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14. ABSTRACT
Effective handwork examines multiple handoff types, in multiple phases of care, and uses multiple dimensions of intervention, based on a previous model offs of care are frequently cited as critical for maintaining safety and avoiding communication problems. This program of of improvement, to fundamentally improve transitions of care along the trauma pathway. We have considered all potential handoffs and care transitions during trauma care, their characteristics and how they might affect care, and mapped out the key transition processes along the care pathway. Next, using data collected during our first phase of work, we conducted an analysis of the variety of paths that patients take, the frequencies of each path, the number of transitions they experience, and the disruptions that occur during transition. Our analysis of flow disruptions, process maps, and direct observations suggest that it is the handoffs to ICU which are the most at risk, as they involve an entire change in care team, happen with the sickest patients, and are relatively unstructured. Observing high risk transfers from the OR to ICU, we have been able to statistically model the process in terms of task, team and technology. We have also studied handoffs into the surgical ICU and found differences in self-reported expectations and performance between the nurses and the physicians. Three interventions are already in development as an extension of previous work, with simulation evaluation planned. We have commenced early development of a Smartphone application that assists in the early management of trauma patient information. A second intervention currently being explored is a checklist for improving patients admission into CT. The final intervention development is based on an adaptation of our previous work from motor racing pit-stops.

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Introduction

Effective handoffs of care are frequently cited as critical for maintaining safety and avoiding communication problems. Transitions in trauma care, like other forms of handoffs, are vulnerable to systems problems and human errors. This project is taking a mixed-methods approach to understanding, modeling, and improving handoffs in trauma care.

Taking a previously successful model of handoff that reported improvements using expertise from aviation and motor racing, this project examines the integration of team, process, and information transfer for efficient patient management and safety. Superimposing interventions upon this human-centered model of care, we are able to examine individually and in combination, interventions associated with technological, training, environmental and task redesign. We will also focus on the post-operative recovery period and identify those flow disruptions and communication failures in care which inhibit early recognition and treatment of complications and other subtle barriers to recovery.

Most handoff studies have been conducted in isolation, examining only one type of handoff during one phase of care, with only rare interventions. This program of work examines the entire trauma pathway, to include multiple handoff types, in multiple phases of care, and uses multiple dimensions of intervention. Additionally, we aim to identify the critical pieces of information, that when omitted during a handoff, may lead to missed warning signs of a deteriorating trauma patient.

Body

We developed three protocols to complete the tasks within our statement of work. The first protocol, titled "Military Operating Room of the Future Phase II – Handoffs: Observations" received approval from HRPO on October 17, 2012. The other two protocols, titled "Military Operating Room of the Future Phase II – Handoffs: Database Review" and "Military Operating Room of the Future Phase II – Handoffs: Focus Groups" were approved on 2nd August 2013.

We are employing a range of methods to understand and strengthen handoff processes in acute care. Incident analysis data has been used to initially inform our approach, which is complemented with interviews, process mapping, and direct observation of disruptions, process, teamwork, and information transfer. To measure before and after effects, we are utilizing modified objective observational tools. We have been investigating the critical handoffs between care providers as traumatized and critically ill patients progress from admission to diagnostic areas, operating rooms and intensive care units. In developmental work, we have considered all potential handoffs and care transitions, their characteristics and how they might affect care, and mapped out the key transition processes along the care pathway. Next, using data collected during our first phase of work, we conducted an analysis of the variety of paths that patients take, the frequencies of each path, the number of transitions they experience, and the disruptions that occur during transition. We have also analyzed previous incident data to examine core weaknesses in handoffs across the breadth of care. Direct observation has identified links between processes, teamwork, and information transfer acuity. Three interventions are already in development as an extension of previous work, with simulation evaluation planned.

Overall, we have made excellent progress, with a large set of statistically modeled data, one intervention in place, a second close to implementation, and a third in preparation for simulation studies.

Aim 3, Aim 4, Task A: process mapping of current state of communication & data transfer at care interfaces

Early pilot observations helped us identify key aspects of the process and enabled subsequent detailed study of specific areas. We are modeling handoffs as having a range of systemic components, and considering them not as a one-off information transfer but as a dynamic part of ongoing care. Our observations and assessments are considering six key areas of the handoff process, of which 1-4 have been studied, and we hope to explore 5 and 6 in the coming months:

1. Emergency Department (ED) to Imaging (CT)
2. Admission to the Surgical Intensive Care Unit (SICU)
3. Operating Room (OR) to the Post Anesthesia Care Unit (PACU)
4. OR to the Cardiac Surgical Intensive Care Unit (CSICU)
5. Step-down Handoffs from ICU to Ward
6. Shift-to-shift handoffs

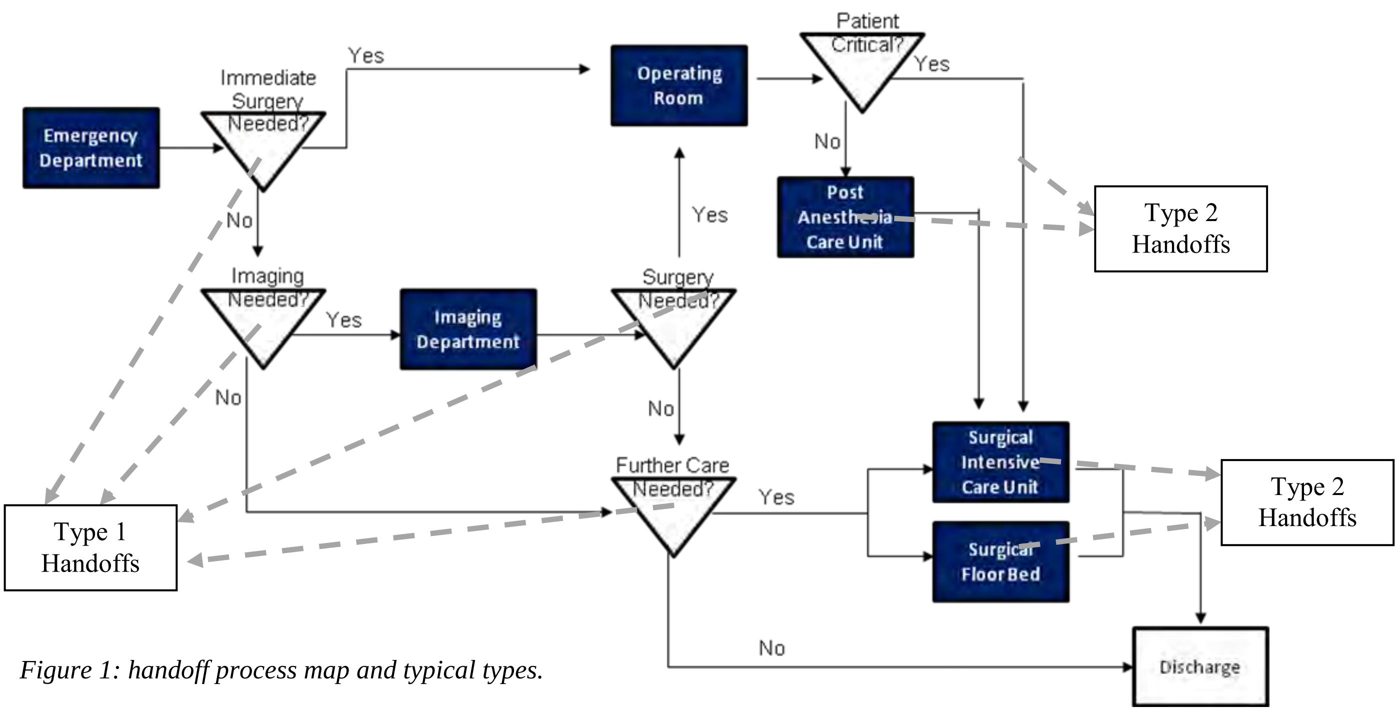


Figure 1: handoff process map and typical types.

Considering the function of each handoff, there are three types.

- Type 1: Care Process Handoff: Decision making, resource management and co-ordination
- Type 2: Team Transfer Handoff: Equipment transfer, teamwork processes, information handoff
- Type 3: Care Continuity Handoff: Maintaining Situation Awareness and shared decision making

Type 1 handoffs – typified by decision making in the ED and CT – are moments at which the care of the patient and their treatment pathway change rapidly, based on the use of dynamic changing resources, and requiring the team (some of whom may be new to that patient) to agree on a decision and co-ordinate the response to ensure the appropriate follow-through. Type 2 handoffs – typified by transfers from surgery – are where the transfer of the patient is both physical and between teams, requiring continuity of information and care between the teams. With these handoffs, the care pathway should be clear, and the patient relatively stable, so the dynamic decision making component is not required, and can be more easily structured. Type 2 handoffs are where we hypothesize will be the greatest need for precise information transfer to better identify deteriorating patients. Type 3 handoffs – typified by within-unit handoffs

– require the maintenance of patient care over a longer period, requiring the continual updating of patient information and strategic shared decision making to move the patient through their care to discharge. All three handoffs are qualitatively different, and so have different requirements. Finally, we have mapped in detail processes for the CT process (figure 2), admission to ICU (figure 3), and for step-down from ICU to ward care (figure 4). All three processes are typified by a non-linear sequence of multiple communications, largely by telephone. Our observations suggest this can create weaknesses.

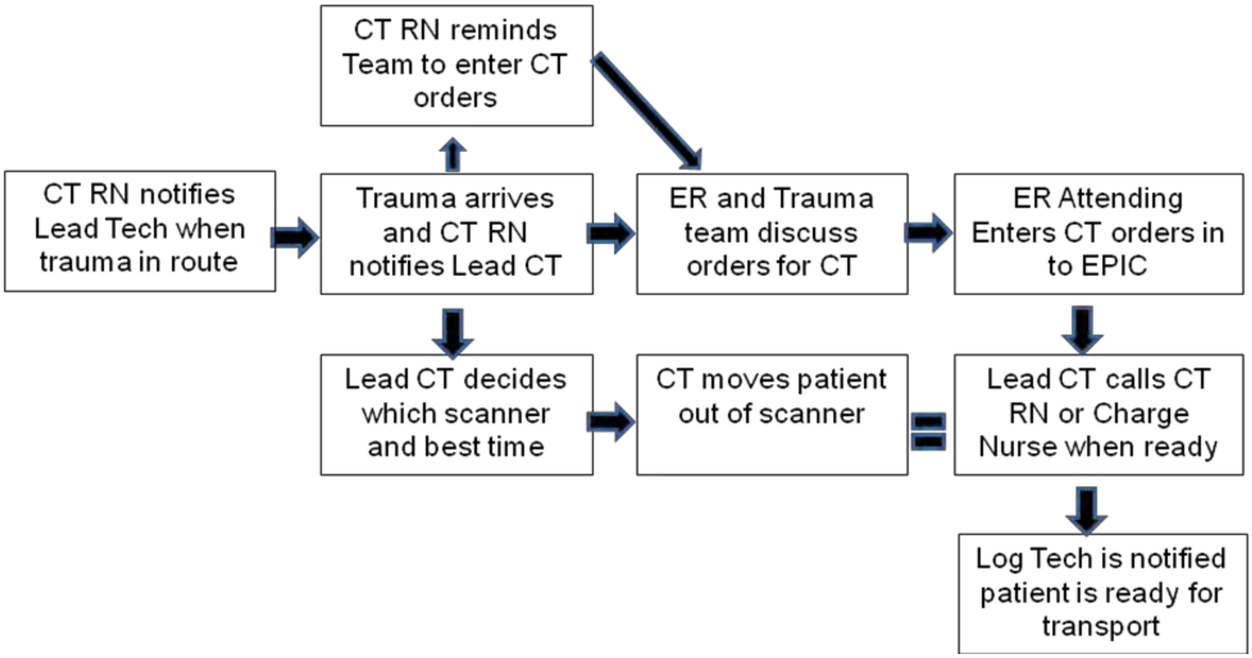


Figure 2: Process for transfer of patient from ED to CT

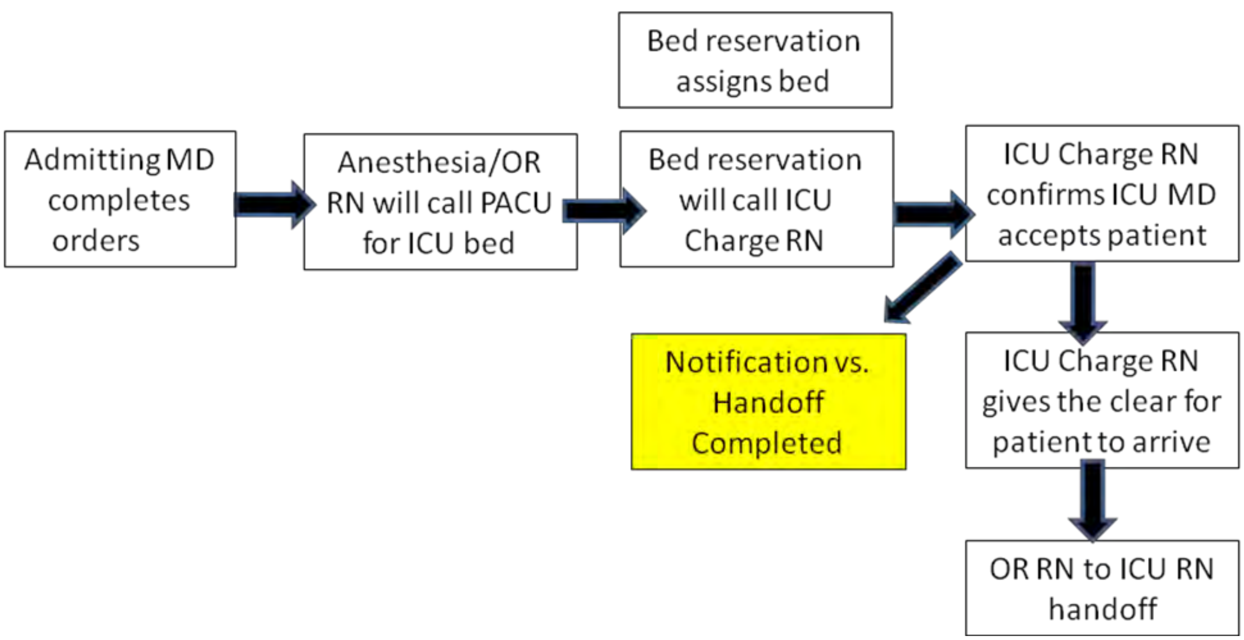


Figure 3: Process for admission of patient from the OR to ICU

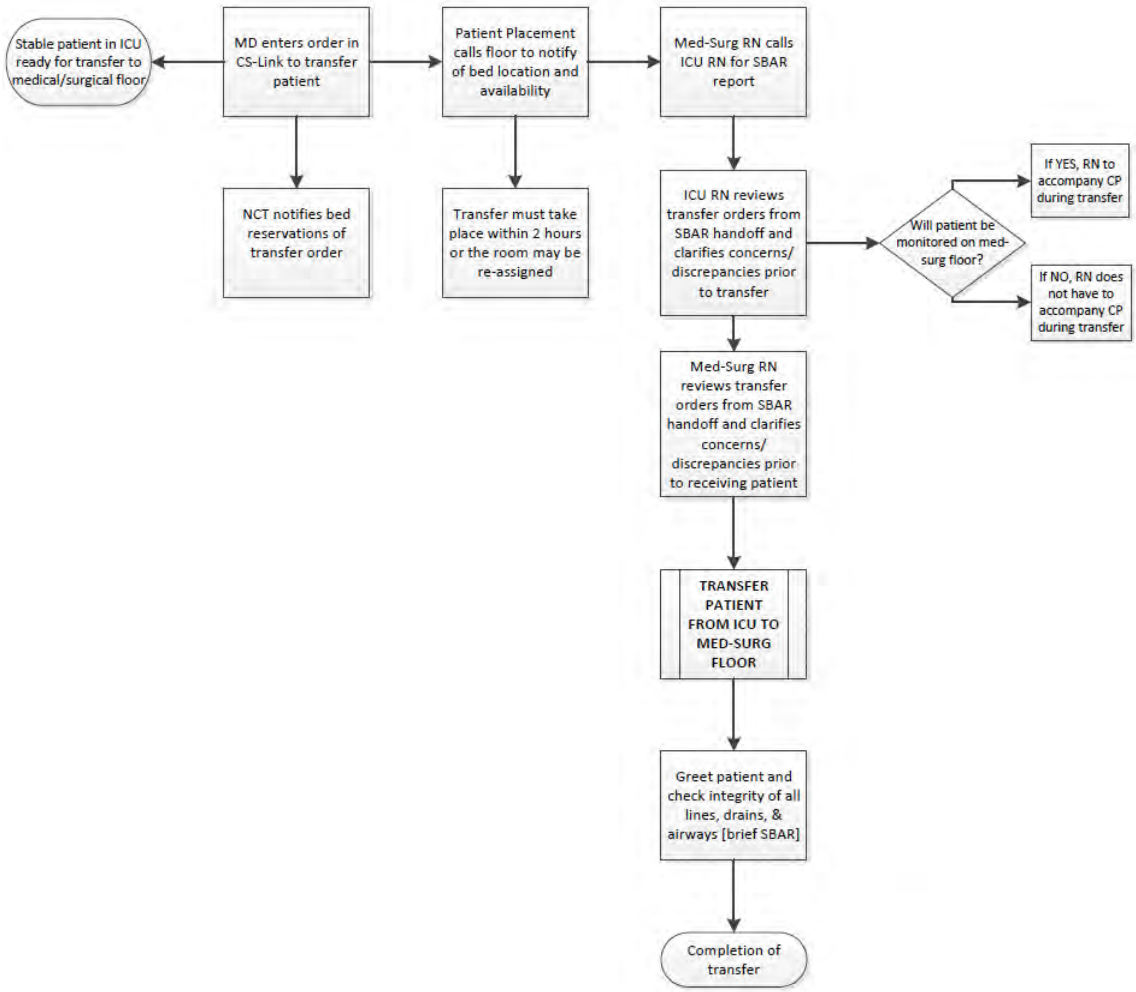


Figure 4: ICU to Ward Step-Down Handoff Process

Aim 3, Aim 4, Task B: data collection on process deviations.

Our phase I work has produced a huge wealth of directly observed details about the trauma care process which can tell us precisely what happens to each patient during their care episode. We have been interrogating this handoff data to examine where patients most frequently transition from and to, and the flow disruptions associated with those transitions (figure 5). A total of 160 patients were studied, and a total of 351 care transitions were observed (mean 2.2 ± 0.09 per patient). Of these patients, 68 (42.5%) experienced at least one disrupted transition during their care, with a mean of 0.66 ± 0.15 flow disruptions per patient and 0.31 ± 0.07 flow disruptions per transition. Mapping the transitions of care shows that 81.8% of patients were assessed and transferred to imaging for further diagnostics, with 72.4% of patients arriving back in the ED following imaging assessment to await further consultation or discharge assessment. 9.4% of patients return to the ED and then are transferred to the ICU or OR. Sicker, time-pressured, and more at risk patients are more likely to experience problems. Thus, reducing the number of transitions and improving co-ordination in transitions along the trauma pathway may reduce risks and improve efficiency.

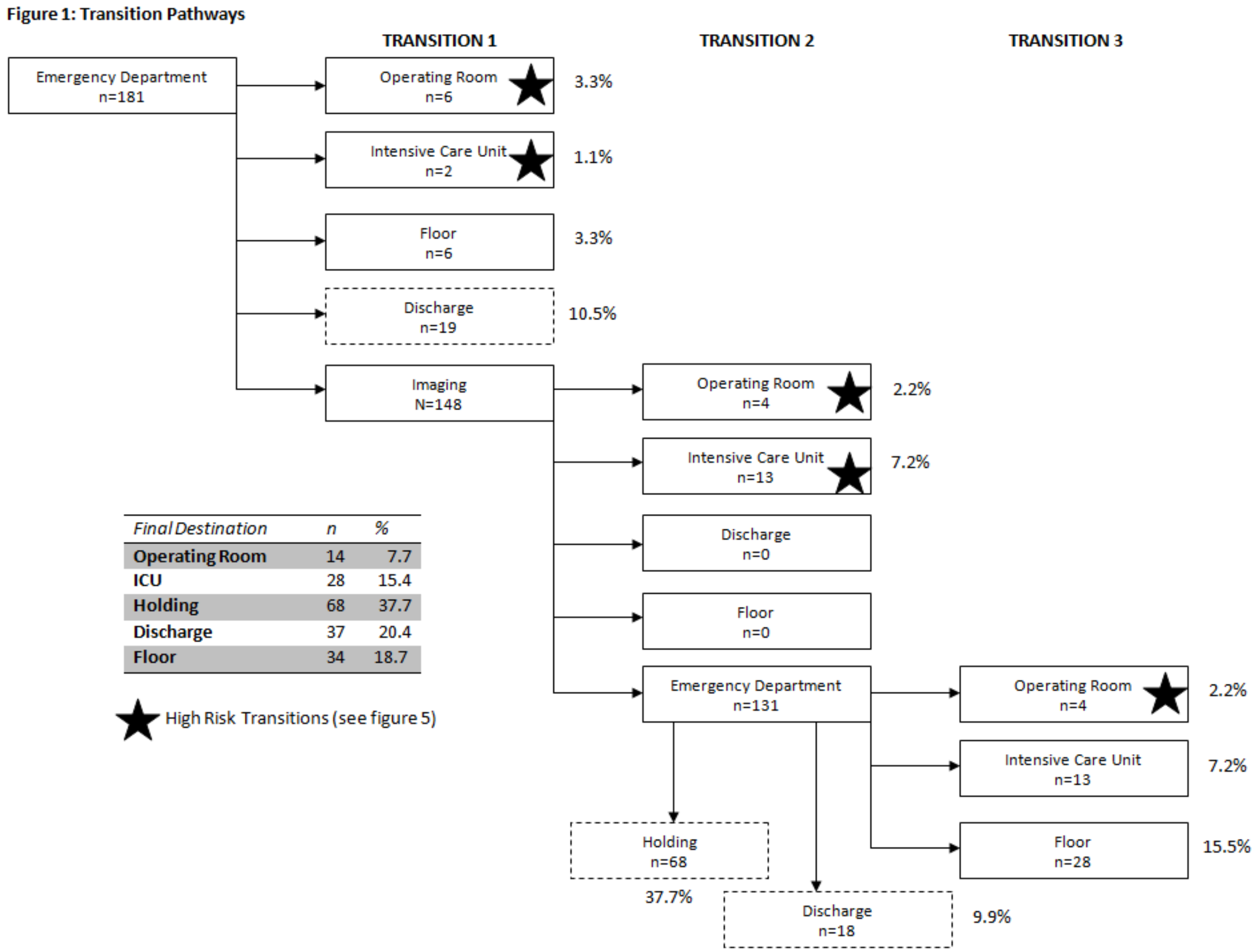


Figure 5: Observed flow disruptions during trauma care transitions.

Aim 3, Aim 4, Task C: analysis and items categorized

The majority of flow disruptions in this study (53%) were related to coordination problems (figure 6), such as where CT was already occupied; the nurses in pre-op did not have the correct paperwork; the patient was taken to the wrong room; or critical team members were missing when needed. There is a small additive effect where multiple transitions equate to a higher number of flow disruption transitions per patient and the number of flow disruptions per transition reduces slightly as patients experience one, two or three transitions. The data also demonstrates “high risk” and “low risk” patient experiences. Whenever a patient goes directly to the OR, or when a patient needs immediate admission to ICU, there is a higher risk of transition disruptions than when they go to the floor, discharge, or a holding area having first been to CT. In high risk transitions 40% of patients experience two or more transition flow disruptions during their care, as opposed to 13% for the low risk transition patients. It is the sicker, more urgent patients who are more likely to experience these non-standard transitions, and in doing so experience more flow disruptions.

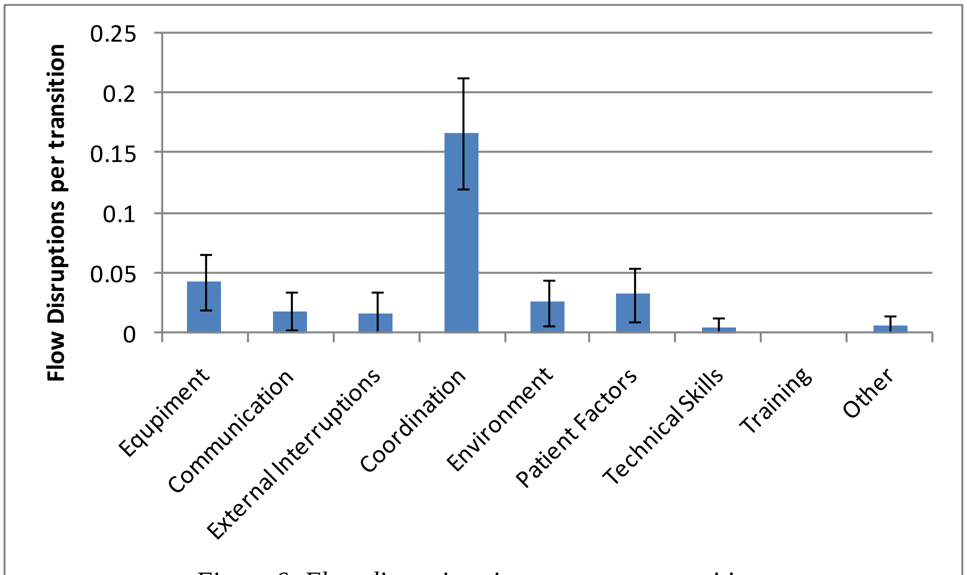


Figure 6: Flow disruptions in trauma care transitions

Aim 3, Aim 4, Task D: prospective data collection

<u>Type 1 handoffs: ED to CT</u>: We are currently at the intervention stage of this research (see below).

<u>Type 2 handoffs: Operating Room (OR) to PACU and CSICU</u>:

STUDY 1: Task, Team and Technology Interaction in Postoperative Handoffs
Handoffs from surgery to ICU are some of the most critical in the hospital. Patients are frequently unstable – or at least have some risk of instability following their operation – are usually receiving a number of medications, are frequently on other means of life support, and are usually semi- or unconscious. These handoffs constitute a entire change in care team from one that has spent at least several hours with the patient (the surgical team) to the post-surgical or ICU teams who have never before seen that patient. Even the physical transfer of the patient carries risks. For trauma care, this is even more critical, since this will be the first change in the care team. Thus, the transfer of patient, equipment and critical care information for these patients from one team to the next is a particularly important part of care.

We chose to take two models of post-OR handoff to study in more detail. Using direct observation methods of process, task and teamwork, we observed 32 handoffs from the OR to PACU, and on 26 handoffs from OR to CSICU using the same data collection template. This direct observation method collects data on patient information (6 items – name, age, history, allergies, diagnosis, procedure, current state), anesthetic information (intraoperative course, bloods, meds, vitals, fluids, pain relief, lines, post-op investigations), surgical information (intraoperative course, blood loss, number of drains, DVT prophylaxis, antibiotics, feeding plan), and on the physical tasks (set up of monitors, pumps, lines, fluid bags, drains). Teamwork was measured on a scale of 1-5 for 6 dimensions (Leadership, Cooperation, Communication, Assessment, Situation Awareness). These data are shown in figure 7.

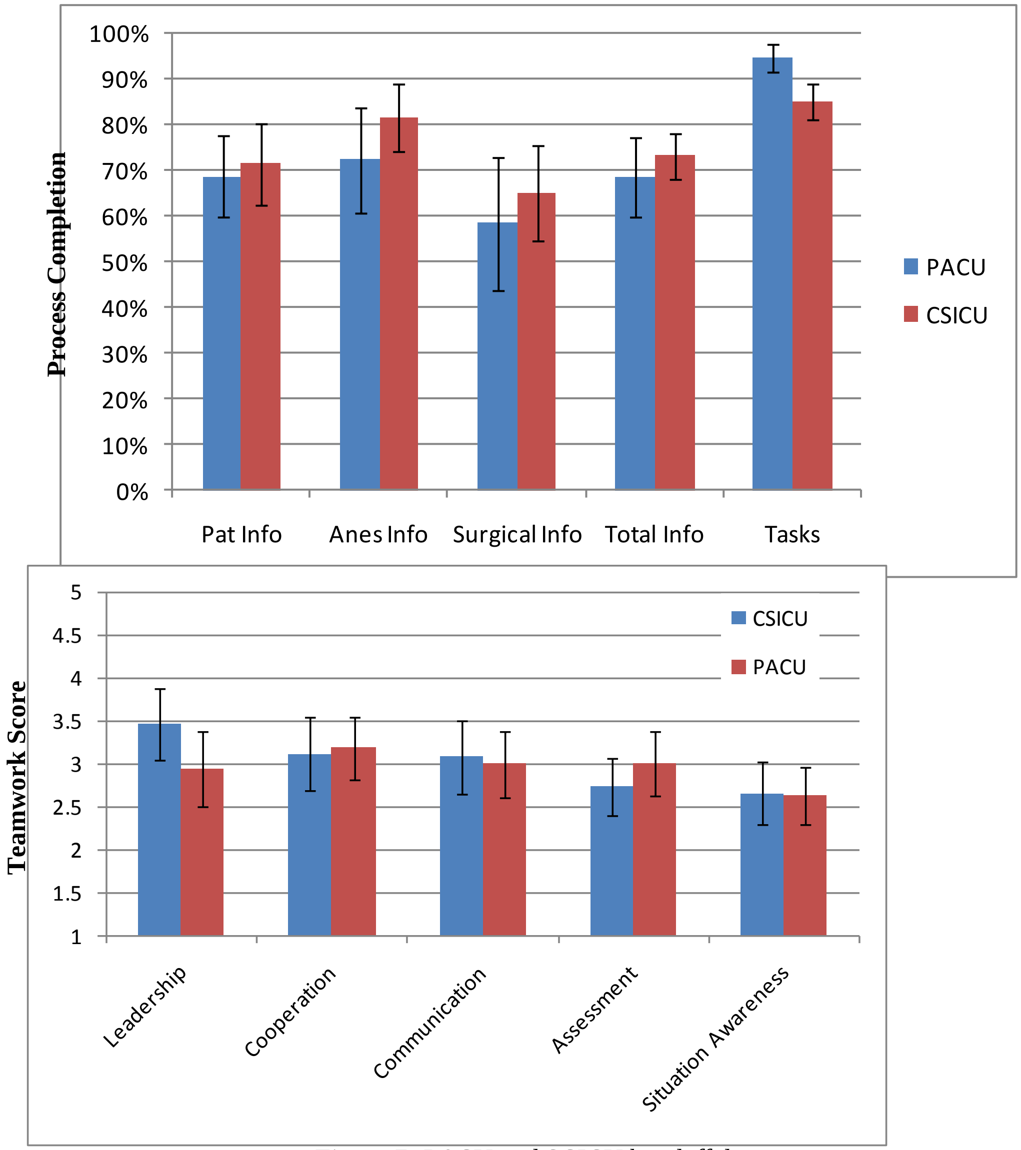


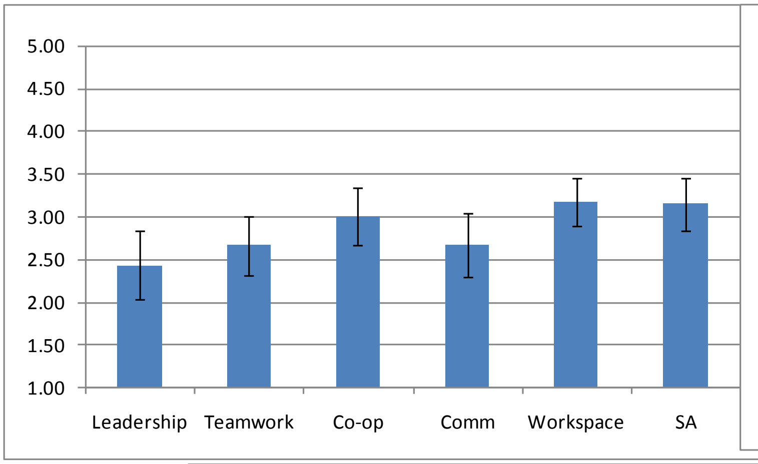
Figure 7: PACU and SCICU handoff data

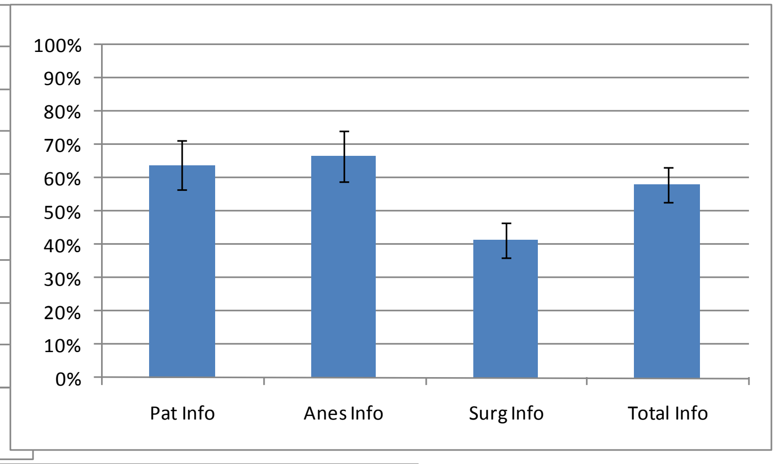
Analysis of these data demonstrates valuable interactions between the teamwork measures and the information transfer. Using a linear multiple regression using total information transfer process completion as the outcome measure, we found that there is a correlation with Leadership (p= 0.0084), Cooperation (p= 0.0002), Communication (p= 0.0089), task completion (p= 0.0017), and PACU vs ICU (p= 0.0072). Essentially, information transfer is significantly better in the CSCIU, but independent of location, is also better if the equipment is set up beforehand and if teamwork is effective. Perhaps most powerfully, this model predicts 61% of the variation in information transfer. This is an important result alone, but also suggests that ensuring equipment setup and better teamwork might lead to improved information transfer in these type 2 handoffs.

STUDY 2: Task, Team and Technology Interaction in CICU Handoffs

Recognizing that the Cardiac ICU patients provided an model for high-risk, complex patients where handoffs are important for ongoing care, we focused on this group for a second set of observations. Adapting the data collection method specifically for cardiac patients, and based on our previous findings, we have collected a further 38 observations. The data are shown below, which provides the baseline for the intervention. Teamwork (p=0.0181) and equipment transfer (p=0.0378) remain correlated with information transfer. On average, less than 60% of the total number of information items were handed off. Patient name is mentioned only 29% of the time; and allergy status only

37% of the time; plan for pain relief 50% of the time; and post-operative investigations 12% of the time. This leaves the distinct possibility to test our theories for improvement. Data are shown in figure 8.





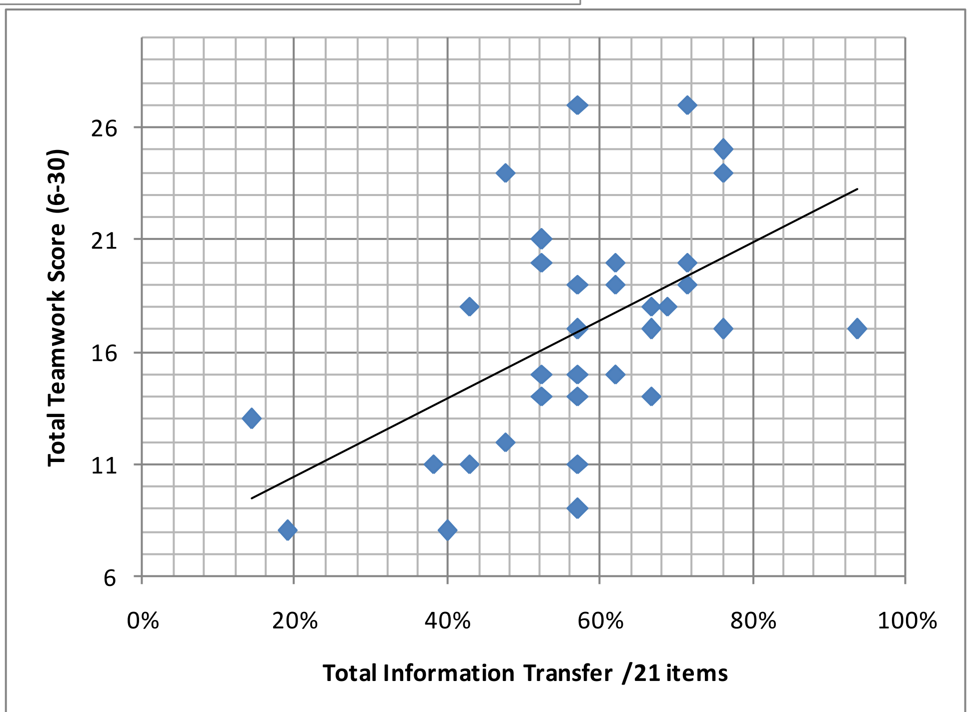


Figure 8: Cardiac Surgical ICU Handoffs

We are currently in the process of completing the chart review in order to identify potential clinical indicators of a deteriorating patient. The chart review will inform our handoff interventions, ensuring that the critical information is included in the handoff transfer. The results from the chart review will be included in a future report.

Type 3 handoffs: Surgical Intensive Care Unit (SICU): We have been gathering data at three levels in the SICU: the receiving nurse, the charge nurse, and the resident physician. Since these handoffs are challenging to observe, we have adopted a self-report methodology. Though reliant on perceptions, it has generated valuable data upon which it will be possible to generate steps toward an intervention. We are examining the process of informing about arrival of the patient; the handoff itself; and any later unexpected events. From the RN data we have received 74 self reports. In 93% of cases the communication prior to patient arrival was timely and appropriate. For the handoff itself, in 85% of cases the report was felt to be complete, with 92% +/- 4% of 13 information items reliably reported. However, in one case only the patient's name was reported. In another, the wrong dosage was indicated.

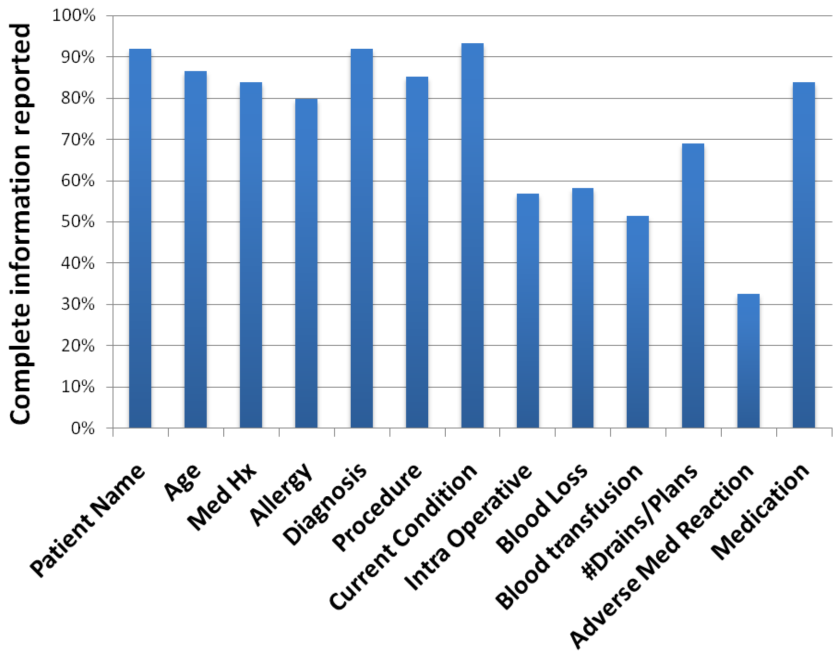


Figure 9: Information handoffs (SICU Nurse)

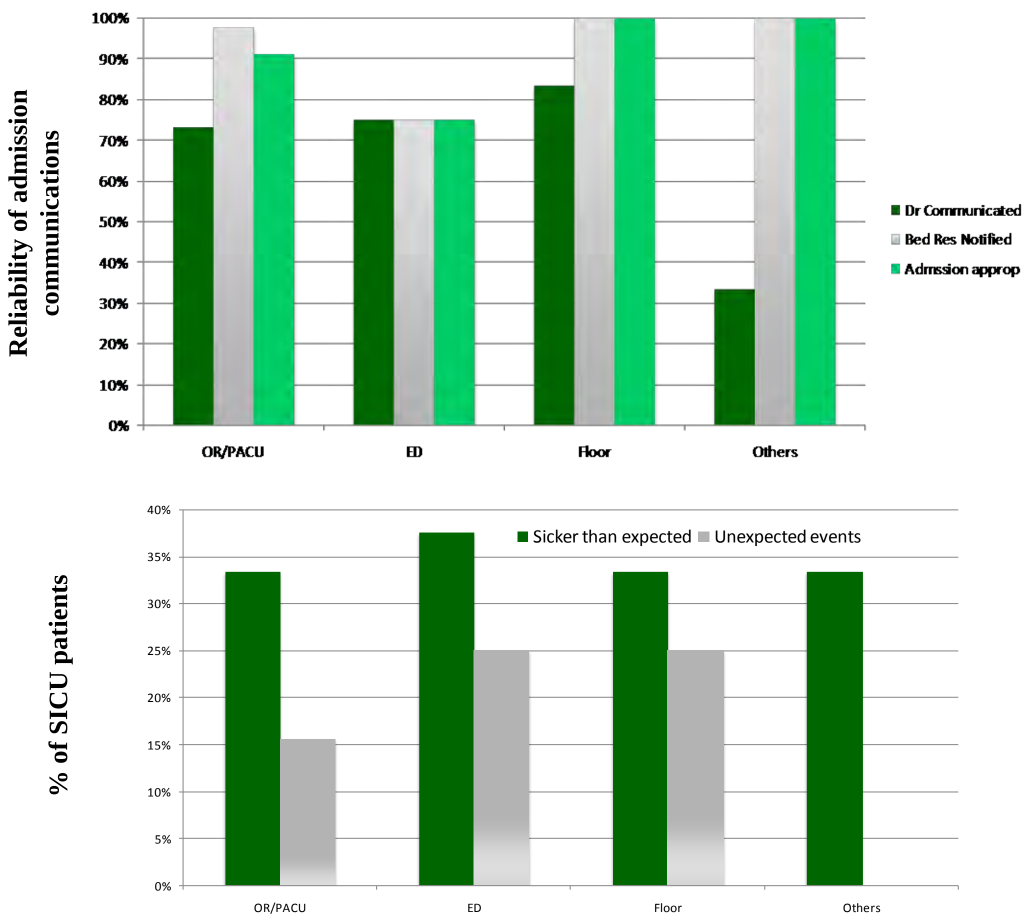


Figure 10: Charge nurse self reports

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From the charge nurse data, a total of 68 handoffs were reported. For those, in about one-quarter of patients (26%) there was no communication between charge nurse and doctor. The admission process from the ED would appear to be the least reliable (figure 4). Importantly, 34% of patients were reported as sicker than expected, and in 18% of patients something unexpected happened. While this may not directly indicate flaws in the system, it suggests that situation awareness (a key feature of type 3 handoffs) might be significantly reduced in these cases

Finally, of the 79 physician handoff self reports, there were also some gaps in quality. 68% of physicians felt that patient acceptance to the unit had been properly communicated, with 16% patients where ICU admission was felt to be inappropriate, with handoffs inappropriate 12% of cases. In comparison with the charge nurse, 9% patients were sicker than expected, and 5% had unexpected events associated with their care.

Overall, there is a perception that handoffs and generally effective, with some small defects. Treatment details can be omitted from nurse reports, while the charge nurses find up to one third of patients are sicker than expected, while one in ten physicians find something similar. In the next quarter we will feed these results back to SICU staff and examine which areas should be addressed for interventions.

Aim 3, Aim 4, Task E: root cause analysis

Sources of co-ordination problems are multi-factorial. We have been able to analyze our previous incident reports from this perspective, finding that team and task issues are most prevalent. This would be supported by a range of previous studies in this area, and provide further weight to our approach of measuring process, teamwork and information flow in handoffs. However, given that this data originates from the more traditional handoffs, it is somewhat in conflict with the direct observations. This supports a more advanced view of transitions that we have already observed as being key to success in trauma handoffs, demonstrating the unique necessity of the current studies.

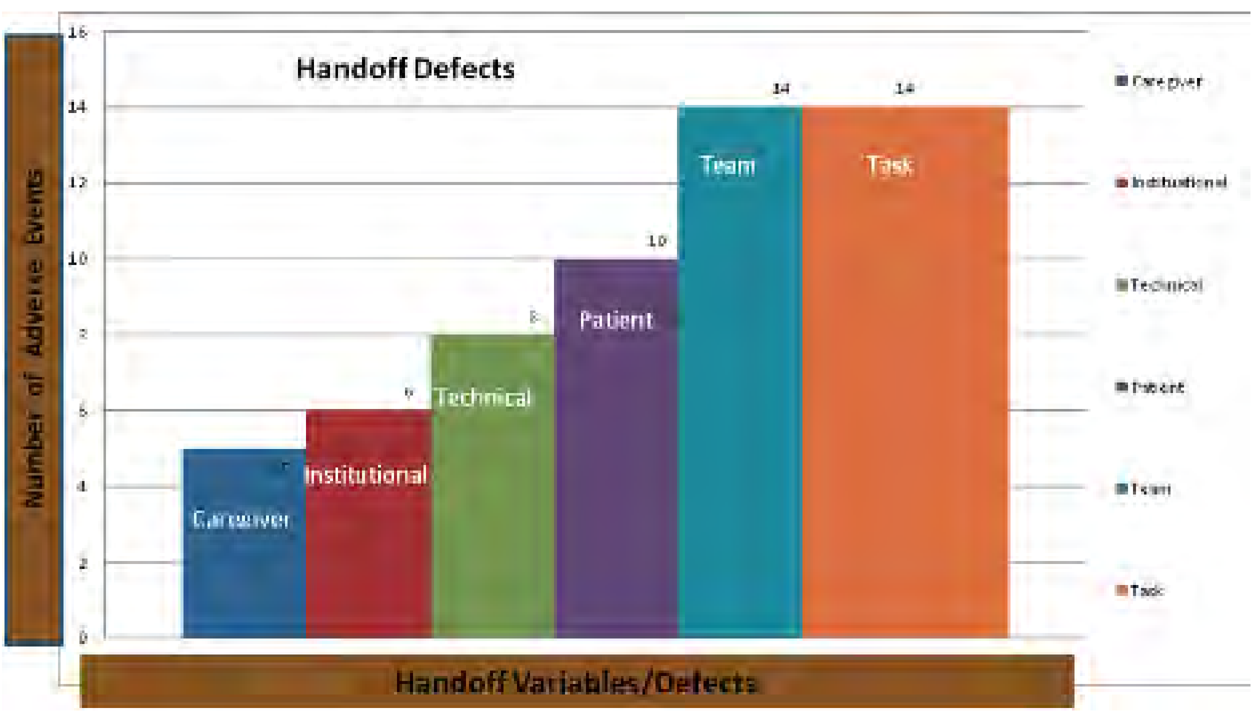

Figure 11: Results of incident database analysis

Aim 3, Aim 4, Task F: feedback to current stakeholders

Feedback has been ongoing throughout the project. We continue to have weekly subgroup meetings, monthly conference calls with the entire collaborative team, as well as bi-annual face-to-face meeting at Cedars-Sinai. We also present to the Cedars-Sinai Trauma Performance Improvement Committee, ED Performance Improvement Committee, and the Department of Surgery Performance Improvement Committee on a regular basis to update the teams on any elements of our research that will affect their respective departments. Our Sharepoint site (eRoom) houses all of our collaborative documents and allows team members to easily keep up with the latest activities and progress. The site is available to both internal Cedars-Sinai team members as well as our outside collaborators.

Additionally, we are in regular dialogue with Madigan Army Medical Center about the application of this knowledge.

Aim 3, Aim 4, Task G: identify areas of high priority/high impact/high risk

Our analysis of flow disruptions, process maps, and direct observations suggest that it is the handoffs to ICU which are the most at risk, as they involve an entire change in care team, happen with the sickest patients, and are relatively unstructured. In terms of improvement, process and teamwork improvements offer the best solution, as indicated by interviews, flow disruption analysis, and direct observation of interactions between teamwork and process. We have focused interventions on cardiac patients as a model of high acuity handoffs and direct admissions to ICU from the OR. Working within the CSICU allows us to observe with reliable frequency these types of handoffs. We have previously found that it is the high risk, less frequent handoffs that created the greatest problems. By expanding the concept of handoff from the traditional mnemonic (e.g. SBAR), to incorporated process redesign, checklists, teamwork, and training, we aim to test the hypothesis that encouraging the optimal task, team and technology interactions will produce measureable improvements in the handoff process.

Aim 3, Aim 4, Task H: design potential interventions

Following excellent progress and data analysis in phase one, three key interventions are currently in development, with more to be defined following the detailed data collection and root cause analysis.

Intervention 1: Smart Phone Application

Originating from our work in phase 1, we have commenced early development of a Smartphone application that assists in the early management of trauma patient information. Though not directly focused on specific handoffs, we are confident that it will with handoffs in general, and may be extended specifically to address handoff issues in particular. Moreover, if it is suitable for deployment within our trauma setting, we will be able to evaluate the effect it has on handoffs. Beforehand, we will assess this software tool in a simulated environment.

Our Phase one work, implementing whiteboards, pre-briefings, checklists and teamwork training demonstrated significant improvements in immediate responses, treatment time, flow disruptions, and length-of-say for extremely sick patients. We recognized that mobile communications displaying the whiteboard information would allow even earlier building of situation awareness and team cohesion. We recognized the value and existing uses of text and photos to communicate about patient care, and became interested in the ways in which our teamwork, communication and patient management interventions could be supported and sustained with well designed smart phone technology. Teamwork can be enhanced through the distribution of information to a smart phone, coupled with the ability to provide information on a constantly updating electronic whiteboard. The provision of this information to OR, CT, and other specialist services geographically distributed in the hospital. Together, this would substantially enhance the ability for clinicians to predict and respond quickly and appropriately to the sickest patients. As well as providing a better response for individual patients and better teamwork, this would also ensure better use of hospital resources. The awareness of the huge range of physicians, nurses and other specialists involved would be improved. This would encourage the delivery of timely, appropriate, error-free care to the patient. A modular approach, coupled with the integration of wider information sources, and designed with a human-centered understanding of decision making could further enhance team performance not only in the initially assessment phase, but right through CT and OR care to ICU admission and beyond.

This simple mobile platform allows a further range of enhancements that might considerably aid in subsequent patient care, and go well beyond the initial purposes of enhancing communication, and information distribution. Like the flight management system in a modern aircraft, this presents an opportunity to investigate a ‘system of systems’ that provides patient-centered communication, sensor integration, real-time remote access to dynamic patient information, diagnostic support, process management, care planning, and hand-off tools. Theoretically, this could improve communication amongst team members and across the hospital system (such as CT, OR or ICU). It would improve integration of care processes and diagnostics, encourage adherence to best practice, and quality & safety processes. It would support handoffs and team member changes, while supporting diversity of patients, patient-centered care, and the complexity of healthcare delivery.

Intervention 2: CT Checklist

A second intervention currently being explored is a checklist for improving patients admission into CT. This is based on concerns information, team and process during transition to CT, and especially in ensuring appropriate preparedness for CT scanning. This need arose from a detailed study of flow disruptions during the CT process, where the hypothesis was generated that many of these disruptions could be addressed with an improved handoff process. 81% of trauma patients visit the CT scanner. We found that this transfer process was fraught, and created many delays, especially in co-ordinating the team and the complex components required for this task. For example, we have found that some patients can be delayed in the corridor waiting for the scanner to become available; and some are not appropriately prepared early for the removal of metal objects (especially earrings) from their person. We have also found flow disruptions in CT due to patients who move and we may be able to more adequately prepare for them for their time in scanning.

Trauma – CT Checklist	❑ CT notified? ❑ Orders in? Orders correct?
A: Airway	❑ Oxygen tank with sufficient O2?
B: Blood	❑ Should you transport with blood?
C: CT ready Cardiac monitor	❑ Jewelry removed? ❑ CT ready? Which scanner?
	❑ Is the patient on a monitor?
D: Drugs	❑ Necessary drugs available (Fentanyl, versed, propofol, antiemetics)
E: Exit	Consider where patient will you go after CT ❑ ICU admission? Request bed. Complete check out in scanner.

Figure 12: CT Imaging Checklist

We instigated a CT checklist to aid in the transfer of patients from ED to CT (figure 12). This has subsequently been in use, and has been well received, and is being evaluated using the scoring system below (figure 13). This was deployed for 41 CT cases before the commencement of the pilot tests on 4/15/2013, and then proceeded for several weeks. Since staff did not always used the checklist we have now also captured 7 traumas where the checklist was not used, and 11 where it has been used. This has allowed us to generate provisional data (Figure 3). The process was evaluated by adding up the number of tasks completed before and after arrival in CT from the key list of required tasks (Patient on monitor; transport bag present; additional pain meds available; CT orders entered; metallic items removed; arm band placed; scanner assigned). Teamwork was measured on a scale of 1-5 for 6 dimensions (Leadership, Cooperation, Communication, Assessment, Situation Awareness). Finally, time data were also measured at different points in the process. So far, the sample size is small, but we have measured a significant improvement in process (p=0.02), and teamwork (p=0.0001), but with an increase in the preparation time in CT (p=0.024). There is still a great deal of variability in the process, but the data is moving in the right direction. However, the time increase needs further investigation. In the next quarter we hope to train a new set of residents to use the checklist and to collect more data for the effectiveness of the CT checklist, and specifically to find out what is causing the delays in CT.

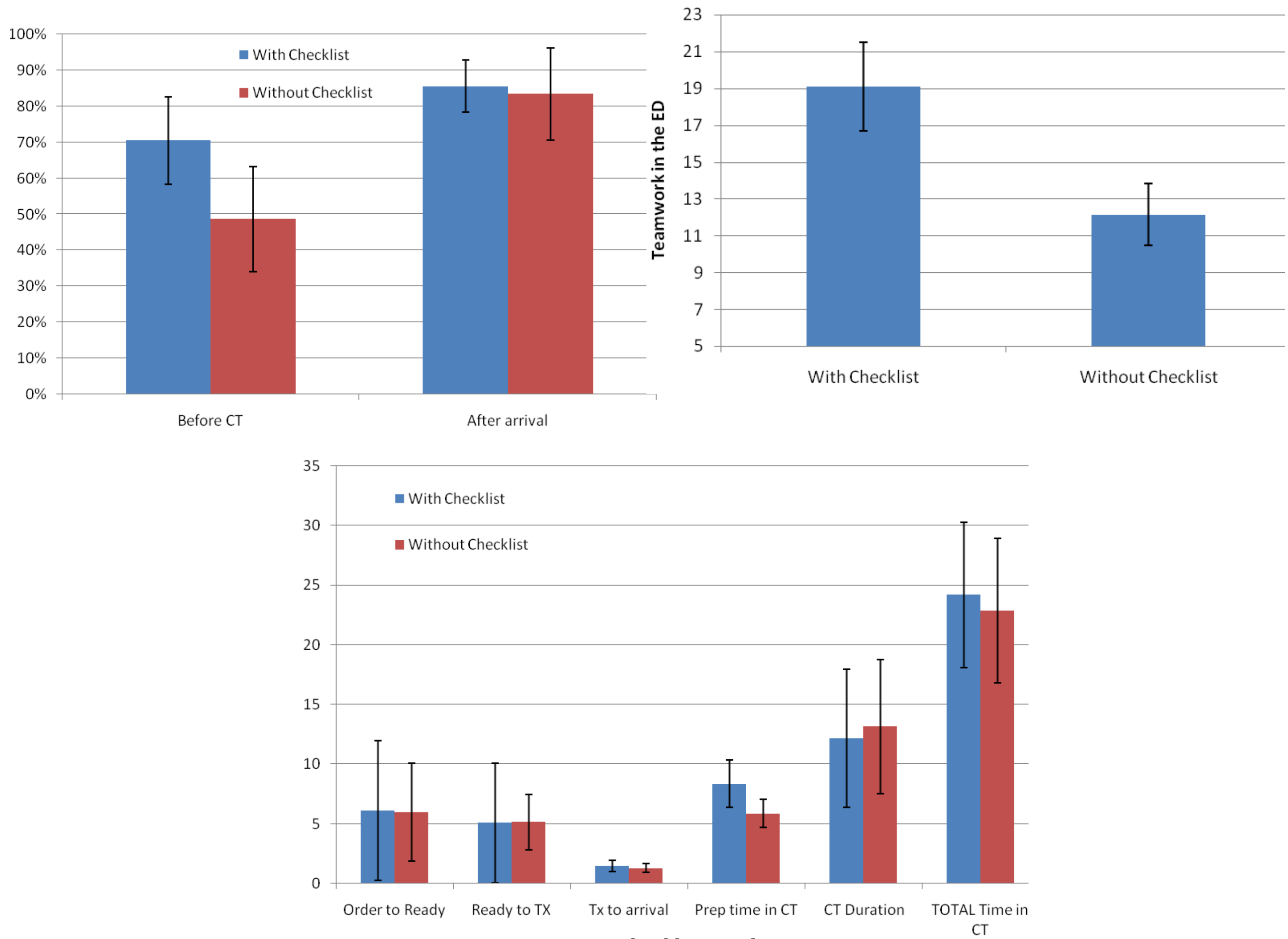

Figure 13: CT checklist results

Intervention 3: Improving handoffs from the OR to ICU.

The final intervention development is based on our initial data collection in the PACU and CICU. We have been developing a handoff intervention protocol based on an adaptation of our previous work from motor racing pit-stops. We have been developing a four stage protocol:

1. Pre handoff (before the patient arrives). We want to encourage better information before the patient arrives. In particular, it would be helpful to know when the patient going to arrive? (<30 mins and >2 mins warning), what sort of condition will they be in, and how to set up the room (vent settings, pumps, drips, lines, support technology).
2. Technology transfer. The next area for potential improvement is when the patient arrives and we need to set up the bedspace. The main problem here is to avoid is people getting in each other's way, and information handoff starting before the equipment is configured. We need to consider the technology that needs to be set up, the order, and then assign tasks to each team member. The current list of technology for cardiac surgery is: Ventilator, BIS & Cables, Urimeter, Bair Hugger, IV Pole + C-clamp, 3x suction (vent, chest, gastric), 6x Monitor Cables (EKG, Sats, BP, 3x pressure monitoring cables), 3x Garbage (Regular, bio material, pharmacy

waste). Occasional additions include: CCO SWAN Catheter monitor and cable, LA pressure line cable, Extra infusion pump, Ventricular Assist Devices.

3. Information handoff. The information handoff is perhaps the most critical component, and could be made more reliable by examining Who hands over information and when, what information is really important (patient details, surgical procedure), what can be obtained from the IT systems and what needs to be transferred verbally. We are considering whether there are forms or checklists that would make this process easier.
4. Discussion and Plan. The final component to strengthen the process is to discuss and agree a plan for the care of the patient and established a shared mental model of the next stages of care. This should involve at least one OR physician and one ICU physician and nurse, but preferably all. We need to consider what should be discussed? (E.g. Bloods/ fluids/ pain/ antibiotics/ feeding/ lines/ drains/ monitoring), and what contingencies to plan for (E.g. monitoring, extubation, expectation).

We are involving the nurses in answering this question and will be moving to trials interventions within the next 6 weeks.

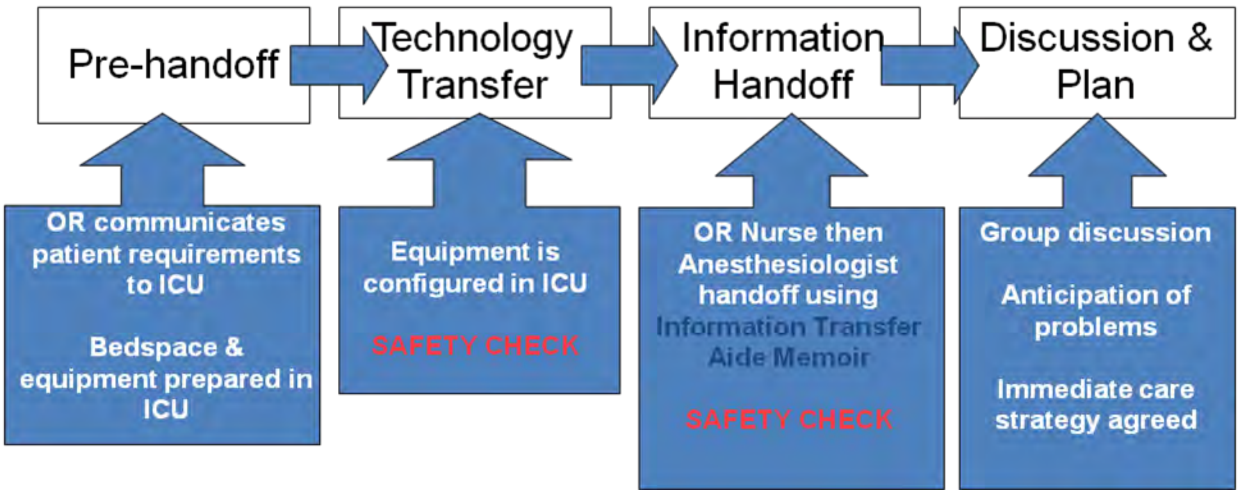

Figure 14: Handoff process from OR to ICU

Aim 3, Aim 4, Task I: develop protocols

These will be fully developed following the results of our interventional tests.

Aim 3, Aim 4, Task J: tests of change in simulation

Simulation provides the opportunity to develop teamwork, task and technology prior to deployment. We will be utilizing simulation within the interventions for both training and evaluation of the new handoff methods.

Aim 3, Aim 4, Task K: successful interventions tested and refined at CSMC and partners

This material should go in the process map & interview sections above. We have not done any proven handoff interventions at Madigan yet.

We are working with Madigan Army Medical Center. Our initial work has focused on assessing the needs for Madigan, which was conducted through a series of interview and focus groups for a total of 113 staff (15 ICU Nurses, Attendings & Residents; 3 respiratory technicians; 34 anesthesia providers; 4 blood bank staff; 8 ED staff; 8 general surgery residents, and 40 OR staff). We recorded 67 individual comments and perspectives that were then classed into several categories. First, we considered the reported purposes of handoff that featured in the comments. Next, the process considerations, and finally, we classified comments according to the SEIPS model of human factors (Figure 15).

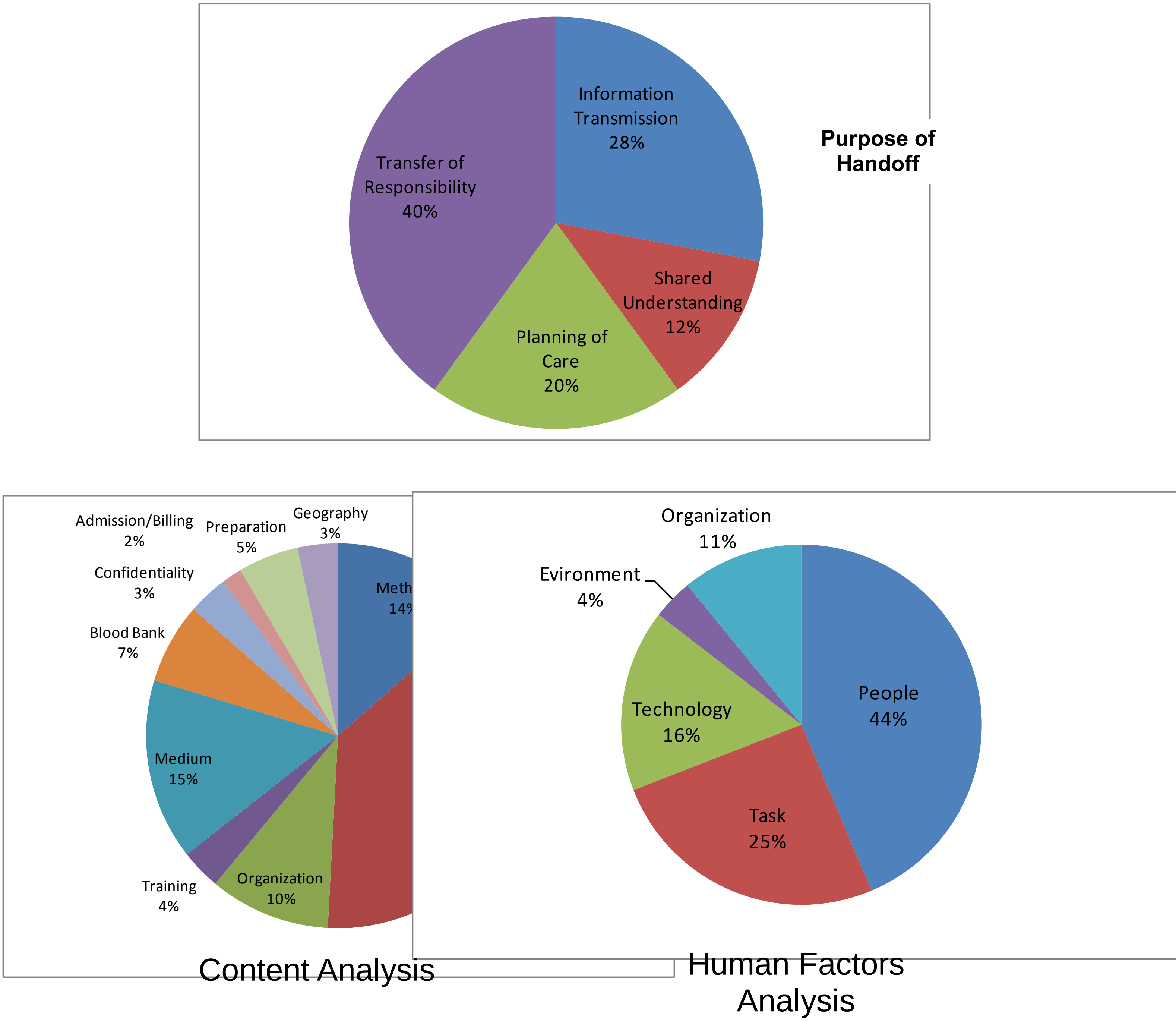

Figure 15: Results from interviews at Madigan Army Medical Center

Overall, we found that a good handoff is defined by the transfer of information, responsibility, and the shared planning of future care. This is influenced by: clear leadership & role definition, face-to-face communication, and a standard template and process to follow. We concluded that an improved handoff process could include

- Face to face handoffs with both physicians and nurses
- Structured process: including notification of patient prior to arrival, standardized information handoff, agree a plan for ongoing care

- Training, role definition, clear trasnfer of accountability
- Technologies – computer systems, whiteboard, paper

This supports our underlying hypothesis and suggests that our interventions will be an excellent fit for Madigan Army Medical Center, and we will continue to work with them to learn and implement the findings from our observational and interventional studies.

Aim 3, Aim 4, Task L: findings disseminated as best practices

This work will be completed following the conclusion of the data collection and intervention components of our studies.

Key Research Accomplishments

The key research accomplishments so far have been in:

- Detailed mapping of handoffs along the trauma pathway and other high-risk analogue handoffs within the hospital
- An analysis of the disruptions during transitions and handoffs along the trauma pathway.
    - Many patients experience some disruption during care transition
    - Co-ordination problems are dominant causes
    - The sicker, more at risk patient experience more problems in handoff transitions.
- Analyzing hospital incident reports of handoffs, which reveals that task and teamwork causes are dominant
- Examining and deploying observational methods to measure specific types of handoffs and transitions
- Identified and statistically modeled the relationships between tasks, teamwork and process in transitions from OR to PACU and ICU.
- Measuring the reliability of handoffs to surgical ICU
- Development and ongoing evaluation of three potential interventions
- Interviews with staff for implementation with Army Hosptial partner.

Reportable Outcomes

Papers published:

- Catchpole K (2013). Toward the modelling of safety violations in healthcare systems. *BMJ Quality and Safety.* doi:10.1136/bmjqs-2012-001604.

- Catchpole K, Gangi A, Blocker R, Ley E, Blaha J, Gewertz B, Wiegmann D (2013). Flow disruptions in trauma care handoffs. *Journal of Surgical Research.* pii: S0022-4804(13)00115-7.

Oral presentations delivered:

K. Catchpole, R. Blocker, E. Ley, A. Gangi, J. Blaha, B. Gewertz, D. Wiegmann. Flow Disruptions in Trauma Care Handoffs. 8th Annual Academic Surgical Congress, February 5-7, 2013 in New Orleans, LA.

K. Catchpole, R. Blocker, Improving Hand-Offs Through Motor Racing Analogies and Human Factors Research, Association for Perioperative Registered Nurses (AORN) Annual Conference in San Diego, USA Mar 3-7, 2013.

K. Catchpole. Task, Team and Technology Integration in Surgical Care. Invited oral presentation at the 2013 Symposium on Human Factors and Ergonomics in Health Care, March 11-13, 2013, Baltimore, Maryland, USA

K. Catchpole. Task, Team and Technology Integration in Surgical Care. Invited oral presentation at the 2013 Institute for Ergonomics and Human Factors Annual Conference, Cambridge, UK, 15-18 Apr, 2013.

A. Gangi, K. Catchpole, R. Blocker, D. Wiegmann, B. Gewertz, J. Blaha, E.J. Ley. Time To Prepare Impacts Emergency Department Efficiency And Flow Disruptions. Quick Shot Presentation at the 8th Annual Academic Surgical Congress, February 5-7, 2013 in New Orleans, LA.

K. Catchpole, E. Salas, D. Wiegmann, S. Parker, B. Wears, R. Blocker. Teamwork and Handoffs in Trauma Care: Measurement, Modeling and Improvement. Panel Discussion at the Human Factors and Ergonomics Society Annual Conference, October 1-4, 2013 San Diego, CA.

Conclusion

Phase II of the Operating Room of the Future program is building a unique set of knowledge around handoffs in high risk patients. We have taken a broad approach to problem definition and early analysis, using incident reports, observation and classification of flow disruptions along the trauma pathway, process mapping, interviews and direct observation. We have found the most important factors to be related to task and teamwork, so aim to redesign handoffs to provide better defined processes that also encourage teamworking. Three interventions are in progress – a smartphone app for improved information delivery, a checklist to assist the passage of the patient into CT, and a combined process, checklist, teamwork and information management intervention for high risk patients in the cardiac ICU. We have sufficient data to move toward academic publication of early results. In the next three months we will fully deploy and evaluate these interventions, and continue to collect interview data and study the contribution of handoffs to patient deterioration.

Appendices: Published Abstracts

FLOW DISRUPTIONS IN TRAUMA CARE HANDOFFS

Ken R. Catchpole, PhD[1], Alexandra Gangi, MD[1], Renaldo C. Blocker, PhD[1], Eric Ley, MD[1], Jennifer Blaha, MBA[1], Bruce L. Gewertz, MD[1], Douglas A. Wiegmann, PhD[2]

[1]Department of Surgery, Cedars-Sinai Medical Center, Los Angeles, CA
[2]Department of Industrial and Systems Engineering, University of Wisconsin, Madison, Wisconsin

Presented at the Annual Meeting of the Academic Surgical Congress in New Orleans, Louisiana, February 5-7, 2013

Introduction: Effective handoffs of care are critical for maintaining patient safety and avoiding communication problems. Using the flow disruption observation technique, we examined transitions of care along the trauma pathway. We hypothesized that more transitions would lead to more disruptions, and that different pathways would have different numbers of disruptions.

Methods: Observers were trained to identify flow disruptions, then followed 181 patients from arrival in the ED to the completion of care using a specially formatted PC tablet. Each patient's journey was mapped and flow disruptions during transition periods were recorded and classified into seven categories.

Results: Mapping the transitions of care shows that approximately 4 of 5 patients were assessed in the ED, transferred to imaging for further diagnostics then returned to the ED. There was a mean of 2.2 $\pm$ 0.09 transitions per patient, a mean of 0.66 $\pm$ 0.15 flow disruptions per patient and 0.31 $\pm$ 0.07 flow disruptions per transition. The majority of these (53%) were related to coordination problems. Though disruptions did not rise with more transitions, patients who went directly to the OR or needed direct admission to ICU were significantly more likely ($p=0.0028$) to experience flow disruptions than those that took other, less expedited, pathways.

Conclusions: Transitions in trauma care are vulnerable to systems problems and human errors. Coordination problems predominate as the cause. Sicker, time-pressured, and more at risk patients are more likely to experience problems. Safety practices used in motor racing and other industries might be applied to address these problems.

PANEL OVERVIEW

Teamwork and Handoffs in Trauma Care: Measurement, Modeling and Improvement

Dr Ken Catchpole
Director of Surgical Safety and Human Factors Research
Cedars-Sinai Medical Center

21st Centuary trauma requires the coordination, support and integration of a range of equipment, technical services and clinical expertise across several hospital locations under time pressure, with considerable uncertainty about the condition or history of the patient. This panel brings together experts in the field to examine the latest human factors approaches to teamwork and process study in trauma care, and handoffs within and between teams across the trauma pathway.

The standard treatment of a trauma patient begins with the Emergency Medical Services, who assess and offer initial treatment to the patient before transport to the trauma center. Upon arrival, the trauma team, who have usually been activated by pager, work with the ED team and a range of other specialists (anesthesia, respiratory, pharmacy, emergency department, radiology) to assess the patient and move them through the process to imagery, and thence to the OR, ICU or floor if needed. This mix of specialists, all working to bring the appropriate resources to the patient with the highest level of effectiveness within the least possible time, within a wider systems context of ongoing patient care, makes trauma care unique in the demands it places upon health systems.

Interview and observational studies conducted at Cedars-Sinai on behalf of the Department of Defense have shown how important teamwork and handoff issues are to this process. In semi-structured interviews leadership and communication are signaled as being the most important factors in determining a good or a bad case (Ley et al. In Prep). In direct observation studies, coordination and communication are the most frequent causes of flow disruptions(Shouhed at al. in Prep; Blocker et al, under submission), and a range of interventions are currently under investigation. Finally, handoff studies show that transition disruptions occur in about 40% of all trauma cases, and are particularly prevalent in the high risk cases that require non-standard care pathways (in particular, patients requiring rapid transit to OR or ICU). It is within this context that the panel has been convened to discuss the theoretical and practical issues with studying communication, teamwork and handoffs in trauma care.

Professor Ed Salas will set the scene by discussing teamwork research and what we know matters in teams. Dr Doug Wiegmann will then discuss the techniques that he and others have employed in trauma and the OR to study events and behaviors. He will particularly focus on direct observation and video methods as a method for understanding and improving trauma systems. Next, Dr Sarah Parker will examine the application of direct observation to the assessment of teamwork in the early phase of trauma resuscitation. She will present her work on the development of a tool to measure teamwork and process in this critical time, and discuss the limitations and advantages of this novel method. Moving from early trauma care to ongoing assessment and care, Dr Bob Wears will then provide a theoretical approach to the study of handoffs. Traditionally this literature has been dominated by simplistic models, and pervading views such as the need to standardize information transfer within handoffs. This section of the workshop will present a broader view of handoff work, and expound the value in understanding the benefits and limitations of different handoff perspectives. Finally, Dr Renaldo Blocker will present his novel work on micro-handoffs in the OR and trauma care, illustrating how even small, incidental changes in personnel are extremely frequent and can require an appropriate handoff; or alternatively, can lead to disruptions, miscommunication, co-ordination failures, and safety problems.

Overall, by covering both theoretical and practical study topics associated with trauma care safety and efficiency, this cutting-edge workshop will illustrate both techniques and interventions to deploy that will help healthcare human factors practitioners to improve performance in this complex and safety-critical aspect of healthcare.