
Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

# The Impact of Workaround Difficulty on Frontline Employees' Response to Operational Failures: A Laboratory Experiment on Medication Administration

Anita L. Tucker

MANAGEMENT SCIENCE
Vol. 62, No. 4, April 2016, pp. 1124–1144
ISSN 0025-1909 (print) | ISSN 1526-5501 (online)

http://dx.doi.org/10.1287/mnsc.2015.2170


# The Impact of Workaround Difficulty on Frontline Employees' Response to Operational Failures: A Laboratory Experiment on Medication Administration

Anita L. Tucker
Brandeis University, Waltham, Massachusetts 02453, atucker@brandeis.edu

Operational failures persist, in part because employees work around them without engaging in actions to prevent recurrence. To break this cycle, we investigate the impact of work design factors on responses to operational failures. We use hospital nurses as subjects in a laboratory experiment, where, unknown to them, two medication administration supplies are missing. We observe their real-time responses to the two failures and whether they contribute an improvement idea. We randomly assign half of the participants to an experiment location far away from a satellite pharmacy where the missing supplies can be obtained ("difficult condition"), and the other half are located near the satellite pharmacy ("easy condition"). Both conditions contain risky, against-policy supplies that can be used to complete the work tasks, giving participants a choice between policy-compliant workarounds and risky, against-policy workarounds. In the first study, we find that participants in the difficult condition are more likely to contribute improvement ideas but are less likely to use policy-compliant workarounds. A second experiment with a $2 \times 2$ design shows that participants in the difficult condition who have high access to the process owner are more likely to use policy-compliant workarounds than when they have low access. Our results suggest that hospitals can increase communication about operational failures by deliberately making it difficult to work around them while simultaneously providing a high level of access to process owners. Otherwise, nurses encountering operational failures are likely to resort to against-policy workarounds, a behavior observed in practice.

*Keywords*: healthcare: hospitals; organizational studies: behavior; reliability: quality control
*History*: Received November 19, 2012; accepted January 7, 2015, by Serguei Netessine, operations management. Published online in *Articles in Advance* September 1, 2015.

## 1. Introduction

Hospitals face an imperative to reduce errors, improve patient experience, and increase operational efficiency. However, operational failures—defined as instances when caregivers are unable to provide care because of missing information, equipment, supplies, or human resources—interfere with these goals by delaying patient care, wasting employee time, and contributing to poor quality of care. Hospitals' frontline employees play a key role in improving organizational performance by identifying operational failures and helping to remove their underlying causes. However, most hospitals have a workaround culture in which staff work around operational failures rather than voicing concerns and contributing improvement ideas (Ash et al. 2004, Koppel et al. 2008, Spear and Schmidhofer 2005), a behavior that has been termed "first-order problem solving" (Tucker and Edmondson 2003, p. 60), or FOPS. Frontline employees in other industries, such as restaurants (Detert and Burris 2007) and technology companies (Detert and Treviño 2010), also tend to remain silent about operational failures. By contrast, second-order problem solving (SOPS) occurs when employees work around operational failures so that care can continue, but they also (1) speak up about the failure to a manager or (2) offer suggestions to prevent recurrence (Tucker and Edmondson 2003). Speaking up is verbal communication that an operational failure has been encountered. For example, a nurse might say to her manager, "I don't have the 10 A.M. medication I need for my patient." Offering suggestions goes further than this by providing ideas to prevent future recurrence. In practice, suggestions can be either verbal or written, although in our study, suggestions are written. A suggestion to prevent missing medication might be that "pharmacy technicians should verify that all medications due that shift are present in the patient's medication drawer at the start of the shift." SOPS is one type of proactive employee behavior, which is defined as employees' discretionary, anticipatory actions that attempt to bring about change (Crant 2000, Grant and Ashford 2008, Parker et al. 2006). SOPS is similar to improvement-oriented behaviors (Burris et al. 2013, Detert and Burris 2007), prosocial behaviors (Brief and Motowidlo 1986, McNeely and Meglino 1994), initiative taking (Frese et al. 1996), and voice (Ashford et al. 2009, Detert and Edmondson 2011, LePine and Van Dyne 1998).

Although SOPS is a desirable behavior in employees, it occurs less frequently than managers would like. Thus, scholars focus on identifying antecedents. Fruitful areas of research are personality differences, such as felt responsibility, (Crant 2000, Frese et al. 1996, Pearce and Gregersen 1991) and organizational dynamics, such as trust, support, and autonomy (Edmondson 2003, Grant and Parker 2009, Parker et al. 2006). The findings from these studies suggest that hiring employees with proactive personality traits can be helpful in fostering SOPS. However, the nursing shortage (Buerhaus et al. 2000) makes it unlikely that hospitals can restrict themselves to employing only proactive nurses. Furthermore, creating a culture of psychological safety and ensuring supportive manager–employee relationships are challenging goals that can take years to develop (Kotter 1995).

The literature on job design suggests a possible link between aspects of how work is designed and employees' responses to operational failures. Hackman and Oldham's (1976) seminal research on job design finds that motivating jobs have meaningful tasks; contain variety in the skills required by employees; and provide to employees a clear work-related identity, autonomy, and feedback about the results of their efforts. Jobs with these characteristics cause employees to experience positive psychological states about their work, which in turn result in positive employee behaviors, such as high levels of motivation, high-quality output, and low absenteeism. Job design theory thus proposes that employees' behaviors at work can be shaped by how their work tasks are structured and are not just an outcome of employee personality or work culture. More closely related to our research question, scholars also examine the link between work design and problem-solving behaviors, such as the impact of lean manufacturing principles on problem identification and solution in software development projects (Staats et al. 2011) and the link between nurse autonomy and nurses' proactive problem solving to prevent patients' conditions from deteriorating ("failure-to-rescue") (Boyle 2004). Because aspects of work design can be manipulated by managers in the short term, have widespread impact, and affect problem-solving behaviors (Grant and Parker 2009, Parker 1998), we focus on work design drivers of SOPS.

More specifically, we explore the impact of the level of difficulty of engaging in a policy-compliant workaround on participants' likelihood of engaging in SOPS. For brevity, we refer to a high level of difficulty of engaging in a policy-compliant workaround as the "difficult condition" in our experiments. This condition is similar to lean manufacturing's work blockages, which is a design feature that automatically stops work from continuing when an employee cannot complete a task in a policy-compliant manner (Imai 1986, Liker 2004, Robinson and Schroeder 2009, Spear 2004, Womack et al. 1990). A work blockage is distinct from an operational failure. An operational failure is the original problem that the worker encounters (e.g., a missing part in a kit), whereas a work blockage is the deliberate job design strategy to make it difficult for employees to work around the operational failure (e.g., no extra parts lying around to compensate for missing parts in the kit). Blockages serve two purposes: (1) they prevent a work unit with a quality defect from continuing down the production line, and (2) they force employees to surface operational failures so that underlying causes can be addressed, not worked around.

Some hospitals have adopted the lean manufacturing concept of work blockages to encourage employees to stop working and call for help when they encounter a situation that puts a patient's safety in jeopardy (Bush 2007, Connolly 2005, Furman and Caplan 2007, Jimmerson et al. 2005, Shannon et al. 2007, Wysocki 2004). However, the healthcare context violates many of the underlying assumptions that make lean manufacturing techniques effective (Radnor et al. 2012, Staats et al. 2011, Young and McClean 2008). Consequently, lean techniques that are beneficial in manufacturing plants may not be as effective in healthcare settings. For example, in manufacturing settings, the customer is the purchaser, but in healthcare, the patient receives the care and an insurance company or the federal government pays for it (Radnor et al. 2012). Of direct relevance to our study, work blockage—a lean concept shown to be effective in manufacturing settings—is associated with medication errors in hospitals that built blocks into their medication administration technology (Koppel et al. 2008). Thus, additional research is needed to understand the link between work blockages and employee behaviors in a healthcare setting.

In a series of laboratory experiments, we examine the impact of how difficult it is for nurses to work around two medication administration-related operational failures in a manner that conforms to hospital policy. Our dependent variable is the contribution of written improvement ideas. All participants experience the same two operational failures (a missing oral medication and a missing insulin syringe) for the same patient scenarios. However, we have two levels of difficulty of accessing the storage location containing the missing supplies (easy and difficult). Participants in the difficult condition experience a work blockage that makes it difficult for them to complete their tasks in a policy-compliant manner, whereas those in the easy condition can quickly locate the policy-compliant supplies. Furthermore, both the easy and difficult conditions contain policy-violating supplies that enable completion of the task but are associated with serious medication errors. Thus, we also examine the impact of the difficult condition on policy-compliant workarounds.

We find that participants in the difficult condition are *more likely* to contribute improvement suggestions than participants in the easy condition. Furthermore, participants in the difficult condition are *less likely* to use policy-compliant workarounds. In a second experiment, we find that when participants have a high level of access to the process owner (i.e., the experimenter) they are more likely to speak up about the operational failures. High access also removes the negative effect of the difficult condition. Participants in the difficult condition who have high access to the process owner are more likely to use the policy-compliant workaround than those in the difficult condition with a low level of access to the process owner. Thus, our findings suggest that work blockages should be used in combination with a high level of access to the process owner to induce improvement-oriented behaviors in employees without the negative side effect of policy-violating, risky workarounds.

Our research advances understanding of employees' responses to operational failures by examining the impact of work blockages—a commonly advocated mechanism for building quality into products and services—on the contribution of improvement ideas as well as the use of policy-violating workarounds that can harm patients. To our knowledge, there has been scant rigorous research testing the impact of work blockages on frontline employees' behaviors. Furthermore, there has been little examination of a potential dark side of making it difficult for employees to work around operational failures: workers are more likely to engage in risky workarounds that put patients in danger of a medication error (Koppel et al. 2008). Our paper contributes to the behavioral operations management literature investigating how employee behaviors undermine the effectiveness of operations management techniques assumed to produce better outcomes (Schultz et al. 1998, Villena et al. 2011).

## 2. Literature on the Impact of Work Blockages

A work blockage is a design feature that makes it difficult for an employee to complete a work task in a manner that violates policy or standard procedure. The concept of work blockage is related to operational failures because operational failures, such as missing equipment, may interfere with the employees' ability to complete work as specified by policy. At an extreme, work blockages can make it impossible for employees to work around an operational failure in a policy-violating manner. These blockages can aid improvement efforts because employees may need to solicit assistance from their manager to complete their task, elevating the visibility of operational failures and enabling documentation of the frequency and impact of the failure. Increased visibility and documentation of the negative impact of operational failures may help justify investment in removing underlying causes. In this paper, we use "work blockage" (or, more simply, "blockage") and "workaround difficulty" interchangeably to refer to the condition where it is difficult to work around an operational failure in a policy-compliant manner. Difficulty is defined in terms of the time and effort required to work around the problem in a policy-compliant manner.

Making it difficult to work around operational failures might be helpful for sparking SOPS among employees. First, consider the impact of workaround difficulty on the contribution of improvement ideas. Prior empirical research suggests that if it is easy to work around operational failures, nurses are likely to remain silent about them (Halbesleben et al. 2010, 2008, Jimmerson et al. 2005, Kobayashi et al. 2005, Spear and Schmidhofer 2005, Tucker and Edmondson 2003). Organizational theory suggests several reasons for this behavior. First, workers' primary focus is on completing routine production tasks (Victor et al. 2000). Contributing improvement ideas takes low priority because it diverts time away from what they view as their main responsibility: completing their production tasks. Workers also find it challenging to switch between production responsibilities and improvement responsibilities, which include communicating about operational failures (Victor et al. 2000). Second, employees may avoid communicating about operational failures with their managers for fear of being considered incompetent or a complainer (Morrison and Phelps 1999, Tucker and Edmondson 2003). Third, workers do not want their coworkers to view them as the cause of a production slowdown (Schultz et al. 1998), which could happen if they spend time contributing improvement ideas rather than completing their work tasks. These studies collectively suggest that if employees can easily work around operational failures such that routine work can continue, they are unlikely to take time away from their production tasks to contribute improvement ideas about the operational failures.

However, when it is difficult to work around operational failures in a policy-compliant manner, employees may be motivated to engage in efforts to prevent them. When an operational failure is difficult to work around, the employee is forced to spend more time completing the interrupted task than if the failure was easily circumvented with a policy-compliant workaround. The time cost to the employee is greater, thereby increasing the expected benefit of trying to prevent recurrence. Prior theory suggests that employees make cost-benefit calculations when determining whether it is worth investing in discretionary behaviors, such as contributing improvement ideas (Fine 1986, Morrison and Phelps 1999, Vroom 1995). It follows that the greater the expected benefit of contributing improvement ideas, the more likely employees will choose to do so. Therefore, workarounds that impose high costs in terms of time will spur people to engage in efforts to prevent them. This is because the potential benefit of removing the underlying operational failure is greater than the cost of doing so (Grant and Ashford 2008). Thus, we hypothesize the following.

Hypothesis 1 (H1) (Difficulty Increases Ideas). *Workers are more likely to contribute improvement ideas related to operational failures when it is more difficult to work around them in a policy-compliant manner.*

Despite the potential benefits of sparking the contribution of improvement ideas, making it difficult for employees to work around operational failures in a policy-compliant manner may be ill-advised because it can increase the likelihood of error. To illustrate, people who encounter an operational failure can choose one of the following: omit the task, engage in a "safe" workaround that complies with policy, or engage in a "risky" workaround that violates policy. Research suggests that when employees are faced with the choice between a taxing but policy-compliant workaround versus a risky but quicker workaround, many workers will chose the risky workaround (Ash et al. 2004, Halbesleben et al. 2008, Holden et al. 2013, Koppel et al. 2008). Unfortunately, in healthcare settings, risky workarounds increase the chance that patients experience harm because safety precautions are bypassed. For example, some nurses work around problems with barcode medication administration technology by placing all of their patients' barcode identification labels on a single piece of paper or on their sleeve. This workaround enables nurses to dispense multiple patients' medications at one time, which is efficient for nurses because they do not have to walk back and forth between each patient's room and the medication machine (Holden et al. 2013, Koppel et al. 2008). Although this workaround makes it faster for nurses to withdraw and administer medications, it is typically against policy because it increases the risk of a patient getting another patient's medication. Similarly, we hypothesize that when workers encounter an operational failure and it is time-consuming to work around it in a policy-compliant manner, employees will be less likely to use a policy-compliant workaround.

Hypothesis 2 (H2) (Difficulty Lowers Compliance). *Workers are less likely to engage in workarounds that are policy-compliant when it is more difficult to do so, given that there is an easier, against-policy (risky) workaround available.*

## 3. Overview of Our Research Methods

### 3.1. Method and Sample

We report on a series of laboratory experiments that test conditions under which nurses are more likely to speak up about operational failures, use policy-compliant workarounds to compensate for the operational failures, and contribute written improvement ideas related to operational failures. We use hospital nurses as participants because they have low levels of SOPS (Halbesleben et al. 2010, Jimmerson et al. 2005, Spear and Schmidhofer 2005, Tucker and Edmondson 2003, Vogelsmeier et al. 2008). Medication administration is a fruitful context for testing our hypotheses because operational failures, such as missing medications or supplies, occur frequently (Halbesleben et al. 2010) and can lead to inefficiency, errors, and frustration (Gurses and Carayon 2007, Hall et al. 2010), which should motivate improvement efforts. We conduct our experiments at national nursing conventions by renting exhibitor space and using the designated exhibitor hours to recruit participants and run experiments. The experiment setup enables us to isolate the impact of our variables of interest while removing the influence of other factors, such as time pressure and organizational culture, which impede the contribution of improvement ideas in hospitals (Tucker and Edmondson 2002). Furthermore, we use laboratory experiments as opposed to field experiments, because they allow us to deliberately create medication-related operational failures. In a real hospital context, this could pose significant health risks to patients. We only recruit nurses who use needles in their daily work—as per the requirements of our institutional review board—because one of the ordered medications is insulin, which puts participants at risk of a needlestick injury. The experiment takes 20 minutes on average, and participants receive $10 after completion.

### 3.2. Overview of the Experiment

The experiment task is to dispense the 11:00 A.M. medications for three fictitious patients—Jack Smith, Sarah Wheeler, and Martina Lopez. In total, five medications are ordered. Unknown to the nurses, we deliberately implant two operational failures (described in detail below) in their medication system. There are three outcome variables: speaking up to the experimenter about at least one of the operational failures, using policy-compliant workarounds for the two operational failures, and contributing at least one improvement idea related to the operational failures.

**3.2.1. Participant Instructions.** Multiple nurses participate in the experiment at the same time, with one person at each experiment station. After recruiting four participants, the experimenter gives an overview of the instructions to the group. The experimenter explains that after answering a few questions about how they are currently feeling, the participants will administer medications to three fictitious patients and then answer a few more questions about how they felt during the medication administration process. If asked, the experimenter explains that the purpose of the experiment is to study the thoughts and feelings of nurses during medication administration. Participants are told that they are coworkers and can ask each other to double-check their medications just like they would on their nursing units. The experimenter uses one of the stations to demonstrate where supplies and medications are located.

**3.2.2. Experiment Setup.** An experiment "cell" consists of either one (Study 1) or two (Study 2) long tables in an exhibitor's $10' \times 10'$ space at the conference. For every table, we have two medication administration stations that are positioned as far apart as possible to make it difficult for participants to be influenced by what their neighbors are doing. Each station accommodates one participant and has a unique identifying color, which matches the color of an identification card within one of the envelopes that we randomly distribute to participants to assign them to a specific station. Tables are arranged at opposite sides of the exhibitor booth facing away from each other, such that each "pair" of participants has their backs to the other participants in the same cell.

Each station has a laptop, which is preloaded with a Web-based survey (Qualtrics) that provides the participant with the clinical information needed for the 11 A.M. medication administration tasks, as well as other survey questions, which we use to check the efficacy of our manipulation and to gather our control variables (described in detail in §4.2). An example of a patient's medication administration script is shown in Figure 1. In addition to the information shown on the computer, all nurses are also provided

**Figure 1** **Experiment Script for the Insulin Patient's Medication Administration Task**

Patient #3: Martina Lopez
Date of birth: 5/2/1961
Diagnosis: Diabetic Ketoacidosis/Type 1 diabetes
Physician: Victor Peacock

11:00 medications
Practi-Regular Insulin (U-100)

Martina Lopez is a 50-year old, newly-diagnosed, insulin dependent diabetic. Her blood glucoses have been ranging from 150 mg/dl to 350 mg/dl.

The lunch tray for Martina Lopez has arrived on the floor and is the correct diet. She is hungry and wants to eat lunch and can eat within the next 15 minutes.

You just checked her blood glucose level; it was 270 mg/dl. Please use the standardized sliding scale provided below to draw up the correct dose.

- - - - -

Standardized Sliding Scale (for Practi-Regular Insulin U-100)

| | |
|---|---|
| 0–60 | Initiate Hypoglycemic Protocol |
| 61–150 | No Insulin |
| 151–200 | 3 units SQ |
| 201–250 | 5 units SQ |
| 251–300 | 8 units SQ |
| 301–350 | 10 units SQ |
| 351–400 | 12 units SQ |
| >400 | 15 units SQ and call MD |

- - - - -

Write your ID number in the box below to signify that you gave the ordered dose, or enter the letter "W" if you would like to withhold the medication dose.

with a binder that contains each patient's complete medication administration record and order, diagnosis, allergies, and other personal information such as birthdate. Nurses can use this additional information to verify that there are no inadvertent medication interactions, patient vital signs, or patient allergies that warrant withholding medication. There are no reasons to withhold any of the patients' medications, so nurses should administer all five of the 11 A.M. medications.

The experimental medication administration system simulates the ones in hospitals. For example, similar to manual medication carts, we use a small plastic chest of 16 drawers for each participant's medication cabinet. Each of the three patients has a drawer labeled with his or her name, and the drawer is stocked with the patient's remaining medications for that day. In addition, to represent the medication preparation room, we stock each station with a bin of general supplies for medication administration, including tuberculin syringes (marked in milliliters), needles, alcohol swabs, and insulin vials. Furthermore, we use fake medication from a company that sells training supplies to nursing schools to make the medications themselves as realistic and safe as possible. The medications have dosages, packaging, shapes, colors, and names that are nearly identical to actual medications (Practi-Digox™ instead of digoxin).

Patients are represented by see-through, plastic, zippered pencil pouches labeled with the patient's name and date of birth. This provides two forms of identification as required by policy to administer medications. Participants put the medication into the pouch to signify that they gave the medication to that patient. After each nurse completes the experiment, we record the medications and dosages he or she administered as well as the medical supplies used, and then empty the pouches, dispose of trash, and restock the medications for the next participant.

**3.2.3. Description of the Operational Failures.** To create opportunities for contributing improvement ideas, we deliberately embed two operational failures in the medication workstation. The first operational failure is a missing oral medication pill (digoxin) for the second patient's (Wheeler) heart condition. Participants do not have to speak to the experimenter to obtain the pill, however, because one is available in the drawer of the first patient, Jack Smith. While preparing Smith's medications, they might notice that his drawer has a digoxin tablet, which is not due until much later that evening. Therefore, nurses can "borrow" the medication from Smith to give to Wheeler. They can also take a digoxin pill from the drawer of a fourth patient, Art Keegan. Participants have no information about Keegan and are not required to treat him. Borrowing a medication from one patient to give to another is a common workaround, although it is typically against hospital policy (Holden et al. 2013). The second operational failure is a lack of insulin syringes at the individual workstations. The third patient, Martina Lopez, requires eight units of insulin. Insulin is typically administered with insulin syringes because they are marked in units, which reduces the chance of medication error because the order is also written in units. However, the supply bins at the experiment stations are stocked with tuberculin syringes, which are marked in milliliters. Participants can work around the missing insulin syringes by converting the unit dose into a milliliter dose by either using the conversion chart that we provide in the medication binder or doing the mathematical conversion themselves. Dividing the number of units ordered (8 units) by the insulin concentration on the insulin vial (100 units/ml) gives them the equivalent 0.08 ml dose. Although it is possible to use a milliliter syringe, doing so violates most hospitals' policies because of the well-documented risk of a 10× overdose when using such a syringe to administer insulin (Cohen 2003).

## 4. Study 1

### 4.1. Methods

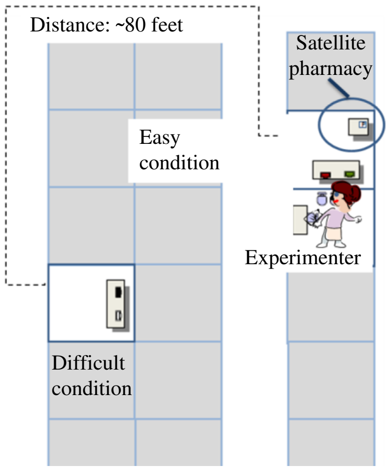
To test H1 and H2, which respectively predict that being in the difficult condition will increase the contribution of improvement ideas and reduce the likelihood of policy-compliant workarounds, we used three exhibitor booths at the Academy of Medical-Surgical Nurses national nursing conference in 2012. More than 900 nurses attended the conference. Participants were placed in one of two exhibitor booths. The "easy condition" exhibitor booth contained two participant stations and the satellite pharmacy, which was set up on a small table in the booth. The satellite pharmacy contained the missing supplies that participants needed to work around the two operational failures in a policy-compliant manner: a bin with 10 insulin syringes and 20 labeled medication boxes, one of which was digoxin. Thus, participants could obtain an insulin syringe and digoxin from the pharmacy without interacting with the experimenter. Half of the participants were randomly assigned to the easy condition. The other experimenter booth was the difficult condition because it did not have a satellite pharmacy in it and was located in an adjacent row in the convention center exhibit space, about 80 feet from the exhibitor booth that contained the satellite pharmacy. Participants in the difficult condition could not see the experimenter or pharmacy.

A third exhibitor booth adjacent to the easy condition served as the recruitment and training space for the experimenter. During the instructions, the experimenter pointed to the satellite pharmacy and told participants that they should feel free to look there if they needed something, such as gloves. The experimenter then walked the participants who were randomly assigned to the difficult condition to their workstations while explaining that the stations were farther away because we required multiple stations to achieve our desired sample size but had made our reservation too late to secure three adjacent cells. The experiment layout is shown in Figure 2.

### 4.2. Variables

**4.2.1. Outcome Variables.** We used an objective, real-time measure of whether the participant contributed a written improvement idea. At the end of the medication tasks, the computer survey script stated, "If you have any ideas about changes to improve the efficiency of the medication dispensing process in this experiment, please write them on the 'Improvement Opportunity' slips located in your unit supply bin." Pens and a stack of papers labeled "Improvement Opportunity" were placed between the two workstations at each table. Participants could also enter free text into the computer under the question prompt. We read through the ideas to verify that they were all valid suggestions, which they were. We used the subset of improvement ideas related to the two operational failures to construct our dependent variable, *Improvement idea*, which is coded 1 if the participant wrote an improvement slip related to at least one of the operational failures and 0 if not.

**Figure 2** (Color online) Study 1 Layout of Experiment




Our second outcome is *Policy-compliant workarounds*, which is a 1 if the participant engaged in the policy-compliant workarounds of obtaining an insulin syringe and digoxin from the satellite pharmacy. At the end of the experiment, we recorded which type of syringe the participant used to administer insulin to Lopez, and—if digoxin was administered to Wheeler—whether it came from the drawer of another patient. This variable is coded as 0 if the participant omitted the insulin or digoxin, used a milliliter syringe to administer the insulin, or used a digoxin pill from another patient's drawer. We also recorded the amount of insulin in the syringe. Participants who drew up 10 times the amount of insulin (80 units) received a 1 on the variable 10× *insulin overdose* and a 0 otherwise.

A research assistant observing the experiment from a slight distance recorded in a data collection sheet whether or not the participant spoke up to the experimenter about at least one of the operational failures. This variable measures verbal communication to the experimenter about the operational failures, such as informing the experimenter that there are no insulin syringes in the bin or that the digoxin is not in the drawer. If asked what to do about the missing supplies, the experimenter would restate that there is a satellite pharmacy that contains supplies and that they could check there, much like they would check the multiple storage locations on their nursing unit. We gathered data on verbal communication to control for the possibility that speaking up could substitute for contributing improvement ideas.

**4.2.2. Independent Variables.** We coded participants in the experiment cell that is a long distance from the pharmacy with a 1 on *Difficult condition*, whereas those who are in the cell with the pharmacy receive a 0 to signify that they are in the easy condition.

To better understand how participants experience the operational failures and why they might decide to write an improvement idea, we gathered self-reported data from participants at the end of the experiment about what, if anything, they spoke to their fellow participants. We coded these responses to create a variable, *Spoke to others*, coded as a 1 if the participant spoke to another participant during the experiment about either the missing insulin syringe or the missing digoxin and as a 0 otherwise. This variable indicates that the participant is aware of the operational failures and considers them a disruption to his or her work.

**4.2.3. Control Variables.** We controlled for individual differences such as education, whether the participant is a direct care provider, and years as a nurse. We also controlled for self-assurance and felt responsibility, as these constructs are associated with improvement-oriented behaviors such as speaking up (Ashford et al. 2009, Morrison and Milliken 2003). We also measured attentiveness to account for participants who were not particularly alert before the medication administration tasks. We measured a participant's *self-assurance* and *attentiveness* at the beginning of the experiment—before administering any medication—by asking questions from the Positive and Negative Aspect Scale (PANAS) (Watson et al. 1988). This statement preceded the questions: "This scale consists of a number of words and phrases that describe different feelings and emotions. Indicate to what extent you feel this way right now (that is, at the present moment)." The five-point response scale is "very slightly or not at all," "a little," "moderately," "quite a bit," and "extremely." The self-assurance construct consists of the following adjectives: "proud," "strong," "confident," "bold," "daring," and "fearless" (Watson et al. 1988). Cronbach's alpha was 0.80 ($n = 44$). We use the mean of these six items to calculate a self-assurance score for each person. The attentiveness construct is calculated in a similar fashion and includes the following adjectives: "alert," "attentive," "determined," and "concentrating" (Cronbach's alpha = 0.91).

After completing the medication administration tasks and filling out the improvement suggestion slips, but before answering any questions about the operational failures, participants answered questions measuring felt responsibility (Pearce and Gregersen 1991). We asked the felt responsibility questions at this point in the experiment so that the questions could not influence participant behavior during the medication administration task or their contribution of improvement ideas. We used a five-point response scale ranging from strongly disagree to strongly agree, with the midpoint being neither agree nor disagree.

We used the mean of three items to create *Felt responsibility*: "It is up to me to bring about improvement in processes I use for work"; "I feel a personal sense of responsibility to bring about change"; and "I feel responsible to introduce new procedures to complete my work more efficiently." Cronbach's alpha is 0.91.

### 4.3. Sample

Our sample size is 46: 22 in the difficult condition and 24 in the easy condition. The majority of participants are nonmanager nursing staff (87%) on medical-surgical units (89%). More than 900 nurses attended the conference, with about 5% participating in our experiment.

### 4.4. Manipulation Check for Difficulty of Engaging in a Policy-Compliant Workaround

We checked the manipulation of the difficult condition through the following question: "It was easy to get the supplies that I needed to administer the medications." The response scale is 1 for strongly disagree and 5 for strongly agree. Participants answered this question after administering the medications and contributing improvement ideas, but before answering any other questions.

A $t$-test of means in response to this question between the easy and difficult condition participants is significant ($t = 2.35$, $p < 0.05$, two-tailed test), with participants from the easy condition reporting higher scores (mean 4.1, $SE = 0.30$) than participants from the difficult condition (mean 3.05, $SE = 0.33$). We also tested whether participants who used the policy-compliant workarounds report lower ease of obtaining supplies. There is no difference between the two groups ($mean = 4.0$, $SE = 0.30$ for the 17 participants who used policy-compliant workarounds; $mean = 3.3$, $SE = 0.33$ for the 24 participants who used the risky workarounds; $p$-value of a two-tailed $t$-test $= 0.14$). Furthermore, for only those participants in the difficult condition, we tested the difference in the score of ease of obtaining supplies between those who used policy-compliant workarounds ($mean = 3.2$, $SE = 0.49$, $n = 5$) versus those who did not ($mean = 3.0$, $SE = 0.41$, $n = 15$). This difference is also not significant ($p$-value of a two-tailed $t$-test $= 0.80$). Thus, we conclude that participants' perception of the ease of obtaining supplies is driven by the distance from the satellite pharmacy rather than whether they used policy-compliant workarounds.

### 4.5. Results from Study 1

Table 1 shows the means, standard deviations, and correlations of our main variables. Being in the difficult condition is positively correlated with contributing improvement ideas about the operational failures ($\rho = 0.60$, $p < 0.001$). However, the difficult condition is negatively correlated with using policy-compliant workarounds ($\rho = -0.35$, $p < 0.05$). Only 27% of participants in the difficult condition used policy-compliant workarounds compared with 63% in the easy condition. Note that six participants omitted the digoxin, and no one omitted the insulin. Of the 17 participants who used a milliliter syringe, 23% ($n = 4$) administered a 10× overdose. All four participants (9% of the 46 participants) who administered a 10× overdose of insulin used a milliliter syringe. Only two participants are male.

We tested our hypotheses using multivariate probit (MVP), "mvprobit" in STATA, version 13. MVP enables the simultaneous estimation of $M$ binary equations (Cappellari and Jenkins 2003). The structure of MVP is similar to a seemingly unrelated regression model, except that the dependent variables are binary indicators (Cappellari and Jenkins 2003). MVP is an appropriate method for our study because we consider three binary dependent variables and the error terms from the three regression could be correlated with each other, which MVP accounts for (Greene 2000). The three behaviors that are our dependent variables are whether the participant (1) spoke up to the experimenter about an operational failure, (2) engaged in policy-compliant workarounds by using an insulin syringe and getting a digoxin tablet from the satellite pharmacy, and (3) contributed an improvement idea related to the operational failures. There could be correlation among these three behaviors. For example, participants who spoke up may have been less likely to write improvement ideas because they felt that they had already communicated about the problems to the experimenter. The mvprobit program relies on the Geweke-Hajivassiliou-Keane smooth recursive conditioning simulator to evaluate the maximum likelihood function (Cappellari and Jenkins 2003, Lyssenko and Martinez-Espineira 2012) and uses the Cholesky decomposition of the covariance matrix for the errors (Cappellari and Jenkins 2003). It uses simulation, so the user has to specify the number of random draws to use. The recommended number of draws is at least the square root of the sample size (Cappellari and Jenkins 2003), which in our study would be 6.48 draws. Furthermore, if the number of draws is greater than the square root of the sample size, parameter estimates will be robust to different initial seeds (Dhakar 2009). For these reasons, we use seven draws. We do not place any constraints on the variance covariance matrix. We use control variables of self-assurance, attentiveness, felt responsibility, tenure as a nurse (1 if greater than or equal to 15 years; 0 if less than 15 years), education level (at least a bachelor's $degree = 1$; 0 if less), and whether the person was a direct care provider

**Table 1 Means, Standard Deviations, and Correlations for Study 1 ($n = 46$ Participants)**

| | Overall mean (SD) | Easy condition mean (SE) | Difficult condition mean (SE) | Correlation coefficients | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 |
| 1. *Spoke to experimenter* | 0.35 (0.48) | 0.25 (0.09) | 0.45 (0.11) | | | | |
| 2. *Policy-compliant workarounds* | 0.46 (0.50) | 0.63 (0.10)$^{\#}$ | 0.27 (0.10)$^{\#}$ | 0.06 | | | |
| 3. *Improvement idea* | 0.30 (0.47) | 0.04 (0.04)$^{\#\#\#}$ | 0.59 (0.11)$^{\#\#\#}$ | −0.09 | −0.23 | | |
| 4. 10× *insulin overdose* | 0.09 (0.28) | 0.08 (0.06) | 0.09 (0.06) | −0.06 | −0.28$^{\wedge}$ | −0.04 | |
| 5. *Difficult condition* | 0.48 (0.51) | — | — | 0.21 | −0.35$^{*}$ | 0.60$^{***}$ | 0.01 |

$^{\#}$Significant at $p < 0.05$; $^{\#\#\#}$significant at $p < 0.001$ (two-sample test of proportions, two-tailed $z$-test).
$^{\wedge}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

(1 = yes, 0 = no). Because we use multiple, continuous, and exogenous control variables, the inherent variation across participants' scores makes it unnecessary to exclude any variables in our MVP models (Wilde 2000).

To compute average predicted probabilities and the average marginal effects, we used the following procedure. After running the MVP, we forced the value of difficult to be a 1 for each participant regardless of which experiment condition he or she was in. We then ran the prediction command ("mvppred") with the predicted margins option ("pmarg"). This generates—for each participant—the predicted probability that, if he or she was in the difficult condition, the participant would have a "yes" on a dependent variable (e.g., speaking up, engaging in a policy-compliant workaround, contributing an improvement idea related to the operational failures). The mean of these probabilities for a given dependent variable is the *average predicted probability* of "success" (a 1) on that dependent variable assuming participants are in the difficult condition. We repeated these steps a second time, this time forcing the value of difficult to be a 0. The mean of these predicted probabilities is the average predicted probability of success on a dependent variable assuming participants are in the easy condition. The average predicted probabilities of being in the difficult condition and being in the easy condition are shown in Table 5 (see §6). The difference between the mean value for difficult = 1 and the mean value for difficult = 0 is the *average marginal effect* (AME) on the dependent variable of being in the difficult condition. We then replaced the 0 value for the variable *Difficult condition* with each participant's original, actual value for "difficult." The procedure is then repeated for the next independent variable until an AME is generated for each dependent variable and control variable. The AMEs are shown in the "AME" column of Table 2.

As shown in Model 1 in Table 2, we find strong support for Hypothesis 1, which predicts that participants in the difficult condition will be more likely to contribute improvement ideas than participants in the easy condition ($\beta = 2.44$, SE = 0.69, $p < 0.001$). Being in the difficult condition rather than the easy condition increases the probability of a participant contributing an improvement idea by 58 percentage points. No control variables are significant in explaining the contribution of improvement ideas at the $p < 0.05$ level.

Hypothesis 2, which predicts that participants in the difficult condition will be less likely to use policy-compliant workarounds of walking to the pharmacy to get an insulin syringe and a digoxin pill, is supported ($\beta = -0.94$, SE = 0.47, $p < 0.05$). The difficult condition decreases the probability of using policy-compliant workarounds by 31 percentage points. No control variables are significant in predicting the use of policy-compliant workarounds. For completeness, we also predict the impact of being in the difficult condition on speaking up. The difficult condition is not significant at the $p < 0.05$ level.

We propose, but cannot conclusively prove, that the higher contribution of improvement ideas by participants in the difficult condition stems from the higher *personal* cost of their operational failures because of the time required to walk back and forth from the pharmacy two times to obtain the missing supplies. We conduct post hoc analyses to rule out alternative explanations. First, all participants have the same patient scenarios and experience the exact same operational failures, ruling out differences in the severity of the operational failures from the patients' perspective as an explanation. A second alternative explanation is that the close location of the satellite pharmacy to participants in the easy condition makes it trivial for them to get the missing supplies, and therefore they do not perceive the missing digoxin and insulin syringe as "problems" that need to be solved. Counter to this explanation, 42% of the participants in the easy condition spoke to their fellow participants about the operational failures, compared with 36% in the difficult condition. The difference is not statistically significant at the $p < 0.10$ level in a two-sample test of proportions, two-tailed test. However, the result indicates that participants in the easy condition are at least as aware of the operational failures as participants in the difficult condition.

Two related alternative explanations stem from the layout of our experiment in Study 1, which places

**Table 2 Study 1 Multivariate Probit Regression Results (Standard Errors in Parentheses) and AMEs**

| Dependent variable | Independent variable | Model 1 Coefficient (SE) | Model 1 AME | Model 2 Coefficient (SE) | Model 2 AME |
|---|---|---|---|---|---|
| 1 *Spoke to experimenter* | *Difficult condition* | 0.75 (0.51) | 0.2 | 0.67 (0.53) | 0.19 |
| | *Self-assurance* (pre) | −0.95* (0.41) | −0.04 | −1* (0.43) | −0.03 |
| | *Attentiveness* (pre) | 0 (0.38) | 0.001 | 0.11 (0.37) | 0.02 |
| | *Felt responsibility* | −0.29 (0.22) | −0.08 | −0.22 (0.21) | −0.07 |
| | *Tenure* ≥ 15 *years* | 0.1 (0.49) | 0.03 | 0.11 (0.5) | 0.03 |
| | *At least bachelor's degree* | −0.8 (0.49) | −0.23 | −0.68 (0.51) | −0.2 |
| | *Direct care provider* | 0.04 (0.65) | 0.01 | 0 (0.66) | 0.001 |
| | *Constant* | 4.11^ (2.26) | | 3.54^ (2.13) | |
| 2 *Policy-compliant workarounds* | *Difficult condition* (*Hypothesis* 2) | −0.94* (0.47) | −0.31 | −1.11* (0.46) | −0.33 |
| | *Spoke to others* | Not included | | 1.4^ (0.81) | 0.41 |
| | *Self-assurance* (pre) | 0.14 (0.41) | 0.04 | 0.43 (0.42) | 0.06 |
| | *Attentiveness* (pre) | −0.26 (0.37) | −0.07 | −0.19 (0.38) | −0.05 |
| | *Felt responsibility* | −0.03 (0.2) | −0.01 | 0.05 (0.2) | 0.01 |
| | *Tenure* ≥ 15 *years* | 0.66 (0.47) | 0.22 | 0.59 (0.45) | 0.19 |
| | *At least bachelor's degree* | −0.68 (0.49) | −0.21 | −0.29 (0.5) | −0.08 |
| | *Direct care provider* | −0.69 (0.57) | −0.22 | −0.65 (0.57) | −0.2 |
| | *Constant* | 1.54 (2.01) | | −0.81 (2.35) | |
| 3 *Improvement idea* | *Difficult condition* (*Hypothesis* 1) | 2.44*** (0.69) | 0.58 | 2.52* (1.01) | 0.57 |
| | *Spoke to experimenter* | Not included | | −1.88 (1.44) | −0.35 |
| | *Other patient's digoxin* | Not included | | 0.29 (0.93) | 0.06 |
| | *Use ml syringe for insulin* | Not included | | −0.18 (0.88) | −0.03 |
| | *Self-assurance* (pre) | 1.07^ (0.63) | 0.003 | 0.83 (0.78) | 0.03 |
| | *Attentiveness* (pre) | −0.53 (0.49) | −0.1 | −0.43 (0.51) | −0.09 |
| | *Felt responsibility* | 0.09 (0.25) | 0.02 | −0.04 (0.26) | −0.01 |
| | *Tenure* ≥ 15 *years* | 0.4 (0.59) | 0.08 | 0.59 (0.63) | 0.11 |
| | *At least bachelor's degree* | 0.06 (0.57) | 0.01 | −0.44 (0.69) | −0.08 |
| | *Direct care provider* | 0.01 (0.75) | 0.003 | 0.35 (0.83) | 0.06 |
| | *Constant* | −4.5 (2.97) | | −2.81 (3.66) | |
| Correlation coefficients | $\rho_{21}$ | 0.12 (0.3) | | −0.59 (0.45) | |
| | $\rho_{31}$ | −0.35 (0.32) | | 0.53 (0.68) | |
| | $\rho_{32}$ | 0.17 (0.4) | | 0.04 (0.69) | |
| | Log-likelihood | −60.97 | | −58.83 | |
| | Wald test $\chi^2$ (df) | 36.42* (21) | | 45.87** (25) | |
| | Likelihood ratio test that $\rho_{ij} = 0$ for all $i \neq j$ | 1.22, $p > 0.10$ | | 2.24, $p > 0.10$ | |
| | $N$ | 44 | | 44 | |

*Note.* The "pre" variables were measured before participants administered the medications.
$^\wedge p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

the experimenter farther away from the difficult condition participants than from the easy condition participants. The third alternative explanation is that difficult condition participants choose to contribute written improvement ideas instead of speaking up to the experimenter simply because the experimenter is far away from them. If this is true, then it is not the personal cost of operational failures that drives the contribution of improvement ideas, but rather, it is the difficulty of speaking up to someone in a position of authority, and writing improvement ideas substitutes for speaking up. However, our data do not support this explanation. First, the correlation between speaking up and contributing improvement ideas is small and not significant ($\rho = -0.09$, $p > 0.10$), suggesting that the two activities are not directly related. Second, 45% of difficult condition participants spoke up to the experimenter about the operational failures, compared with only 25% of the easy condition participants. A two-sample, two-tailed proportions test is not significant at the $p < 0.10$ level. Nonetheless, far distance to the experimenter does not appear to impede the difficult condition participants' verbal communication. We formally test this alternative explanation in Model 2 in Table 2 using an MVP model with speaking up as an independent variable in the regression predicting policy-compliant workarounds and speaking up and the two policy-violating workarounds of using another patient's digoxin and using a milliliter syringe as independent variables in the regression predicting the contribution of an improvement idea. MVP analysis enables simultaneous analysis of multiple regression equations that have correlated error terms and for dependent variables in one regression to be the independent variable in the related regressions (Lyssenko and Martinez-Espineira 2012). This analytical approach enables us to include speaking up and engaging in safe workarounds as independent variables in the prediction of the contribution of improvement ideas while also running regressions for the predictors of speaking up and engaging in workarounds (Greene 1998). Being in the difficult condition is *not* associated with a lower likelihood of speaking up to the experimenter ($\beta = 0.67$, $\mathrm{SE} = 0.53$, $p > 0.10$). Furthermore, speaking up is not significant in explaining the use of policy-compliant workarounds ($\beta = 1.40$, $\mathrm{SE} = 0.81$, $p = 0.085$), nor is it significant in explaining the contribution of improvement ideas ($\beta = -1.88$, $\mathrm{SE} = 1.44$, $p > 0.10$). These results eliminate the third alternative explanation that the close proximity of easy condition participants to the experimenter enables them to speak up, which reduces the need for, or substitutes for, the contribution of improvement ideas.

A fourth, and closely related, alternative explanation is that participants in the easy condition can more easily speak up to the experimenter, who can then remind them about the extra supplies in the satellite pharmacy. Participants in the easy condition may thus be more likely to use the policy-compliant workarounds and consequently would be less motivated to contribute an improvement idea. In other words, the trigger among the difficult participants for contributing improvement ideas is the moral discomfort of using against-policy workarounds, which participants in the difficult condition are more likely to experience because of their far distance from the experimenter and the satellite pharmacy. As Model 2 in Table 2 shows, this fourth alternative explanation is also ruled out. The two variables for the policy-violating workarounds are not significant in predicting the contribution of improvement ideas ($\beta = 0.29$, $\mathrm{SE} = 0.93$, $p > 0.10$ for using another patient's digoxin and $\beta = -0.18$, $\mathrm{SE} = 0.88$, $p > 0.10$ for using a milliliter syringe to administer insulin), whereas the difficult condition remains significant ($\beta = 2.52$, $\mathrm{SE} = 1.01$, $p < 0.05$). These results indicate that it is not the use of against-policy workarounds that sparks the contribution of improvement ideas but rather being far from the pharmacy.

To address Study 1's limitation that the experimenter is located closer to easy condition participants than to difficult condition participants, we conduct a second experiment that explicitly investigates the impact of the level of access to the experimenter on the contribution of improvement ideas.

## 5. Study 2: Level of Access to the Process Owner

In Study 2, we examine the level of access to the experimenter, who is the person responsible for the medication administration process. Thus, the experimenter plays the role of the "process owner." The level of access is higher ("high access") when the experimenter is physically present with the participant in the same exhibitor booth and is lower when the experimenter is in a distant exhibitor booth ("low access"). Prior research suggests that the physical presence of the process owner can foster speaking up about operational failures. The process owner has responsibility for the process that causes the operational failures and therefore should be able to help the person work around the operational failure. Consequently, workers might decide to speak up about the failures if the process owner is easily available because this action might yield assistance in obtaining the missing supplies. A qualitative study of hospital nurses finds that when managers are physically present on the nursing unit, nurses are more likely to communicate about operational failures than when managers are not (Tucker and Edmondson 2003). The physical presence of a manager reduces the time required to communicate about the operational failure, lowering the cost to the nurse of speaking up. Similarly, Halbesleben et al. (2010) find that when a pharmacist is physically present on the nursing unit, the nurses report their medication administration problems to that person rather than working around them on their own. Studies of help-seeking behavior show that accessibility of the help provider is a key driver of whether or not the person in need of assistance speaks up (Borgatti and Cross 2003, Hofmann et al. 2009).

Process owners also play an additional role: monitoring compliance with organizational policies and procedures (Bernstein 2012). Survey research has found that employees are more likely to speak up about problems or errors when they feel that their managers are more readily available and open to communication about problems or errors (Detert and Burris 2007, Edmondson 2003). It is possible that employees would be reluctant to communicate with process owners about operational failures because they risk getting in trouble for violating procedures or angering the process owner by pointing out faults in the process for which he or she is responsible. However, under these circumstances, the physical presence of the process owner should have no effect on communication about operational failures, as participants will remain silent about operational failures whether or not the process owner is easily accessible. Taking all of the above arguments into consideration, we believe that a high level of access to the process owner should result in a higher probability of communication about operational failures because some of the workers with high access might take advantage of the ease of asking questions about the operational failures. Communication from workers who are not physically close to the process owner will be lower because of the combination of low access and possible negative consequences. We thus hypothesize that a high level of access to the process owner will be associated with higher levels of speaking up about operational failures than will a low level of access.

Hypothesis 3 (H3) (Access Increases Speaking Up). *Workers are more likely to speak up about operational failures when they have high levels of access to the process owner than when they have low levels of access.*

High access to the process owner can also spur workers to contribute improvement suggestions. The physical presence of an authority figure helps generate employees' commitment to the organization (McGuire and Kennerly 2006). Organizational commitment is a necessary condition for employees' willingness to participate in process improvement efforts (Lukas et al. 2007, Repenning 2000, Zohar and Luria 2010), such as contributing suggestions for improvement. In addition, when the process owner is physically closer to the worker, the process owner can observe operational failures in context, creating a deeper understanding of the impact of the operational failures and their underlying causes, which leads to more successful problem-solving efforts (Spear 2004, von Hippel 1994). Thus, high levels of access to the process owner should create confidence in workers that their improvement ideas could result in a positive change. Such problem-solving efficacy can increase willingness to provide suggestions for improvement (Tucker 2007). We therefore hypothesize that when workers have high levels of access to the process owner, they will be more likely to contribute improvement ideas.

Hypothesis 4 (H4) (Access Increases Ideas). *Workers are more likely to contribute improvement ideas related to operational failures when they have high levels of access to the process owner than when they have low levels of access.*

High levels of access to the process owner may increase policy-compliant workarounds in response to operational failures. As mentioned above, one role of process owners is monitoring compliance with the standard procedures associated with their process. If the process owner is physically close to the workers, she can observe whether or not the workers adhere to safe practice guidelines, such as administering insulin using an insulin syringe rather than a milliltier syringe. As a result of the monitoring ability of a physically close process owner, employees might respond differently to operational failures than when the process owner is physically distant. Employees who know they can be observed because of high access to the process owner might take the time required to follow safe procedures when they encounter operational failures than when they know they cannot be monitored because of low access.

Prior research provides support for this hypothesis. Halbesleben et al. (2010) find that the physical presence of pharmacists on nursing units is associated with lower medication errors. Halbesleben et al. (2010) speculate that the reduction in error rates in his study was partly driven by the pharmacist's oversight of the nurses' actions, which dampened policy-violating behaviors. Similarly, an empirical study of employees in a cell phone manufacturing plant finds that oversight from an authority figure increased compliance with the standard practice for manufacturing the cell phones (Bernstein 2012). In addition, the support role played by the process owner reinforces the tendency for employees with high levels of access to the process owner to adhere to policies and standard procedures when working around operational failures. High levels of access to an expert encourages people to seek help rather than working around problems on their own (Borgatti and Cross 2003, Hofmann et al. 2009). For these reasons, we hypothesize as follows.

Hypothesis 5 (H5) (Access Increases Compliance). *Workers are more likely to engage in policy-compliant workarounds when they have high levels of access to the process owner than when they have low levels of access.*

Furthermore, this effect might be stronger for workers who face a work blockage as a result of an operational failure that is difficult to work around in policy-conforming manner. Under these conditions, workers will be tempted to violate policy and engage in an easier, but riskier, policy-violating workaround, especially if the process owner is not physically present to observe their actions. On the other hand, when it is easier for workers to work around operational failures in a policy-compliant manner, they should be less tempted to use the nonpolicy-compliant, risky workaround. As a result, high levels of access to the process owner should have little impact on their use of the policy-compliant work around when it is easy to work around problems. Thus, we hypothesize the following.

Hypothesis 6 (H6) (Access and Difficulty Increase Compliance). *A higher level of access to the process owner will have a greater impact on increasing the use of policy-compliant (safe) workarounds for workers who experience difficult-to-work-around operational failures than for those who experience easy-to-work-around operational failures.*

### 5.1. Methods

To test our hypotheses about the impact of high levels of access to the process owner, we held a second study at another national nursing conference. This conference attracts over 7,000 nurses. The experiment setup was similar to that of Study 1, with a few modifications. Because of the specific booths available to us at the conference, the difficult condition stations were about 60 feet from the pharmacy. This distance is 33% closer to the pharmacy than in Study 1. Another change is that we had four experiment stations per booth. Most critically, we had a second component—the level of access to the process owner—in addition to difficulty, which enabled us to run a $2 \times 2$ experiment design. The four conditions in Study 2 are (1) easy condition, low level of access to the process owner; (2) easy condition, high level of access to the process owner; (3) difficult condition, low level of access to the process owner; and (4) difficult condition, high level of access to the process owner. We operationalized high level of access to the process owner by having the experimenter in the exhibitor booth with the participants. Participants in the condition with a low level of access to the process owner did not have the experimenter physically present in their exhibitor booth. The experimenter was instead about 60 feet away in the high access condition. All participants were recruited from the booth where the experimenter was and received their instructions there. Those randomly assigned to the low access condition were walked to their station in the unmanned booth. These participants were told to return to the experimenter after completing the experiment to claim their \$10 payment. To gather data from low access participants, an undercover research assistant observed from a slight distance, cleaned up the workstations, and recorded data after all participants in the booth finished.

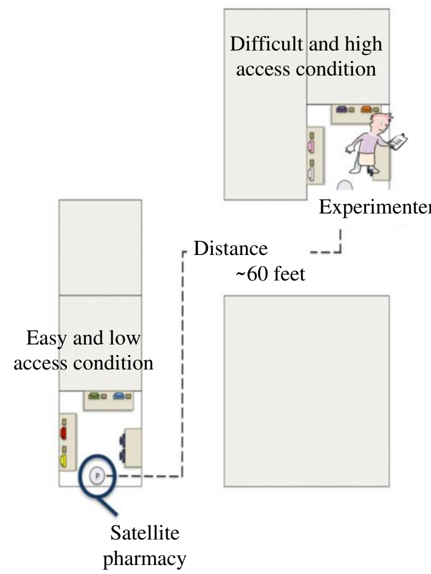
A diagram of the experiment setup for Study 2 is shown in Figure 3. In particular, the figure depicts the condition where participants in the difficult condition have a high level of access to the process owner and those in the easy condition have a low level of access to the process owner. To create the other two conditions (difficult/low and easy/high), the experimenter was in the easy condition station for half of the runs.

### 5.2. Sample and Manipulation Check

A total of 137 nurses participated in the experiment, which was less than 2% of the conference attendees. Nearly 75% of the participants worked in an intensive care unit, and 94% were nonmanager nursing staff. There is no difference in self-assurance and felt responsibility between participants randomly assigned to the easy condition and difficult condition.

We checked the manipulation of the difficult condition with the same question as in Study 1 about

**Figure 3** (Color online) Study 2 Layout of Experiment




the ease of getting supplies. A $t$-test between the easy and difficult workstations is significant ($t = 3.41$, $p < 0.001$, two-tailed test), with participants in the easy condition reporting higher scores (mean = 3.85, SE = 0.13) than participants in the difficult condition (mean = 3.05, SE = 0.15). As in Study 1, there is no difference in the reported ease of getting supplies by whether or not participants engaged in policy-compliant workarounds ($t = -0.46$, $p > 0.10$, two-tailed $t$-test).

### 5.3. Results from Study 2

Table 3 shows the means, standard deviations, and correlations from Study 2. Twenty-two percent of the participants wrote an improvement slip about the operational failures. There is a strong correlation between being in the difficult condition and the contribution of an improvement idea ($\rho = 0.31$, $p < 0.001$). High access to the process owner is positively correlated with speaking up ($\rho = 0.58$, $p < 0.001$) but is not correlated with the contribution of improvement ideas ($\rho = -0.03$, $p > 0.10$).

In terms of policy-compliant workarounds, 58% of participants used the insulin syringe to administer insulin and obtained digoxin from the satellite pharmacy. To provide additional information not shown in Table 3, nearly 8% of participants omitted the insulin dose ($n = 11$), and 14% ($n = 20$) omitted the digoxin. Of the 36 participants (26% of the total sample) who used the risky workaround of using the milliliter syringe to administer the insulin, 22% ($n = 8$) administered a 10× overdose. All eight participants who administered a 10× overdose of insulin used the milliliter syringe.

We tested Hypotheses 3–6 using mvprobit with the same control variables as Study 1, with the addition

**Table 3** Means, Standard Deviations, Standard Errors, and Correlations for Study 2 ($n = 139$ Participants)

| | | Mean (SE) | | | | Correlations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Easy condition | | Difficult condition | | | | | | |
| | Overall (SD) | Low access ($n = 36$) | High access ($n = 36$) | Low access ($n = 32$) | High access ($n = 35$) | 1 | 2 | 3 | 4 | 5 |
| 1. *Spoke to experimenter* | 0.44 (0.50) | 0.03 (0.03) | 0.64 (0.08) | 0.28 (0.08) | 0.80 (0.07) | | | | | |
| 2. *Policy-compliant workarounds*[#] | 0.58 (0.50) | 0.56 (0.08) | 0.58 (0.08) | 0.38 (0.09) | 0.77 (0.07) | 0.11 | | | | |
| 3. *Improvement idea* | 0.22 (0.42) | 0.14 (0.06) | 0.06 (0.04) | 0.34 (0.08) | 0.37 (0.08) | 0.08 | 0.11 | | | |
| 4. 10× *insulin overdose* | 0.06 (0.23) | 0 (0) | 0.08 (0.05) | 0.16 (0.06) | 0 (0) | −0.09 | −0.29*** | 0.02 | | |
| 5. *Difficult condition* | 0.48 (0.50) | — | — | — | — | 0.22** | 0.01 | 0.31*** | 0.07 | |
| 6. *Level of access to the process owner* | 0.51 (0.50) | — | — | — | — | 0.58*** | 0.21* | −0.03 | −0.07 | 0.02 |

[#] *Policy-compliant workarounds* = 0 for participants who omitted either the insulin or digoxin.
^$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

of a male variable because 12% of the participants in Study 2 are male compared with only two male participants in Study 1. Our sample size is larger than in Study 1, and therefore we use 12 draws. As shown in Model 1 in Table 4, Hypothesis 3 (predicting that access increases speaking up) is supported. High levels of access to the process owner are strongly associated with a higher probability of speaking up about the operational failures ($\beta = 2.77$, $SE = 0.58$, $p < 0.001$). Average marginal effects are calculated with the same procedure as Study 1. Participants who have a high level of access to the process owner have a 68-percentage-point higher likelihood of speaking up about the operational failures than participants who do not. Although we do not hypothesize an effect on speaking up from the interaction between being in the difficult condition and having a high level of access to the process owner, we include the interaction in our model for completeness given our $2 \times 2$ experiment design. The interaction is significant and negative ($\beta = -1.32$, $SE = 0.67$, $p < 0.05$). A Wald test of joint significance of the two main effects and the interaction term is significant ($\chi^2(3) = 35.99$, $p < 0.001$). The interaction is depicted in Figure 4(a), which shows the average marginal effects for the four different conditions of the experiment (Ai and Norton 2003, Greene 2010).

There is no support for Hypothesis 4 (that access increases ideas) because in Model 1 of Table 4, high access to the process owner is *not* associated with a higher likelihood of contributing an improvement idea ($\beta = -0.43$, $SE = 44$, $p < 0.10$). An explanation for the lack of significance is that a high level of access to the process owner might enable workers to speak up about the operational failures, which substitutes for the contribution of improvement ideas. To test this explanation, Model 2 in Table 4 shows results from an additional MVP that includes speaking up as an independent variable in the regressions for policy-compliant workaround and the contribution of improvement ideas. Speaking up is not significant in the regression for contributing improvement ideas ($\beta = 0.97$, $p > 0.10$). Thus, it does not appear that a high level of access to the process owner influences the probability of contributing improvement ideas. For completeness, we test the interaction between access and difficult condition on the contribution of improvement ideas. The interaction is not significant (Ai and Norton 2003, Greene 2010). Figure 4(c) shows the interaction graph.

There is no support for Hypothesis 5 (that access increases policy compliance), as the main effect of high access to the process owner is *not* associated with an increased probability of engaging in policy-compliant workarounds ($\beta = 0.24$, $SE = 0.32$, $p > 0.10$). However, the interaction between a high level of access to the process owner and the difficult condition is positively associated with policy-compliant workarounds, providing support for Hypothesis 6 (that access and difficult increases compliance) ($\beta = 0.94$, $SE = 0.47$, $p < 0.05$). Participants who have a high level of access to the process owner and who are in the difficult condition have a 30-percentage-point-higher likelihood of using policy-compliant workarounds than other participants. A Wald test of the joint significance of the two main effects and the interaction term is significant ($\chi^2(3) = 11.47$, $p < 0.01$). A test of the linear combination of the three coefficients is significant ($\beta = 0.82$, $SE = 0.34$, $p < 0.05$). Figure 4(b) shows the interaction graph of average marginal effects.

Study 2 enables a replication of Hypothesis 1 (that difficulty increases ideas) and Hypothesis 2 (that difficulty lowers compliance), this time controlling for the interaction between access to the process owner and the difficult condition. As Table 4, Model 1 shows, Hypothesis 1 remains supported, as the difficult condition participants are more likely to contribute an improvement idea ($\beta = 0.80$, $SE = 0.37$, $p < 0.05$). Being in the difficult condition is associated with a 21-percentage-point-higher probability of contributing an improvement idea than being in

**Table 4 Study 2 Multivariate Probit Regression Results (Standard Errors in Parentheses) and AMEs**

| | | Model 1 | | Model 2 | |
|---|---|---|---|---|---|
| Dependent variable | Independent variable | Coefficient (SE) | AME | Coefficient (SE) | AME |
| 1. *Spoke to experimenter* | *Difficult condition* | $1.63^{**}$ (0.57) | 0.36 | $1.60^{**}$ (0.51) | 0.35 |
| | *Access* (H3) | $2.77^{***}$ (0.58) | 0.68 | $2.78^{***}$ (0.54) | 0.68 |
| | *Difficult condition* × *Access* | $-1.32^{*}$ (0.67) | −0.23 | $-1.31^{*}$ (0.62) | −0.22 |
| | *Self-assurance* (pre) | $-0.47^{\wedge}$ (0.28) | −0.08 | $-0.71^{*}$ (0.3) | −0.09 |
| | *Attentiveness* (pre) | $0.73^{*}$ (0.29) | 0.04 | $0.96^{**}$ (0.31) | 0.02 |
| | *Felt responsibility* | −0.12 (0.15) | −0.03 | −0.16 (0.15) | −0.03 |
| | *Tenure* ≥ *15 years* | 0.25 (0.29) | 0.06 | 0.44 (0.3) | 0.10 |
| | *At least bachelor's degree* | −0.07 (0.33) | −0.02 | −0.2 (0.3) | −0.05 |
| | *Direct care provider* | 0.44 (0.34) | 0.1 | 0.16 (0.34) | 0.04 |
| | *Male* | −0.07 (0.46) | −0.02 | Not included | |
| | *Constant* | $-3.28^{**}$ (1.11) | | $-2.92^{**}$ (1.03) | |
| 2. *Policy-compliant workarounds* | *Difficult condition* (H2) | −0.36 (0.33) | −0.12 | 0.08 (0.39) | 0.03 |
| | *Access* (H5) | 0.24 (0.32) | 0.08 | $1.19^{*}$ (0.51) | 0.36 |
| | *Difficult condition* × *Access* (H6) | $0.94^{*}$ (0.47) | 0.30 | 0.39 (0.51) | 0.13 |
| | *Spoke to experimenter* | Not included | | $-1.31^{*}$ (0.54) | −0.39 |
| | *Self-assurance* (pre) | $-0.49^{*}$ (0.25) | −0.06 | $-0.63^{**}$ (0.22) | −0.05 |
| | *Attentiveness* (pre) | $0.45^{*}$ (0.23) | 0.08 | $0.68^{**}$ (0.23) | 0.05 |
| | *Felt responsibility* | $0.31^{*}$ (0.15) | 0.08 | 0.18 (0.15) | 0.06 |
| | *Tenure* ≥ *15 years* | $-0.42^{\wedge}$ (0.25) | −0.14 | −0.21 (0.24) | −0.07 |
| | *At least bachelor's degree* | 0.06 (0.28) | 0.02 | −0.02 (0.26) | −0.01 |
| | *Direct care provider* | 0.27 (0.28) | 0.09 | 0.29 (0.27) | 0.09 |
| | *Male* | −0.6 (0.37) | −0.21 | Not included | |
| | *Constant* | −1.19 (0.86) | | −1.2 (0.78) | |
| 3. *Improvement idea* | *Difficult condition* (H1) | $0.80^{*}$ (0.37) | 0.21 | $0.92^{*}$ (0.37) | 0.27 |
| | *Access* (H4) | −0.43 (0.44) | −0.11 | 0.62 (0.65) | 0.17 |
| | *Difficult condition* × *Access* | 0.28 (0.56) | 0.08 | 0.04 (0.53) | 0.01 |
| | *Spoke to experimenter* | Not included | | $-1.03^{\wedge}$ (0.53) | −0.28 |
| | *Policy-compliant workarounds* | Not included | | −0.67 (0.41) | −0.20 |
| | *Self-assurance* (pre) | −0.06 (0.26) | −0.02 | −0.28 (0.25) | −0.09 |
| | *Attentiveness* (pre) | 0.15 (0.24) | 0.03 | 0.4 (0.25) | 0.03 |
| | *Felt responsibility* | 0.15 (0.17) | 0.02 | 0.14 (0.15) | 0.03 |
| | *Tenure* ≥ *15 years* | 0.31 (0.28) | 0.08 | 0.22 (0.26) | 0.06 |
| | *At least bachelor's degree* | 0.02 (0.3) | 0.01 | −0.08 (0.28) | −0.02 |
| | *Direct care provider* | −0.07 (0.33) | −0.02 | 0.07 (0.3) | 0.02 |
| | *Male* | 0.5 (0.38) | 0.15 | 0.41 (0.32) | 0.13 |
| | *Constant* | $-2.26^{*}$ (1) | | $-1.88^{*}$ (0.9) | |
| Correlation coefficients | $\rho_{21}$ | 0.02 (0.17) | | $0.76^{*}$ (0.3) | |
| | $\rho_{31}$ | 0.24 (0.18) | | $0.71^{**}$ (0.23) | |
| | $\rho_{32}$ | $0.3^{\wedge}$ (0.16) | | $0.77^{***}$ (0.2) | |
| | Log-likelihood | −197.39 | | −197.27 | |
| | Wald test $\chi^2$ (df) | $76.75^{***}$ (30) | | $108.23^{***}$ (31) | |
| | Likelihood ratio test that $\rho_{ij} = 0$ for all $i \neq j$ | 4.39, $p > 0.10$ | | 4.52, $p > 0.10$ | |
| | N | 137 | | 135 | |

*Note.* The "pre" variables were measured before participants administered the medications.
$^{\wedge}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

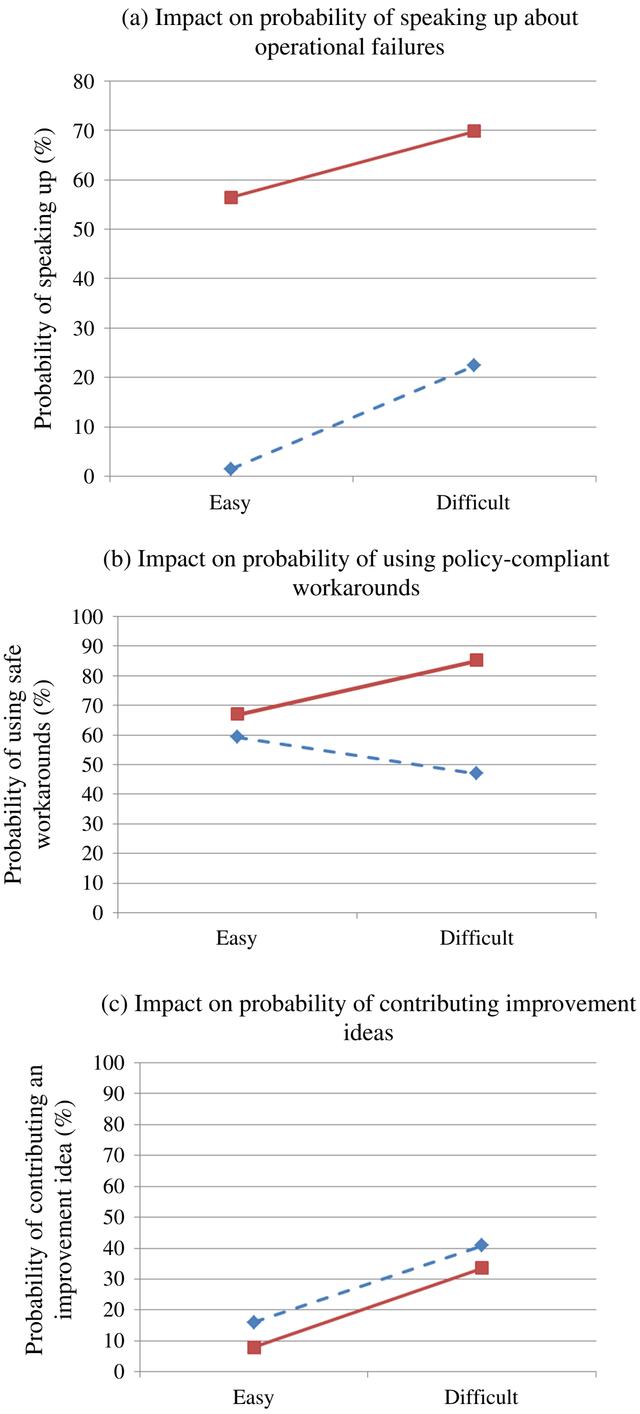
the easy condition. Hypothesis 2 is not supported in Study 2. Participants in the difficult condition are not less likely to use policy-compliant workarounds than participants in the easy workaround condition ($\beta = -0.36$, SE $= 0.33$, $p > 0.10$).

Model 2 in Table 4 tests for the alternative explanations to Hypothesis 1 (that difficulty increases ideas): that speaking up to the experimenter substitutes for contributing an improvement idea and that using the safe workaround decreases the contribution of improvement ideas. To run this MVP, we have to omit the variable *Male* from the regression for speaking up and the regression for policy-compliant workarounds. The difficult condition variable remains significant ($b = -0.92$, SE $= 0.37$, $p < 0.05$), whereas the variables for speaking up and policy-complaint workarounds are not significant at the $p < 0.05$ level.

## 6. General Discussion and Conclusions

We describe two experiments that test the impact of the level of difficulty in obtaining policy-compliant

**Figure 4** (Color online) Plots of the AME of the Difficult Condition and Level of Access from Model 1, Table 4




*Note.* The solid line indicates a high level of access to the process owner; the dashed line, low ($n = 139$).

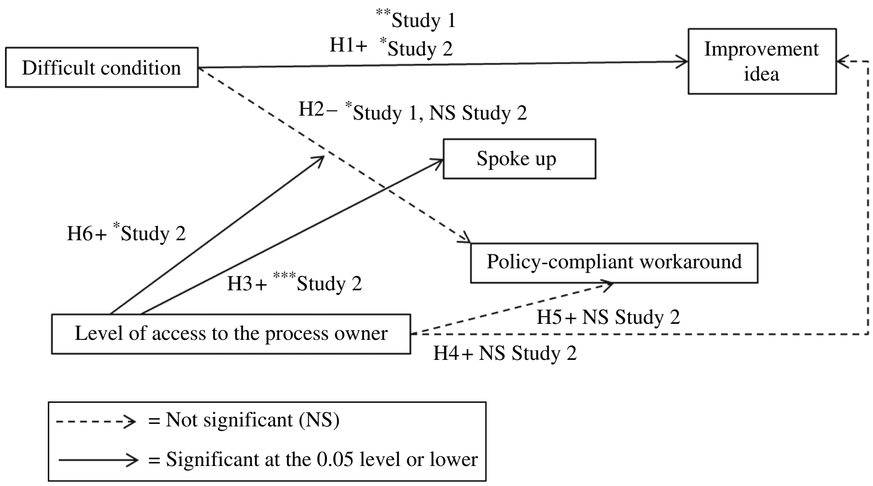
supplies to work around operational failures on three responses to operational failures: the likelihood that participants (1) speak up about operational failures, (2) engage in policy-compliant workarounds, and (3) contribute an improvement idea related to the operational failures. One of the two operational failures in our experiment, having no insulin syringes at a participant's workstation, poses a serious safety risk to the fictional patient who needs insulin. Nearly a quarter of the nurse participants who used the risky workaround of using a milliltier (rather than an insulin) syringe to administer insulin gave a 10 times overdose of insulin, a serious medication error that could cause death (Cumbie 2012, National Patient Safety Agency 2010).

To summarize our findings from Studies 1 and 2, Figure 5 presents a model of the relationships among the independent and dependent variables in the two studies. As Figure 5 shows, the difficult condition is the only variable in our study that impacts the contribution of improvement ideas. A high level of access to the process owner does not influence the contribution of improvement ideas. Although we do not formally hypothesize about these relationships, Model 2 in Tables 2 and 4 shows that speaking up does not impact improvement ideas. Furthermore, the use of risky workarounds (see Table 2) and policy-compliant workarounds (see Table 4) also do not influence the contribution of improvement ideas. Furthermore, the interaction between the level of access and difficult condition is not significant in predicting the contribution of improvement ideas.

Table 5 shows the average predicted probabilities for the independent variables from the MVP regressions that we use to test our hypotheses. Recall that we explain the method for calculating average predicted probabilities in §4.5. The more difficult it is to work around operational failures—as measured by the physical distance to the missing supplies—the greater the probability of contributing an improvement idea. The average predicted probability of contributing an improvement idea in Study 2, where the missing supplies are 60 feet away, is 33%, whereas in Study 1, where the supplies are 80 feet away, it is 61.4%. The average marginal effect of the difficult condition on the contribution of improvement ideas is 21.5 percentage points for Study 2 and 58 percentage points for Study 1. Based on additional analyses, we propose that it is the inconvenience to the workers themselves that motivates them to contribute improvement ideas. The larger the inconvenience is, the higher the likelihood of contributing an improvement idea.

Our second finding is that in Study 1, when it is very difficult to work around the failures in a policy-compliant manner, the probability of using policy-compliant workarounds is only 27.8% compared with 59.1% when it is easy to do so. Thus, purposely creating work blockages that make it difficult for employees to work around operational failures in a policy-compliant manner is a risky strategy to use to foster the contribution of improvement ideas.

**Figure 5** **Summary of Significant Hypothesized Relationships from Studies 1 and 2**




$^{*}p < 0005$; $^{**}p < 0001$; $^{***}p < 00001$.

Third, as Table 4 shows, we find that the downside of using the difficult condition to spark improvement is mitigated by simultaneously providing a high level of access to the process owner. For participants in the difficult condition, a high level of access to the process owner makes them more likely to use the policy-compliant workaround than when there is a low level of access.

Finally, we find that an additional benefit of high access to the process owner is that it increases from 8.6% to 77% the probability that participants will speak up about operational failures. However, as Figure 5 shows, speaking up does not lead to the contribution of improvement ideas. In fact, 55% of the 45 participants across the two studies who spoke up to the experimenter about the operational failures did not contribute an improvement idea. Thus, process owners should perceive communication about operational failures as a valid and unique source of data about opportunities for improvement. Gathering data from requests for missing materials and acting on it could lead to additional improvement beyond that sparked by formal suggestion programs.

### 6.1. Implications for Research

Our study has important implications for research on improvement-oriented proactive employee behaviors and process improvement. First, our paper extends the literature on proactive behaviors by studying frontline employees in service organizations, an understudied employee group compared to the more commonly studied managers (Morrison and Phelps 1999) and manufacturing employees (Parker et al. 2006). We show that work design can encourage hospital nurses—who typically work around operational failures (Halbesleben et al. 2008, Tucker and Edmondson 2003)—to instead engage in high levels of proactive, improvement-oriented behaviors.

Our methodology makes a contribution to the literature on proactive behaviors. We develop a laboratory experiment that creates conditions that warrant, yet do not mandate, speaking up and contributing improvement ideas. This enables us to gather

**Table 5** **Summary of Results: Average Predicted Probabilities from MVP Regressions with Controls**

| | *Spoke to experimenter* | | *Policy-compliant workaround* | | *Improvement idea* | |
|---|---|---|---|---|---|---|
| Condition = | Easy | Difficult | Easy | Difficult | Easy | Difficult |
| | | | Hypothesis 2 (difficulty lowers compliance) | | Hypothesis 1 (difficulty increases ideas) | |
| Study 1: Very difficult (pharmacy 80 ft away) | 23.3 | 43.7 | 59.1* | 27.8* | 3.5*** | 61.4*** |
| Study 2: Difficult (pharmacy 60 ft away) | 24.1** | 59.8** | 62.9 | 50.9 | 11.5* | 33.0* |
| | Hypothesis 3 (access increases speaking up) | | Hypothesis 5 (access increases compliance) | | Hypothesis 4 (access increases ideas) | |
| Level of access to the process owner = | Low | High | Low | High | Low | High |
| Study 2 | 8.6*** | 77.1*** | 53.7 | 61.8 | 28.3 | 17.3 |

$^{\wedge}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

objective measures of proactive employee behaviors close in time to when they occur rather than relying on recollections by the employee or the supervisor about the employee's general behavior in the past (Morrison and Phelps 1999, Parker et al. 2006). Furthermore, our study answers the call for research that isolates the impact of specific independent variables in studies of proactive behaviors because we use an experiment with random assignment of participants to conditions (Parker et al. 2006). We are able to gauge the impact of two work design variables—the difficulty of engaging in a policy-compliant workaround and access to the process owner—independent of the organizational-level variables (e.g., job autonomy, coworker trust, supportive supervision) that often confound research on employees' proactive behaviors. We also are able to control for individual-level differences (Parker et al. 2006). Unlike prior literature (Crant 2000, Morrison and Phelps 1999), we do not find any evidence that felt responsibility is associated with the contribution of improvement ideas. It is possible that we fail to replicate prior studies because our participants are nurses who elect to attend a national nursing conference and therefore have a higher and less variable level of felt responsibility. However, our data do not support this explanation, as the mean and standard deviation for felt responsibility in our studies ($M = 4.1$, $SD = 0.99$) are very similar to the mean and standard deviation ($M = 3.7$, $SD = 0.78$) in the Morrison and Phelps (1999) study. Instead, our inability to replicate the significance of this individual-level variable may be because prior studies ask respondents to recall one's own or coworkers' general tendencies to engage in proactive behaviors, whereas we gather data about real-time, specific responses to operational failures. Prior research in social psychology finds that personality effects disappear when situational variables are manipulated, as we did in our study (Monson et al. 1982, Schlenker et al. 1973).

Finally, our research highlights the importance of controlling for potential negative side effects, such as risky workarounds and errors, in future examinations of proactive behaviors. For example, prior research identifies situational antecedents of proactive behavior, such as ambiguity, autonomy (Grant and Ashford 2008), and flexible role orientation (Parker et al. 2006). It may be possible that these conditions also facilitate risky workarounds when workers encounter operational failures. Future research could investigate both positive and negative consequences of these antecedents.

### 6.2. Implications for Practice

Our research also has implications for practice. The large effect size in our study is an important finding because healthcare scholars characterize nursing culture as "oppressed," which makes it unlikely that nurses will engage in proactive behaviors, such as contributing improvement ideas (Roberts et al. 2009). However, our study finds that—given the right work design—nurses are willing to contribute and capable of contributing valid improvement ideas. Prior observational research of hospital nurses finds that after encountering an operational failure, nurses contribute zero improvement ideas (Tucker and Edmondson 2003). By contrast, in our experiments, the minimum level of contribution is 3.5%–11.5%. This nonzero "baseline" rate in our experiment may be because we explicitly ask participants for suggestions and provide them with slack time free of patient care to write down their ideas. These two conditions are not present in a typical hospital nurses' workday. Slack time has been shown to be an important driver of frontline learning in organizations (Haas 2006, Wiersma 2007).

Participants in our study had a positive learning response to operational failures while simultaneously using policy-compliant workarounds when the following four work design conditions were present: it was difficult to engage in policy-compliant workarounds, there was a high level of access to the process owner, improvement ideas were solicited, and slack time to write down these ideas was provided. Our study thus finds a "bundled intervention" that could be useful for fostering improvement-oriented behaviors in employees. The concept of implementing a bundle of steps has been used for specific clinical interventions, such as reducing ventilator-associated pneumonia (Resar et al. 2005) but, to our knowledge, has not been applied to the broader topic of creating an improvement culture in hospitals.

Our results highlight a tension in deliberately trying to prevent employees from using workarounds. On the one hand, many healthcare managers try to prevent workarounds by creating deliberate blockages, such as stocking only certain types of supplies on units or having information technology (IT) checks and safeguards that do not allow work to continue if some condition is not met. However, this may backfire. Studies of barcode medication administration medication systems in hospitals find that nurses engage in risky workarounds when the system blocks their ability to administer medications to their patients (Halbesleben et al. 2010, Koppel et al. 2008). On the other hand, if it is easy to work around operational failures, workers may not make the effort to contribute improvement ideas. Under these conditions, operational failures are likely to remain latent in the system. Toyota seems to avoid these negative outcomes by simultaneously providing both work blockages and high levels of access to process owners. Thus, when workers encounter a problem, they can easily signal for and receive help (Liker 2004). Our results suggest that a similar approach might work on hospital nursing units, despite the fact that the hospital context violates many of the underlying assumptions of the Toyota Production System. Our results suggest that a tightening of inventory on nursing units, either because of space or cost pressure, and IT workflow blockages should be accompanied by an increased support system for resolving operational failures. However, financial pressure may make this infeasible. An alternative approach would be to foster policy-compliant workarounds by deepening expertise through education—such as learning how to correctly calculate medication conversions. This would provide employees with the ability to safely circumvent operational failures.

### 6.3. Limitations, Future Research, and Conclusions

Our paper has several limitations that should be addressed in future research. Our laboratory experiment setting creates several limitations. Thus, replicating the study in a field setting would provide useful validation of our results as well as new information. First, the physical closeness of the experimenter is a low fidelity measure for access to a process owner. A field experiment at a hospital would enable the physical closeness of an actual staff person, such as a pharmacist, to serve as a higher fidelity measure of this variable. Given that some hospital nursing units have pharmacists located on the unit rather than in the pharmacy, it is feasible to vary this measure in practice. Second, our study may be an upper bound in predicting improvement-oriented behaviors because our participants are not embedded in an established organization and do not have to provide care to actual patients. It is possible that replicating our study in a hospital would result in lower levels of contribution of improvement ideas because hospital nurses embedded in their work context are also thinking about providing care to their current patients and their past interactions with the hospital management. Third, the participants in our study knew that they had a one-shot interaction with the medication administration system, which reduces the benefit of contributing improvement ideas. A field study at a hospital would eliminate this limitation because the nurses who work at the hospital would benefit from improvements that might result from their contribution of ideas. However, despite the potential benefits of conducting a field study, it is challenging to imagine how to create controlled operational failures to test interventions for operational failures without putting patients at risk. Thus, it may be necessary to partner with nursing schools that have simulation centers with mannequin patients to approximate hospital settings.

Another limitation is the inability to have the same physical setup for our two studies because the experiments were run at different conferences. We find different rates of contribution of improvement ideas in the difficult condition across the two studies, which may have been due to the different distances to the pharmacy. Future research could test whether medium difficulty can successfully spark the contribution of improvement ideas without driving employees to engage in risky workarounds.

In competitive environments, it is essential that organizations develop techniques to increase employees' willingness to speak up about operational failures and contribute their improvement ideas while also complying with organizational policies. This is especially important in complex, risky service organizations, such as hospitals, where employees have a wide range of discretionary activities that they can perform and lower levels of supervision. We believe that designing work that considers the natural responses of employees when they encounter operational failures will be helpful in creating improvement programs that are successful over multiple dimensions, such as safety and efficiency.

### Acknowledgments

The author is grateful to Ethiopiah Al-Mahdi, Rhea Ghosh, Joshua Hatfield, and Jo Ellen Holt for assistance running the experiments. The author is especially grateful to Jo Ellen for noticing the 10× insulin overdose errors. The author also thanks all of the nurses who participated in the experiments, as well as the American Association of Critical Care Nurses, and the Emergency Nurses Association for allowing her to run the experiments at their conferences. She appreciates advice about experiment design from Max Bazerman, Francesca Gino, Kathleen McGinn, Mary Carol Mazza, Michael Norton, and Maegan Tucker. Paul Carson and Michael Munsell helped proofread drafts of the paper. Michael Toffel, Zhuan Pei, and Roberto Martinez-Espineira provided guidance on analysis. The author's research assistant, Ypsse (Lydia) Kim, provided cheerful and excellent assistance on all aspects of the paper and the experiments. The author is also grateful for the helpful suggestions from faculty at the Wharton empirical conference as well as from the following universities: Baruch, Brandeis, Brigham Young, Columbia's School of Public Health, Cornell School of Hotel Administration, Dartmouth, Indiana, Ivey, McGill, North Carolina, Southern Methodist, Syracuse, Texas A&M, South Carolina, and Wisconsin. An earlier version of the manuscript was Harvard Business School Working Paper 13-044. Financial support was provided by Harvard Business School's Division of Research, the Gordon and Betty Moore Foundation, the Sloan Foundation, and the American Association of Critical Care Nurses.

### References

Ai C, Norton EC (2003) Interaction terms in logit and probit models. *Econom. Lett.* 80(1):123–129.

Ash JS, Berg M, Coiera E (2004) Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *J. Amer. Medical Informatics Assoc.* 11(2):104–112.

Ashford SJ, Sutcliffe KM, Christianson MK (2009) *Speaking Up and Speaking Out: The Leadership Dynamics of Voice in Organizations* (Emerald Group Publishing, Bingley, UK).

Bernstein ES (2012) The transparency paradox: A role for privacy in organizational learning and operational control. *Admin. Sci. Quart.* 57(2):181–216.

Borgatti SP, Cross R (2003) A relational view of information seeking and learning in social networks. *Management Sci.* 49(4):432–445.

Boyle S (2004) Nursing unit characteristics and patient outcomes. *Nursing Econom.* 22(3):111–119.

Brief AP, Motowidlo SJ (1986) Prosocial organizational behaviors. *Acad. Management Rev.* 11(4):710–725.

Buerhaus PI, Staiger DO, Auerbach DI (2000) Implications of an aging registered nurse workforce. *J. Amer. Medical Assoc.* 283(22):2948–2954.

Burris ER, Detert JR, Romney AC (2013) Speaking up vs. being heard: The disagreement around and outcomes of employee voice. *Organ. Sci.* 24(1):22–38.

Bush R (2007) Reducing waste in the US health care systems. *J. Amer. Medical Assoc.* 297(8):871–874.

Cappellari L, Jenkins SP (2003) Multivariate probit regression using simulated maximum likelihood. *Stata J.* 3(3):278–2094.

Cohen MR (2003) Syringe mix-up: Code orange. *Nursing* 33(4):18.

Connolly C (2005) Toyota assembly line inspires improvements at hospital. *Washington Post* (June 3) A01.

Crant JM (2000) Proactive behavior in organizations. *J. Management* 26(3):435–462.

Cumbie J (2012) Jury hold hospital and transcription company responsible for fatal medication error: $140 million verdict. *PR Newswire.com* (December 17), http://www.prnewswire.com/news-releases/jury-holds-hospital–transcription-company-responsible-for-fatal-medication-error–140-million-verdict-183799281.html.

Detert J, Burris E (2007) Leadership behavior and employee voice: Is the door really open? *Acad. Management J.* 50(4):869–884.

Detert JR, Edmondson AC (2011) Implicit voice theories: Taken-for-granted rules of self-censorship at work. *Acad. Management J.* 54(3):461–488.

Detert JR, Treviño LK (2010) Speaking up to higher-ups: How supervisors and skip-level leaders influence employee voice. *Organ. Sci.* 21(1):249–270.

Dhakar NS (2009) Modeling face-to-face and Internet based social activity participation decisions. Master's thesis, University of Florida, Gainesville.

Edmondson AC (2003) Speaking up in the operating room: How team leaders promote learning in interdisciplinary action teams. *J. Management Stud.* 40(6):1419–1452.

Fine CH (1986) Quality improvement and learning in productive systems. *Management Sci.* 32(10):1301–1315.

Frese M, Kring W, Soose A, Zempel J (1996) Personal initiative at work: Differences between East and West Germany. *Acad. Management J.* 39(1):37–63.

Furman C, Caplan R (2007) Applying the Toyota production system: Using a patient safety alert system to reduce error. *Joint Commission J. Quality Patient Safety* 33(7):376–386.

Grant AM, Ashford SJ (2008) The dynamics of proactivity at work. *Res. Organ. Behav.* 28:3–34.

Grant AM, Parker SK (2009) Redesigning work design theories: The rise of relational and proactive perspectives. *Acad. Management Ann.* 3(1):317–375.

Greene WH (1998) Gender economics courses in liberal arts colleges: Further results. *Res. Econom. Ed.* 29(4):291–300.

Greene WH (2000) *Econometric Analysis* (Prentice-Hall, Upper Saddle River, NJ).

Greene W (2010) Testing hypotheses about interaction terms in nonlinear models. *Econom. Lett.* 107(2):291–296.

Gurses AP, Carayon P (2007) Performance obstacles of intensive care nurses. *Nursing Res.* 56(3):185–194.

Haas MR (2006) Knowledge gathering, team capabilities, and project performance in challenging work environments. *Management Sci.* 52(8):1170–1184.

Hackman JR, Oldham GR (1976) Motivation through the design of work: Test of a theory. *Organ. Behav. Human Performance* 16(2):250–279.

Halbesleben JRB, Wakefield DS, Wakefield BJ (2008) Work-arounds in health care settings: Literature review and research agenda. *Health Care Management Rev.* 33(1):2–12.

Halbesleben JRB, Savage GT, Wakefield DS, Wakefield BJ (2010) Rework and workarounds in nurse medication administration process: Implications for work processes and patient safety. *Health Care Management Rev.* 35(2):124–133.

Hall LM, Pedersen C, Fairley L (2010) Losing the moment: Understanding interruptions to nurses' work. *J. Nursing Admin.* 40(4):169–176.

Hofmann DA, Lei Z, Grant AM (2009) Seeking help in the shadow of doubt: The sensemaking processes underlying how nurses decide whom to ask for advice. *J. Appl. Psych.* 94(5):1261–1274.

Holden RJ, Rivera-Rodriguez AJ, Faye H, Scanlon MC, Karsh B-T (2013) Automation and adaptation: Nurses' problem-solving behavior following the implementation of bar-coded medication administration technology. *Cognition, Tech. Work* 15(3): 283–296.

Imai M (1986) *Kaizen: The Key to Japan's Competitive Success* (Random House Business Division, New York).

Jimmerson C, Weber D, Sobek DK (2005) Reducing waste and errors: Piloting lean principles at Intermountain Healthcare. *Joint Commission J. Quality Patient Safety* 31(5):249–257.

Kobayashi M, Fussell SR, Xiao Y, Seagull FJ (2005) *Work Coordination, Workflow and Workarounds in a Medical Context* (ACM Press, New York).

Koppel R, Wetterneck T, Telles JL, Karsh B-T (2008) Workarounds to barcode medication administration systems: Their occurrences, causes, and threats to patient safety. *J. Amer. Medical Informatics Assoc.* 15(4):408–423.

Kotter JP (1995) Leading change: Why transformation efforts fail. *Harvard Bus. Rev.* 73(2):59–67.

LePine JA, Van Dyne L (1998) Predicting voice behavior in work groups. *J. Appl. Psych.* 83(6):853–868.

Liker J (2004) *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* (McGraw-Hill, New York).

Lukas CV, Holmes SK, Cohen AB, Restuccia J, Cramer IE, Shwartz M, Charns MP (2007) Transformational change in health care systems: An organizational model. *Health Care Management Rev.* 32(4):309–320.

Lyssenko N, Martinez-Espineira R (2012) "Been there done that": Disentangling option value effects from user heterogeneity when valuing natural resources with a use component. *Environmental Management* 50(5):819–836.

McGuire E, Kennerly SM (2006) Nurse managers as transformational and transactional leaders. *Nursing Econom.* 24(4):179–186.

McNeely BL, Meglino BM (1994) The role of dispositional and situational antecedents in prosocial organizational behavior: An examination of the intended beneficiaries of prosocial behavior. *J. Appl. Psych.* 79(6):836–844.

Monson TC, Hesley JW, Chernick L (1982) Specifying when personality traits can and cannot predict behavior: An alternative to abandoning the attempt to predict single-act criteria. *J. Personality Soc. Psych.* 43(2):385–399.

Morrison EW, Milliken FJ (2003) Speaking up, remaining silent: The dynamics of voice and silence in organizations. *J. Management Stud.* 40(6):1353–1358.

Morrison EW, Phelps CC (1999) Taking charge at work: Extrarole efforts to initiate workplace change. *Acad. Management J.* 42(4):403–419.

National Patient Safety Agency (2010) Safer administration of insulin. Rapid Response Report NPDA/2010/RRR013, National Health Service, Redditch, UK.

Parker SK (1998) Enhancing role breadth self-efficacy: The roles of job enrichment and other organizational interventions. *J. Appl. Psych.* 83(6):835–852.

Parker SK, Williams HM, Turner N (2006) Modeling the antecedents of proactive behavior at work. *J. Appl. Psych.* 91(3):636–652.

Pearce JL, Gregersen HB (1991) Task interdependence and extra-role behavior: A test of mediating effects of felt responsibility. *J. Appl. Psych.* 76(6):838–844.

Radnor ZJ, Holweg M, Waring J (2012) Lean in healthcare: The unfilled promise? *Soc. Sci. Medicine* 74(3):364–371.

Repenning NP (2000) Drive out fear (unless you can drive it in): The role of agency and job security in process improvement. *Management Sci.* 46(11):1385–1396.

Resar R, Pronovost PJ, Haraden C, Simmonds T, Rainey T, Nolan T (2005) Using a bundle approach to improve ventilator care processes and reduce ventilator-associated pneumonia. *Joint Commission J. Quality Patient Safety* 31(5):243–248.

Roberts SJ, Demarco R, Griffin M (2009) The effect of oppressed group behaviours on the culture of the nursing workplace: A review of the evidence and interventions for change. *J. Nursing Management* 17(3):288–293.

Robinson AG, Schroeder DM (2009) The role of front-line ideas in lean performance improvement. *Quality Management J.* 16(4):27–40.

Schlenker BR, Helm B, Tedeschi JT (1973) The effects of personality and situational variables on behavioral trust. *J. Personality Soc. Psych.* 25(3):419–427.

Schultz KL, Juran DC, Boudreau JW, McClain JO, Thomas LJ (1998) Modeling and worker motivation in JIT production systems. *Management Sci.* 44(12, Part 1):1595–1607.

Shannon RP, Frndak D, Grunden N, Lloyd JC, Herbert C, Patel B, Cummins D, Shannon AH, O'Neill PH, Spear SJ (2007) Using real-time problem solving to eliminate central line infections. *Joint Commission J. Quality Patient Safety* 32(9):479–487.

Spear SJ (2004) Learning to lead at Toyota. *Harvard Bus. Rev.* 82(5): 78–91.

Spear SJ, Schmidhofer M (2005) Ambiguity and workarounds as contributors to medical error. *Ann. Internal Medicine* 142(8): 627–630.

Staats BR, Brunner DJ, Upton DM (2011) Lean principles, learning, and knowledge work: Evidence from a software services provider. *J. Oper. Management* 29(5):376–390.

Tucker AL (2007) An empirical study of system improvement by frontline employees in hospital units. *Manufacturing Service Oper. Management* 9(4):492–505.

Tucker AL, Edmondson AC (2002) Managing routine exceptions: A model of nurse problem solving behavior. Friedman LH, Goes J, Savage GT, eds. *Advances in Health Care Management*, Vol. 3 (Emerald Group Publishing, Bingley, UK), 87–113.

Tucker AL, Edmondson AC (2003) Why hospitals don't learn from failures: Organizational and psychological dynamics that inhibit system change. *Calif. Management Rev.* 45(2):1–18.

Victor B, Boynton A, Stephens-Jahng T (2000) The effective design of work under total quality management. *Organ. Sci.* 11(1): 102–117.

Villena VH, Revilla E, Choi TY (2011) The dark side of buyer–supplier relationships: A social capital perspective. *J. Oper. Management* 29(6):561–576.

Vogelsmeier AA, Halbesleben JRB, Scott-Cawiezell JR (2008) Technology implementation and workarounds in the nursing home. *J. Amer. Medical Inform. Assoc.* 15(1):114–119.

von Hippel E (1994) "Sticky information" and the locus of problem solving: Implications for innovation. *Management Sci.* 40(4): 429–439.

Vroom VH (1995) *Work and Motivation* (Jossey-Bass, San Francisco).

Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: The PANAS scales. *J. Personality Soc. Psych.* 54(6):1063–1070.

Wiersma E (2007) Conditions that shape the learning curve: Factors that increase the ability and opportunity to learn. *Management Sci.* 53(12):1903–1915.

Wilde J (2000) Identification of multiple equation probit models with endogenous dummy regressors. *Econom. Lett.* 69(3): 309–312.

Womack JP, Jones DT, Roos D (1990) *The Machine That Changed the World* (Macmillan, New York).

Wysocki BJ (2004) To fix health care, hospitals take tips from factory floor. *Wall Street Journal* (April 9) A1.

Young TP, McClean SI (2008) A critical look at lean thinking in healthcare. *Quality Safety Health Care* 17(5):382–386.

Zohar D, Luria G (2010) Group leaders as gatekeepers: Testing safety climate variations across levels of analysis. *Appl. Psych.* 59(4):647–673.