Worker-centered investigation of issues with procedural systems: Findings from interviews with a representative sample of workers in high-risk process industries

S. Camille Peres [a], Alec Smith [b], Farzan Sasangohar [b],*

[a] *Environmental and Occupational Health, Texas A&M University, USA*
[b] *Industrial and Systems Engineering, Texas A&M University, USA*

A R T I C L E   I N F O

A B S T R A C T

Issues related to procedural systems have been found to contribute to incidents in many high-risk industries such as petrochemical, oil and gas, etc. While previous research has focused on understanding issues with procedural systems from the perspective of the workers (who are the end-users of procedures), most of this research suffers from samples that only include companies with programs focused on improving safety by improving procedures. These companies may have inherent differences in their safety practices and thus the experiences of these workers may not completely represent all workers' experiences in this domain. The purpose of this study is to gain insights into the thoughts and perceptions from a representative and broad sample of workers concerning procedure use and purpose. To improve the generalizability of previous findings, interviews were conducted with workers from a broad range of high-risk process industries to investigate issues related to procedure adherence that may be present in companies not currently implementing. Findings from a qualitative data analysis provide support for the generalizability of issues previously discovered, such as: more experience workers being more likely to deviate; procedure quality being inconsistent; and the procedure revision process being problematic. However additional prominent issues were found as well. Most importantly, this study found that adherence to procedures is often motivated by potential liability issues instead of genuine concerns for safety in organizations and many deviations from procedures were due to pressure from immediate supervisors. These findings suggest a relationship between the effectiveness/quality of procedural systems and the safety climate of the organization or work unit.

1. Introduction

High risk industrial work settings such as chemical plants, refineries, and oil and gas operations require workers to regularly perform tasks that, if not done specifically and correctly, can result in incidents which harm the business, the environment, and most importantly people (Hale and Borys, 2013; Bullemer and Nimmo, 1994). For instance, reports investigating the BP Texas City refinery explosion found that the lack of maintenance on safety critical systems and inconsistent methods of performing regular tasks were contributing factors to the incident (Hopkins, 2008; CSB, 2007). After major disasters in the 1980s including Bhopal, India and BP Texas City, many standards and regulations require employers to provide written procedures and safety statements for employees (Peres et al., 2016). Companies often have workers use

standardized procedures as a safeguard against major incidents. Typically, workers are trained on these procedures when they begin a new job or position within a facility and will use a written copy of a version of the procedure while conducting the task (Amyotte et al., 2007).

Given the large number of incidents where the root cause is associated with problems with the procedures (CSB, 2016; Bullemer and Hajdukiewicz, 2004), it is clear that many current procedural systems are not sufficient for mitigating the risks present in these industries. Some of the deficiencies in procedural systems are associated with the procedures not being correct (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004), not being available (Bartlit et al., 2011; CSB, 2016), not being updated (Sasangohar et al., 2018), and some with the workers simply not using the procedures (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004). Additional studies were based on

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* Corresponding author. 3131, TAMU, College Station, TX, USA.
  E-mail address: Sasangohar@tamu.edu (F. Sasangohar).

interviews with workers from multiple sites in the petrochemical industries and overall supported the notion that systematic issues regarding procedural system quality, i.e., lack of available, correct, and clear procedures, were occurring (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004). In addition to not being available or correct, some of the procedures were perceived as being too long, too difficult to use, and workers were not clear about the company's policies regarding when they should use procedures when performing a task (Bullemer and Hajdukiewicz, 2004).

While there have been specific efforts at addressing these issues, there continues to be a remarkable number of incidents associated with procedural systems (COS, 2018). To better understand contributing factors, we previously made an effort to investigate field and control personnel experiences when performing tasks using written procedures at nine different facilities around the world (Sasangohar et al., 2018). Overall, findings indicate that workers perceived procedures as very important for non-routine tasks. The findings also supported the literature regarding problems with procedures being incorrect or not-current and in addition, it was often a cumbersome and lengthy process to get procedures corrected. Importantly, Sasangohar et al. (2018) found two additional variables associated with workers' perception of whether they needed to use written procedures (regardless of whether the procedures were correct and available): worker experience (the more experienced the worker, the less likely they were to use a procedure) and task frequency (the more frequent the task, the less likely they were to use a procedure regardless of the criticality of the task).

A potential challenge with these previous studies was the sampling methodologies. Specifically, these studies involve interviews from workers at companies that allowed researchers to come on their site and interview (and sometimes observe) their workers (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004; Sasangohar et al., 2018). These companies were all in the process of improving their procedure and safety systems and having the researchers conduct interviews was part of this improvement effort. Anecdotal evidence indicates that not all companies focus on issues related to procedure adherence and safety in the manner reported in these studies. Procedure professionals who audit procedure systems in multiple companies and industry workers who work at these sites report that many of the issues they see are not being identified in the published studies involving interviews with workers. For example, one person (who asked for anonymity) reported that at the chemical plant where he worked, procedures were seen as property of the company that provided a competitive advantage. Thus, the procedures were kept locked at all times and if workers needed to use the procedure, they needed to get the supervisor to obtain the procedure from a locked cabinet.

Indeed, safety management studies have found clear, systematic differences between companies that are putting substantial time, effort, and resources into their safety systems and those that are not (Razuri et al., 2007; Arocena, and Núñez, 2010). However, to date, most of the research reporting "issues with procedures" has been from companies focused on improving safety. This sampling bias may suggest that documented findings may not be reflective of the range of experiences, perspectives, and issues present in these industries. Thus, any conclusions based on these findings may not be a complete representation of issues that workers have with procedures and procedural systems. Therefore, to fully understand the issues associated with procedural adherence and reasons for deviations from standardized procedures, direct input from workers from a representative sample and broader range of companies is necessary.

To address this issue and to document findings from a representative sample of workers, workers who had experience in process industries (e. g., refining, chemical plants) from a wide range of companies were recruited using a recruitment agency (as opposed to from a specific company) to participate in semi-structured interviews. Some of the workers had been employed with large companies (e.g., Dow, Chevron) while others had been employed with smaller independent companies

throughout the region. The workers were recruited from across the general Gulf Coast region of the United States and the study was hosted at Shell's training facility in Robert, Louisiana. The purpose of the study was to better understand documented issues associated with procedural adherence from a representative sample of workers with experience in a variety of high-risk process industries.

2. Materials and methods

2.1. Participants

To improve the representativeness of the sample and reduce sampling bias, a professional staffing agency specialized in oil and gas industry was used to recruit twenty participants. The recruitment criteria were that the workers: 1) had experience working in an oil and gas or processing environment; and 2) had experience working with specific equipment (e.g., compressors/pumps). Participants received a $200 gift card for participation in the study. All elements of the study were approved by the Institutional Review Board at the Texas A&M University.

All participants were male and ranged in age from 20 to 63 (mean = 43.75, st. dev. = 11.9). Their years of experience in process industries ranged from 1 to 37 (mean = 16.47, st. dev. = 12.74) and they had previously worked in industries such as: drilling (10), chemical plants (9), refineries (8), and electrical management (8) (Note: many had worked in more than one industry so sum does not add up to 25). An important consideration when reviewing the results is that for those participants who worked for the same large company, none of them worked for the same facility or unit.

2.2. Protocol

Semi-structured interviews were conducted by 2 researchers using an interview guide (Table 1). All interviews were recorded, and the recordings were transcribed by a professional transcription service.

Table 1
Interview guide used for semi-structured interviews.

The following items refer to your procedure use on the job.
- What comes to mind when I refer to the term "Procedure" for your work?
- Given your experience in this industry, we expect that you have used written procedures to perform these types of tasks before. Is that correct? (should be a yes or no response)
- Based on your experience, what percentage of tasks you perform are procedure-based?
- Has this number changed over time? How?
- Do you find procedures helpful for these tasks? Why or why not?
- When you use procedures for some of the frequent tasks you mentioned, how often do you deviate from the procedures? What about others in your unit?
- Can you describe some of the reasons for such deviations?
- How often do you NOT look at procedures? Or how often do you feel like you can "skip" over steps when looking at the procedure?
- Do you think your use of procedures has changed as you have become more experienced?
- When did this change occur? Or when did you start to feel less dependent on procedures?
- What are the expectations of procedure use at your current (most immediate previous) job?
- If you find a mistake or something confusing in a procedure, what is the process for getting it changed at your current job?
- If you could change the way procedures are used, what would you do?
- How do you define a "high quality" procedure?
If time allows:
- How do written procedures uniquely address your safety/job needs? I.e., considering the way you use them, what unique advantages do they offer?
- Can you list the name of every type of procedural tool you can think of? [Probe: JSA, JLA]
- Imagine you could redesign ideal procedures or change the way they are used. How does this new design look/process look like?

2.3. Analysis tool: MAXQDA 12

A Qualitative Data Analysis (QDA) software, MAXQDA 12, was used to sort and categorize, or code, responses and findings. Coding refers to the systematic categorization of interview responses using deductive and inductive reasoning. Deductive coding involves the development of an initial list of codes (Braun and Clarke, 2006; Guest et al., 2012). The deductive coding yielded 27 codes and 18 subcodes (Table 2). Not all codes are presented in the results, but only those that are relevant to the current discussion. Due to the nature of semi-structured interviews to wander and not follow a strict script, many responses may fall outside of the initial list of codes (Braun and Clarke, 2006; Guest et al., 2012). Repeated thoughts or responses from different participants were recorded as new codes (a process called inductive coding). This process yielded a total of 2 new codes along with 7 subcodes. The 'Codes' and 'Sub Codes' were created based on the interview script through deductive reasoning. After completing the first phase of coding, the iterative process of inductive coding yielded a total of 9 new codes that were placed in existing 'Codes' and 'Sub Codes' rather than as new concepts or categories. One coder, experienced in QDA, conducted both the deductive and inductive coding. Throughout the coding process, the coder discussed and reviewed the codes and reasoning with other authors and an expert in qualitative data analysis.

3. Results and discussion

Table 2 outlines the codes, sub codes and inductive codes from the coding process for those questions outlined in Table 1. The results are represented with frequency of responses. Due to the nature of semi-structured interviews, not all questions were asked, some participants provided multiple responses to some questions and others did not answer the question even when asked.

3.1. Description of procedure

Two main constructs that workers associated with procedures were "safety" and "guidance." Most of the interviewed workers (14/20) described their understanding of procedures as *a set of steps* or *guidelines* to follow. Several workers (8/20) mentioned *safety* as the primary thought when discussing procedures. Procedures are generally perceived to contribute to improved safety and important to accident prevention.

"I mean, it's there for a reason. It's there to do the job safely. I mean, safety comes to mind. There's a reason we have the procedure. There's a reason to do things the right way. Everybody wants to go home alive. Everyone wants to go home. It's safety, number one. Absolutely."

"That's what procedures are for. For somebody [who] could walk out off the street and do it. With a little bit of experience, I mean."

These findings are in line with previous research where participants discussed safety as an important (possibly even the primary) issue for using procedures, particularly for new or infrequent tasks (Sasangohar et al., 2018). Other studies identified that from management's perspective, procedure use fills several needs in the organization in addition to safety. Specifically, both Bullemer and Hajdukiewicz (2004) and Jamieson and Miller (2000) found that procedures were used not only to support safe operations but also: to meet regulatory requirements; as a training tool; to support operational excellence; for loss prevention and environmental safety; and as records of historical information.

3.2. Use of written procedures

All participants (18/18) reported using written procedures in their current or previous work and claimed that this experience provided the basis for their responses. In addition, most workers (19/20) stated that they were expected (by their companies) to use procedures if they were available. Some participants (7/20) had experience with electronic or computer-based procedures. Because most participants were more familiar with written procedures, the analysis only included responses concerning their experience with this type of procedure.

3.2.1. Number of tasks with procedure

Participants had mixed reactions regarding the percentage of tasks that required procedures. Some workers (5/17) reported that very few of their tasks had accompanying procedures and some reported that most or all their tasks were procedure-based (12/17). The range of which tasks were procedure-based was 5–100%. One participant mentioned that the lack of procedures accompanying tasks was producing deleterious effects at their workplace such as multiple, repeated mistakes, breakdowns in communication and repercussions from management. This finding is remarkably different from previous results where most tasks had an accompanying document that provided guidance on how to perform the task (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018). These different findings indicate a wider variety in procedural discipline and policies in this sample that in some of the previous samples reported (e.g., some companies are very strict while others are lax in procedure use).

"I can tell you 99% of the mistakes that we made, there was no detailed procedure."

"Every time I got to a safety meeting and they listed the incidents, I realized those incidents that happened had no detailed procedures."

3.2.2. Changes in requirements for procedures

Most workers (10/14) mentioned an increase over time in tasks using procedures due to a focus on accurate performance, while others experienced a decrease in the use of procedures as time progressed (4/14). However, of the workers who experienced a decrease in the use of procedures over time, a majority (3/4) experienced this change when moving to a new company.

"Pretty much everything that – not exactly sampling, that's not exactly procedure-based. But if something happens then it's going to

Table 2

List of codes, sub codes and inductive codes.

Codes	Sub Codes	Inductive Codes
Description of Procedure		Guidelines
		Safety
Use of Written Procedures	Number of Tasks with Procedures	Training
	Changes in Requirements for Procedures	Job Security
	Process for Changing Procedures	Creating New Procedures
Workers' Perspectives Regarding Procedure Use	Perceived Utility of Procedure	Safety
	Effects of Experience	When Became Less Dependent On When Attitude Change Occurred
Deviations from Procedures	Others Deviating from Procedure	Reasons for Not Using Procedure
	Reasons for Deviation	

be a procedure. So most procedures come after an incident. So once you do a job house analysis and see how we got to that, procedure comes after that. "

"the tasks that are daily occurrences, like sampling, … we don't need those procedures. We don't have to use those procedures because they're so frequent … We startup and shutdown all the time. We're a chemical plant. So, those procedures are still in place. We still use those. But they have taken some out that we don't need to use on a daily basis- unless we're training. If we're training on a new unit, yeah, we have to use that procedure."

"Yeah, whenever I was out there with [my previous place of employment], they had a lot more procedures associated with the work. They had found a gap with their procedures. In pretty much most of the activities, they had put some type of procedure, in-house step plan, of what you're doing, one through ten; some of them more formal, ten, twelve-page procedures."

Our mixed findings show variability in procedure use that were not captured in previous studies. In particular, not all companies have specifically and intentionally increased the number of procedures they require workers to use on a regular basis as suggested by previous literature (e.g., Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018).

3.2.3. Process for changing procedures

Even when companies have been effective at having procedures be immediately available and generally correct, there are times when they need to be changed or updated. Indeed, significant problems can occur when they do not align to operator needs. A majority of our participants (13/17) reported going to a supervisor or manager to start the process of changing a procedure. Two participants referred to a hierarchical reporting structure.

"Usually, go see your supervisor. Let him know what you've found, and go get it approved, chain of command. Then the safety would get involved, the Safety Department. Then they would upload the change once it was all approved. Then have it blessed by management. Then bring it to the document control person to upload it and put it on file."

Workers often used the term "redlining" as a common step (9/17) that took place in the process to change a procedure. Redlining comprises of marking a document with suggested changes and allowing others to review the changes for approval.

Of the operators who expressed an opinion regarding the change process, some (3/7), especially those who regularly used procedures, perceived the change process as positive and effective because of factors such as safety, expertise, and experience with certain tasks, were considered throughout the process. Other operators (4/7) had a more negative view of the change process for a number of reasons: 1. The change process was started but never completed, 2. It took too long, 3. Operators did not find the process necessary for themselves or others, and 4. The culture did not approve of the process.

"You can get feedback relatively quickly, which is nice … You don't have to submit it, and hopefully two weeks for now, you might get an answer."

"The biggest thing now to kill a system like this is a technician gets a procedure that isn't quite right, he redlines it, he turns it in to get approval, and a month later, he pulls it, and nothing's been done with it. That's what kills morale."

Other studies have found that procedures are often outdated or incorrect (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000), however these studies did not discuss the process for correcting the procedures. Sasangohar et al. (2018) found that the time required for

completion of a procedure update could vary wildly—even between units in the same facility—from a couple of weeks to 6 months. Additionally, this time lapse before redlines were resolved impacted workers' attitude toward using procedures. If it took too long, then they experienced not only that their input was not valued, but also, that they still had to contend with an incorrect procedure. Further, it indicated to the workers that there were likely other incorrect procedures in the system that had not been corrected. Peres, Hendricks, Kannan, and Ahmed (2019) found that workers' attitudes regarding the procedure change process was highly related to their perceived procedure quality. They further found that perceived procedure quality was predictive of reported deviations, incidents and near misses. These findings in concert with the findings from the current study clearly indicating that having an efficient and effective change process is necessary for an effective procedural system and for increasing procedure use.

3.2.4. Summary of procedure use

Although most of the companies for whom the workers were working (or had previously worked) had expectations that they were supposed to use procedures if they were available, the procedural systems themselves seemed to vary widely. These differences are evident in the number of tasks which had procedures available and whether the companies were increasing or decreasing their use of procedures to control safety and effectiveness.

3.3. Workers' perspective

Participants' perspectives regarding procedures and their use tended to vary based on the company culture and how management addressed the expectation for procedure use. While some workers' attitudes reflected a more negative perspective on the procedural system at their place of employment, other workers had a positive look on their employer's expectations of procedure use. Further, most workers (11/17) described procedures as a document to be followed "to the letter", while others (6/17) described procedures more as guidelines than a document of what to do specifically.

"We even preach at work that the procedure is set in stone, but it's also used- it's there to be a guideline."

"They believe that you should have a procedure for everything and everything can be and will be proceduralized."[this was said from the perspective that this is not necessary or helpful]

3.3.1. Perceived utility of procedure

Our findings suggest that there is a consensus among workers (15/20) that procedures are helpful, especially to accomplish tasks with unfamiliar equipment, to facilitate training, and to complete their work safely. Workers (4/20) also reported that using procedures protected them from liability for issues with the task or process itself. Further, over half of the workers (9/14) mentioned that the procedures are specific for their job only and provide necessary information that will allow them to complete their tasks.

"Without the written procedures, there would be no parameters as far as getting the job done. And I think that's scary for everybody, for the company and for the employee."

"Number one, it gives you clear direction. Number two, it protects both the worker and the process, the engineer over the DCS operator. Number three, all the safety hazards that can't be anticipated, have been. Also for positive ID, make sure you're on the right system, double check."

Similar to this study, previous research found that workers' perceived procedures as helpful with training (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018).

Interestingly, workers in the previous studies mentioned that they tended to think that procedure use was more helpful with infrequently done tasks than all tasks but these findings were not mirrored in the current study. The construct of "pressure from management" to use procedures has been identified in previous studies but the implications of this pressure were different in the current study. Previously, "pressure from management" was described as having to use procedures because if they did not and were discovered, they might lose their jobs Jamieson and Miller (2000) and Sasangohar et al. (2018). However, in this group, using procedures was perceived as helpful, almost as a "protection from management" because as long as they had done the task as indicated in the procedure, they could not be blamed for the outcome (even if they knew the procedure was wrong). Both of these situations could be dangerous because they do not involve the worker thinking critically about the task he or she is performing and instead has the worker engaged in rote adherence to company policy to protect his or her job.

3.3.2. Effects of experience on perceived utility of procedures

Workers presented mixed results when discussing the change of their use and attitudes towards procedure over the course of their career. Over half of the workers (10/15) said that their use of procedures changed over time and those were split between increasing procedure use (5/15) and decreasing procedure use (5/15). The other workers (5/15) stated that their procedure use had not changed over time at all.

> "My use of procedures has increased. I use procedures more now than I had in the beginning of my career. I guess- I don't know. For me, it's just like, the more I understand the process, the more I understand everything else."

> "Well, I don't read them. I don't follow them, you know? Every experience I get, the less I need them, you know? I don't need that. I did that a million times, you know?"

One reported reason for the decrease in procedure use over time, which is supported by previous studies (Sasangohar et al., 2018) is that participants with more experience often report they do not need the procedure to perform effectively and safety. Specifically, some reported that if a procedure has not been changed in several years and the operator has performed the task repeatedly, there was no need to go back and look at it again (thus reflecting a reduced use of procedures with more experience). With regard to those who increased their procedure use, many reported that their understanding of the importance of using procedures had changed over time and that they now thought procedure use was more important than they had before.

3.3.3. Summary of participants' perceptions on utility of procedures

Participants generally reported safety and job performance as positive motivators in using procedures. Procedures were perceived to contain relevant information surrounding the task including hazards, cautions and other potential details that workers needed to be aware of when performing a task. These were perceived as helpful with preventing injury or harm, for training and for providing necessary information (such as target levels) for completing a task.

A surprising and concerning attitude about procedures was reflected in workers' mentioning that using procedures helped to mitigate potential liability issues. This attitude, while likely supporting actual procedure use, is concerning in that it is a deflection of accountability from the worker to the administrators of the procedural system. An effective procedural system would likely have accountability at all levels but more specifically should have buy-in from all levels. If the workers are following procedures blindly for the sake of not getting in trouble, they are likely not doing any critical thinking regarding the specific task at hand and any environmental considerations that could make it dangerous or inefficient to perform the task as specified in the procedure. Vicente (1999) described this phenomenon as "malicious procedural compliance" where sometimes workers were following procedures

rigidly even though they knew it would not work or be successful. When a procedural system is designed such that the workers have this attitude about the use of the procedures, it indicates that the workers experience procedures as a tool for management as opposed to a tool to support their performance and safety. Given that these findings were mirrored in Sasangohar et al. (2018), such attitude about procedures may be more pervasive than has been previously realized in these high-risk industries.

3.4. Deviation from procedures

Over half of our participants (11/18) reported that they deviate from procedures, either by not following the steps exactly or by not using the procedure at all. These deviations were typically due to equipment malfunctions or contextual changes in the task. Several workers (7/18) claimed that they never deviate due to managerial pressure or concerns about safety.

> "30-ish percent of the time, probably. I mean, you don't deviate to the point where it's dangerous. You just kind of … you operate. You know, you're an operator—you operate the equipment."

> "So, for me once they're there no matter what you need to follow them, you need to follow the procedure … I prefer to take my time because it's better not to get the job done than get the job done and maybe do something that will either cost you or cost the company"

These results are very similar to what has been reported by workers in previous studies in that workers in some facilities made specific efforts to not deviate from procedures (at least nominally) out of fear of reprisal or because of safety and performance concerns (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018).

3.4.1. Others deviating from procedure

Half of the participants (9/11) mentioned that others tended to deviate from procedures while only a few (2/11) claimed that no one else deviates from the procedures.

> "The older guys, they'll try to deviate, or they know what they can get away with, what the system will see, what the system won't see."

> "Everybody usually follows the procedures pretty well. I don't see – I never seen anyone didn't follow any or skipped over anything or cut corners."

The reports here are interesting in that the proportion who reported that their co-workers never deviated (2/11) are much lower than the participants who reported that *they* never deviated from procedures (7/11). This may be indicative of the workers wanting to be perceived more positively by the experimenter (social desirability) and that the workers felt more comfortable talking about their co-workers' use of (or lack thereof) procedures than their own.

3.4.2. Reasons for deviating

Workers provided many reasons as to why they or their coworkers deviated from procedures. Reducing time (7/16) was a major reason for deviation and often this was reported to be associated with pressure from immediate supervisors. Operator experience (6/16) and when a task is physically impossible to complete due to equipment malfunction (5/16) (where procedural deviation is understandable and possibly the only action available) were other frequently reported reasons for deviation. Some workers (2/16) indicated that their company had processes for requesting an emergency deviation from procedures that they would regularly use.

> "Sometimes when you are under pressure you tend to find a shortcut, get the task done."

"Sometimes they have to be deviated. Sometimes a certain line would be out of service that you have to switch over to, switch off of, and the procedure says to use this one, and that line is, for whatever ungodly reason, isn't working and it has to be, we got to run anyway. We could jump this over here, and we could write up a temporary deviation."

Most of the reasons for deviating from procedures were remarkably similar to those found in previous studies (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018). However, the results in this study regarding deviating from procedures due to time pressure is in stark contrast to the reports from participants in the previous study who reported that sometimes taking more time is better because it allows for a more careful, and thorough completion of the task (e.g., Sasangohar et al., 2018). Further, the fact that in this study many workers reported the pressure coming from their direct supervisor to deviate is markedly different from the findings from other studies in which no one reported such pressure. This finding provides evidence that the sample in the current study may be more representative than previous studies and indicates that these findings are important new contributions regarding issues with procedures systems. Specifically, it is highly unlikely that at a company where there was an intense focus on safety, a supervisor would instruct a worker to deviate from a procedure. Further, even if this were to happen, there is a low likelihood that a worker would report it if being interviewed at his or her place of work because it would be known to be an unacceptable practice.

3.4.3. Number of times not using procedure

Although some workers (6/20) admitted to not using procedures sometimes, they qualified that it was a rare occurrence or because of prior experience. No one provided specific responses to the number of occurrences of not using the procedure but instead provided rather general statements. These results are in the same vein as procedure deviation (section 3.4.1).

"Most operators, once they've been operating a while, once they get their routines down, they never look at them again"

"I don't need a procedure, because I already know how to do it."

Although deviating from procedures and not using procedures seem similar on the face of it, they are markedly different because when workers do not use the procedures at all, there is no opportunity to design them in a manner that could improve adherence to the specific steps of the procedure. Previous work investigating this found that the number of tasks participants did not use procedures was specifically related to the frequency of the task, specifically the more frequent task, the less they use procedures and that this relationship was attenuated by the participants' experience (Peres et al., 2019). Peres et al. also found that the experience of the worker was related to decreased use of procedures as well. Those findings seem to be echoed by the participants in this study.

3.4.4. Summary of deviation from procedures

The reasons for deviating from procedures seem to be consistent with previous research, i.e., workers deviate when procedures are deemed to be inaccurate, outdated, or contain unnecessary information. Further, usage of procedures over time decreased for some workers due to workers' familiarity with the tasks and requirements.

For some of the workers, there seemed to be an attitude of disinterest or pride which guided their perception of procedure use, i.e., the workers perceived the tasks to be too mundane, or themselves too experienced, to require the use of a procedure. This may suggest that experienced workers may develop procedures that are perceived as more "efficient" or "adequate" experientially. While this approach may be justified if the procedure is outdated, it is also possible that such perceptions may result in deviation from procedure steps that decrease

perceived efficiency and are included as safety measures. In addition, such experiential procedures may be "knowledge in the head" as opposed to "knowledge in the world" (Norman, 1989) and may put workers at risk of committing errors of omission if they do not always remember to do every step.

An important reason for deviating from procedures unique to this study was the pressure from supervisors to get the work done more quickly than the procedure would allow. This was a source of frustration for some workers because they felt they were helpless to change the situation, i.e., they had to do what their direct supervisor told them to (for fear of reprisal) but they knew it was going against the company's policies and safety procedures.

Almost half of the participants stated that they had never deviated from procedures; however, it is possible (if not likely) that this is an under-reporting of this behavior—particularly given the disparity between self-reported deviation behaviors versus that of their co-workers. This could be due to workers being unwilling to report their own deviance; their not realizing how much they deviate, either due to cognitive dissonance or simply by accident; or that workers perceive that everyone else deviates more than they do.

3.5. Summary of findings

Table 3 provides a succinct summary of our findings and how they compare to previous studies. In this table, the themes and sub-themes from the current study are listed in the first column the comparison of the results from the current study and outcomes of previous studies (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018) are provided in columns three and four.

4. Implications

This study was conducted to better understand workers' experience with procedural systems and to identify if there were issues with procedures that had not been documented in previous studies (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004; Sasangohar et al., 2018). Using a thematic analysis approach, the interview content was analyzed and compared to previous studies. The results indicate that many of the attitudes and use patterns are similar between the participants in this study and previous studies (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004; Sasangohar et al., 2018), however there were some important unique findings as well.

The new findings from this study combined with those from previous studies illustrate the multiple dimensions of a procedural systems: the procedure documents themselves (e.g., having them available, correct, and well written); the management of those procedures (e.g., making sure they are updated regularly, all risks have been assessed and addressed, and appropriate personnel have reviewed them); and the implementation of the procedural system (e.g., the requirements for use, management's policies regarding following them versus production timelines). Issues associated with the procedure documents themselves (e.g., outdated, too long, incorrect, not available), while non-trivial, can be addressed in a relatively straightforward manner by organizations both large and small. The management and implementation of the procedures is a more complex issue that becomes even more complex for larger organizations with thousands of procedures and multiple sites in multiple locations around the world. Indeed, three specific issues workers reported in this study and others are specifically associated with the management and implementation of procedures: **pressure from supervisors** to deviate from procedures; workers' attitude regarding procedures as a **protection from liability**; and **long turnaround times for redlined** procedures. These findings indicate that the content of the procedures and the training of the personnel implementing those procedures are necessary but not sufficient for an effective procedural system. Our findings suggest that understanding behaviors pertaining to procedures requires a holistic understanding of the inextricable link

Table 3
Comparison between the findings from the current study and other studies.

Theme	Sub-themes	Current Study's Findings	Previous Studies' Findings
Description of Procedure		Attributed to Safety and Guidelines	Attributed to Safety and Training (Sasangohar et al., 2018); Safety, Regulations, Training, Operations, Records (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000)
Use of Written Procedures	Percent of Tasks with Procedure	5–100%	Almost 100% (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018)
	Changes in Requirements for Procedures	Mixed: Participants experienced both increase and decrease	Participants experienced an increase in number of procedures (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018)
Workers' Perspectives Regarding Procedure Use	Perceived Utility of Procedures	Used for unfamiliar equipment, training, safe work	Used for training and infrequent tasks (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018)
		Felt pressure due to liability and job security	Felt pressure from management (Jamieson and Miller, 2000; Sasangohar et al., 2018)
	Effects of Experience on Perceived Utility of Procedures	Mixed: For some usage increased; for some decreased or no change in use	Usage decreased as experience increased (Sasangohar et al., 2018)
Deviations from Procedures	Reasons for Deviating	Equipment malfunction, task changes, time pressure, pressure from supervisors	Equipment malfunction, task changes (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Sasangohar et al., 2018)

between the procedural systems, their implementation, and the Safety Climate (SC: i.e., workers' perceptions of workplace safety norms, priorities, and expectations) of the organization or work unit (Beus et al., 2010). For example, even if an organization has perfect procedures and perfectly trained workers, if the SC is such that productivity is valued over safety, workers will likely be put in a position where they are asked to violate procedures to save time and increase productivity (as some of the participants in this study reported).

Workers experiencing **pressure from supervisors** to deviate from procedures to meet deadlines is a canonical example of a work environment that values productivity over safety (Beus et al., 2010). The results of this study do not allow for any inferences regarding the specific motivations for the supervisors' behaviors. Indeed, their motivations could range from: not being particularly focused on safety to having rigid timelines set by more senior management that they are required to meet. If supervisors' motivations were more similar to the former, then training and other interventions would be necessary to correct this behavior. However, if their motivations were associated with the latter, it could be that a procedural system that prioritized adherence to procedures (particularly for safety issues) could support supervisors' making decisions that would not require their pressuring workers to deviate from procedures. For instance, if adherence to procedures are prioritized, supervisors may be empowered by upper management to adjust timelines so adherence to procedures can be maintained. This would be reflective of a higher SC given that priorities and expectations at all levels (e.g., worker, supervisor, and upper management) reflect norms associated with working safely. This is an elegant example of how a procedural system and the SC of a unit are linked and how an effective procedural system could support a positive SC and more safe behavior.

Another possible example of a linkage between SC and procedural systems is workers' perceiving procedures as **protection from liability** if an issue occurs. Specifically, if something goes wrong, as long as a worker had used the procedure, it was not "their fault." While on the surface of it, this could seem like a motivator for workers to use procedures, there are some distinct and insidious problems with this approach. First, it removes from the workers the responsibility of thinking critically about how they are performing the task because, in this paradigm, they are supposed to perform the task exactly as written in the procedures. However, procedures are often incorrect–whether that is due to being poorly written from the beginning or because some attribute of the task situation has changed (e.g., a new type of pump is being used that requires a different series of steps). When this is the case, workers should indicate the difference and not use the current procedure given that it is incorrect. However, if workers are not thinking critically about the task, they may not notice this and perform the task incorrectly—even though they are following the procedure exactly (see

Dekker, 2003). The second issue with procedures being used as a protection from liability is when workers have this attitude about the use of the procedures, workers experience procedures more as a tool for management as opposed to a tool to support their performance and safety. This may be reflective of a poor SC where workers may not perceive reliable norms, priorities, and expectations regarding the enforcement of workplace *safety* in their organizations (Beus et al., 2010). The perceived use of procedures to enforce work-specific protocols instead of safety may inadvertently communicate to the worker that work protocols are more important than safety.

The **turnaround time for redlined procedures** is the final finding that seems to have clear interconnections with SC in these work settings. Specifically, in Sasangohar et al. (2018), they found that the timing for responding to a procedure change request varied widely—ranging from a few days to up to three years. The efficiency of the change process was primarily dependent on the organization or the unit. In that study, interview results indicated that having a slow response to requested changes clearly impacted workers' decisions to use procedures as evident by one worker's quote below:

"I mean we have procedures out there right now that we know are wrong … I know there's some that we try to get them changed and redline them, but until that gets changed, we know at that point, well, I can't do that or that isn't feasible to do." (Sasangohar et al., 2018, p. 35).

Peres et al. (2019) as well as Sasangohar et al. (2018) found that organizational units appearing to be the most committed to procedural adherence were vigilant about ensuring that the procedures were correct. This vigilance led to consistent recommendations for edits to procedures to account for changes in the task, equipment, or technology. Conversely, there were units where the experience of the worker was more reflective of the quote below. In these units, workers reported that the focus was more on whether they were using the procedure and much less on putting resources into ensuring that the procedure was helpful, safe, or even correct.

"… often they will go unrevised for a while until someone takes the initiative - which is usually the operator. Usually somebody's got to get mad [before they will change it]" (Sasangohar et al., 2018, p. 35).

It is important to note that given the nature of the qualitative interview data, the workers' reports could not be verified. Nevertheless, these reports are reflective of the workers' *experience* with the procedural systems at those workplaces. Research in SC indicate that workers' perceptions of and experience with safety systems is often predictive of their behavior and indicative of the effectiveness of the safety system itself (Beus et al., 2010; Christian et al., 2009; Nahrgang et al., 2011). Thus, workers' attitudes (and the type of data presented here) regarding

procedures may be reflective of the safety climate at that facility or unit.

Given that in many domains, the level of SC in an organization is predictive of relevant safety outcomes and that many negative safety outcomes have been associated with poor procedural adherence, it is not necessarily surprising to find SC issues associated with effective (or ineffective) procedural systems (Beus et al., 2010; Christian et al., 2009; Nahrgang et al., 2011). However, most previous studies focused on identifying issues associated with procedure adherence have focused on attributes of the procedure document itself and attributes of the worker (Jamieson and Miller, 2000; Bullemer and Hajdukiewicz, 2004; Hale and Borys, 2013; Alper and Karsh, 2009). By conducting interviews focused on the entire procedural *system*—including cultural and organizational factors—this research has been able to discover a potential link between SC and procedural adherence. Specifically, a higher SC may facilitate the development of a good procedural system and conversely a good procedural system may facilitate the maintenance of a higher SC. However, although we have made specific arguments to support the relationship between procedural systems and safety climate, this finding was not necessarily expected and thus not one of the original focus' of the study. Therefore, future work is warranted to explore this relationship more directly.

5. Conclusion

This study indicates that to fully understand some of the current issues associated with procedural deviation and misuse, it is important to gather information from workers who are representative of a large population of workers and not just from specific organizations who invest more in safety initiatives. With this framing, this study identified unique issues with procedures not reported in previous research (e.g., pressure to deviate from supervisors and differing number of procedures available) and provides a fuller picture of some of the current challenges with procedural systems. It is noteworthy that the workers' reports regarding the procedural systems at their place of employment may not be completely correct, and for some behaviors, may be reliable over- or under-stated. This could be due to fear of reprisal, incorrect recall of their behaviors, or social desirability. However, given the similarities between the participants' responses (for both this study and Sasangohar et al., 2018), the extent of this is likely low.

The findings from this study, along with other recent research on procedural adherence, indicate that an effective procedural system can be defined as one that is consistently and reliably used and does not result in incidents associated with procedures (Peres et al., 2019; Sasangohar et al., 2018; Hale and Borys, 2013; Bullemer and Hajdukiewicz, 2004). To accomplish this, procedural systems should:

- Consider procedures a tool for workers' safe and effective performance, not as accountability method for management
- Have established methods for quickly getting approval for needed exceptions to procedures (e.g., if the equipment has changed and the procedure is no longer appropriate)
- Have an effective and efficient system of continuous quality checks of procedure content and format. Further this system should insure that:
  ○ Workers take ownership of making sure the procedures are correct and
  ○ Timely feedback is provided for any corrections or suggestions (redlines) workers make for procedures
- Confirm that procedures are easy for workers to use and tasks are as easy as possible to perform
- Leverage empirical guidance regarding how procedure documents should be designed
- Require that most (and certainly critical) procedures be physically validated before they are deployed.

Based on evidence from this study and others, procedural systems

that meet these criteria are much more likely to meet workers' wants and needs and are associated with increased compliance with procedure use (Bullemer and Hajdukiewicz, 2004; Jamieson and Miller, 2000; Peres et al., 2019; Sasangohar et al., 2018). Having systems with these characteristics allows employers to show the commitment and focus they have to their employees and safety. When done well, this can ultimately result in improved safety climate which could help reduce incidents and therefore reduce loss of life and economic setbacks.

CRediT authorship contribution statement

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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