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Anita L. Tucker
W. Scott Heisler
Laura D. Janisse

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ANITA L. TUCKER
Harvard Business School
Boston MA 02163

W. SCOTT HEISLER
Kaiser Permanente

LAURA D. JANISSE
Kaiser Permanente

Abstract: The performance gap between hospital spending and outcomes is indicative of inefficient care delivery. Operational failures—breakdowns in internal supply chains that prevent work from being completed—contribute to inefficiency by consuming 10% of nurses' time (Hendrich et al. 2008, Tucker 2004). This paper seeks to identify organizational factors associated with operational failures, with a goal of providing insight into effective strategies for removal. We observed nurses on medical/ surgical units at two hospitals, shadowed support staff who provided materials, and interviewed employees about their internal supply chain's performance. These activities created a database of 120 operational failures and the organizational factors that contributed to them. We found that employees believed their department's performance was satisfactory, but poorly trained employees in other departments caused the failures. However, only 14% of the operational failures arose from errors or training. They stemmed instead from multiple organizationally-driven factors: insufficient workspace (29%), poor process design (23%), and a lack of integration in the internal supply chains (23%). Our findings thus suggest that employees are unlikely to discern the role that their department's routines play in operational failures, which hinders solution efforts. Furthermore, in contrast to the "Pareto Principle" which advocates addressing "large" problems that contribute a disproportionate share of the cumulative negative impact of problems, the failures and causes were dispersed over a wide range of factors. Thus, removing failures will require deliberate cross-functional efforts to redesign workspaces and processes so they are better integrated with patients' needs.

Key Words: health care, internal supply chain, operational failures, workarounds

1. Introduction

Hospitals struggle to improve efficiency, quality of care, and patient experience (Berwick et al. 2006), despite a pressing need to do so (Institute of Medicine 1999, Institute of Medicine 2001, Leape and Berwick 2005, Wachter 2010). Operational failures—defined as instances where an employee does not have the supplies, equipment, information, or people needed to complete work tasks—contribute to hospitals' poor performance (Tucker 2004). They waste at least 10% of caregivers' time, delay care, and contribute to safety lapses (Beaudoin and Edgar 2003, de Leval et al. 2000, Gurses and Carayon 2007, Hall et al. 2010, Hendrich et al. 2008, Tucker 2004). Therefore, a critical step in improving the performance of hospitals is identifying and addressing underlying causes of operational failures.

However, research suggests that reducing operational failures may prove to be challenging. Operational failures manifest as minor glitches that take, on average, only three minutes to work around and range across many different types (e.g. missing medication, linen shortages, incorrect dietary trays, etc.) (Beaudoin and Edgar 2003, Fredendall et al. 2009, Gurses and Carayon 2007, Gurses and Carayon 2009, Hendrich et al. 2008, Sobek and Jimmerson 2003, Tucker 2004). The diffusion of impact and type makes it unlikely that traditional quality improvement methods will be successful at preventing operational failures because these methods are designed to detect and address a few, large-impact problems that disproportionately contribute to poor performance—the so-called 20% of problems responsible for 80% of the negative impact (Juran et al. 1999). Furthermore, only a handful of published studies have systematically examined the causes of operational failures (Fredendall et al. 2009). Thus, additional research is needed to understand what leads to operational failures and what hospitals can do to address the underlying causes.

This paper seeks to increase hospital productivity and quality of care by uncovering organizational factors associated with operational failures so that hospitals can reduce the frequency with which these failures occur. The authors, together with a team of 25 people, conducted direct observations of nurses on the medical/surgical wards of two hospitals, which surfaced 120 operational failures. The team also shadowed employees from the support departments that provided materials, medications, and equipment needed for patient care, tracing the flow of materials through the organizations' internal supply chains. Our approach enabled us to discover organizational factors associated with the occurrence and persistence of operational failures.

We used a grounded, inductive reasoning approach, which examines a research question through iterative cycles of analyzing data to allow patterns to emerge from observations (Miles and Huberman 1994). We compared what we learned to existing theory to determine which ones best reflected the underlying dynamics (Shah et al. 2008). Our methods resembled those of other operations management scholars who conducted qualitative, interview and observation-based investigations of healthcare organizations to discover drivers of productivity (Fredendall et al. 2009, Ghosh and Sobek 2006, Jimmerson et al. 2005, Shah et al. 2008, Sobek and Jimmerson 2003).

We contribute to the body of knowledge on process improvement in hospitals by providing insights about potential strategies for preventing operational failures. In contrast to workers' beliefs that operational failures arose from other people's mistakes or lack of training, we found that violations of Toyota's four rules of effective work design (Spear and Bowen 1999) explained many of the operational failures that we observed. This finding implies that attention to work design should reduce operational failures in hospitals (Fredendall et al. 2009, Ghosh and Sobek 2006, Sobek and Jimmerson 2003). In addition to work design flaws, low levels of internal and external integration also contributed to operational failures. Most prior operations management research on integration has examined its impact on organizational performance, such as the speed of new product development (Flynn et al. 2010), financial performance (Dröge et al. 2004), and processing time (Shah et al. 2008), but did not specify mechanisms through which integration leads to better performance. Our study makes a contribution by developing propositions that low levels of internal integration among upstream supply departments contributed to operational failures experienced by downstream frontline staff, thus negatively impacting performance outcomes, such as quality, timeliness, and efficiency.

2. Prior Research on Operational Failures and Lean Manufacturing Work Design

Many researchers have documented the existence of operational problems that impede efficient completion of work tasks. These have been referred to as glitches (Uhlig et al. 2002), operational failures (Tucker 2004, Tucker and Spear 2006), performance obstacles (Gurses and Carayon 2007), hassles (Beaudoin and Edgar 2003), blockages (Rathert et al. 2012), and situational constraints (Peters and O'Connor 1980, Villanova and Roman 1993). In this paper, we refer to them as operational failures. Operational failures occur in everyday work, particularly when the work is complex and requires inputs from more than one department within the organization, as is typical in healthcare (Beaudoin and Edgar 2003, Gurses and Carayon 2007, Hendrich et al. 2008, Tucker 2004). Categories of operational failures include those related to information, tools and equipment, materials and supplies, budgetary support, help from others, and aspects of the work environment such as lighting (Gilboa et al. 2008, Klein and Kim 1998, McNeese-Smith 2001, Peters and O'Connor 1980, Peters et al. 1985, Villanova 1996).

A common response to operational failures is to work around them (Halbesleben et al. 2008, Kobayashi et al. 2005, Rathert et al. 2012, Spear and Schmidhofer 2005). Halbesleben et al. (2010) define a workaround as "a situation in which an employee devises an alternate work procedure to address a block in the flow of his or her work" (p.1). An operational failure takes an average of only three minutes to work around; however, nurses experience these failures repeatedly throughout their shift, thus causing interruptions, decreasing efficiency and increasing the risk of medical error (Tucker 2004, Tucker and Spear 2006). Although workarounds facilitate task completion, which is a positive outcome in the short term, they preclude the additional effort to remove underlying causes of the operational failures, which enables them to recur (Tucker and Edmondson 2003).

Operational failures negatively impact performance (Gilboa et al. 2008, Peters and O'Connor 1980, Peters et al. 1985). For example, a meta-analysis of seven different kinds of work-related stressors found that operational failures were most strongly correlated (-0.29) with job performance (Gilboa et al. 2008). This may be because operational failures erode employee productivity through workarounds. To illustrate, studies of hospital nurses have found that approximately 10% of their time is spent working around operational failures (Hendrich et al. 2008, Tucker 2004). Wasted employee time is particularly problematic for hospitals, where nursing labor is often the largest expense (Spear 2005, Tucker 2004). Furthermore, having to continually work around operational failures burns out employees and contributes to turnover (Beaudoin and Edgar 2003). Finally, operational failures delay care and can lead to errors that harm customers (Halbesleben et al. 2008, Jimmerson et al. 2005, Spear and Schmidhofer 2005). Despite their cumulative impact, operational failures prove difficult to address in practice, in part because they manifest as a wide-ranging set of small-scale problems rather than as a single, large problem (Beaudoin and Edgar 2003, Gurses and Carayon 2007, Gurses and Carayon 2009, Tucker 2004).

Our search for the organizational factors that contributed to operational failures focused on the physical movement of materials through the organization. More precisely, we studied the internal supply chains (ISC) of the hospital, which are the sets of processes that provide customer-facing employees with the materials, information, equipment, and human resources they need to provide service (Fredendall et al. 2009, Halbesleben et al. 2010, Pagell 2004, Shah and Singh 2001, Swinehart and Smith 2005). In hospitals, the resources required for patient care also include medications and knowledge necessary to perform one’s tasks correctly.

Figure 1 serves as an example of ISCs in hospitals. It shows the flow of information, materials, equipment and medication required for medication administration, as well as the employee roles responsible for enacting or supporting these flows. First, a physician uses a computerized system to order a medication for a patient. This system relays the order to the pharmacy, where a pharmacist dispenses the medication. A pharmacy technician may deliver the medication to the nursing unit, placing it in one of several possible storage locations, including a medication refrigerator. Alternatively, the technician may send it through a pneumatic tube system, or place it into an automated dispensing device on the unit. Engineering is responsible for maintaining the refrigerator and tube system, while IT is accountable for the automated dispensing devices, as well as the computers used to order medications. Nurses administer medications, which often requires them to first gather medication-related supplies located in various places throughout the nursing unit, such as syringes (which the central supply department stocks) or a pump (which is maintained by biomedical equipment and cleaned by the sterile processing department). In addition, the nurse may need to administer the medication with food, such as applesauce or ice cream, which dietary services keeps stocked in the unit's kitchen for such purposes. In total, nine departments are involved in the medication administration ISC: medical staff, pharmacy, nursing, engineering, central supplies, dietary, IT, biomedical equipment, and sterile processing. Operational failures can occur at any stage of the ISC and can be caused by a variety of factors including human error, delay, equipment malfunction, or miscommunication. When an operational failure occurs, the nurse typically only knows that the required medication or supply is not on the unit, but not why it is missing or where the ISC has broken down.

---------- Insert **Figure 1** about here ----------

Lean manufacturing principles provide a starting point for understanding the causes of operational failures. Lean is a production strategy that enables companies to efficiently produce what customers have ordered, in part by supplying workers with required materials and equipment in a timely manner (Liker and Hoseus 2010, Shah and Ward 2003, Spear and Bowen 1999, Womack and Jones 2003). In particular, after conducting our analyses, we found that the categories that emerged from our study mapped onto Spear and Bowen's (SB's) (1999) four work design rules from Toyota, the quintessential "lean" company. Thus, we selected SB's four design rules for activities, connections, pathways, and improvement as an organizing mechanism for reporting our findings. Furthermore, although SB's rules originated in automobile manufacturing, they have been applied to hospital work (Fredendall et al. 2009, Furman and Caplan 2007, Jimmerson et al. 2005, Shannon et al. 2007, Spear and Schmidhofer 2005, Thompson et al. 2003, Toussaint et al. 2010, Wysocki 2004). Below, we briefly list the four rules, as adapted by Ghosh and Sobek (2006).

- Activity Specification: Activities should be highly specified as to content, sequence, timing and outcome.
- Connection Clarity: Connections between internal suppliers and their customers should be direct, with a clear yes or no request for work to be completed.
- Pathway Simplification: The pathways through which materials travel through the organization should be direct, without any repeat loops or branches.
- Improvement Oversight: Improvement should be done at the lowest organizational level possible and under the guidance of an experienced coach.

The connection and pathway rules increase internal integration, which is defined as the degree to which a firm's procedures are coordinated across functional areas to most efficiently fulfill customer requirements (Zhao et al. 2011). High levels of integration leads to better cost, quality, and delivery performance (Dröge et al. 2004, Germain and Iyer 2006, Gimenez and Ventura 2005, Iansiti and Clark 1994, O'Leary-Kelly and Flores 2002, Stank et al. 2001). It is particularly beneficial in environments characterized by high levels of uncertainty because it enables the organization to respond to interruptions in organizational routines (Anderson and Parker 2012, Iansiti and Clark 1994). Therefore, we believe that a lack of integration can contribute to failures. Integration is related to, but distinct from, supply chain coordination, which is typically used to describe inventory ordering decisions and contracts between external suppliers and retailers (Cachon 2003).

3. Methods

We conducted our study at two of the hospitals operated by an integrated healthcare organization of 36 hospitals. We selected these hospitals because they were supported by our geographically based grant. Data was gathered from October to December 2011 using multiple methods, including surveys, direct observation, and interviews.

We gathered multiple kinds of data to investigate the organizational factors that contributed to operational failures. At the start of the project, we asked support department managers at the two hospitals what metrics they used to gauge their department's performance on timeliness, quality, and cost. Furthermore, we evaluated the extent to which the departments' work was driven by patient needs and we also gathered observational data. Together with a larger team of 25 people, the authors observed nurses as they worked in medical/surgical nursing units. When they were available, we also observed employees in the support departments that provided the materials, medications, equipment, food, and general support services needed for patient care. The team conducted a total of 66 observations over 112 hours; 82 hours were spent observing nursing care, and 30 hours were spent observing support departments. Two-hour observations were conducted individually and consisted of shadowing participants while they did their job as well as open-ended conversations intended to identify the reasons behind each action. There were two observation periods per day, for three or four days at each hospital. Our sample consisted of a variety of professionals, including nurses, aides, nurse managers, charge nurses, unit assistants, pharmacists, pharmacy technicians, engineers, central supply technicians, biomedical engineers, and dietary and IT staff. Study participants were given the option to refuse participation, although none did.

On average, 5.7 of 25 team members were observing at a given time in the hospital. Having multiple people observing at the same time enabled us to simultaneously observe multiple employees within the same nursing unit and in the support departments. The individuals who helped us with the observations included support department managers and front-line employees, nurse managers from the nursing units we observed, and staff nurses. Observers were not assigned to the hospital in which they worked. The authors standardized the process by instructing observers to take notes on blank paper and then summarize what they had discovered using "contact summary sheets" (Miles and Huberman 1994). These sheets had space to record the subject's position, any observed operational failures, the causes of these failures, what actions were taken in response, and the number of minutes that the failure delayed care. These sheets were one of our data sources.

After each two-hour observation block, team members gathered to make verbal reports of who was observed, his or her role, and the key incidents directly observed (Gilmore 2002, IDEO 2011, Lin et al. 2011). Verbally describing key events from all of the different observers' perspectives allowed a more complete understanding of events to emerge. For example, one nurse might engage in behavior (e.g., tampering with a computer to make it appear broken, so that no one else would use it) that causes a different nurse to encounter an operational failure. As this example illustrates, having a group discussion brought to light different perspectives on the same incident, providing a deeper understanding of the causes of operational failures. The debrief discussions were recorded and transcribed, replacing real names with pseudonyms. These transcripts supplemented information from the contact summary sheets.

In addition to the observations, the authors interviewed managers and staff from all nine departments involved in the ISC. Interviewing one or two people at a time, we asked about the challenges they faced, what contributed to the challenges, how departments coordinated their work, and how work requests were transmitted across boundaries. These interviews were also recorded and transcribed. **Table 1** provides details on the number of people who participated in observations and interviews, and the departments to which they belonged.

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After compiling all of the observation and interview data, the authors conducted a qualitative analysis. This involved multiple iterations of collectively distilling and analyzing the information gathered from the observations and interviews (Miles and Huberman 1994). The operational failures that we directly observed the nurses encounter were recorded on the contact summary sheets and served as the primary data for our qualitative analysis. We used a grounded approach (Glaser and Strauss 1967, Miles and Huberman 1994, Strauss and Corbin 1998) to extract information from the debrief transcripts. To give all the authors an understanding of the operational failures, we divided the transcripts among us and individually extracted information. However, we first established inter-rater reliability by having all authors code the same transcript and comparing which sentences we had individually highlighted as important. Our inter-rater reliability was .72 (kappa), which indicated substantial agreement (Landis and Koch 1977). This high inter-rater reliability provided confidence that we could divide the transcripts among us to identify and extract key passages. We then summarized the main issue from each passage onto a single sticky note. This resulted in 680 notes, which we used for our qualitative analysis.

Over the course of eight workdays, the authors used a structured process ("affinity diagrams") to convert the extracted qualitative data contained in the 680 notes into a framework of the organizational factors associated with operational failures as well as the consequences of the failures (Shiba et al. 1993). First, we collapsed notes that had the same information (e.g. multiple occurrences of nurses encountering a computer with a dead battery) and placed related notes in a cluster (e.g., all notes related to computers). We then created a higher-level classification of how the events related to each other (Glaser and Strauss 1967, Miles and Huberman 1994, Strauss and Corbin 1998). **Figure 2** shows a photo of a grouping of sticky notes during analysis.

---------- Insert **Figure 2** about here ----------

After establishing an initial set of insights, we consulted the literature on operational failures. Post hoc, we found that our framework was similar to SB's four rules (1999) because our identified organizational factors could be categorized as activities, connections, pathways, and improvement activities, which form the four rules (Ghosh and Sobek 2006, Sobek and Jimmerson 2003). Therefore, in a second analytical phase, the authors individually categorized each of the 120 operational failures that nurses had experienced in terms of SB's categories of activity, connection, pathway, or improvement. We also created subcategories within each of the four main categories to provide more specific information about the operational failure. Because research has found that accidents and errors result from multiple causes rather than just one (Reason 2000), we allowed operational failures to have multiple factors associated with their occurrence. We discussed the coding of each failure as a group to reach agreement on which codes to apply. After completing this step, we realized that SB's framework needed to be augmented by theory about integration in new product development projects and supply chains (Anderson et al. 2013, Chang Won et al. 2007, Flynn et al. 2010, Germain and Iyer 2006, Gimenez and Ventura 2005, Pagell 2004, Stank et al. 2001, Zhao et al. 2011) to fully explain our findings. As a result, our final model represents a combination of SB's rules as well as factors related to internal integration.

4. Results

While shadowing nurses, we directly observed 120 operational failures. On average, a nurse experienced one failure every 37 minutes and working around them consumed 12% of their day and delayed care by 5.5 minutes. These findings are similar to prior research, lending credibility to our data (Hendrich et al. 2008, Sobek and Jimmerson 2003, Tucker 2004).

4.1 Employees' Responses to and Beliefs about Operational Failures

Nurses compensated for the lack of reliability in supply by searching for functional items and securing them for their own use, which in turn created operational failures for other nurses. Forty-four percent of the nurses we interviewed complained that the equipment needed to do their job was often unavailable and that it was an accepted practice to "go shopping" in the dirty utility room, in other patients' rooms, or on other units. One nurse said, "If you can't find it, you go get it, no matter where it is." We observed nurses violate policy by personally claiming shared equipment for their entire shift by putting notes (e.g. "Mary's computer") on computers so that other care providers—who also needed to use the equipment to do their jobs—would feel social pressure not to use these items. More troubling, we saw nurses make functioning equipment appear broken. For example, one observer saw a nurse change the computer's settings so that the screen text was displayed vertically rather than horizontally to discourage other people from using "her computer". A second observer's nurse attempted to use the computer, but abandoned it due to the rotated text. These behaviors exacerbated equipment shortages.

With regard to employees' beliefs about the causes of operational failures, all employees with whom we spoke expressed satisfaction with their own department's work. No one in the support departments believed their department's routines needed to change to improve overall ISC performance. Instead, people attributed operational failures to shortcomings of workers in other departments. For example, a sterile processing worker attributed poor performance to a general lack of training, stating, "I don't know why our organization doesn't care about training." A pharmacy technician stated, "Nurses don't know where medicines go." This tendency to blame other departments' employees created a significant impediment to improvement because opportunities to work collaboratively across boundaries to improve organizational work systems went unrecognized. Healthcare specifically, and people in general, tend to attribute blame to individuals rather than to systematic causes (Holden 2009). For example, in Gurses' study (2009), nurses felt that supply-related problems were caused by sloppy work by central supply technicians because they did not understand the importance of stocking supplies meticulously. One nurse expressed frustration with supply technicians. "They just kind of throw things in [the central supply storage area] that do not belong there. They just don't have a grasp of why this is such a big deal." (pg. 514)

4.2 Basic Needs

We now describe the organizational factors associated with the operational failures that we observed and comment on the implications for preventing operational failures. **Table 2** summarizes these findings.

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The most frequent organizational factor associated with operational failures was not having basic work needs met. Examples included nurses having insufficient space or infrastructure to complete their work, equipment not being properly maintained, or nurses not being trained on a new policy. This category accounted for 29% of the causes. One of the most frequent factors was the physical space of the nursing unit, such as having computer workstations-on-wheels (WOWs) blocking the sinks where nurses needed to wash their hands. This was because the only available electrical outlets to plug in the WOWs were above the sinks (11%). A second frequent cause in this category (11%) was broken equipment, such as bar code scanners used for medication administration that did not scan because a buildup accumulated on the glass surface protecting the scanning device. The information technology (IT) department was responsible for maintaining the scanners, but when interviewed, IT staff acknowledged that they did not prioritize the maintenance of bar code scanners because other issues, such as the electronic medical record software, were higher priority. The IT staff's names, phone numbers and office locations were purposely unlisted in the hospital directory because they didn't want to be interrupted by nurses' requests for assistance. Nearly a third of the operational failures could have been avoided by ensuring that the physical space was sufficient for completing the work tasks and the equipment was properly maintained.

4.3 Activities

Eighteen percent of the failures stemmed from violations of SB's activity rule. The single largest cause of failures (13%) was a lack of standard procedures and methods to ensure the accuracy of an individual's work activities. This was similar to Fredendall's finding (2009) that unstandardized processes resulted in missing surgical equipment. Another activity-related issue included when nurses had conflicting work requests that made it unclear what was the proper action to take (3.6%), and a work routine that required the nurse to do a considerable amount of walking because necessary equipment was located far from where the work was being performed (1.7%).

4.4 Connections

Twelve percent of the operational failures were due to violations of SB's connection rule. For example, we saw nurses use the last of a particular item without informing the internal supplier that the item needed to be restocked (e.g. food item, linens, medication, medical supplies). The subsequent nurse who tried to retrieve the item found only an empty shelf (5%). Our observations and interviews suggested that this dynamic existed because there was (1) no efficient or automatic way to re-order materials that were running low, and (2) no reliable "out of cycle" delivery process to bring stocked-out items to the unit, especially for dietary and material supplies. There were also instances where it was difficult to communicate with others (2%), most often due to a physician's pager number not being listed. The cause of these operational failures was related to SB's rule that there should be a clear yes or no signal that work is needed from the internal supplier. Relatedly, operational failures occurred when there was no signal from the internal supplier back to the internal customer that the request was received or there was no information about when the material would be delivered. For example, we saw nurses repeatedly follow up to check whether a requested material had been delivered, causing interruptions for both the nurse and the supplying department, such as pharmacy (5%). Sobek and Jimmerson's (2003) study of a hospital pharmacy observed that this dynamic was the primary driver of interruptions to pharmacists' work. Finally, interruptions occurred when there was no way to "store" a request for help so that the person could attend to the help request after finishing the current task. To illustrate, twice we observed a nurse interrupt another nurse who was administering medications and, by hospital policy, was wearing a reflective vest which signaled that she was not to be interrupted. However, the policy does not include a method for placing a request for help—such as a message board or a cell phone text message—which could then wait in queue until the nurse finished with medication administration.

4.5 Pathways

Violations of SB's (1999) pathway rule accounted for 6% of the causes. For example, many medications, materials and equipment did not have a single, designated storage location, forcing nurses to look in multiple places before finding what they needed. One nurse commented, "We have two Pyxis® (automated dispensing devices for medications) machines on the unit. But sometimes the medicine is only in one of them. So if you open this machine, and the medicine is not here, you have to go to the other one. You end up taking two medications from this Pyxis and two other medications from the other. But then you have to sign in twice, which drives you crazy."

4.6 Integration

Nearly one fourth of the causes of failures were related to low levels of internal integration in the hospitals' ISCs (23%). These issues were not explicitly addressed in SB's rules-in-use, suggesting—as other scholars have found—that the rules are insufficient for fully preventing operational failures in hospitals (Ghosh and Sobek 2006). We define internal integration as the extent to which separate departments within an organization work together to efficiently meet end-customers' needs (Kahn and Mentzer 1998, O'Leary-Kelly and Flores 2002, Pagell 2004). We argue that high levels of internal integration were required to prevent operational failures due to distinctive features of medical/surgical nursing units, which resulted in uncertainty in the supplies needed for patient care. Large variability in the range of patient conditions treated on medical/surgical units and changes in individual patients' conditions over time meant that a wide variety of materials and equipment were needed on the nursing units. In addition, highly technical and specialized knowledge was required for the supply of equipment, materials, and services involved with patient care. As a result, as Figure 1 showed, nurses interacted with several disparate knowledge communities, increasing the possibility of a breakdown across these boundaries. Literature on integration in new product development and supply chains has shown that integration is most helpful under these conditions, which are characterized by high levels of uncertainty and the need for coordination across different knowledge disciplines (Anderson and Parker 2012).

In our study, three types of internal integration issues led to operational failures. Thus, hospitals could reduce operational failures by increasing integration along these dimensions. First, operational failures arose when supply departments' activities were not executed in response to specific needs of current patients (6%). As a result, materials or equipment on the nursing unit did not always match what patients needed, prompting the nurses to "go on an expedition" to find the required item. Thus, in our setting, which was characterized by high levels of uncertainty and variability in the required supplies, compliance with the activity rule that work be highly specified was insufficient to prevent operational failures. Instead, suppliers' work activities needed to be triggered by a work request on behalf of a specific patient. This source of operational failures is therefore a combination of SB's activity and connection rules. The work of the sterile processing department provides an example. This type of operational failure also occurred with pharmaceuticals and food items. Nurses put used intravenous pumps in the dirty utility room, which were subsequently cleaned by the sterile processing department and returned to the clean utility room. Though the cleaning and restocking was performed correctly (in accordance to SB's activity rule), this work did not always meet the needs of current patients because it was driven by discharged patients' cessation of pumps rather than by the needs of *current* patients. We observed that a patient needed a specific type of pump (a triple pump), but this pump was unavailable in the clean (or dirty) utility rooms. The nurse had to search in multiple patients' rooms before finding a dirty triple pump that she had to clean. This example illustrated the lack of a planning and control mechanism to connect the current patients' pump needs with the work of the sterile processing department. Thus, we observed that without high levels of internal integration, nurses experienced frequent operational failures because they were at the interface between having to provide customized care to patients and being supplied by "supply-to-stock" ancillary support services, such as biomedical engineering and central supply.

A second internal integration-related cause of operational failures was insufficient *knowledge transfer* between internal suppliers and internal customers. Although the customer-supplier connection was specified, direct, and included a yes/no signal for communication as per SB's connection rule, there were instances when the internal customer lacked enough knowledge to process the material efficiently (8%). For example, we observed a nurse search unsuccessfully for over an hour for two bags of IV medication that she needed for her patient, despite the fact the pharmacy had confirmed delivery and— in accordance with SB's pathway rule—the bags were in the appropriate, designated location. However, an operational failure still occurred because the nurse did not realize that, due to the amount of a certain type of medication in the bags, they were placed in the medication refrigerator—the one place out of eight possible storage locations where the nurse had not looked. Research on new product development has found that essential knowledge is often inadvertently not transferred across discipline boundaries, because it is so central to one discipline's work that that person does not realize that their counterpart in the other discipline does not possess it (Carlile 2002, Carlile 2004, Kellogg et al. 2006, Malone and Crowston 1990, Orlikowski 2002). Our example is similar to Sobek and Jimmerson's (2003) study of a hospital pharmacy, which found that nurses frequently thought that refrigerated medications were "missing" because they were not with the patient's other, non-refrigerated medications. As a solution to this problem the pharmacy began placing an index card with the words "refrigerated medication" on it with the non-refrigerated medications as a signal to the nurse to look in the medication refrigerator.

The integration literature also discusses the importance of providing cross-departmental visibility to information contained in IT systems (Chang Won et al. 2007). We found that IT-compatibility issues prevented efficient connections between nursing and the laboratory (1%). Even though an order for a laboratory test was in the main computer system, the nurse had to call the laboratory to inform them of the test because the lab's IT system was unconnected to the main system.

The third type of internal integration-related driver of operational failures involved poor handoff of materials between departments. Although pathways were direct and specified as required by SB (1999), in some situations, materials and equipment stalled between processing steps, which we call "process gaps" (8%). This happened when multiple departments could be responsible for processing the material, with the specific department being dictated by the particular circumstances. One example was the cleaning and maintenance of vital sign monitors, a responsibility shared across nursing, biomedical engineering, and the sterile processing department. Another example was the maintenance of computers and medication bar code scanners, which involved nursing, engineering, and IT. Equipment remained nonfunctional as a result of these process gaps because each department assumed that the equipment was going to be taken care of by the other department, when in fact no one was working to fix it.

4.7 Detecting Poor Performance of ISCs and Improving Performance

SB's improvement rule implies that improvement activities exist, but that they are not as effective as they could be if they were conducted by frontline employees using scientific methods, such as plan-do-check-act cycles. Our qualitative data found instead that improvement efforts related to operational failures were non-existent, even for frequent, repetitive operational failures. The lack of improvement effort enabled failures to persist.

The first cause in this category was that there were few hospital-level measures to expose failures in the internal supply chains (5%). One nurse described how late medications for newly admitted patients resulted from processes that involved multiple departments, but despite the systemic nature of these failures, the involved departments did not take responsibility for changing the process. "Imagine that a new patient doesn't arrive on our floor from the emergency department until 3:45 pm. At 3:00 pm, his physician had written an order for antibiotics to "start now." The medication is considered late if it is given more than 30 minutes after the administration time. So the medication is already late before he even arrives on the floor. The medication becomes even later because pharmacy can't "see" the order in the IT system until the patient arrives on the floor because that is the earliest his nurse can "release" it to the pharmacy. At that point, pharmacy has to verify the order to make sure there aren't any interactions, and if it is an IV medication, they have to mix it before the technician can bring it to the nursing unit. I wish pharmacy would try to fix this."

We believe the lack of effort on the part of pharmacy was due in part because there were no ISC-level measures that held them accountable for the poor performance of the hospital-wide medication administration process. To provide more information about the role of measures, we asked managers about the metrics they used to evaluate their department's performance. As **Table 3** shows, the majority focused on department-level rather than hospital-level performance. For example, the pharmacy's metric for timeliness was the average time it took them to verify an order, which was just one piece of the entire medication administration process. Department-level metrics made it possible for departments to be satisfied with their performance even if their processes were contributing to poor hospital-level performance. The hospitals also did not use tools that illuminated problems with the flow of materials through the organization, such as the supplier-inputs-process-outputs-customers (SIPOC) tool in six-sigma (Anil et al. 2004).

---------- Insert Table 3 about here ----------

In addition, there were few opportunities for employees from different departments to come together to discuss long-standing inefficiencies and problems and work on solutions (7%). Specifically, there were no regularly scheduled meetings between pharmacy, laboratory, biomedical, sterile processing, IT, and the nursing units.

5. Propositions for Future Research

Drawing on our findings, we created a model, shown in **Figure 3**, which depicts the drivers of operational failures in hospitals and provides a set of propositions for future research.

---------- Insert Figure 3 about here ----------

We propose that hospitals with fewer operational failures will achieve better performance along dimensions such as quality of care, timeliness of care, patient satisfaction, and length of stay (proposition 1). However, employees can compensate for poor ISC performance by creating stashes of materials or equipment. Thus, we propose that the relationship between operational failures and performance will be moderated by the amount of inventory on hand, either in inventory stores or in unofficial, "workaround" stashes held by the service department employees (proposition 2).

We also propose that there will be fewer operational failures when organizations address the factors described in Section 4. Proposition 3 states that the more employees' basic work needs are met, such as having sufficient space to do one's work and regularly maintained equipment, the fewer the operational failures. Adhering to SB's rules, such as having highly specified activities, clear connections between internal suppliers and customers, and simplified pathways will also reduce operational failures (proposition 4). Sobek and colleagues have shown that application of SB's rules results in process improvement in hospitals (Ghosh and Sobek 2006, Jimmerson et al. 2005).

Increasing integration among the departments in the internal supply chain will reduce operational failures (proposition 5). This can be accomplished by ensuring that support departments' work is triggered by specific needs of patients. In other words, nursing departments that provide "make-to-order" services will experience more operational failures if their supply departments "supply-to-stock" rather than "supply-to-order." Operational failures will also be lower if key knowledge related to supply usage is translated across departmental boundaries. Research on internal integration has found that having a person responsible for managing the internal supply chain is associated with better performance (Iansiti and Clark 1994, Pagell 2004). Our research suggests that this may be because that person can design supply and maintenance processes that enable materials to flow efficiently and reliably from the start of the chain to the patients' bedside.

Operational failures are more likely to occur on units with greater variability in the materials and equipment needed by patients. In hospital settings, such conditions are found on units with short patient stays and a wide range of patient diagnoses, such as medical/surgical units. We thus propose that higher levels of integration will be more helpful in reducing failures on medical/surgical units than on specialized, long-term care units, such as bone marrow transplant units (proposition 6).

Finally, proposition 7 states that hospitals that have mechanisms to foster process improvement, such as internal supply chain level measures of performance and regular cross functional meetings, will have lower rates of operational failures.

6. Discussion

With an objective of shedding light on how hospitals can use operations management principles to improve performance, we examined organizational factors that contributed to operational failures in medical/surgical units at two hospitals. We found a wide range of causes, thus calling into question the general applicability of the "80/20 rule" to guide solution efforts. Just over a third of the operational failures that we observed could be categorized as violations of Spear and Bowen's (1999) work design rules related to activities, connections, and pathways. However, SB's rules were insufficient at fully explaining the causes of the operational failures. A third of the causes were related to basic work needs not being met. Another quarter stemmed from a lack of integration in the ISC, both with other departments and with current patients' needs. The final 12% of the causes were due to a lack of improvement efforts to prevent recurring operational failures. Another implication of our findings is that operational failures in hospitals result from work processes that are low on lean design principles and integration rather than from the reasons hypothesized by the employees we interviewed. These reasons, which included human error and a lack of training in other departments, collectively contributed to only 14% of the failures. Thus, to reduce operational failures, hospital managers need to address a wide variety of issues, such as ensuring that employees have the basic infrastructure needed to do their work; and redesigning ISCs to adhere to SB's design rules, be responsive to end-customers' needs, and enable effective handoffs of materials.

6.1. Implications for Research

Our research joins the stream of operations-based literature examining the impact of operational routines on performance in service organizations. Similar to Pagell's (2004) study of ISC integration, we highlight the importance of cross-departmental coordination and measurement. However, as

Fredendall (2009) points out, not all of Pagell's framework is applicable to a hospital setting, because clinical licensing requirements make it difficult to use job rotation and cross-functional teams to drive communication across departments. Our study highlights the importance of process design and integration as mechanisms for smooth equipment handoffs between departments.

We find that operational failures can occur if the work of supply departments is not directly connected to patients' needs, even if those employees correctly follow their department's standardized work routines. Thus we find that standardized routines are not enough, in and of themselves, to prevent operational failures. Routines across departments need to be connected both with one another and with patients' needs, and there needs to be unambiguous assignment of responsibility for material and information processing. Furthermore, deliberate knowledge transfer across department boundaries is of key importance (Carlile 2002, Carlile 2004, Kellogg et al. 2006, Malone and Crowston 1990, Orlikowski 2002). Prior research has identified knowledge transfer challenges in new product development teams (Carlile 2002, Iansiti and Clark 1994) and custom production of manufacturing equipment (Bechky 2003), but to our knowledge there is little research on knowledge transfer problems in the routine work of service organizations, which is a contribution that we make. Similarly, Gittell (2000) has researched coordination among *clinical* disciplines, which although important, is an incomplete assessment because it does not consider the interaction between non-clinical departments and clinical workers. Thus, our work extends Gittell's (2000, 2002) by examining coordination among non-clinical support departments and nursing units. With regard to measures, shared goals—a key part of the relational coordination literature (Gittell 2002, Gittell et al. 2000)—are helpful in aligning conflicting objectives between different, yet interdependent departments (Pagell 2004). We find that a lack of ISC-level measures of performance hinder performance, much like misaligned incentives can reduce a supply chain's performance (Lee 2004, Narayanan and Raman 2004).

6.2. Implications for Practice

Our study offers lessons for managers of service organizations. Workarounds occurred at the interface between a supply department that used predetermined "routines" (Adler 1995) to drive its work tasks and a patient-facing department that used "practice" (Faraj 2006) for customized patient care. We observed that supply departments insulated themselves from variability in patient demand by stocking equipment and supplies on a fixed schedule independent of current patients' needs. In contrast, because of the high level of uncertainty in patients' conditions, nurses had to use practice—an unfolding set of tasks that emerge in real time—to achieve their goals (Faraj 2006). To avoid workarounds or the need to keep large stocks of materials on the units, managers should create a method for customer-facing employees to request and receive patient-specific supplies in a timely fashion. One example would be for a supply department to assign a customer-support person to frequently restock the unit. Although this seems expensive, it can increase organizational efficiency by avoiding stock outs and reducing hoarding of supplies. We believe that the ever increasing breadth and price of supplies in combination with limited storage space and funds available to nursing units make frequent restocking a more feasible long-term solution than increasing the quantities of supplies stocked on units.

In addition, managers need to create an organizational focus on ISC-level design and performance. Employees are unlikely to recognize systemic causes of workarounds, because they often blame poor performance on other people's shortcomings rather than on poor work-system design (Institute of Medicine 2001). Similarly, uninformed managers might not recognize the need for a system-level focus, because their hard-working employees are executing required tasks successfully and meeting within-department goals. Unfortunately, such false feedback mechanisms can mask poor system-level performance. Our research builds on the findings of other operations management studies that managers' uninformed intuition about work systems can lead to suboptimal decisions (White et al. 2011). In addition, our paper contributes to the body of operations management lessons for white-collar work (Hopp et al. 2009, Hyer et al. 2009).

6.3. Limitations and Future Research

Our study has several limitations. First, we use qualitative data to draw descriptive conclusions, limiting our ability to test relationships among constructs and performance measures. The development of measures of integration with patient needs would enable researchers to test hypotheses related to our findings. Another limitation is that we were unable to do deep investigations of the underlying root causes of all of the operational failures. Future studies could examine fewer failures, but in more depth to provide additional insight into causal factors. Furthermore, we collected data from four units in two hospitals, limiting generalizability. Examining more hospitals, as well as other service industries, would strengthen the applicability of our findings. An important question for future research is what steps organizations can take to improve integration of their ISCs. A logical extension would be the development and testing of interventions to improve integration. By testing whether various interventions have the anticipated positive impact on performance measures, researchers could more accurately gauge the value of specific practices to create more integrated environments. Finally, we leave it to future research to test whether workarounds occur more frequently at interfaces between routine-driven and practice-driven departments than at interfaces where both departments' work is driven by customers' needs.

6.4. Conclusions

The design and operation of ISCs are important drivers of efficiency, job satisfaction, and quality, but are understudied in service organizations. By better leveraging the competencies of the different communities of practices responsible for delivering customer service, organizations can reduce operational failures, freeing up employees' time to provide service. Reducing operational failures will require an explicit emphasis on integrating the routines of the different departments within organizations to meet the needs of end customers.

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Figure 1. Internal Supply Chain for Medications in the Two Hospitals.
The larger arrows depict that the nurse gathers supplies from the nursing unit, as well as medications from the medication storage areas on the unit, to administer the medications to the patient.

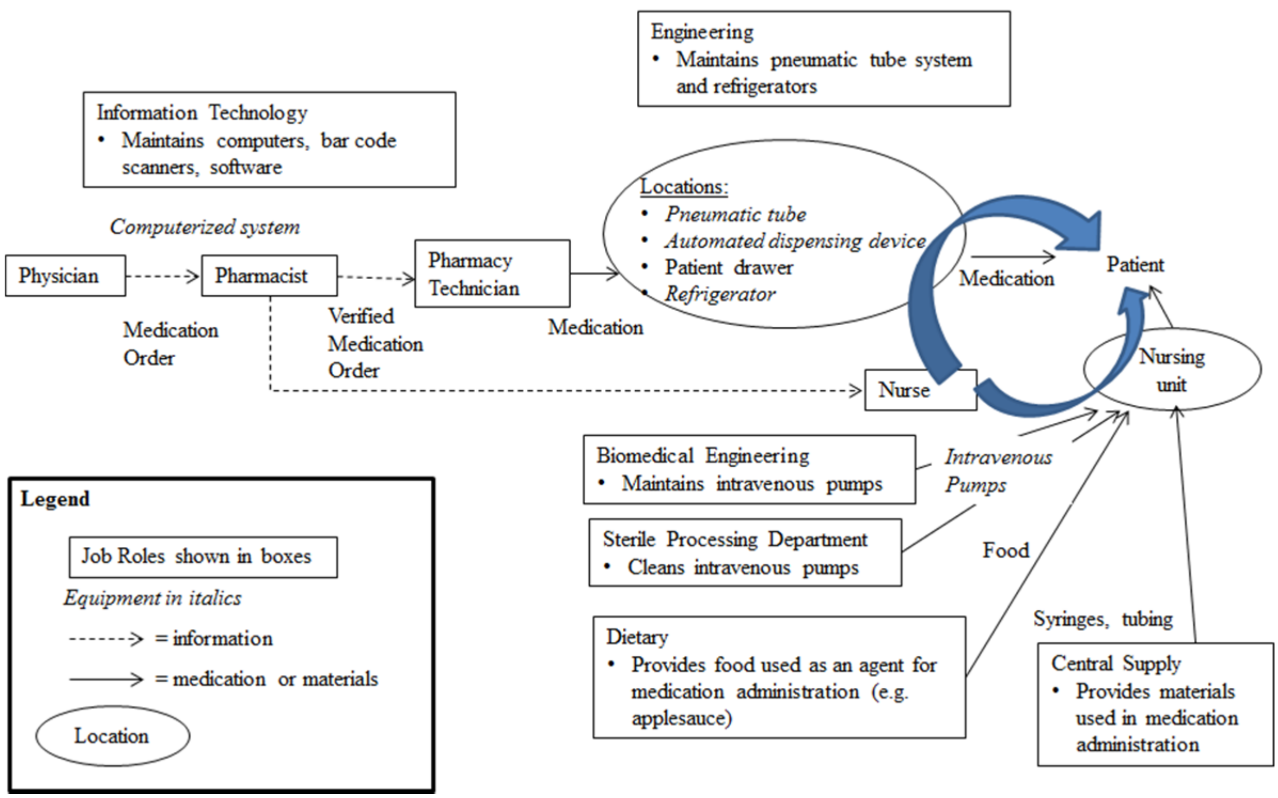

Figure 2. An Example of Data Analysis: Grouping Data Related to Searching for Equipment

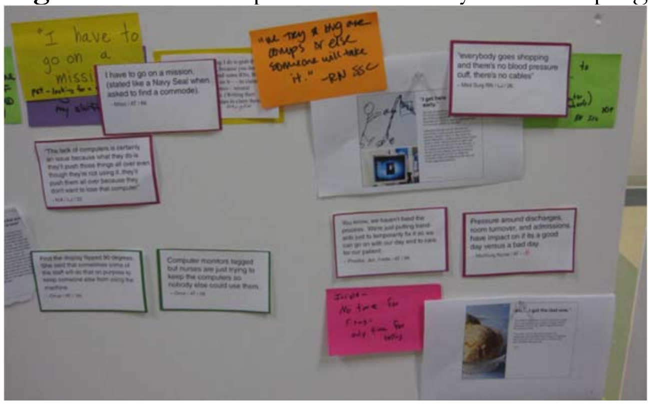

Figure 3. Model of Organizational Factors Associated with Operational Failures and Propositions for Future Research

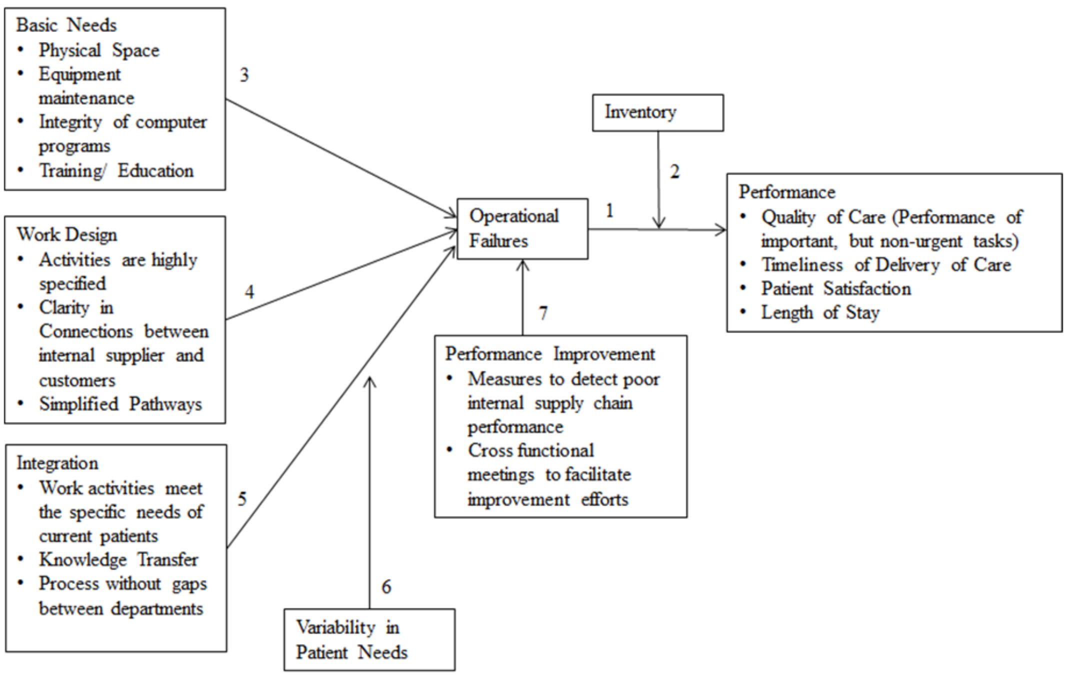

Table 1. Details from Research Phase: Observations and Interviews

	Observations				Interviews				Observations and Interviews	
Perspective	**Hosp.1**	**Hosp. 2**	***Total***	***Total Hours***	**Hosp. 1**	**Hosp. 2**	***Total***	***Total Hours***	**Total No. of Observations and Interviews**	**Total Hours of Observations and Interviews**
Physician	0	1	*1*	*2*	0	1	*1*	*0.7*	**2**	**2.7**
Pharmacy	2	1	*3*	*4*	0	0	*0*	*0*	**3**	**4.0**
RN	21	27	*48*	*82.3*	12	4	*16*	*7.2*	**64**	**89.4**
Engineer	1	0	*1*	*2*	0	0	*0*	*0*	**1**	**2.0**
Central supplies	1	0	*1*	*2*	0	0	*0*	*0*	**1**	**2.0**
Nutrition	1	1	*2*	*4*	0	0	*0*	*0*	**2**	**4.0**
CPED	1	1	*2*	*4*	0	1	*1*	*0.3*	**3**	**4.3**
Biomed	1	1	*2*	*2.7*	0	0	*0*	*0*	**2**	**2.7**
EVS	4	2	*6*	*9.2*	1	0	*1*	*0.3*	**7**	**9.6**
IT	0	0	*0*	*0*	3	0	*3*	*0.3*	**3**	**0.3**
Total	32	34	*66*	*112.2*	16	6	*22*	*8.7*	**88**	**120.9**

Table 2. Categorization of Organizational Factors Associated with the 120 Operational Failures

Category	Example Operational Failure	Number	Pct. of total
Basic Needs			
Space, equipment insufficient	Computers on wheels are plugged into only electrical outlets, which are in front of the sink area. Nurse has to push computers out of the way every time she washes her hands. (Two nurses observed, n=2)	19	11%
Equipment maintenance	Bed rail broke. Bar code scanner was not working.	18	11%
IT software	Unit assistant unable to process patient's admission because more than one physician was writing a discharge in IT system.	5	3%
Simultaneity of work	Nurse was documenting care of her patient when she was interrupted to help another nurse pull her patient up in bed.	5	3%
Insufficient training	The nurse did not know the weight requirement for patients to be included in a bariatric study.	2	1%
Total		**49**	**29%**
Activity Specification			
Work not done, done incorrectly, or against policy	Patient arrives on unit after lunch time and needs a lunch tray, but has no dietary order from physician for food. Nurse calls physician to request an order in the computer system.	22	13%
Conflicting orders	Patient requested she be authorized to purchase a hospital bed for when she was discharged home. Physician approved, but the medical equipment approver did not. Nurse has to resolve the inconsistency.	6	3.6%
Poor work design/routine	Change in policy requires nurse to have patient sign the discharge instructions, then make a copy for the patient to keep. Photocopier is far from the patient room, resulting in inefficient process.	3	1.7%
Total		**31**	**18%**
Connection Clarity			
No trigger to request work	The linen cart was out of pants (and none had been ordered).	8	5%
Timing of connection (too slow, or request interrupts work)	Nurse was interrupted by another nurse, who asked her a question while she was preparing medications, despite the fact that the nurse was wearing a 'do not interrupt' medication sash.	8	5%
Status or work request unknown or difficult to contact the supplier	Nurse needed to contact the patient's physician, but her pager number was not listed.	3	2%
Total		**19**	**12%**
Pathway Simplification			
No designated storage locations	Had to look around for a flashlight because there is no designated storage location.	**10**	**6%**
Internal Integration			

Work not customized for end customer needs	Patient's medications require a triple pump, but there was no triple pump in the clean or dirty utility room.	10	6%
Transfer of knowledge between internal supplier and internal customer	Nurse looked in four different locations for bags of IV medication. She called the pharmacy, who confirmed delivery, but the nurse never found them. Due to the amount of Lidocaine in the IV bags, they were in the medication refrigerator, in compliance with a storage rule known to the pharmacy, but not to the nurse.	13	8%
Information Sharing: Lack of IT compatibility	Nurse called the laboratory to tell them about a lab test, even though it was already in the main computer system; the laboratory is on a different IT system and cannot see the laboratory orders in the main system.	2	1%
Gap in the process of getting materials through the organization	There are not enough functioning computers on the unit, they take a long time to reboot, and run out of batteries if not plugged, and there are few outlets on the unit. The nurse went to use a computer, but the display image had been rotated by 90 degrees by another nurse to prevent others from taking "her" computer.	14	8%
Total		**39**	**23%**
Detect and Improve			
Improvement: No measures of overall system performance	Scanners, which are maintained by the IT department, are not working, delaying medication administration by the nurses.	8	5%
Improvement: No meetings between ISC departments	There were not enough working vital sign monitors.	12	7%
Total		**20**	**12%**
Grand total		**168***	**100%**

* Does not sum to 120 because some operational failures had multiple causes.

Table 3. Level of Integration of Departments' Work Routines and Performance Metrics with Patient Needs

Department	Nursing	Environmental Services (EVS)	Dietary	Pharmacy	Sterile Processing	Biomedical	Engineering	Materials	IT
The degree to which their work is integrated to a specific pt.	High	High to Moderate	High to Moderate	High	Low	Low	Low	Low	Low
Measure of Timeliness	*% of ED patients transferred in 2hours. Time from written discharge until leaves*	Avg. time to clean a room, % rooms cleaned within time limit	Completed within time limit	Avg. time to verify an order	None	Time to respond to individual failure	Timeliness to respond to repair request	None	None given
Measure of Quality	*Scheduled med. Admin. time versus actual. Falls, patient satisfaction*	Adherence to cleaning procedure, *Pt satisfaction with cleaning*	*Taste of food, Courtesy of employees*	Accuracy of order verification	*Documented complaints*	*Internal customer satisfaction survey*	*Repeat calls about the same issue*	Number of open orders to be filled	None given
Measure of Cost	Dept. actual expenses vs. budgeted	EVS labor expenses versus budget	*Cost of meals*	Inventory, equipment, labor costs	None	None	None	Dept. expenses versus budgeted	None given
% of three measures at org. level	(2/3) = 66.7%	33.30%	66.70%	0%	33.30%	33.30%	33.30%	0%	0%

Italics= Measure of patient or internal customer satisfaction with department performance; normal font = Department-level measure