64 (91.4)	5.0 (1.9-13.3)	<0.001
Significant labs	42 (60.9)	66 (94.3)	10.6 (3.5-32.5)	<0.001
IV access	48 (69.6)	54 (77.1)	1.5 (0.7-3.2)	0.27
Pain management plan	30 (43.5)	64 (91.4)	13.9 (5.3-36.3)	<0.001
Cumulative score, mean (SD)	63.6 (8.7)	81.9 (8.5)	18.3 (15.3-21.2)	<0.001

DVT, deep venous thrombosis; IV, intravenous; PACU, postanesthesia care unit; RN, registered nurse; SD, standard deviation; TOC, transfer-of-care.
*Preintervention dates January 20, 2015 to March 8, 2015, postintervention dates May 14, 2015 to September 1, 2015.

APPENDIX TABLE B. Erroneous Data Element Reporting During the Postoperative OR-PACU Verbal Handover

	Preimplementation* (*n* = 69) *n* (%)	Postimplementation* (*n* = 70) *n* (%)	OR (95% CI)	p Value
Surgery				
Medical history	1 (1.4%)	0 (0%)	–	0.496
Diet	4 (5.8%)	0 (0%)	–	0.130
Activity	1 (1.4%)	0 (0%)	–	0.496
Antibiotic Plan	7 (10.1%)	0 (0%)	0.	0.006
Foley	9 (13.0%)	1 (1.4%)	.10 (0.0-0.8)	0.009
DVT prophylaxis	1 (1.4%)	0 (0%)	–	0.496
Drains/wound care	11 (15.9%)	1 (1.4%)	0.1 (0.0-0.6)	0.002
Call triggers	2 (2.9%)	0 (0%)	–	0.245
Disposition	13 (18.8%)	0 (0%)	–	<0.001
Anesthesia				
Airway	0 (0%)	0 (0%)	–	–
Anesthesia type	0 (0%)	0 (0%)	–	–
Induction agent	1 (1.4%)	0 (0%)	–	0.496
Nausea/emesis prophylaxis	3 (4.3%)	4 (5.7%)	1.3 (0.3-6.2)	1.000
Vasopressor Agent	1 (1.4%)	3 (4.3%)	3.0 (0.3-30.0)	0.620
Antibiotic administered	3 (4.3%)	0 (0%)	–	0.120
Time of last antibiotic dose	0 (0%)	0 (0%)	–	–
Pain medication	0 (0%)	0 (0%)	–	–
Paralytic agent	5 (7.2%)	3 (4.3%)	0.6 (0.1-2.5)	0.493
Time of last paralytic dose	3 (4.3%)	1 (1.4%)	0.3 (0.0-3.1)	0.366
Paralytic reversal	7 (10.1%)	10 (14.3%)	1.5 (0.5-4.1)	0.606
Special medications	4 (5.8%)	0 (0%)		0.058
Blood products	2 (2.9%)	1 (1.4%)	0.5 (0.0-5.5)	0.620
Fluids	1 (1.4%)	0 (0%)	–	0.496
EBL	1 (1.4%)	0 (0%)	–	0.496
Urine output	6 (8.7%)	5 (7.1%)	0.8 (0.2-2.8)	0.764
Significant labs	15 (21.7%)	2 (2.9%)	0.1 (0.0-0.5)	0.001
IV access	2 (2.9%)	0 (0%)	–	0.245
Pain management plan	3 (4.3%)	0 (0%)	–	0.120
Cumulative errors, *n* (%)	106/1932 (5.5%)	31/1960 (1.6%)	0.4 (0.3-0.6)	<0.001

DVT, deep venous thrombosis; IV, intravenous; OR, operating room; PACU, postanesthesia care unit; RN, registered nurse; SD, standard deviation; TOC, transfer-of-care.
*Preintervention dates January 20, 2015 to March 8, 2015, postintervention dates May 14, 2015 to September 1, 2015.