NSW GOVERNMENT

Exploring the culture for safety in manufacturing

Centre for WHS

Griffith UNIVERSITY
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Prepared by:

Dr Tristan Casey[1]
Janis Hanley[1]
Patricia ni Ivor[2]
Angelica Vårhammar[3]

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[1] Griffith University, Nathan Campus, Kessels Road, Brisbane, Queensland, 4111, Australia

[2] Word Map, 181 Franklin Street, Melbourne, Victoria, 3000, Australia

[3] Centre for Work Health and Safety, 92-100 Donnison St, Gosford, New South Wales, 2250, Australia

Executive summary

Manufacturing remains a dangerous industry, with unsafe machine operating behaviours considered a significant risk of injury. It is also thought that behaviours can be improved by fostering a culture of safety through forming a positive and strong safety climate. In this project, we explored the safety climate and culture in 70 NSW wood and metal manufacturers, inquiring into their day-to-day operations and organisational procedures regarding safety, including safety leadership and performance (safe and unsafe machine operating practices).

Research questions

Seven research questions guided the analysis and interpretation of the research. The major findings are summarised below, with detailed answers contained within the body of this report.

1. What is the nature of manufacturing-specific safety climate?
2. How can safety leadership and performance be operationalised within manufacturing?
3. What are the relationships between safety climate, leadership, and performance?
4. What perspectives can be gained through exploring the tensions between safety and production?
5. How does industry 'culture for safety' influence machine operators' safety capability?
6. What differences exist, if any, between young and old workers' safety perceptions and behaviours?

7. What is the impact of an online safety leadership training package on safety climate, leadership, and/or performance?

Conclusions

Overall, we found that safety climate used in isolation lacks enough specificity to identify shortcomings in the organisational culture that carry effects on safety. Although safety climate can be used as a coarse measure of the underlying safety culture and can potentially distinguish organisations based on the conduciveness of their cultures for safety, the quantitative differences may be small, and thus runs the risk of generating a 'false negative' — failing to detect important issues that contribute to safety capability and performance.

Importantly, the qualitative data highlighted the dynamic interplay between production and safety goals, and the tactics manufacturers use to resolve this tension. Exploring this tension provides fertile ground for drawing together strategies to raise the priority of safety. Acknowledging that safety will sometimes not be first, due to the viability of the business, but always prioritised so far as reasonably practicable, provides a more inspiring and motivating vision for safety.

There was little quantitative evidence of younger workers (<25 years) being exposed to less effective safety practices in the participating workplaces. To some extent the opposite was found, whereby young workers were more positive than older workers on some elements, particularly training and development. However, in the interviews, some workers raised that younger workers lack focus and attention, e.g. forgetting PPE and not concentrating on what they are doing. The data also suggest that there may be some role modelling by experienced operators that causes younger workers to think they can adeptly take shortcuts and risks.

Another cause for concern was the observation of increased frequency of at-risk machine operating behaviours among culturally and linguistically diverse (CALD) workers. Interviewees raised examples of CALD workers being actively discouraged from reporting safety issues and generally experiencing a higher level of job insecurity. However, as the number of CALD workers in this study was small (n=15), these results should be treated with caution.

In addition to these results describing the nature of safety culture within manufacturing, the performance of the new safety climate, leadership, and machine operating behaviour scales were evaluated. The safety climate scale was found to be a stronger predictor of machine operating behaviours than safety leadership, so could be used as an organisational diagnostic tool to target

areas for improvement. The safety climate scale was correlated with an existing measure and showed acceptable psychometric properties.

Finally, our evaluation of the leadership intervention did not find quantitative evidence of change over time. Improving safety culture in manufacturing likely requires a multi-pronged approach that goes beyond an online safety leadership training program.

Recommendations

Synthesising the findings of this project, we make the following strategic recommendations regarding the manufacturing culture for safety and its role in driving safety performance:

Recommendation 1:

The resources developed during this project could be made into a manufacturing safety culture toolkit that includes these new resources as well as those already in existence. Concurrent development of suitable interview/focus group protocol(s) that could be used in combination with the newly-developed safety climate scale could also be created. Focus on the needs of small-medium operations who likely require support to help resolve safety-production tensions favourably, which could include tools like safety requirement factsheets, template procedures, and other practical resources that would help to integrate safety within production processes.

Recommendation 2:

Organisations could periodically (6-12 monthly) measure organisational culture for safety using a combination of methods — combine a quantitative safety climate survey with qualitative investigations that can be done via interview or focus group methods. Use the safety climate data as an initial pulse check of the state of safety and expand on this information with targeted interviews that provide detail around the nature of the survey themes and findings.

Recommendation 3:

The manufacturing industry could shift the focus for safety to one that takes it beyond ‘safety first’ and towards one that recognises the trade-offs and tensions that can exist between production and safety, and that it needs ongoing attention to keep in front. Use words and phrases that are about pushing safety forward; advancing, evolving, innovation, imagination, or vision; words that suggest that there is no limit for the organisation to moving forward, and that the journey will be ongoing.

Recommendation 4:

Organisations could seek to enhance supervisor and managerial leadership capabilities through

leadership development training and resources (such as the ones developed for this project) and peer mentoring/networking opportunities. Focus leadership development initiatives around being visible on the floor, spending time understanding and appreciating operators' experiences in the manufacturing environment and engaging in regular two-way communication to be abreast of safety and work-related issues.

Recommendation 5:
Organisations could identify and explore factors that shape machine operator behaviour and contribute to production-safety tensions in the organisation by using a combination of surveys and interviews/focus groups. Deal with these underlying issues rather than focussing on resolving the tension directly. For example, redesign jobs to provide workers with adequate rest breaks and time for secondary work task, rather than penalising short-cuts and messy work environments directly, as rushing behaviours tend to be shaped by the broader organisational context rather than individual attitudes and beliefs around safety.

Recommendation 6:
Further investigations are needed to understand the challenges faced by CALD and migrant workers. Engage with these vulnerable groups directly to understand the factors that contribute to reduced safety capability. It might be a matter of creating competencies for them in understanding safe work practices and their rights.

Recommendation 7:
Follow-up investigations could also target young manufacturing workers, specifically, to understand more about their experiences working safely. Our data were in conflict, as quantitative measures purported that younger workers have more positive social experiences with safety, whereas some of our qualitative data suggested that younger workers are implicated in incidents due to inattention or overloading of their capabilities. The discrepancy between qualitative and quantitative data means that relying solely on survey information to research young worker safety is problematic and should be avoided.

Recommendation 8:
Ongoing development of safety climate scales contextualised for industry could be undertaken to integrate the findings of this report and to re-operationalise safety climate into a measure that is more sensitive to underlying safety-production tensions.

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Introduction

> *"Safety is a very big concern, but efficiency and productivity are kind of the main [concerns]. You need to be productive and efficient, but that can't happen if it's going to be unsafe. But equally, if the site's not safe, then they're not going to force you to get it done, so they're all ranked very highly. They actually are quite good in the way of safety standards where I work"* [Operator from this study]

In 2019, Griffith University's Safety Science Innovation Lab was engaged to investigate and trial a leadership-focussed method to improve the culture for safety in the manufacturing industry. The outputs from this research will be used by the Centre for WHS to develop a manufacturing safety culture toolkit that industry can readily use to measure, evaluate, and improve organisational culture for safety.

Manufacturing is a high-risk industry as evidenced by injury statistics around the globe. In Australia, manufacturing is a priority industry according to the national safe work authority (Safe Work Australia, 2019), which means it accounts for a higher percentage of serious injuries and fatalities than other industries. Also, workers' compensation statistics show that younger workers in manufacturing are at an increased risk of serious injury (Safe Work Australia, 2020).

These high injury and illness rates continue despite a concerted investment in the safety of technologies and work processes. Broader organisational factors like culture, climate, and leadership have thus far only penetrated the industry in a limited way, despite a strong body of research highlighting their importance.

Traditionally, manufacturing organisations have over-emphasised physical interactions between people and machines. For instance, micro-ergonomics focusses on control panels, visual displays, workstations, and physical movements of operators. Undoubtedly, these methods can result in 'quick and easy' fixes to immediate physical safety problems. However, they may fall short of dealing with deeper organisational conditions that contribute to poor safety such as safety culture, climate, and leadership.

One solution often proposed is to foster a culture for safety across manufacturing organisations. A sociotechnical approach to safety acknowledges the role of social forces like culture and leadership. Sociotechnical thinking recognises the organisation as an open and complex system, with behaviour driven by the broader social context in which work takes place (Adebiyi et al., 2009; Wilson-Donnelley et al., 2005).

The manufacturing environment is a dynamic socio-economic one, characterised by high competition, rapidly changing technologies, and fluctuating supply and demand (Moyano-Fuentes & Martinez-Jurado, 2016). Profit margins are often tight, which adds pressure when delays are experienced. With the introduction of advanced manufacturing technologies like automated robots and processing lines, safety may be affected because operators experience longer periods of monotony interspersed with breakdowns that they may not be qualified to fix, but must cope with anyway, due to lack of resources or access to specialty skills.

Competitive pressure and tight profit margins in the manufacturing environment are likely to flow through into shaping the culture for safety within the organisation. For example, taking seemingly minor risks to clear blockages from machines may become an ingrained cultural norm due to production pressures, and encourage the types of behaviours that are valued and rewarded by senior management. Rapid introduction of new technologies, like automated robots, may also create risk through interactions with the organisational safety culture. It takes time for norms and rules to develop in a culture around specific workplace hazards. Rapid innovation may introduce underappreciation of the hazards associated with automated technology, as workers operate from incomplete or inaccurate beliefs and assumptions drawn from the prevailing organisational culture.

A pathway to creating a culture for safety in manufacturing is through sustaining positive and strong safety climate perceptions over an extended period of time (Zohar, 2010), which in turn are promoted through leadership that supports and prioritises safety (Barling et al., 2002). Safety climate is a momentary and more superficial snapshot of the underlying safety culture (Griffin & Curcuruto, 2016). Safety climate is shared perceptions of policies, procedures, and practices that convey the importance and value of safety at a point in time (Neal et al., 2000; Neal & Griffin, 2002; Zohar, 1980, 2000).

Yet, safety climate is not without its controversies and limitations. In this project, we found that relying on safety climate scores alone to detect cultural shortcomings and identify areas of improvement is fraught with challenges. Reflecting the findings of others (e.g., Antonsen, 2017; Dekker, 2019), we found that dealing with quantitative and aggregated metrics of safety priority can mask important and rich variation that would otherwise signal issues worthy of exploration. Our data suggest that using a safety climate tool in isolation from qualitative techniques is akin to relying on a ruler marked only in feet, when the measurement fidelity requires centimetres.

Understanding the culture for safety in manufacturing, and identifying actionable levers for sustainable change, require going beyond the quantitative (although useful as an indicator) and

exchanging breadth for qualitative depth. In this research, we explore the tensions inherent between safety and production—two core organisational goals that are in a constant state of flux. We articulate the nature of these tensions through synthesising findings across a broad sample of workers, supervisors, managers, and inspectors, and integrating qualitative and quantitative data sources.

Within this context, the current research was guided by seven key questions, some of which revealed themselves over the course of this project as data were collected, investigated, and analysed. These key questions are:

1. What is the nature of manufacturing-specific safety climate?
2. How can safety leadership and performance be operationalised within manufacturing?
3. What are the relationships between safety climate, leadership, and performance?
4. What perspectives can be gained through exploring the tensions between safety and production?
5. How does industry 'culture for safety' influence machine operators' safety capability?
6. What differences exist in workers' experiences of safety at their workplaces?
7. What is the impact of an online safety leadership training package on safety climate, leadership, and/or performance?

This report is structured around these core questions, each of which is embedded into the results, findings, and discussions contained therein. Our intention, through this report, is to encourage manufacturing organisations to focus less on what safety culture *is*, and more on what safety culture *does*. Thus, the term 'safety culture' becomes 'a culture for safety'. A culture for safety is comprised of all the entities (e.g., people, systems, processes, and technologies) that affect each other and contribute (or detract) from overall safety capability. Therefore, a culture for safety cannot be fully understood using quantitative approaches and measures alone. Both qualitative and quantitative techniques should be used, in unison, to arrive at a more holistic understanding.

Cultural tensions of safety first

One cultural paradigm that has resonated with manufacturing and other related industries like construction and transportation is 'safety first'. Safety first is supported through slogans and campaigns, ranging from 'vision zero', to 'safety priority', through to 'work safe, home safe'. Safety

first is a cultural phenomenon stemming from the core belief that safety must take priority over competing organisational goals like production: workers must be unwavering in their commitment to safety despite the temptations to reduce workload and prevent the organisation from economic collapse (Rasmussen, 1997). Safety first emphasises the tension that occurs between production and safety. Indeed, safety is often described as a trade-off against production, meaning that without safety first, workers must choose which goal to emphasise and which to allow to languish (Reason, 2000).

Contemporary ideas in safety management challenge the utility of 'safety first' as a blanket rule. For example, scholars such as Hollnagel and Woods (2005) describe principles such as the efficiency-thoroughness trade-off and explain that safety is established through understanding the source and nature of variability (Hollnagel, 2017). Indeed, resilience engineering is based on the notion that safety is achieved through recognising and resolving trade-offs, sometimes in ways that jointly optimise competing goals like safety and production. In resilience engineering, violations, deviations and non-conformances (traditionally outlawed under a 'safety first' doctrine) are sometimes crucial to organisational resilience and success (Reason et al., 1998).

Further challenges to the 'safety first' mantra are apparent in the seminal works of Rasmussen (1997). Rasmussen argues that gradients of workload and economic viability push work systems closer to a strictly defined safety boundary, and that most safety campaigns tend to exert a counterpressure, pushing the work system back behind that boundary line and towards safe territory. This idea of a counterpressure pushing against an organisation's fundamental need to survive economically exemplifies the 'safety first' tension.

More recently, scholars such as Mitropoulos (2012) and Casey (2017, 2019) expanded on Rasmussen's original ideas by suggesting that safety can be achieved through strategies that a) enlarge the 'safety zone' in which work is conducted through better understanding and applying variability to increase resilience, b) make the safety boundary more visible to operators, and c) equip operators with the skills to recover once they cross into unsafe areas and risk is increased. Therefore, 'safety first' is just one of many cultural strategies or 'control measures' that can be used to achieve safe production. Can these approaches be helpful, or might they be seen as weakening safety capability? In this study, we delved more deeply into the data to consider how tensions are played out, and the kind of measures manufacturing organisations themselves are taking to manage these tensions, and what remedies might be considered.

In many situations, safety first can only be achieved directly at the expense of production (e.g.,

stopping a machine to remove a blockage rather than reaching inside while it is running). However, in this study, we found that the machine operation data revealed a number of situations where safety *has been* legitimately deprioritised, e.g., when a deviation or non-conformance is needed to complete the work successfully. There are also situations where safer alternatives exist, but the organisation has insufficient resources to, for example, procure state-of-the-art machinery that would avoid any possibility of injury. Even organisations with the best safety intentions will arrive at a boundary where safety first is beyond the limits of what they can achieve at that time. Clinging to the 'safety first' mantra in situations where an organisation's need for production or efficiency has been prioritised not only undermines workers' perceptions of leaders' authenticity and the credibility of safety itself (creating cynicism) but may in fact be riskier than adopting an alternative strategy. Paradoxically, in some situations, safety first can actually increase uncertainty among operators as they struggle to invent ways to achieve it in complex and demanding conditions, especially where immediate and effective action is required. The data we collected in this project suggest the reality of safety first can be counter-productive to safety if treated as an absolute: instead, it may be more practical to approach it as a tension to be negotiated, particularly at its margins.

The interview data revealed the interplay between safety and production. The evidence highlighted three categories of tension management:

a) Enablers of safety: Positive integration between production and safety
b) Unresolvable antagonisms: Inevitable tensions between production and safety
c) Inhibitors to safety: Potentials to lift the prioritisation of safety

Bringing the survey and interview data together

One major insight that became more apparent to us throughout this project was the synergy that can be achieved by integrating qualitative and quantitative data. Quantitative data trades depth for speed and efficiency — a short safety climate survey can rapidly provide an organisation with intelligence regarding the state of safety. Qualitative data emphasises detail and depth but is expensive and time consuming. Yet, qualitative data captures the micro-fluctuations, and allows the numbers to speak with words that identify specific avenues for safety improvement. Taken alone, a safety climate survey is no more than a tell-tale in the wind; it shows changes in organisational trends over time, and drastic differences to a sometimes-arbitrary group mean or benchmarking sample, but other differences may be masked when statistical methods alone are used. In isolation, qualitative data is cumbersome and can be difficult to analyse. Is there a happy medium between these two methods that capitalises on each other's strengths? We believe so.

In this project, we discovered that the high and low performing organisations, from a safety climate perspective, differed only by less than one scale point. However, by linking qualitative data to the survey responses, we amplified this difference and gave it context through elucidating the differences in language used by workers in how they described safety prioritisation at their workplace. We also found that sentiment analysis, a quantitative analysis of qualitative data, was able to verify our analysis objectively through highlighting the markedly different tone and language used by the organisations' workers. In high performing safety climate organisations, safety and production were described as simultaneously achievable, with safety folded into the fabric of how things are done. In lower performing safety climate organisations, safety and production were described as being in tension, with corporate messages regarding safety first being met with workforce cynicism and, in some instances, clear deprioritisation of safety.

Summary

There are many tensions at play in organisations, and none greater, perhaps, than the push and pull between safety and production. The data we collected as part of this project suggest there are gains to be made in exploring the nature of these tensions and the activities occurring at their boundaries and intersections. How people at different levels choose to manage production-safety tensions not only affects safety capability, but also travels throughout the organisation like a ripple effect, influencing others' and contributing to the culture for safety over time. Sometimes, the safety-production tension is unresolvable at that moment in time, resulting in temporary trade-offs that nonetheless still consider and balance competing goals in the best ways possible. To make further inroads into the culture of safety across manufacturing and improve injury outcomes, the safety-first mantra must be dispensed and instead the safety-production tensions should be explored. Approach these tensions, understand them, as well as the broader organisational context that created them, and consider the best strategy to move forward, even if it means accepting a temporary trade-off in the short term to enable long term cultural growth and safety investment.

The remainder of this report delves more deeply into the basis for these conclusions, where we outline the method, findings, and discussion.

Method

The project used a two-phase approach. The first phase provided an understanding of the industry context and development of the research tools. The second phase implemented and evaluated their effectiveness.

To recruit eligible manufacturing organisations, the study was promoted via a short film and a supporting flyer located on the Centre for WHS website. The promotion material was distributed through a range of networks, including traditional media, online media and electronic direct mail (EDM) to industry contacts. Traditional media was restricted to an article in the Manufacturing Industry Magazine. Online media included social media posts on the Centre for WHS's Facebook, Twitter and LinkedIn profiles as well as mentions on the SafeWork NSW Safety Wrap blog. EDM's were sent to the Construction, Forestry, Maritime, Mining and Energy Union; Australian Manufacturing Workers' Union; and other industry contacts supplied by the Centre for WHS and Griffith University.

Contact details of manufacturing organisations registered in Australia were obtained from the Australian Business Register. Those with email addresses were invited via an email, including a link to the Centre for WHS website where they could register their interest in participating. A sample of those who had provided phone numbers was reached via a phone call. The research team also tapped into manufacturing networking meetings conducted by Workplace Health & Safety Queensland and SafeWork NSW. Out of the 106 manufacturing organisations that registered their interest, 70 matched the eligibility criteria of having a minimum of four workers (LeBreton & Senter, 2008) and operating in the wood or metal manufacturing industries.

Once recruited, 60 interviews were conducted with manufacturing workers, managers and safety personnel. These personnel volunteered by responding to a message broadcast by each organisation's management team on behalf of the researchers. The interviews also included inspectors from SafeWork NSW. The sample size is in line with other published examples of safety climate scale development (e.g., Huang et al., 2013). The interviewees were asked about their experiences relating to machine operation and safety behaviours by workers, supervisors and managers. They were also asked about the priority placed on safety compared to other work goals, and their interpretation of others' actions and behaviours (for a complete list of questions, see Appendix).

The interviews were synthesised to develop a suite of manufacturing-specific measures: a safety

climate scale, a safety leadership scale, and a safety performance scale (i.e., safe and unsafe machine operating practices). The scales were validated using an online survey panel. Of the 687 Amazon Mechanical Turk users who responded to the online survey (MTurk is a crowdsourced online survey panel platform that offers $1USD reward upon survey completion), 564 satisfied the criteria for inclusion (i.e., employed on some basis within the manufacturing industry); 90% were employed on a full-time basis, 8% on a part-time basis, and 1% on a casual or contract basis. MTurk respondents reported working in manufacturing for an average of 9.1 years (standard deviation was 8.27 years). Feedback on the draft survey items was also sought from SafeWork NSW inspectors and project staff, with item wording changes incorporated into the final version.

An online leadership training course was developed to assist improvement of safety culture. The training incorporated topics and stories from the interviews and was pitched as an educational experience for leaders that concentrated on soft-skills, including persuasion, influencing, recognition, and advanced communication skills. The training also briefly covered contemporary safety science topics including leading indicator measurement and 'Safety-II'. The intention was to provide a broad array of learning experiences that would appeal to as wide a group of leaders as possible. The online learning platform Udemy was used to host the training materials given its suitable IT infrastructure and user cost-free business model.

The second phase comprised implementation and evaluation. Baseline data on safety climate, safety leadership and safety behaviours were collected via the survey tool from two groups of 35 participating organisations, separated in time by approximately three months. Both online and hardcopy survey options were offered. The original two-wave design was used to demonstrate replication of the training effects in a second similar group, and to use the second group as a control for the first group (as per the rolling groups design methodology; Cigularov et al., 2008; Quinones & Tonidandel, 2003). Both groups were provided with the online training link and asked to distribute it to their staff internally. Unfortunately, limitations with the Udemy platform prevented tracking and follow-up of individual staff participants, so the organisations had to be relied upon to disseminate and promote the training themselves.

After baseline safety climate measurement and approximately two-three months to implement the online training, a follow-up safety climate measurement was conducted. The organisations were given the survey materials again to distribute internally to their staff. Given the attrition experienced throughout the study, the two waves were collapsed into one group consisting of 15 organisations, and before and after scores compared statistically at the organisation level (i.e., aggregated safety

climate, leadership, and safety performance). Despite the attrition throughout this study, the final sample size of 15 organisations is sizeable compared to other published studies. For example, a study by Payne et al. (2010) investigating the 'shelf-life' of safety climate assessments, drew on data from 62 sites contained within just one organisation. Another study validating a new safety climate measure used a small sample of only three organisations (Beus et al., 2019). In general, there is a dearth of industry-level research that includes data from multiple organisations.

Finally, interviews were conducted with participants and 'drop out' organisations to evaluate the research materials and process. These interviews were designed to elicit details regarding experiences participating in the study or reasons for not participating, and to identify additional support or tools and resources that would be beneficial to improve safety culture. Thematic analysis was conducted on the interview data to identify similarities and points of difference.

Mixed methods analysis

One advantage of collecting both qualitative and quantitative data throughout this project is the potential for powerful mixed methods analysis. Mixed methods research involves the integration and synthesis of both forms of data; in this case, combining survey and interview responses to deliver greater insights than what would be achieved using either in isolation. Throughout data collection, we captured basic demographic and identifiable information (in the form of a deidentified organizational code), which allowed us to match interview transcripts to organisational safety climate survey data. After eliminating SafeWork NSW Inspectors from the participant pool, 80% (41) of the interviewees were able to be linked with corresponding organizational safety climate data.

Honing in on culture through the interview data

The interview data was analysed by applying a New Materialism (Fox & Alldred, 2017) lens and methodology. The New Materialism approach treats organisational culture as a macro-level phenomenon, and focusses on the interactions and interrelations between objects, people, and non-tangible things like ideas, aspirations, and memories. Culture is thus in constant movement as these interactions ebb and flow and take on alternative forms. In this analysis, culture was treated as an industry-level phenomenon, and scanned for patterns and differences that were common across multiple organisations.

Practically, 'entities' (objects, people, things) that exert affects on each other were identified. For example, disciplinary processes (an organisational entity), personal protective equipment (PPE; a physical entity), and health and safety representatives (HSRs; a human entity). Every relevant

statement that referenced an affect from one entity to another was coded (in terms of whether the affect was to increase, decrease, or maintain safety capability), which collectively describe the industry culture for safety in manufacturing. For example, cranes can exert an affect over operators that increases safety capability by highlighting a danger of suspended loads and increased vigilance (e.g., checking strapping, slings, and equipment functionality). Cranes can also decrease safety capability when new or untrained operators are using them, which in turn causes supervisors to step up their monitoring of operations and engage in informal on-the-job training where required.

Stories related by operators, and others, highlight the flow of affect between entities, the micropolitics of given situations. These can be diagrammed to give a visually interpretation of the flow of enabling and limiting affects, to provide insight into specific interactions.

The qualitative method used with the interview data was extended to include our Proxy Analysis tool, derived from research by an author of this report (ni Ivor), as part of her doctoral thesis (unpublished). The tool is based on the self-inquiry process and proxying technique of Shankarananda (2008), enabling us to explore our own feelings in response to the interview transcripts, and those of the interviewees. By identifying our own feelings as researchers, we gained clarity around our own responses to the safety attitudes that we as researchers encountered in the manufacturing organisations. Through understanding the feelings of interviewees, we get insight into the beliefs and attitudes that affect the behaviours of individuals and the flows of affect that influence organisational culture. The specific proxying process also enables us to reframe the feelings to be more beneficial and provide ways to expand safety capabilities, which point the way to hopefully more effective and targeted training and safety practices. We found that the proxying process highlights inconsistencies in thinking and feeling and the potential solutions these inconsistencies raise. The findings for this report focus on the interviewees, and our own learnings around safety needs. In discussing our findings, all interviewees have been given a pseudonym to protect their anonymity.

Developing measures of safety leadership, safety climate, and safety performance

Safety leadership is typically measured using an adapted transformational leadership scale (Barling et al., 2002), with traditional leadership items supplemented with the word ‘safety’. Although many researchers use Barling’s et al (2002) survey tool, it captures only a narrow suite of behaviours that are relevant to safety leadership. For instance, in their recent review of safety leadership, Donovan et al. (2016) found that a range of different leadership theories have been applied to safety, including: transactional, transformational, empowering, authentic, servant, and leader-member exchange.

Further, a generic or general leadership model may not be accepted in different industries because the target behaviours do not fit within the existing macro-level culture (e.g., if 'transformational' leadership is not an accepted practice or way of doing things in the industry, it is less likely to be adopted).

A similar argument is applicable to safety performance measurement. Often, general behaviour scales are used to measure safety activities, such as Neal and Griffin's (2002) generic safety compliance and participation scales. Such items include: "Wears all appropriate PPE according to the site safety plan" and "Complies with all relevant safety rules and procedures". These generic items could reduce response variability as compared to more specific and nuanced items (e.g., people may tend to 'agree' with all items if they are worded in general terms). In other words, general safety behaviour items may 'average out' differences in responding, resulting in a skewed distribution of answers where most people provide the same response. Statistically, there is less chance of finding a meaningful relationship between predictors and outcomes like safety behaviour in this situation.

Safe operating behaviours covered a spectrum of both compliant and proactive practices, which is supported by studies that have shown safety performance requires going beyond compliance. For instance, Neal et al. (2000) were the first to differentiate safety compliance from safety participation (going beyond minimum role expectations) and found that both types of behaviour were related to workplace accidents. This line of thinking draws on the work of Borman and Motowidlo (1997) who argued that job performance is comprised of both task and contextual performance. A plethora of studies have since shown that accidents at work are predicted by combinations of compliance and proactive safety behaviours (Christian et al., 2009).

With these considerations in mind, industry-specific scales of safety leadership and machine operating behaviours (both safe and 'at risk' types of behaviour) were developed. Interview data were coded for specific instances of safety leadership and machine operating practices. Themes were identified in these data and survey items written to measure both types of behaviour.

Further background information regarding safety leadership and safety behaviour is shown in the Appendix.

Contextualisation of the dataset

Within the dataset of organisations, we identified three high performing and three lower performing organisations as determined by their organizational safety climate scores. These organisations also had multiple interviewees at worker, supervisor, manager, and/or safety manager levels, which

provided a rich picture of the state of safety from a qualitative perspective. We concentrated our analysis on the responses to a single question within the interview set: "How is safety prioritized relative to other organisational goals such as productivity, efficiency, quality, profitability?". Table 1 shows a summary of characteristics for this combined dataset.

Table 1: Safety climate measures for three highest and three lowest performing organisations

Organisation Code	Category	Safety Climate Level	# Survey Respondents	Interviewees
JHAYU	High performer	6.31	3	Operator Supervisor x 2 Manager
LBCYS	High performer	6.24	3	Operator Supervisor x 2 Safety Manager
PIXRH	High performer	6.04	22	Operator Supervisor Manager Safety Manager
7B3S4	Lower performer	5.35	7	Supervisor Safety Manager
PBY0H	Lower performer	5.63	10	Operator Supervisor Manager
WMMME	Lower performer	5.69	10	Operator Supervisor Manager Safety Manager

The average safety climate level for the 'high performing' organisations was 6.20, and the average level for the 'lower performing' organisations was 5.59. The grand mean (across all participating manufacturing organisations at baseline) safety climate level was 5.96, with a standard deviation of 0.52. Converting these scores to standardised values, it was apparent that none of the organisations differed at a statistically significant level from this grand mean (either above or below this average value).

Interestingly, as shown above, none of the organisations differed from the group mean at a statistically-significant level. However, inspection of qualitative responses revealed markedly different content when it comes to describing the priority of safety within the organisation. Details regarding how each group of organisations differed in their qualitative responses overall are

summarised in the sections below.

Sentiment analysis uses algorithms to quantify the tone of written language into a spectrum that ranges from positive to negative. One algorithm ranges from -100 to +100. A sentiment analysis performed on the verbatim text responses from these participants revealed overall a fairly positive score (28.8 / 100; Soper, 2020). The same analysis performed on the verbatim text responses from participants in lower performing organisations revealed a generally negative tone, with a sentiment score of -19.4 / 100 (Soper, 2020). We used this information to justify further exploration of the data within and between these groups of organisations.

High Performing Organisations

This group of organisations tended to describe safety priority in terms of being either superior to other goals or integrated and complementary to other goals. For example, an operator at one high performing organisation said: "*safety is definitely the number one priority*" and described an example of management reviewing an innovative solution and then denying it, based on safety concerns, which illustrates a clear emphasis on safety over other goals. Another described safety as being a completely enfolded part of the way the business operates:

> "*I would describe it as part of our fabric. It [safety] goes one hand with the other [goals]. We don't ask anyone to do anything unsafe or outside the realms of their job.*"

Other respondents appeared to be more grounded in their responses with respect to acknowledging the importance of production for business survival, such as this manager from a high performer:

> "*I think it's probably equivalent to the rest of them [goals]. Obviously, we're a business and we need to make money. But at the same time, we need to keep safety in the forefront of everyone's mind. So, we do make it a priority as well*."

Lower Performing Organisations

Across the lower performing organisations, the nature of participants' responses changed dramatically. Although some did mention phrases such as 'safety as a priority' and even 'safety first', the nature of their language qualified these statements, sometimes quite cynically.

The exchange between interviewee and interviewer below highlights a cynical view of safety first from a safety manager at one of these companies:

Interviewee:	With our culture, unfortunately productivity comes first.
Facilitator:	Although you said before that they say safety is a number one priority?
Interviewee:	Yep.
Facilitator:	I see.
Interviewee:	So that's the message coming from corporate, it comes from our bosses but really, on the floor, no.

Others mentioned that safety is a priority, but tended to focus on extrinsic constraints or requirements, and tended to describe safety as being in tension with other goals or priorities such as production, as this statement from a supervisor shows:

> "*Yeah, because we have a strict rule on safety, safety first. Our company, the company strictly [taught/talked] to us before, telling us that we should obey and respect the safety rules.*"

Others from this group of companies emphasised that safety is done to avoid personal liability or fines from regulators, such as this operator:

> "*All the way down to the worker, we're all responsible now, and the worst thing about it is, we can all be fined. Where if it's going to hit somebody in the head, if it's going to hit somebody in their wallet, everybody starts to think*".

Finally, some respondents wished to express that the company culture is 'trending in the right direction' with respect to safety prioritisation, but has not completely achieved a desired level at this point, such as this supervisor:

> "*There are still a few accidents, slightly outside of what you would call 100 per cent safe, but the ridiculous things don't happen anymore. So, if you wind back five to 10 years, there were things that would end in a fatality if it went wrong. Whereas now there's nothing that would come even close, no job's worth that. But then maybe a slight personal risk is taken which probably should not be taken, but that's what I mean, the culture's heading in the right direction. It's probably 75 % there and not 100 %*".

Results

The following key research questions guided the conduct of this project:

1. What is the nature of manufacturing-specific safety climate?
2. How can safety leadership and performance be operationalised within manufacturing?
3. What are the relationships between safety climate, leadership, and performance?
4. What perspectives can be gained through exploring the tensions between safety and production?
5. How does industry 'culture for safety' influence machine operators' safety capability?
6. What differences exist, if any, between young and old workers' safety perceptions and behaviours?
7. What is the impact of an online safety leadership training package on safety climate, leadership, and/or performance?

Each of these research questions is answered below with reference to evidence collected throughout this project and the extant research literature, where applicable. However, to contextualise these findings, due to some of the patterns we saw emerging, we decided to carry out mixed methods analysis between the interview data and the quantitative measures.

RQ 1 What is the nature of manufacturing-specific safety climate?

To validate and shorten the preliminary safety climate scale (from an original list of 35 items), data were collected from an MTurk sample. MTurk is a web-based crowdsourcing platform that enables researchers to gather survey data in exchange for a minor fee per person. After eliminating inattentive and acquiescent respondents, there were a total of 497 valid cases. The Stanton et al. (2002) scale reduction procedure was used to shorten the list of items down to a more practical amount (less than 20). The procedure requires at least four inputs — standardised factor loadings, internal consistency reliability alphas, pairwise correlations with an established measure, and expert ratings of each item's adequacy. Items were rank-ordered based on these metrics, and the top 15 items were selected, ensuring adequate depth and breadth to validly and reliably measure safety climate in manufacturing environments.

In the preliminary validation survey, an established measure of safety climate from NIOSH was included (Hahn & Murphy, 2008). This short safety climate scale includes just six general items and is designed to be used as a quick 'pulse check' regarding the current state of health and safety within

a workplace. The correlation between the manufacturing safety climate scale and the NIOSH scale was 0.85 (ranges between -1.0 and +1.0). This result suggests that the new manufacturing safety climate scale is measuring a similar phenomenon to the shorter NIOSH scale. Exploratory factor analysis (EFA) including both scales in the model further validated the new scale. Only one factor emerged, which indicates that the combined pool of items (full manufacturing safety climate scale and NIOSH short safety climate scale) is measuring the same underlying phenomenon (i.e., safety climate).

However, while exploratory analyses with the validation sample (the MTurk respondents) identified a single overall safety climate dimension, analysis of the baseline manufacturing sample identified that a two-factor solution fit the data best. The first dimension was labelled 'management safety commitment' (11 items) and the second dimension was labelled 'training and competency' (4 items). Together, these two dimensions comprise manufacturing-specific safety climate.

Management safety commitment items cover a range of topics, which include the following:

- Allocating adequate resources to machine safety
- Initiating safety-related discussions with workers
- Balancing production pressure appropriately
- Developing and supplying appropriate machine safety procedures

Training and competency items focussed on ensuring adequate skills and supervision to use new machines, and for new workers to 'learn the ropes' through support from experienced workers and leaders.

The data were then subjected to a more thorough test of factor structure using confirmatory factor analysis (CFA). The CFA provides fit indices and also models the error variance of individual survey items. It is a more robust test of the dimensionality of the research scale than EFA. The CFA confirmed that a two-dimension model fit the manufacturing baseline data the best (for more technical details, see Appendix).

An important feature of safety climate is that it is a group-level or 'shared' construct. In other words, if the scale is functioning correctly, people within a given organisation should share consistent and coherent perceptions of safety through being exposed to the same types of policies, procedures, and practices within the organisation. Consequently, there are a suite of metrics that can be used to evaluate this 'sharedness' property of safety climate.

As shown by Figure 1, the participating organisations with greater than four respondents (the

minimum for calculating a climate-like variable; LeBreton & Senter, 2008), generally had similar levels of safety climate when aggregated to the organisational level. There was also little variation between organisations, which was reflected by the between-groups statistical testing conducted (the differences between organisations were not statistically significant).

This result means that within organisations, on average, people tended to provide similar perceptions and generally agreed with each other about their experiences. These metrics suggest that the safety climate scale is performing well *within* organisations and that the safety climate scale could be represented by an overall organisation-level metric that exhibited favourable properties.

Across the participating manufacturing organisations, the overall levels of safety climate were also generally high. This result may be due to the voluntary nature of the study, with organisations already performing well being more likely to participate. Another possible reason for the generally high scores received is social desirability bias, whereby respondents were completing the survey on computers in the presence of managers or other team members (e.g., where a single computer is available for staff to use in an office area). Attempts were made to mitigate the effects of such bias by providing each organisational contact with a list of recommended survey administration practices (see Appendix).

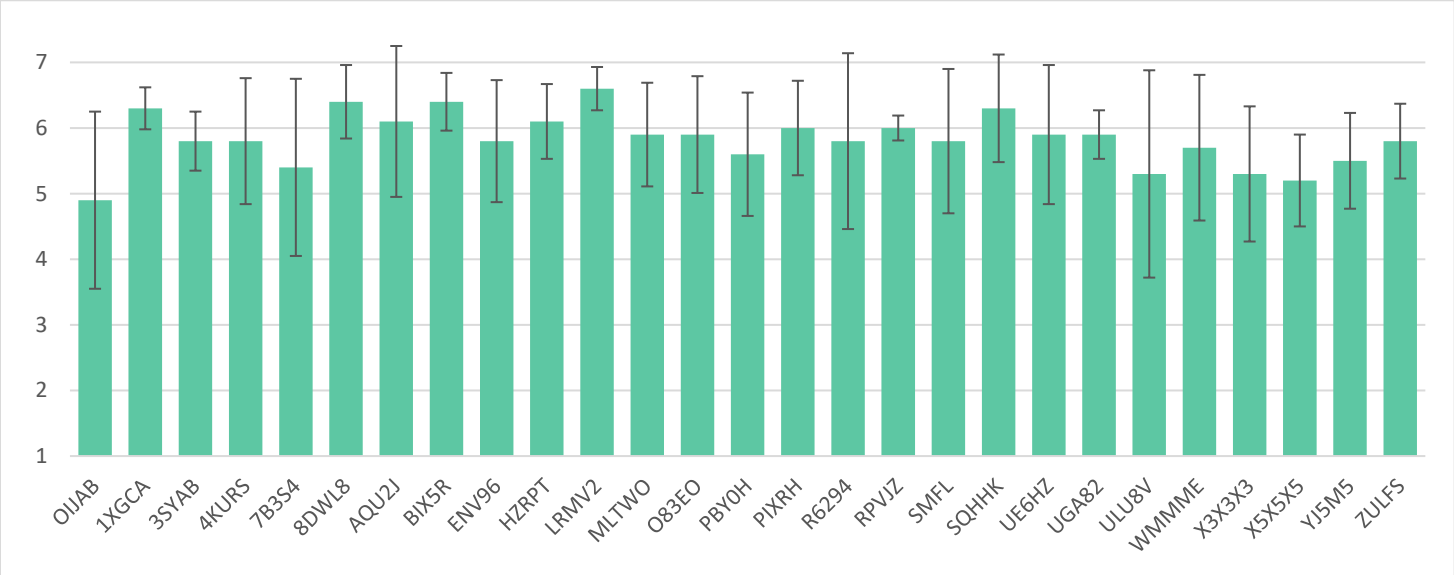

Figure 1. Organisation-level safety climate scores across the participating cohort (group average was 5.8). Note: Error bars represent +1 and -1 standard deviation around the mean and indicate the spread or variability of scores within each organisation.

RQ 2: How can safety leadership and performance be operationalised within manufacturing?

Analysis revealed that safety leadership was best represented by a single factor or dimension, but with distinct behaviours that covered a broad spectrum of general leadership theories. As only one dimension emerged from the analysis, it suggests that workers tend to make global or overall assessments of safety leadership rather than more nuanced ratings of individual behaviours (i.e., workers see leaders as being either overall 'good' or 'bad' safety leaders). This result could be due to the use of a lengthy survey questionnaire; more detailed and varied ratings might be apparent if the safety leadership scale were to be used by leaders as a self-assessment reflective tool or as part of a 360-degree assessment of an individual leader.

Behaviours measured by the safety leadership scale span all major theories of general leadership, and include:

- Transactional leadership: Correcting poor safety performance, observing and monitoring safety activities.
- Transformational leadership: Develops positive relations, actively participates in safety activities.
- Empowering leadership: Educating workers, encouraging consultation and active input into decision-making.
- Leader-member exchange: Develops positive relationships with workers.

The Appendix contains the final safety leadership survey items.

Table 2 shows the most and least positive safety leadership behaviours across the cohort group. In general, senior leaders could spend additional time on the floor interacting with operators, delivering safety-related discussions and generally being visible to workers.

Table 2. Most and least frequent safety leadership behaviours across the cohort.

Safety leadership behaviour	% agree that leader demonstrates the behaviour	% disagree or undecided that leader demonstrates the behaviour
Talks about safety during team meetings	93%	7%
Explains the reasons why operators need to adhere to machine safety requirements	90%	10%
Encourages machine operators to suggest what to do about a safety issue	90%	10%
Verifies that machine operators are adhering to safe standards of work	89%	11%
Asks machine operators for their input into safety procedures	89%	11%
Participates in workplace safety activities and initiatives (e.g., committee meetings)	89%	11%
Educates workers on the benefits of working safely with machines	88%	12%
Encourages machine operators to share their views on how machine safety should be achieved	88%	12%
Makes it known that machine operators can stop or refuse the job if it is unsafe	87%	13%
Interacts with machine operators and listen to their concerns about safety	86%	14%
Takes the time to develop a positive working relationship with machine operators	86%	14%
Walks around the shop floor observing machine operators' safety	85%	15%
Gathers operators together to talk about machine safety	81%	19%

The safety performance (machine operating behaviours) items were split into two groups: 'safe' and 'at-risk' behaviours. Interestingly, most safety behaviours identified from interviews concentrated on compliance. This result may be a cultural artefact of the manufacturing industry, where it is common to see highly routinised, standardised, and over-specified jobs. Further, there may be a tendency within the industry to rely on procedures as a tool to upskill and control the behaviours of workers, as opposed to training and other initiatives designed to build expertise and adaptability.

Safe machine operating behaviours comprised the following practices:

- Wearing of personal protective equipment
- Speaking up and disclosing safety issues or potential concerns with machinery (e.g., vibrations and noises)
- Showing care and concern for other operators
- Complying with procedures and standards

Unsafe or at-risk machine operating behaviours related primarily to the removal or modification of guarding or safe machine processes, such as:

- Reaching past moving parts to clear blockages
- Removing or modifying guarding
- Failing to adjust or change machine guarding based on the materials being worked on
- Failing to reset the machine guard to its original position after working

Table 3 shows the most and least frequent machine operating behaviours across the cohort group. Generally, the safe machine operating behaviours were positively skewed, which might have been due to a social desirability response bias. Interestingly, the unsafe or at-risk operating behaviours were fairly prevalent across the group. For instance, 20% of the respondents said they reach past dangerous parts of a machine to clear blockages.

Table 3: Most and least frequent machine operating behaviours.

Machine operating behaviour	% sometimes, mostly or always demonstrate the behaviour	% never or rarely demonstrate the behaviour
Tell a supervisor if anything about the job seems unsafe (e.g., faulty machine)	98%	2%
Keep a watch for signs of any problems with machinery and the surrounding environment	99%	1%
Show concern for the safety of other machine operators	100%	0%
Report any examples of damaged or missing personal protective equipment	97%	3%
Make sure all machinery safety devices or controls are working as designed	99%	1%
Discuss the details of any out-of-the-ordinary machine job with others before getting started	97%	3%
Follow all workplace safety plans (e.g., SOPs, SWMS)	100%	0%
Make sure the machine is setup correctly before starting work	100%	0%
Focus attention on the machine operation task	99%	1%
Use safe lifting technique for all manual handling tasks	99%	1%
Wear all required personal protective equipment required for machine operation	100%	0%
Reach past a dangerous part of an operating machine to clear a blockage	80%	20%
Remove any machine guards that stop or slow down production	90%	10%
Take a guard off a machine to make it work faster	92%	8%
Move a guard out of the way to access inside the machine and keep it running	93%	7%
Set the adjustable machine guard to the maximum size rather than adjust to suit every piece	87%	13%
Forget to return a machine guard back to its original position before carrying on with the next task	87%	13%

RQ 3: What are the relationships between safety climate, leadership, and performance?

Analysis revealed that the correlation between management safety leadership behaviours and safety climate scores were very high (r=0.86). Further, the EFA revealed that all but two of the management safety leadership items loaded onto the safety climate scale. This result means that there was inadequate discrimination between the leadership and safety climate items (i.e., the respondents answered all these items in a similar way). Finally, when examining the relationships between safety climate, safety leadership, and behaviour, safety climate was a stronger predictor of behaviour (i.e., an increase in safety climate produces a greater increase in safety behaviour as compared to an increase in safety leadership). Consequently, safety climate was the focus of predictive analysis.

Figure 2 shows the relationships between manufacturing safety climate and safety performance (safe and at-risk operating behaviours). The results show that organisations with a more positive safety climate tended to have more frequent safe machine behaviours, but the frequency of at-risk machine behaviours did not depend on safety climate. However, a closer and more detailed analysis of individual at-risk behaviours revealed that poor safety climate did significantly predict taking off machine guards to make a machine work faster and increase production, but not the remaining at-risk behaviours. Consequently, manufacturing safety climate likely predicts at-risk machine behaviours that concentrate on production at the expense of safety, but not behaviours that are driven by more proximal human factors, like individual attitudes, competence, or inattentiveness.

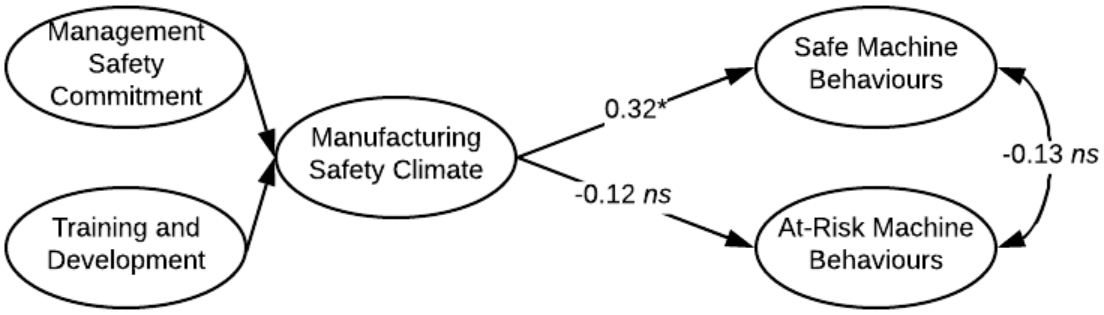

Figure 2. Relationships between safety climate and safety behaviour.
Note: An asterisk indicates the relationship was statistically significant at a p<0.01 level, and ns means the relationship was non-significant (i.e., it could have occurred by chance and so is unlikely to be meaningful).

RQ 4: What perspectives can be gained through exploring the tensions between safety and production?

Core to the culture for safety in the manufacturing industry is the notion of safety first, and our discussions with participants revealed that it is as an underlying dynamic tension. These tensions are less visible in larger and more successful organisations where safety practices are deeply embedded in all decisions ranging from procurement of machines, to work practices, and ongoing training programs. However, in smaller, less successful organisations, the data indicated the tensions are more evident: the feelings were that production must often be the top priority otherwise the organisation would not exist. In some cases, it was difficult to ascertain where safety came in priorities. Interviewees talked about safety being a 'very big concern' but efficiency and productivity being the main priorities. Others described the tension more directly, indicating the managers concern themselves with organisational survival, and the workers concern themselves with completing the work safely while keeping their job. The result in these safety deficient organisations is a seesawing action between production and safety priority — managers driving faster, cheaper, more profitable outcomes, and workers pushing back against being asked to do things that are risky.

Manufacturing organisations exist through a dynamic interaction of production and safety priorities. In reality, safety and production dance an intricate pattern of lifts and dips, sometimes in unison, sometimes in opposition, and at times can challenge the organisation's purpose for existing. Organisational culture can be conceptualised as a dynamic interrelation of entities, people, objects, things, that influence each other in a continually-shifting pattern of relationships.

In the sections that follow, we summarise three manifestations of safety first in manufacturing organisations. The first is where safety and production have been integrated. Safety first has been 'folded in' to the production territory, meaning that safety supports and enhances production. The two are equal priority and complementary rather than prioritised over each other. The second is where tensions between safety and production exist, and these tensions are permitted. The third is where safety has clearly been deprioritised to a level that increases risk. The nature of the production territory is one where production trumps safety, and there is a safety 'hole' in the fabric that is best compared to the concept of a latent condition (i.e., a decision, action, or hazard that goes unnoticed or ignored but can trigger a disaster).

The following analyses highlighted three categories of tension management:

a) Enablers of Safety: positive integration between production and safety
b) Unresolvable antagonisms: inevitable tensions between production and safety
c) Inhibitors to safety: potentials to lift the prioritisation of safety

a) Evidence of the enablers of safety: Positive integration between production and safety

Choosing the customer based on safety

Some managers disclosed that safety is prioritised to the point of choosing specific customers based on their effects on safety within the manufacturing organisation. In these instances, managers make the decision to pass on the work to others or cut the job short to eliminate the risk of undue customer pressure, production-first mentality, or other demands that are unrealistic and dangerous. For instance:

> "*if they come to the conclusion that the risk is too high, and there is a potential for harm or injury, they would rather put the job away. They'd then give it to another customer*." [Operator]

> "*If I'm quoting a job, I will make sure I allow a few hundred dollars to come up with the SWMS first - safe work method statements - first before we start the job. I charge the client for that. In my view, I'm charging - I am charging a client to work safely so that we can work safely*." [Supervisor]

> "*I guess our values, our core values within our business. One is customers and one is safety, and we know that we can't have one without the other. So, safety does take a front seat in everything we do*." [Manager]

Evaluating the risk of innovations

Some managers talked about evaluating the risk of innovations before approving their implementation. In this instance, managers and supervisors form a vital layer of defence against new solutions that may carry increased risk. Potentially, workers may miss hazards that are introduced by new designs, processes, or activities. Such risk assessment by management is likely to be deemed as an example of management's safety commitment. For instance:

> "*they [management] decided to go against it [our idea with wheels] and put safety over the [efficient] priority in order to make sure no one gets hurt, which now obviously has cost us efficiency and time*." [Operator]

A culture of taking the time to be safe

The manufacturing environment conveys a sense of production pressure. Process lines run on the basis of throughput, and there is an emphasis on time and efficiency. Thus, the pressure to produce as a baseline aspect of the manufacturing culture is likely to be strong. Safe manufacturing organisations appear to challenge or balance this environmental pressure with cultural norms and expectations around taking the time to be safe. For example:

> "*safety's always the priority anywhere I've worked, to be honest. No one wants to see you rush to get something out and lose a finger. Take your time, be careful of what you're doing and that's the same here as anywhere else I've worked as well*." [Operator]

Safety is everyone's responsibility

Rather than being pushed down as an individual with responsibility to which workers are held accountable, safe manufacturing workplaces suggest that safety is a shared responsibility. Everyone at each level of the organisation plays their part in being safe, creating a collective sense of mission and purpose. For instance:

> "*so, it's not only the supervisors, the operations manager, the directors, it's everybody. It goes all the way down the line*." [Operator]

> "*We basically have the attitude that it is anybody's prerogative to stop the job. If they feel that there's something not quite right, they're more than free to stop the procedure. We'd discuss it and if they are happy to continue we continue, if they're not happy we find a different way of doing it. Even though it's my money out of my back pocket I would rather stop and discuss the task at hand again or change what we're doing so that everybody's happy*." [Supervisor]

> "*What it actually means is that we care about each other*." [Manager]

Folding safety into machinery and process

Workers and Inspectors described modern machines that use design features to enforce a safety-first approach — legitimising stop work activities due to crossing a risk threshold. Workers saw these features as generally helpful to create safety over production, describing innovations such as guillotine designs that prevent fingers from entering dangerous spaces, and light curtains that automatically shut off machines when penetrated.

> "*...we don't talk about how to do things safely because it's already set up in the workshop that we can't do it in an unsafe manner*." [Supervisor]

Culture change requires 'the intangibles'

Inspectors from SafeWork NSW talked at length about the importance of building a culture of safety first but acknowledged that many manufacturing managers and owners may lack the knowledge to do so. The inspectors described a mindset of focussing on the tangible to drive improvements—buying certain machines to increase output, putting in place physical procedures and resources, redesigning a workspace to reduce ergonomic challenges. Yet, the building blocks of a culture are mostly intangible—communication, leadership, attitudes, and beliefs.

> "*I think they all acknowledge that they can improve but they just seem to lack the tools or the mentoring or the ability to actually make it happen. For example, if you were a manufacturing business and you needed to make extra widgets, you just go and buy another widget machine. … If you want to change the safety culture, you have to rely on a consultant, perhaps. That gives you a lot of generally intangible stuff.*" [Inspector]

Changing societal values

Forces outside the organisation can nevertheless influence the culture inside the organisation. Respondents talked about the changing industry culture that has resulted from broader societal expectations and values around safety. Specifically, there was consensus that society no longer thinks that injuries at work are acceptable:

> "*in this day and age, it's not accepted to have any major injuries. Potentially, it's we don't want anyone going home in any other condition than they did coming to work.*" [Operator]

Safety is 'good for business'

Managers and supervisors resolved the inherent tension between production and safety through a belief that they are mutually reinforcing. Safety was described as being 'integral' to production and suggested that there is an equivalence in priority rather than one being above or greater than another. Some managers described the overlap between production capabilities and safety capabilities, particularly in relation to training and machinery maintenance — that both aspects contribute simultaneously to production and safety. This was also noted by inspectors and recognised through the processes like pre-starts.

"*managers and senior executives realise they're accountable for production but they're accountable for the health and safety of their workers; having well-maintained, trained workforce, you're going to maintain your output and you're going to prevent people or minimise the risk of their workers getting injured*." [Inspector]

"*Safety not conflicted with productivity: I'm thankful that they feel about on par because it is recognised that productivity and efficiency and safety are not unachievable together, and in fact they are, or do, they complement one another. So, by improving standards of safety and by reducing the number of incidents, you are reducing your lost time, you are reducing your unnecessary costs, your premiums*." [Safety Manager]

"*I've come to realise that the safety meeting and the pre-start is actually beneficial to my productivity as well as the safety. Everybody understands what their task is, how they're going to go about it and what they need to safely perform that task. The productivity in a lot of cases - not always, but in a lot of cases - is better because everybody understands what the task is*." [Supervisors]

b) Evidence of unresolvable antagonisms: Inevitable tensions between production and safety

We identified several places where there are seemingly unresolvable tensions or where resolutions are not immediately available, and hence need to be accepted for the time being. These will exist in any sort of organisations — ones trying to stay ahead of safety as well as those who are lagging.

Production over safety

Several managers, and even safety managers, acknowledged that their organisation prioritised production over safety. They described safety being higher in priority than in days gone by, but still subservient to production. Business size, profitability, and access to resources likely accentuates this tension, with smaller operators potentially finding themselves trading off production against safety more often than those with greater capacity to absorb upfront costs and delays:

"*it [safety] does need to be a bit more of a priority and taken a bit more seriously in some aspects. But it's up there. It's not down at the bottom where I believe it used to be, but it's still below productivity and making a profit. For example: just with the safety training being put off for a couple of months to ensure that we don't cut into production time*." [Manager]

Experienced operators applying their skills

Older and more experienced operators seem to have less time for safety, and may appear on the surface to deprioritise it, but nevertheless seem to be involved in fewer injuries. Although the

mechanism for ensuring safety is unclear, respondents' statements ranged from it being a case of luck, or change, that older workers haven't been injured, through to complacency, through to the application of their superior skills:

> "*Yeah, production and time but a lot of it can be the culture in the workplace. It's just we've been doing it this way for years; we've never had a problem.*" [Operator]

One inspector questioned the attitude and belief:

> "*Not sure there's an answer to operators removing guards to work faster. Do they actually believe it is safer for them with a guard?*" [Inspector]

It is possible that as experienced operators apply their skills, they can skirt the edges of the safety boundary more effectively than newer workers, so they have less need for standardised procedures and ways of working.

Proactivity can impact safety

Operators may believe they are doing the 'right thing' when removing guards and manually clearing blockages — their sense of risk in doing so is reduced and they believe that the momentary danger is outweighed by the production demands and requirements. Manufacturing organisations would likely desire to capture this proactivity and redirect it:

> "*there would be an operator saying, 'well rather than calling this in to get a maintenance personnel or just somebody, who's authorised to really open up this machine and look at it. I feel like I can do it myself and just clear a blockage myself because that's quicker and easier and then we can keep the production line moving'*." [Inspector]

> "*Then again, because they're rushing, they take shortcuts, so they'll skip pre-starts, they'll skip take-fives*." [Safety Manager]

> "*That would be either not doing it to procedural work instruction or short cutting*." [Manager]

c) Evidence of inhibitors to safety: Potential to lift the prioritisation of safety

Production before safety

Several examples were shared where the production-safety tension was resolved squarely in favour of the former. Aspects of fear and bullying were apparent in some of the statements made by workers, with respect to managers exerting power and control over them to drive production at the expense of safety. For example, threatening workers either directly, "you'll

lose your job", or indirectly, "this place will close down because safety costs too much money", as reported by an Inspector.

Another driver of the production mentality was self-legitimisation; in other words, managers or owners justifying to themselves and others as to why safety was unable to be prioritised.

> "*Lots and lots of little things like that, just costs money and it's just a money-making thing. We're all for safety, but [you know] you can go too far sometimes*." [Manager]

> "'*I can't afford this; it's going to cost me too much or that's not my problem; we've told them how to do it safely'*." [Inspector telling of what managers say in the workplace]

Production may also be prioritised out of ignorance of the core issues relating to machine guarding, or otherwise a lack of technical knowledge to fully appreciate the risk to workers: a "blindness" to safety issues by many in the process particularly in machine guarding requirements.

> "*When they installed that, the fencing and everything that came with it, it didn't go anywhere near meeting our local workplace health and safety requirements. Until that was pointed out they really didn't see that as an issue. You could actually roll under the fences because they were that high off the ground as well.*" [Operator]

Production-oriented Key Performance Indicators (KPIs)

Several workplaces described incentive and reward or recognition schemes that emphasised the production-safety tension, with a drive towards pushing operators towards efficiency at the expense of safety. For instance, the use of ambitious production quotas and targets, and making comparisons between different teams or shifts in terms of throughput and overall productivity.

> "*If people are often on a quota, they've got to do so many an hour, if they haven't done it, then they're trying to push to get their quota. The supervisor's role is to make sure they get their quota up*." [Supervisor]

> "*every six weeks, management would come along and they would reward the shift that was the most productive in that time. The adverse effect: people would not isolate a machine if they could reach in or if there was a bit of blockage or before a build-up occurred of the wool. They'd reach in by hand and pull it out. That way they kept production going because they knew they were being compared to the other shifts*." [Inspector]

Procedures are 'perfect'

Some supervisors and managers adopted a simplistic view of safety; namely, that incidents occur primarily due to 'bad' operators who do not follow procedures to the letter. Implicit within this view is the belief that procedures are 'perfect' and match work-as-done exactly.

> "*generally, every time it's because someone hasn't followed the right procedure or have tried to get around it without following the procedure and, yeah, they've come up hurting themselves*." [Operator]

Safety is punitive — Don't get caught!

To some, the main reason for practising safety is to avoid punitive measures from regulators, such as fines and notices. This rationale is inherently extrinsic in nature — safety is done to prevent the application of a negative external punishment rather than internalised as a way for the business to be successful and achieve its goals.

> "*...and the worst thing about it is, we can all be fined. If it's going to hit somebody in their wallet, everybody starts to think*." [Operator]

Safety is an individual responsibility

In contrast to the enabling effect of 'safety as a shared responsibility', some workplaces were described as having a culture of 'everyone for themselves', or safety as an individual responsibility. This culture epitomises negligence around duty of care and other legislated obligations on businesses. Workers described managers shirking their duties in relation to safety, and instead emphasising the role of workers in personally ensuring their own safety:

> "'*I've told them what to do, told them to do it safely and it's up to them to do it safely; I've done my bit; so if they don't do it safely, that's their problem*'." [Inspector telling of what managers say in the workplace]

Safe technology out of reach

Although safer machines exist in the market, such as automatic shutoff devices on bandsaws, inspectors and managers complained that these technologies are often out of reach. In particular, small businesses are unlikely to be able to afford expensive state-of-the-art safety-infused technologies. Thus, safe technologies and safety resources are perhaps only available to the larger organisations:

> "*Examples of that [prohibitive costs] is when they don't invest in work health and safety professionals. That side of the business is sort of tacked on to someone's role*." [Safety Manager]

> "*the downside is that it's only the guys with the financial resources, because I've heard quotes between say $70,000 and $90,000 per band saw*." [Inspector]

Removing machine guarding

There were several reasons cited as to why workers remove machine guards. First is forgetfulness—operators and maintenance personnel simply forgetting to return the guard to its original position after a blockage has been removed: "so, they take the guards off and they just don't put them back on". Another reason could be the perceived effort involved in replacing the guards. Workers may seek to optimise their effort-reward balance and elect to take an easier or quicker option rather than following the safest course of action:

> "*It was either it was quicker to do it that way or we didn't have a qualified operator to do the task*." [Manager]

> "*you can have a table saw where you can manually raise and lower the guard over the top of the blade and people raise it to cover a thicker piece of material but then don't lower it back down when they've got a thinner piece of material*." [Inspector]

Work pressure and 'practical drift' may be another reason why guards are defeated by operators. Operators may feel a pressure to produce, so engage in risky behaviours to ensure smooth operations and continual throughput. Over time, these risky practices become normal and engrained in the culture of how work is done:

> "*a lot of our stuff is extremely heavy and instead of stopping and trying to arrange for the crane to come out or something to come and lift it, it's just, no, we've only got to move it a little bit, pick it up, grab it*." [Operator]

> "*when a product jams, instead of following a process, they'll try and push it with their hands, rather than turning the machine off. They'll do it while it's still operating. But they try and do it without stopping the machine, so the product doesn't pile up behind them*." [Inspector]

Gaps between standards and verification

Mostly inspectors raised the issues associated with importing machinery from overseas, and failures at multiple levels with respect to risk assessing these machines and ensuring compliance with standards. These issues point to a misalignment between the standards as outlined and the protocols associated with machinery import and verification. In particular, inspectors outlined how machines can be purchased overseas without adequate guarding and imported into Australia non-compliant without any issues, yet the same machine could not be sold domestically in the same condition.

> *"...you can't use it in Europe without the guard, you can't sell it in Europe without the guard. But in Australia you can buy an Italian one with the guard or without a guard*." [Inspector]

Workload management

Safety is likely to be deprioritised relative to production when workload demands exceed operators' capacity to cope. Sometimes, the manufacturing process drivers are time-based, meaning that operators are given goals to produce certain numbers of widgets within a given time period. Consequently, their workload management strategy is typically to work as quickly as possible to increase rest and break times.

> "*if my task is time specific and the manufacturing process gives us a certain amount of time to do it, if I can get it done quicker, then I can have more time off*." [Operator]

Other workers described businesses that drive heavy and unrelenting production schedules, working both machine and people to exhaustion. In these situations, safety is degraded due to an eroding safety boundary that creeps inwards as workers become fatigued and machines fall out of maintenance and into a state of disrepair:

"*sometimes production rates are too much for the guy to keep up with; the machinery isn't maintained; the machinery isn't inspected; we haven't got any operating procedures here; we're expected to use faulty equipment; they work on live equipment rather than having proper isolation procedures in place; they're prepared because of production restraints to work live or work on your equipment without having the proper procedures and protocols in for cleaning or maintaining equipment*." [Operator]

Leadership competence

Leaders were described as lacking competence and capability, particularly in relation to soft-skills. There seems to be a reliance on the TAFE system to provide these skills, but the consensus among respondents was that it is inadequate and further leadership training is required:

"*There's a couple of things here that I think we've still got quite a journey to go when we're talking about frontline leadership in safety*." [Safety Manager]

"*it's just it would be good to have something that I could go to, to learn a little bit more about [safety leadership] on my side of things*." [Supervisor]

"*they [management] rely on whatever training that the person may receive from TAFE as being the training to use a particular machine or that, and again very production-focused*." [Inspector]

Migrant workers

Some inspectors described the occurrence of migrant mistreatment within the manufacturing industry. Some business owners seem to purposefully engage migrants as a form of cheap and disempowered labour who are less aware of their work, health and safety rights. Consequently, these owners fail to invest in the basics when it comes to safety.

Significant challenges with communication and training are likely to exist, further increasing the risks faced migrant workers, generally. This group may become injured or experience problems within the workplace but may be undetected as they are terminated from the business and move onto alternative employment.

"*the person that doesn't understand English, doesn't understand their rights. The employer knows that they know nothing about workers compensation, they can't fill the form in. They just terminate them and leave them.*" [Inspector]

Small business complexities

In small businesses, safety often takes a backseat to production due to several reasons. First, small businesses are less likely to be aware of their duties and responsibilities — there are simply too many competing demands that capture attention. Other factors include the contingent or tenuous employment arrangements in small business environment. Workers know that small businesses have less stringent hiring and firing laws, and so feel reluctant to push safety issues harder. Access to resources and overall capability are also issues faced by small businesses; in a way they can be described as 'safety poor'. Low access to financial resources, time, and skilled personnel mean that small businesses are continually hiring, training, and producing product. Little time or money is left for investment in formal safety systems.

"A lot of times, the small business operation, they're strapped for cash; they're time-poor; they're resource-poor; there are sometimes transient workers there; young workers that aren't trained; young workers that aren't sometimes supervised adequately; got no procedures; no risk assessments; don't consult with the workers regarding purchases or maintenance of equipment." [Inspector]

Outgrowing and failing to reinvest

Although some businesses have fallen on good times, with increased profits and customer demand, some have failed to reinvest the profits into the business, resulting in compromised safety. Physically, the business may have outgrown the work area in which the product is manufactured, resulting in tighter coupling between people and machines. Tools and machines are not adequately maintained, with the focus being on continual production. People are continually being hired to cope with the demand, but physical space is limited. For instance:

"*it was supposed to be a very small site doing a little bit of product and taking it out there and getting to sell it and see if the product will pick up. Then, the product did pick up and now we are running that machine to its max. There are a lot more pallets, more product coming out, more people working there, more hours. The space is a bit*

small and the space for people to move around is quite tight." [Safety Manager]

RQ 5 How does industry 'culture for safety' influence machine operators' safety capability?

The operators view of the world drawn from the interviews

Of the 51 interviews conducted, nine were with machine operators. Operators provide us with a 'grass roots' view into the safety issues faced by those in the front line in terms of risk of injury.

The machine operators are in a precarious position at the bottom of the hierarchy, and organisationally vulnerable to the chains of command above. As in any cohort, operators appear to range from the extremely experienced to those new to the job. The experienced wield a depth of job knowledge, and often feel that their knowledge is overlooked when key decisions are made in term of machine procurement, installation, siting and set up. They then suffer the insult of having to live with uninformed decisions that may have been made. They spend all day with the machines and can readily see any shortcomings in safety practices. These shortcomings can be both 'over the top' precautions and inadequate guarding. They know the safety practices (what really goes on) but appear to be unavailable to inspectors, unless there is a serious incident.

Experienced operators may be aged anywhere from 30 onwards. The younger ones have an advantage in effectively growing up, and being trained in a safety aware culture, whereas the older ones will have 'seen' what can happen, and have experienced times when safety was not a priority.

Skilled operators know the value of their hard-earned experience:

> "*If it's someone unexperienced, then it's a whole different - then that would easily be the most dangerous machine, if you didn't have the experience.*" [Operator]

Some nearing retirement may have entrenched attitudes around the 'questionable' masculinity of those who beat the safety drum, and be vocal about it, but no one wants to be permanently injured or see a mate hurt.

> "*I've never come across anybody here or myself doing anything that's not safety orientated at all, especially to sacrifice an arm [for] production, that's for sure*." [Operator]

> "*There's always that one per cent I think, the biggest problem with safety here, and I've done 10 years in construction before this, is complacency. People get too used to doing the same things and they just get complacent. So, I did that - I'll be alright today, you know what I mean?*" [Operator]

In some places there is no tolerance for any deviation:

> "*generally, people that don't follow the safety instructions are held accountable very quickly, and either instructed or removed from the workplace*." [Operator]

To experienced operators, intrusions from outside are viewed with scepticism, as one inspector explained:

> "*I think that what they're trying to convey is that, I guess, they don't like, … outsiders, [who] come in and tell them how to do their job safely - better. I think there's a resistance to that, or what they're trying to say is, I know how to do my job better than anybody else and I don't want to get hurt, so trust me that I'm doing the right thing*." [Inspector]

These operators are also acutely aware of the knowledge and skill gap between themselves and managers, and would like managers to be willing to learn more about their work and recognise their experience:

> "*To me the best thing a manager can do is actually spend some time around the machine with the operator. I know it's not - it's going to be me sounding a bit with an attitude - but it's not walking down, scratching nuts and going, 'Oh isn't this a great big machine?'*" [Operator]

There is a sense that comes across of older workers just wanting to get the job done but are less safety conscious than younger operators:

> "*You get a lot of different ones. I think the younger people - not very young, but younger - they see it as something that's really important and needs to be taken seriously. You get a lot of the people who've been in the trade for 10, 20 years, they just wing it and their safety standards are a lot lower. They just want to get the job done*." [Operator]

> "*Myself, and some of the other younger employees, it's something that's been drilled into us, that you need to do it safely otherwise you might not go home. That's the thing, so it's just working to the guidelines and the rules, using the correct procedures for things and not just trying to get the job done as quick as possible, regardless of what can happen*." [Operator]

The experience is carried and embodied by the operator; it's tactile, and it appears there is the ability to make judgement calls in complex situations by the 'feel' for what is going on and their honed

awareness.

> *"...but the overhead cranes, sometimes we've got six tonnes of steel travelling over the top of stuff and you've got too many variables with it, like you've got the crane ropes, the steel ropes on the crane. You've got the slings. You've always got to be watching it and checking the equipment and make sure it's all good*." [Operator]

It is akin to a billiard player; too many variables to deal with mathematically in a human head, but years of experience makes them alert to how to respond. It is somatic; in an alert state, their body 'knows' and they draw on intuition to successfully complete the shot, or in the case of operators, take precautions to avoid injury.

These operators are aware of who they rely on for the machines' proper functioning, and the importance of good maintenance teams:

> "*...things I can't see, like brakes inside the crane and stuff like that, so you're relying on the service of the equipment and the people of service to make sure they do their job right. You've always got to keep clear or it, always keep an eye on it*." [Operator]

These operators are also politically aware as they know what's outside their range of influence, how much they can push things, and how the politics play out in a given situation. There is also a sense of pride, and perhaps an element of arrogance in knowing they know stuff that the 'big wigs' do not.

But there is complacency that arises:

> "*People get too used to doing the same things and they just get complacent. So, I did that - oh, it was alright yesterday, I'll be alright today, you know what I mean?*" [Operator]
>
> "*Bad habits can arise from frequent shortcuts and an attitude of "we got away with it last time*." [Operator]

Also at play are the behaviours when no one is looking. This emphasises the needs for engaged supervisors and bosses willing to spend time on the floor:

> "*when it's 'she'll be right this time', there's no bosses around. If the bosses are around, there's no way anyone would cut that corner. They don't want to be seen to be doing the wrong thing in front of the bosses*." [Operator]

This, coupled with the desire of operators to get through things quickly:

> "*We've had a few injuries like that. I injured myself that way, just trying to get the job done a little bit quicker. Just trying to save those couple of hours and cutting corners*." [Operator]

The other value that comes with experience is knowing the adequacy of guarding. Knowing the limitations of the supplied guarding and measures needed for protection. There is being aware of site conditions and that these are not always ideal:

> "*Sometimes you can't really have ideal working conditions, so you've just got to pick the best out of the spots and go from there*." [Operator]

For the very young, inexperienced workers there are attentions issues as well:

> "*tend to forget about the PPE. That becomes a bit of a problem too. But all that it is, is probably just trying to refresh everybody's memory all the time. That is the biggest thing. That is the hardest thing, and also because we've got a couple of young kids there too, where they do tend to forget themselves as well*." [Operator]

Other issues for young, and particularly those culturally and linguistically diverse, are lack of awareness of their rights around safety, to the extent of discouragement of reporting incidents.

> "*They might be told not to report it to their doctor as a workplace injury. The boss will pay for all the medical claims, the costs. That does happen. It's not uncommon, particularly with young, vulnerable, and migrant workers as well*." [Inspector]

Personal factors also contribute to behaviours around safety:

> "*...everyone has personal things going on in their lives, you don't know what's going through peoples' heads at any point in time. So, we do encourage - and the guys here are pretty good - anyone that's got stuff going on at home will typically come and see me or one of the safety reps to let them know what's going on. So, we'll basically say, all right, if you're not feeling the best as far your headspace, don't want to be on a nine-grinder, we'll get you onto something else for today if we can and that sort of thing*." [Operator]

The operators view of the world from an ethnographic perspective

In the following section, we take an ethnographic perspective to explain two examples of workers at the frontline, 'Eddy' and 'Peter'.

Eddy has a long-time experience of the manufacturing industry and, while primarily an operator, has at various times held supervisory and management roles. Eddy was called out in his own section given this eloquent and articulate perspective of machine safety, and so he can provide insights into some of the issues faced by frontline workers. People like Eddy can give us an insight into the challenges and opportunities faced by machine operators and employers.

Experience in machine operation is key to Eddy, and he sees it as an area of disconnect between management and operators affecting site safety:

> "*it's so abstract to some people that are sitting in a chair [management], that unless someone points something out to them on the machine, like we need a guard here for this reason, they never really have an understanding or feel a need for an understanding*."

We immediately get a strong sense of Eddy's pride in his experience and knowledge of the machines, see his frustration with management's lack of both knowledge, and the need for understanding in making decisions around machine guarding. To Eddy:

> "*my experience is that a lot of them [managers] take it for granted that the guarding that is required is supplied*."

This highlights the danger of assumptions in purchasing decisions, and points to the experiential knowledge and vigilance in buying decisions, installation and procedures for safe operation of equipment. It suggests the need for a rigorous procurement process in relation to guarding offered.

Eddy, and others, refer to the '*operator's mentality',* and he provides a description:

> "*You'll generally find most machine operators are driven by getting the job done, getting the run finished or whatever they're doing*."

Eddy described it in terms of fixing an issue that needs removal of guarding: the operator will take the 30 second shortcut rather than taking the 5 minutes to follow the correct procedure:

> "*If there's a hiccup in the middle of the process they want it resolved as quickly as they can. Sometimes that might lead them to yeah, she'll be right, we'll just do this this time. The problem is, then, [when] it happens again because we got away with it last time*."

He describes it as the willingness to cut a corner when no one is watching, and the 'Australianness'

of *she'll be right*. Interestingly though, when Eddy was asked whether the speed was self-imposed by the operator, or came from the organisation's culture, his response was:

> "*It's a bit self-imposed for sure. Then there's also a bit of time constraints that probably get on their mind as well [as] that we've got to get this one out today and that sort of thing*."

Both play a role in operator 'mentality' and behaviours. Eddy takes a fairly prescriptive view of safety, namely, that there's one way to do safety by

> "*allowing for the lowest common denominator. You can have the biggest idiot walk into a place and they can't possibly hurt themselves because you've got adequate [guarding].*"

This raises a lot of questions in terms of practicality. Most of the time it is about following the rules, but what happens if the rules are not enough? Is it always cheating to take a short cut? How do you manage this? Are there situations where there is more variation in operation? How do you maintain safety *and* be flexible?

Another operator, 'Peter', proposed a solution that caters for the varying levels of experience of operators:

> "*a levelling system where we've got people, based off their experience or knowledge, or competency, I guess you could say, on the machine. So, new people will have a zero level, so obviously they'll need a lot of monitoring, a lot of attention to make sure they don't damage the machine, or damage themselves by doing something stupid, and obviously going all the way up to level three, where you should be competent enough that no one needs to pay attention to you. You're responsible for your own actions. No removal of guardings, obviously, because that would remove one of the only safety features the machine has*."

People like Eddy and Peter are invaluable in helping operators see the problems with risky shortcuts and assisting management to understand the effect on operator behaviour when they still exert time pressures. Experienced operators can assist in finding ways for workers to manage the pressures inherent in production schedules, without compromising safety, and have an important role in educating the leaders and decision makers.

RQ 6: What differences exist, if any, between young and old workers' safety perceptions and behaviours?

Young workers (<25 years old) were a focus of this study, given their overrepresentation in manufacturing-related WHS incidents. According to Safe Work Australia (2019), young workers in manufacturing experience an incident rate that is 44% higher than older workers.

Only minimal differences were found between younger and older machine operators. Constraining the survey sample to only workers without supervisory responsibilities and dividing it into the two groups (25 young workers, and 88 older workers), comparative analyses were undertaken. Interestingly, safety climate perceptions were generally *more positive* among younger workers as compared to older workers. Overall safety climate scores did not significantly differ statistically by levels of age, so differences in individual items were examined. Three safety climate items differed between younger and older workers, with younger workers being more positive overall. These three items included:

1. Operators are adequately trained to operate new machines safely
2. In this organisation, we have detailed instructions about how to use machines safely
3. Evaluating the safety of new machines (e.g., identifying missing guards) is done before production starts

These results are heartening because they suggest that younger machine operators are perceiving safety practices in a more positive light, which could mean they are being exposed to training and instruction, at least in the participating cohort of organisations. In particular, young workers appear to be receiving safety training, exposure to standard operating procedures, and involvement in pre-shift checks of machinery before production commences. However, there is a possibility that the positive results reported here could be due to social desirability bias, with some prior research suggesting that younger people are more prone to this bias than older people (Stober, 2001).

None of the machine operating behaviours differed significantly between younger and older workers, either at the overall aggregated level or for individual items. Additional analyses revealed that workers from a CALD background (n=15) engaged in at-risk machine operating behaviours much more frequently than those identifying as English-speakers. The average frequency of at-risk machine operating behaviours for both groups are shown in Table 4. However, the small sample means these results should be treated with caution.

Table 4. Average frequency of at-risk machine operating behaviours, by English-speaking background.

At risk machine operating behaviour	English-speaking background	CALD background
Reach past a dangerous part of an operating machine to clear a blockage	1.6	2.6
Remove any machine guards that stop or slow down production	1.3	1.5
Take a guard off a machine to make it work faster	1.3	1.7
Move a guard out of the way to access inside the machine and keep it running	1.2	1.6
Set the adjustable machine guard to the maximum size rather than adjust to suit every piece	1.5	2.0
Forget to return a machine guard back to its original position before carrying on with the next task	1.5	2.2

Note: The frequency of behaviours ranged from 1=Never to 5=Frequently, so for the at-risk operating behaviours shown above, a higher number is less positive.

RQ 7: What is the impact of an online safety leadership training package on safety climate, leadership, and/or performance?

The final analysis involved the evaluation of an online safety leadership training program that targeted supervisors and managers in the manufacturing industry. The training consisted of 41 x 3-to-5-minute lectures. Topics covered by the training program concentrated on leadership and communication skills, and included the following:

- Safety culture: Definition and measurement of safety culture, along with a short history of safety culture as a practical concept.
- Chronic unease: Describing the nature of chronic unease (a form of functional worrying about hazards) and how to create it within a team through descriptions of incidents and safety-related stories.
- Social bias: Identification of ways in which mental short-cuts (i.e., social bias) can impact safety-related decision making.
- Effective questioning: Techniques to design and ask effective questions that aim to build trust between people.
- Active listening: Micro-skills to develop rapport and engage fully in a safety-related discussion.
- Demonstrating safety commitment: Advice for managers to demonstrate visible commitment to health and safety through role-modelling and participating in safety initiatives.
- Delivering safety toolboxes: Strategies to effectively engage with workers when delivering Toolbox Talks about safety topics.
- Conflict resolution: Ways to effectively resolve conflict through finding common interests and compromising.
- Developing safety knowledge in others: Discussion about the importance of safety knowledge to drive improved machine safety behaviours and a model to teach safety skills to others (i.e., the MEDICS model).
- Leading safety-related change: Overview of the transtheoretical model of behaviour change and how to use this information to influence others in the workplace.
- Behaviours of a safety leader: Description of the safety leadership model developed through this research project that is specific to manufacturing.
- Just culture: Creating accountability through restorative rather than retributive justice, and the benefits to organisational learning that it brings.

- Work as imagined versus work as done: Learning to understand the gap between how work is prescribed (i.e., in the form of a safety procedure or management system) and how it is implemented.
- Safety metrics and measurement: Distinguishing leading and lagging safety indicators, and best practices for measuring safety performance.

Each training module was broken down into at least three components: an introductory lecture, a practical or applied lecture (that included at least one tool that could be applied in the workplace) and stories taken from the interviews that tell the perspective of workers, managers, and WHS inspectors in manufacturing settings. Downloadable summaries and toolbox talk sheets were also provided for each lecture, to encourage participants to disseminate the concepts among their staff. A total of 120 leaders participated in the training from the cohort of organisations. These leaders were from at least 19 organisations. Unfortunately, privacy restrictions within the Udemy platform prevented identification of email addresses, which prevented tracing of individual training participants back to their companies of origin.

Training reactions

A total of 45 student ratings were provided for the course as of 11 December, 2019. The overall feedback rating for the training package was 4.2 out of 5.0. Figure 4 shows detailed ratings as provided by the students who participated in the course.

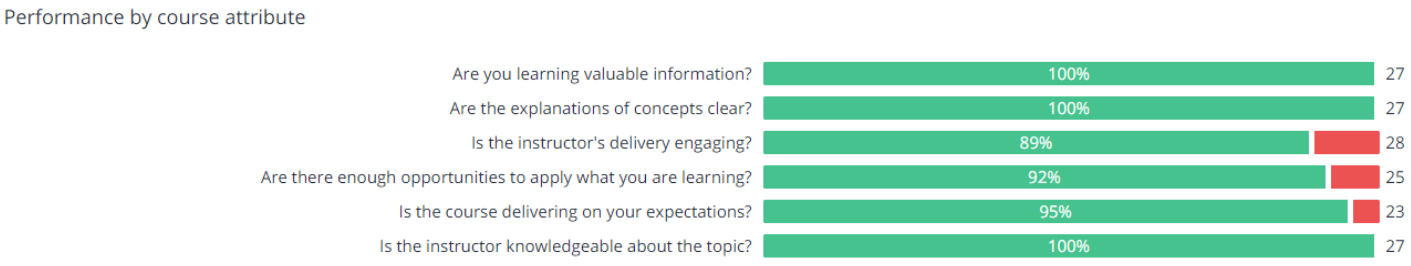

Figure 3. Detailed course feedback from the Udemy platform

An additional and more detailed training feedback survey was distributed to the participating organisations' key contacts. A total of 10 contacts completed this detailed survey.

The results showed that the 10 contacts were likely 'active promoters' of the course since they rated the likelihood of recommending the course as an 8.0 out of 10.0 (on average, across all 10 respondents). Similarly, 80% reported completing all modules in the training, with the remaining

citing “lack of time” as the main reason for not finishing.

The main positive feedback on the training centred in the videos, describing them as varied, interesting and engaging. Others merely called the course “informative”. Conversely, criticisms primarily concerned a lack of interactivity and knowledge-testing, which would have been helpful in consolidating the information. The main recommendations for improvement, therefore, are the addition of activities to get participants more involved with the content and to consolidate what was learnt. Similarly, using a greater variety of lecturers or speakers could have improved participant engagement. Other contacts thought additional readings and developmental references and resources could have improved the training.

Before and after analysis

The original study described the implementation of a two-wave rolling groups design (Cigularov et al., 2008; Quinones & Tonidandel, 2003). Unfortunately, attrition at the time of follow-up measurement meant that this strategy had to be abandoned, and the two waves combined into one overall group. With the combination of waves, 15 organisations could be matched between time points (i.e., sufficient respondents participated in the follow-up survey). All 15 organisations nominated personnel to participate in the online training program, however, their participation status was unconfirmed due to the privacy limitations on the Udemy platform. Analysis of safety climate, safety leadership, and safety behaviour revealed no statistically significant changes over time. Table 5 shows the before and after results.

Table 5. Results of before and after testing for effects of the training program on study variables in 15 manufacturing organisations.

Variable	Before (Average)	After (Average)
Safety climate	5.9	6.0
Safety leadership	6.0	5.9
Safe machine behaviours	4.6	4.7
At-risk machine behaviours	1.4	1.3

Discussion

Notably, we found that there is an augmenting effect through using both quantitative and qualitative methods together to explore safety climate in the manufacturing industry. A short safety climate survey can provide an efficient window into the overall state of safety in an organisation but misses many important details. Quantifying safety in this way and relying on statistical differences may mask important details between organisations, if they are being compared. For instance, an overall safety climate score may differ by only a few points on the scale, yet qualitative data will reveal marked differences in how safety is considered and applied in practice. We also found that a relatively simple sentiment analysis that is run over qualitative interview data can be used to enhance the interpretation of safety climate scores—small differences between organisations in quantitative results were picked up by markedly different sentiment scores in the qualitative data.

Further, qualitative data revealed evidence of the dynamic interplay between production and safety goals, and the tactics manufacturers use to resolve these tensions. Exploring these tensions provides a fertile ground for drawing together strategies to raise the priority of safety. Organisations should be encouraged and supported to integrate safety within existing production processes. We refer to this strategy as 'folding safety in' to production. Akin to the way a whisked egg white is folded into batter, retaining its unique aerated properties, so too should organisations seek to combine safety requirements within production systems, rather than layering them separately or choosing one over the other. This should be an organisations default position when it comes to resolving safety-production tensions: seamless integration of safety into the operational fabric.

Of course, there will be times when the production-safety tension cannot be completely resolved and so must be lived with until a better solution is made. We refer to this strategy as 'patching'. Patching is akin to applying the hierarchy of controls to substitute, isolate, proceduralise, or protect workers from risk. Patches can be seamless (elimination or substitution), permanently changing the operational fabric, or they could be temporary, such as a stitch, in the form of a procedure or piece of PPE. In the former, the seamless mending of the 'hole' in the safety space is completely closed and largely impervious, whereas with

the ‘stitch in time’, the hold is only temporarily shut and can be forced open through interactions with and effects from other entities in the organisation.

Finally, in some organisations, production will overtake safety in priority. This resolution strategy is a risky one, because although an incident may not be immediately triggered, the safety hole remains as a latent condition. Importantly, operators may compensate for these holes through displaying their technical prowess or inventing workarounds that enable the job to be completed. They may hide or ignore a squeaky machine, make a mental note not to touch an energised machinery part, or otherwise engage in shortcuts that continue to achieve production goals yet compromise safety goals. Oftentimes, operators may not be aware of safety holes in the operational fabric, particularly if they lack job experience (as in the case of younger workers).

In sum, this project discovered that safety and production exist in tension within manufacturing organisations. The nature of the manufacturing environment is such that production will always be a core priority for organisations; without it, the organisation cannot survive. Environmental conditions internal and external to the organisation, combined with the dynamic interplay and affects within and between entities, will ensure that many instances of the safety-production tension are apparent across an organisation at any point in time. Organisations will be aware of some, ignore others, and be blind to the rest. Teaching organisations to find these tensions, evaluate the ‘holes’ in safety that they create, and select the optimum strategy to either ‘fold’ safety in or ‘patch’ the hole is a recommended way forward.

Research questions

Seven research questions guided the analysis and interpretation of the research. These questions and the major findings are summarised below, with detailed answers contained within the body of this report.

1. What is the nature of manufacturing-specific safety climate?

Two dimensions for manufacturing safety climate stand out: 1) *management safety commitment* and 2) *training and competency*. Management safety commitment includes:

- Allocating adequate resources to machine safety

- Initiating safety-related discussions with workers
- Balancing production pressure appropriately
- Developing and supplying appropriate machine safety procedures

Training and competency are focussed on ensuring adequate skills and supervision to use new machines, and for new workers to 'learn the ropes' through support from experienced workers and leaders.

2. How can safety leadership and performance be operationalised within manufacturing?

Workers tend to make global or overall assessments of safety leadership rather than more nuanced ratings of individual behaviours. They see leaders as being either overall 'good' or 'bad' safety leaders. Behaviours associated with positive leadership include: spending additional time on the floor interacting with operators, delivering safety-related discussions and generally being visible to workers.

3. What are the relationships between safety climate, leadership, and performance?

Overall, safety climate was a stronger predictor of operators' safety behaviour than leadership ratings. Organisations with a more positive safety climate tended to have better safety performance (more frequent safe machine behaviours) although the reverse is not true – more frequent at-risk machine behaviours did not depend on safety climate. However, there is one important exception: when culturally and linguistically diverse (CALD) workers were excluded from the sample, safety climate predicted both safe and unsafe machine behaviours. CALD workers' unsafe behaviours may be influenced by factors outside safety climate, such as leadership and prior training, and individual factors like knowledge and motivation. There may also be differences in how safety climate perceptions form and persist over time among CALD workers—they may rely on cues other than verbal interactions between managers and workers, or even interactions with co-workers, due to language barriers and other cultural differences.

4. What perspectives can be gained through exploring the tensions between safety and production?

Core to the culture for safety in the manufacturing industry is the notion of 'safety first'. Yet, the evidence revealed the relentless nature of the underlying and dynamic tension between safety and productivity. The resulting seesawing action between production and safety priorities is shown in

three key manifestations of safety first in manufacturing organisations we chose to explore:

- Where safety and production have been integrated and become enablers of safety
- Where tensions between safety and production exist, and these tensions are permitted for the time being as inevitable or as yet unresolvable antagonisms
- Where safety has clearly been deprioritised to a level that increases risk, inhibiting safety yet with the potential to lift safety priority

The approaches used by organisations to resolve the production-safety tension become part of their cultural fabric, influencing operators' safety capability.

5. How does industry 'culture for safety' influence machine operators' safety capability?

For operators, the production pressures aside, the main tensions are around older experience workers who push the boundaries of safety and the young, safety aware, but often unfocussed workers. The older workers know the value of their experience, but are possibly underutilised in decisions on procurement, installation and procedures. Experienced workers are aware of the knowledge gap that can exist between themselves and the manager decision-makers around operational requirements. A number of operators report of the shortcuts taken when the 'boss isn't looking', which points to the need for greater presence on the floor by both supervisors and managers. In many cases it is not necessarily direct production pressures that causes shortcuts, but the workers own drive to get the work done so they can take a break. Where operators perceive management safety commitment favourably, it in turn enables proactive machine operating behaviours such as stopping the job, supporting colleagues, internalising safety responsibility, and slowing down work pace as risk increases. Unresolved tensions are permitted to exist, and effectively maintain the 'status quo'. Unresolved tensions may, inconsistently, contribute to operators' safety capability, either increasing it in the case of an experienced operator expertly improvising and filling the gap between 'work as imagined' and 'work as done', or decreasing it such as when an inexperienced operator decides to reach in and remove a blockage from a machine. Finally, when the tension is resolved in favour of production, operator safety capability is reduced, dramatically. For example, passing safety responsibilities down the line, encouraging risky machine behaviours like removing guarding, and increased operator fatigue.

6. What differences exist, if any, between young and old workers' safety perceptions and behaviours?

Safety climate scores did not differ significantly by age, so we examined individual items and found three where younger workers were more positive overall. These were: 1) adequate training to operate new machines; 2) having detailed instructions on how to use machines safely; 3) evaluating the safety of new machines before production starts. Further, safety climate perceptions were generally more positive among younger workers, compared to older workers. However, the qualitative data suggest that young workers may be exposed to role modelling from older workers that encourages them to engage in short cuts and taking risks. Older workers may use their formidable expertise to skirt the edges of the safety boundary, whereas younger workers lack the intuitive and deep knowledge required to maintain safety in high-risk settings. Further targeted research is required to understand why younger workers are involved in greater numbers of injury in manufacturing.

7. What is the impact of an online safety leadership training package on safety climate, leadership, and/or performance?

The overall rating for the training package by the 45 participating students was 4.2 out of 5.0. Additional feedback from 10 key contacts rated the likelihood of recommending the course as an overall 8.0 out of 10. Positive feedback centred on the videos, describing them as varied, interesting and engaging. Others called the course "informative". Criticisms concerned a lack of interactivity and knowledge-testing, to help in consolidating the information. However, before and after analysis of safety leadership and safety climate scores across a group of 15 participating organisations did not show statistically significant changes.

Conclusions

Overall, the cultures for safety across the participating manufacturing workplaces were best evaluated using a combination of qualitative and quantitative data. Used in isolation from each other, or only drawing on one method over another, runs the risk of a 'false negative'—failing to detect important issues that contribute to safety capability and performance. Safety climate can be a useful leading indicator but must be interpreted in light of qualitative information regarding the nature of production-safety tensions. Otherwise, aggregation of worker responses can mask important variation and subtle differences from benchmarking data like group averages (typically tested using statistical techniques). We found evidence that the state of safety within organisations can be markedly different qualitatively, but in the order of less than one scale point quantitatively.

Importantly, there was little quantitative evidence of younger workers (<25 years) being exposed to less effective safety practices in the participating workplaces. To some extent the opposite was found using the survey data, whereby respondents who identified as young workers were more positive than older workers on some elements, particularly training and development, through their TAFE training. However, in the interviews, some workers raised the younger workers lack of focus and attention being an issue, e.g. forgetting PPE and not concentrating on what they are doing. There may be some role modelling of experienced operators that causes younger workers to think they can adeptly take shortcuts and risks.

Another cause for concern was the observation of increased frequency of at-risk machine operating behaviours among culturally and linguistically diverse (CALD) workers. Also, interviewees raised examples of CALD workers being actively discouraged from reporting safety issues by supervisors and generally experiencing a higher level of job insecurity. However, as the number of CALD workers in this study was small (n=15), these results should be treated with caution. Both of these areas should be explored in future targeted research.

In addition to these results that describe the nature of safety culture within manufacturing, the performance of the new safety climate, leadership, and machine operating behaviour scales were evaluated. The safety climate scale was found to be a stronger predictor of machine operating behaviours than safety leadership, so could be used as an organisational

diagnostic tool to target areas for improvement. The safety climate scale was correlated with an existing measure of safety climate and showed acceptable psychometric properties. Overall, the tools developed for this project are valid and reliable.

Finally, our evaluation of the leadership intervention did not find quantitative evidence of change over time. Improving safety culture in manufacturing likely requires a multi-pronged approach that goes beyond an online safety leadership training program.

Recommendations

Synthesising the findings of this project, we make the following strategic recommendations regarding the manufacturing culture for safety and its role in driving safety performance:

Recommendation 1:

The resources developed during this project could be made into a manufacturing safety culture toolkit that includes these new resources as well as those already in existence. Concurrent development of suitable interview/focus group protocol(s) that could be used in combination with the newly-developed safety climate scale could also be created. Focus on the needs of small-medium operations who likely require support to help resolve safety-production tensions favourably, which could include tools like safety requirement factsheets, template procedures, and other practical resources that would help to integrate safety within production processes.

Recommendation 2:

Organisations could periodically (6-12 monthly) measure organisational culture for safety using a combination of methods — combine a quantitative safety climate survey with qualitative investigations that can be done via interview or focus group methods. Use the safety climate data as an initial pulse check of the state of safety and expand on this information with targeted interviews that provide detail around the nature of the survey themes and findings.

Recommendation 3:

The manufacturing industry could shift the focus for safety to one that takes it beyond ‘safety first’ and towards one that recognises the trade-offs and tensions that can exist between production and safety, and that it needs ongoing attention to keep in front. Use

words and phrases that are about pushing safety forward; advancing, evolving, innovation, imagination, or vision; words that suggest that there is no limit for the organisation to moving forward, and that the journey will be ongoing.

Recommendation 4:
Organisations could seek to enhance supervisor and managerial leadership capabilities through leadership development training and resources (such as the ones developed for this project) and peer mentoring/networking opportunities. Focus leadership development initiatives around being visible on the floor, spending time understanding and appreciating operators' experiences in the manufacturing environment, and engaging in regular two-way communication to be abreast of safety and work-related issues.

Recommendation 5:
Organisations could identify and explore factors that shape machine operator behaviour and contribute to production-safety tensions in the organisation by using a combination of surveys and interviews/focus groups. Deal with these underlying issues rather than focussing on resolving the tension directly. For example, redesign jobs to provide workers with adequate rest breaks and time for secondary work task, rather than penalising short-cuts and messy work environments directly, as rushing behaviours tend to be shaped by the broader organisational context rather than individual attitudes and beliefs around safety.

Recommendation 6:
Further investigations are needed to understand the challenges faced by CALD and migrant workers. Engage with these vulnerable groups directly to understand the factors that contribute to reduced safety capability. It might be a matter of creating competencies for them in understanding safe work practices and their rights.

Recommendation 7:
Follow-up investigations could also target young manufacturing workers, specifically, to understand more about their experiences working safely. Our data were in conflict, as quantitative measures purported that younger workers have more positive social experiences with safety, whereas some of our qualitative data suggested that younger workers are implicated in incidents due to inattention or overloading of their capabilities.

The discrepancy between qualitative and quantitative data means that relying solely on survey information to research young worker safety is problematic and should be avoided.

Recommendation 8:
Ongoing development of safety climate scales contextualised for industry could be undertaken to integrate the findings of this report and to re-operationalise safety climate into a measure that is more sensitive to underlying safety-production tensions

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Appendix

Interview protocol

Briefing Note

- This research is founded on the premise that unsafe machine operating behaviours are a product of a poor safety culture, which in turn is driven by the behaviours of supervisors and senior management.
- The objective of this research is to identify behaviours, practices, and characteristics of the workplace that influence machine operating behaviours; therefore, please encourage interviewees to be as detailed and specific as possible, as their answers will be used to form items in a survey instrument.

General Protocol Instructions

- Introduce yourself and ask general questions of the interviewee to develop rapport and put him/her at ease (e.g., 'tell me a bit about what you do around here').
- Ensure that the interviewee has read and understands the informed consent statement in full. If this has not been read or is not understood, please provide another copy to the interviewee and explain any points as required. If informed consent is not given for any reason, terminate the interview immediately.
- Advise the interviewee that although his/her employer may know that he/she attended the interview, neither information about what was said nor his/her actual participation status will be divulged.
- Advise around the nature and limits of confidentiality; specifically, that nothing that the interviewee says will be identified and shown directly to anyone else except members of the independent research team; however, confidentiality may be breached if the interviewee threatens harm to themselves or others, or there is a current and significant threat to health and safety that must be addressed to safeguard others in the workplace.
    - In both instances, the interviewee must be encouraged to seek support/assistance independently and a commitment obtained that these actions will be carried through; otherwise, the interviewer is bound to act.
- Maintain verbal and non-verbal encouragers throughout the interview.
- Utilise paraphrasing to reflect back what was said at key points to ensure accurate understanding
- Clarify points that are ambiguous or difficult to interpret.
- Use probes throughout the interview to capture additional detail; use additional ad-hoc or rephrased questions if the original question is not understood by the interviewee.

Privacy Statement

The conduct of this research involves the collection, access and/or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information please telephone (07) 3735 4375.

Limits of Confidentiality

Everything stated during this interview will be treated with confidentiality. However, if you disclose a threat of harm to yourself or others, or a current and serious health and safety issue at your organisation, we may be required to breach confidentiality. Our preference will be to obtain a verbal commitment from you that you will seek support or take the matter further, however, if this is not possible we may need to inform others about your disclosure.

Audio Recordings

The interview today will be audio recorded. After the interview is finished, it will be professionally transcribed by a company with secure procedures to safeguard data. Then the recording will be destroyed. No identifying information will be retained.

☐ I agree to be audio recorded for this interview.

Participant Consent Statement

By agreeing to participate, you will be confirming that:

- You understand what participation in this research entails [list of key points];
- You have had any questions answered to your satisfaction;
- You understand that if you have any additional questions you can contact the research team;
- You understand that your participation is voluntary and that you are free to withdraw at any time, without explanation or penalty; and
- You understand that you can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 4375 (or research-ethics@griffith.edu.au) if you have any concerns about the ethical conduct of the project.

☐ I agree to participate in the project.

☐ I do not agree to participate in the project.

Name	
Date	

Machine workers interview questions

1.0 What types of machines do you use in your job?
1.1 Of these, which do you feel the least safe using?
    1.1.1 Why do you feel unsafe using this machine?
    1.1.2 What do the rules say about how people should use this machine?
    1.1.3 How do people actually use this machine?
1.2 Which machine do you feel the most safe using?
    1.2.1 Why do you feel safe using this machine?
    1.2.2 What do the rules say about how people should use this machine?
    1.2.3 How do people actually use this machine?
2.1 What do your co-workers say about safety?
    2.1.1 What do you think your co-workers really mean when they say that?
    2.1.2 What do you co-workers do that tells you how much they care about safety?
2.2 What does your supervisor say about safety?
    2.2.1 What do you think your supervisor really means when he/she says that?
    2.1.2 What does your supervisor do that tells you how much they care about safety?
2.3 What do your managers say about safety?
    2.3.1 What do you think your managers really mean when they say that?
    2.1.2 What do your managers do that tells you how much they care about safety?
3.1 How would you describe the overall priority of safety in this business as compared to other work goals like productivity?
3.1.1 Please describe some specific examples where safety has been deprioritised below other work goals (situation, actions, results).
3.1.2 Please describe some specific examples where safety has been prioritised above other work goals (situation, actions, results).
4.0 Please share some examples of when a valid safe option did not exist, or was not possible, to deal with a situation at work?
5.0 Our goal with this research is to develop a safety culture toolkit that can be used by the manufacturing industry to improve safety performance. We will be developing a safety culture survey, training for supervisors and managers, and guidance materials for business owners. Is there anything else related to this research that you think would help us to achieve this goal and outcomes?
Thank you for your time and participation in this interview.

We will be undertaking our analyses of the data over the coming month and will incorporate your feedback into the next stage of the project. Results will be shared at the end of the project.

Supervisors and managers interview questions

1.1 Think about the safest machine operator you have in your workplace. What are some of the safe behaviours that he/she uses on machines?

1.2 Think about the most unsafe machine operator you have in your workplace. What are some of the unsafe behaviours that he/she uses on machines?

2.1 What do your direct reports say about safety?

2.1.1 What do you think your co-workers really mean when they say that?

2.1.2 What do you co-workers do that shows you how much they care about safety?

2.2 What do your peers (other leaders) say about safety?

2.2.1 What do you think your supervisor really means when he/she says that?

2.1.2 What do other leaders do that shows you how much they care about safety?

3.1 How would you describe the overall priority of safety in this business as compared to other work goals like efficiency and productivity?

3.1.1 Please describe some specific examples where safety has been deprioritised below other work goals (situation, actions, results).

3.1.2 Please describe some specific examples where safety has been prioritised above other work goals (situation, actions, results).

4.0 Please share some examples of when a valid safe option did not exist, or was not possible, to deal with a situation at work?

5.0 Our goal with this research is to develop a safety culture toolkit that can be used by the manufacturing industry to improve safety performance. We will be developing a safety culture survey, training for supervisors and managers, and guidance materials for business owners. Is there anything else related to this research that you think would help us to achieve this goal and outcomes?

Thank you for your time and participation in this interview.

We will be undertaking our analyses of the data over the coming month and will incorporate your feedback into the next stage of the project. Results will be shared at the end of the project.

Safety staff interview questions

1.1 What do the rules and procedures say about how workers should be using machines here?
    1.1.1 How to workers actually use machines around here?
    1.1.2 What at-risk machine operating behaviours do you observe or hear about in your workplace?
    1.1.3 What reasons do machine operators typically cite to you around why they are non-compliant or engaging in unsafe behaviours?
2.1 Think about the safest machine operator you have in your workplace. How does he/she go about using machines?
2.2 Think about the most unsafe machine operator you have in your workplace. How does he/she go about using machines?
3.1 What do workers at your workplace say about safety?
    3.1.1 What do you think workers really mean when they say that?
    3.1.2 What do workers do that shows you how much they care about safety?
3.2 What do supervisors at your workplace say about safety?
    3.2.1 What do you think supervisors really mean when they say that?
    3.1.2 What do supervisors do that shows you how much they care about safety?
3.3 What do managers at your workplace say about safety?
    3.3.1 What do you think managers really mean when they say that?
    3.1.2 What do managers do that shows you how much they care about safety?
4.1 How would you describe the overall priority of safety in this business as compared to other work goals like efficiency and productivity?
    4.1.1 Please describe some specific examples where safety has been deprioritised below other work goals (situation, actions, results).
    4.1.2 Please describe some specific examples where safety has been prioritised above or just as important as other work goals (situation, actions, results).
5.0 Please share some examples of when a valid safe option did not exist, or was not possible, to deal with a situation at work?
6.0 Our goal with this research is to develop a safety culture toolkit that can be used by the manufacturing industry to improve safety performance. We will be developing a safety culture survey, training for supervisors and managers, and guidance materials for business owners. Is there anything else related to this research that you think would help us to achieve this goal and outcomes?

Thank you for your time and participation in this interview.

We will be undertaking our analyses of the data over the coming month and will incorporate your feedback into the next stage of the project. Results will be shared at the end of the project.

Machine inspectors interview questions

1.0 During your walk-arounds at manufacturing businesses, what non-compliance or at-risk issues do you tend to see among machine operators?

1.1 In what situations do you tend to issue the most non-compliance notices or warnings to manufacturing businesses?

1.2 What at-risk machine operating behaviours do you observe or hear about when dealing with manufacturing businesses?

1.3 What reasons do machine operators typically cite to you around why they are non-compliant or engaging in unsafe behaviours?

2.1 Thinking about the best manufacturing workplaces in terms of health and safety, what are examples of the behaviours that senior management shows?

2.2 Thinking about the best manufacturing workplaces in terms of health and safety, what are examples of the behaviours that frontline leaders and supervisors show?

2.3 Thinking about the worst manufacturing workplaces in terms of health and safety, what are examples of the behaviours that senior management shows?

2.4 Thinking about the worst manufacturing workplaces in terms of health and safety, what are examples of the behaviours that frontline leaders and supervisors show?

3.1 What do workers typically say to you about health and safety when you visit manufacturing workplaces?

3.1.1 What do you think they really mean when they say that?

3.2 What do supervisors typically say to you about health and safety when you visit manufacturing workplaces?

3.2.1 What do you think they really mean when they say that?

3.3 What do senior managers typically say to you about health and safety when you visit manufacturing workplaces?

3.3.1 What do you think they really mean when they say that?

4.0 Our goal with this research is to develop a safety culture toolkit that can be used by the manufacturing industry to improve safety performance. We will be developing a safety culture survey, training for supervisors and managers, and guidance materials for business owners. Is there anything else related to this research that you think would help us to achieve this goal and outcomes?

Thank you for your time and participation in this interview.

We will be undertaking our analyses of the data over the coming month and will incorporate your feedback into the next stage of the project. Results will be shared at the end of the project.

Survey administration tip sheet

Overview

This document contains the key elements critical to the successful administration of the Machine Guarding Safety Culture Survey in your organisation.

Survey communication plan

It is helpful to plan communications around the delivery of your survey. How you communicate, who you communicate to, and who delivers these communications can all impact the response rates to your survey. A survey communication plan should include a list of all the key stakeholders in your business, such as the relevant workgroups, what messages will be sent to them, and the timing of additional messages such as reminders. Ideally, a senior leader should be identified as the survey 'sponsor' who can communicate about the survey and emphasise its importance to the workforce.

Preparing the survey for distribution

Preparation involves ensuring your staff have access to the online survey, drafting your welcome email, and collating staff email contact information. It may also involve printing out copies of the survey for paper and pen completion (if applicable), organising for someone to ensure all staff receive a copy, and having a process ready to collect them when completed.

Inviting the staff to participate

When inviting staff to participate in the survey, they should be fully informed about the purpose of the survey and how the data they provide will be used by your organisation. Responses must be anonymous – you may get more responses, and more honest responses, if respondents do not give their name. Be explicit about confidentiality – reassure respondents that their answers are confidential, and only aggregated data will be reported on. The survey does not capture demographic information that would identify individual workers, which helps preserve anonymity and confidentiality. Please instruct workers to thoroughly read the information statement that displays at the start of the survey (it is provided by the university and is required by their Ethics Committee).

Ensuring high quality data

Collecting high quality survey data is crucial because your leadership team is relying on this information to guide decision-making around health and safety. If employees feel uncomfortable participating in the survey, their information could be less accurate and lead to incorrect decisions being made. Some of the signs of poor-quality survey data include the following:

- Large amount of missing data,

- Biased responding where employees might feel they should answer in a particular way,
- Ambivalent responding where employees give the same answer to every question, and,
- Random responding where employees simply pick any answer that comes to mind.

Therefore, it is important to consider how the survey administration can be done in a way that promotes openness and honesty in responses. Make sure employees know that they can ask questions if they do not understand the survey. Explain the survey question using simple language if needed. Make sure employees feel comfortable around the steps to maintain their confidentiality. Answer their concerns directly and reassure them. Give employees extra time to finish the survey if needed. Look for signs that employees do not understand the items, such as distracting or disruptive behaviour, skipping questions, obvious confusion, or asking lots of questions. Consider arranging a separate session for any employees who cannot participate in the survey on their own. If you know that some employees have trouble reading or writing, please consider the following:

- Ask the employee if they need help to participate, and if so, organise for someone to sit with them to provide support.
- Consider forming small groups for employees that need more support so help like, reading questions aloud, can be delivered at one time.

Survey reminders

Depending on how long you intend to leave your survey open for, ensure you plan to send reminders. Using the promotion strategies above will assist in reminding people to complete the survey. You should remind people to participate in the survey weekly, using a combination of electronic and face-to-face reminders.

Closing the survey

We will advise you when the data collection period is completed. Please send out a thank you communication to workers and communicate the next steps for the organisation in processing the results and the upcoming training.

Understanding and interpreting the results

The results from the survey are designed to be used to inform your organisation's future action planning and the safety leadership training. A guide for reporting and interpreting these results will be included in the forthcoming results summary.

Survey scales

Management Safety Commitment (Focussed Dimension of Safety Climate)

Evaluated on a 7-point Likert agreement 'strongly disagree' to 'strongly agree' scale.	
clm_improve	If machine safety needs improving, management will put money towards fixing the issue
clm_adequate	Operators are adequately trained to operate new machines safely
clm_money	Management allocates enough money to ensure machine safety requirements are met
clm_unsafe	Any unsafe machine operating behaviour is addressed immediately by managers
clm_dealt	Machine safety issues are dealt with quickly by management
clm_instruct	In this organisation we have detailed instructions about how to use machines safely
clm_trained	People are adequately trained to operate machines safely
clm_evaluate	Evaluating the safety of new machines (e.g., identifying missing guards) is done before production starts
clm_time	Management gives operators enough time to do the job and maintain high safety standards
clm_preprod	Pre-production discussions include safety
clm_stop	When people here want to stop a machine for safety, they know management will support the decision
clm_newideas	Management actively supports new ideas from operators about how to improve machine safety
clm_resources	Management gives time and resources to improve machine safety
clm_nopress	There is no pressure to keep operating unsafe or faulty machines in this organisation
clm_superv	New machine operators are closely supervised until they acquire the necessary skills to work safely

Management Safety Leadership Behaviours

Evaluated on a 7-point Likert agreement 'strongly disagree' to 'strongly agree' scale.	
mgr_educate	Educate workers on the benefits of working safely with machines
mgr_verify	Verify that machine operators are adhering to safe standards of work
mgr_explain	Explain the reasons why operators need to adhere to machine safety requirements
mgr_share	Encourage machine operators to share their views on how machine safety should be achieved
mgr_talks	Talk about safety during team meetings
mgr_input	Ask machine operators for their input into safety procedures
mgr_gather	Gather operators together to talk about machine safety
mgr_walks	Walk around the shop floor observing machine operators' safety
mgr_interact	Interact with machine operators and listen to their concerns about safety
mgr_partic	Participate in workplace safety activities and initiatives (e.g., committee meetings)
mgr_positive	Take the time to develop a positive working relationship with machine operators
mgr_stop	Make it known that machine operators can stop or refuse the job if it is unsafe
mgr_suggest	Encourage machine operators to suggest what to do about a safety issue

Positive (Safe) Machine Operator Behaviours

Evaluated on a 5-point Likert frequency ‘never’ to ‘always’ scale.	
bh_tellmach	Tell a supervisor if anything about the job seems unsafe (e.g., faulty machine)
bh_watch	Keep a watch for signs of any problems with machinery and the surrounding environment
bh_concern	Show concern for the safety of other machine operators
bh_damage	Report any examples of damaged or missing personal protective equipment
bh_working	Make sure all machinery safety devices or controls are working as designed
bh_outord	Discuss the details of any out-of-the-ordinary machine job with others before getting started
bh_SOPS	Follow all workplace safety plans (e.g., SOPs, SWMS)
bh_setup	Make sure the machine is setup correctly before starting work
bh_focus	Focus attention on the machine operation task
bh_lifttech	Use safe lifting technique for all manual handling tasks
bh_ppe	Wear all required personal protective equipment required for machine operation

Negative (Unsafe) Machine Operator Behaviours

Evaluated on a 5-point Likert frequency ‘never’ to ‘always’ scale.	
bh_n_block	Reach past a dangerous part of an operating machine to clear a blockage
bh_n_remove	Remove any machine guards that stop or slow down production
bh_n_takeoff	Take a guard off a machine to make it work faster
bh_n_running	Move a guard out of the way to access inside the machine and keep it running
Evaluated on a 5-point Likert frequency ‘never’ to ‘always’ scale; note: additional N/A response option.	
bh_n_max	Set the adjustable machine guard to the maximum size rather than adjust to suit every piece
bh_n_forget	Forget to return a machine guard back to its original position before carrying on with the next task

Additional statistical analyses

The statistical analyses, shown in this section of the report, cover three aspects. First, a summary of descriptive results aggregated to the organisational level are summarised, including mean, standard deviation, and an agreement index that summarises the extent to which survey responses exhibited internal consistency across respondents (an indication of safety climate 'strength'). The second analysis shows the simple pairwise correlations between continuous variables included in the study. These results highlight potential relationships between the variables, but do not imply causality. The final series of results show confirmatory factor analysis results, which provide evidence of the construct validity of the measures used in this research, as well as the results of structural equation modelling, which is a robust method to test for possible causal relationships between variables.

Table A 1: Descriptive statistics for participating organisations at Baseline (where survey respondents were four or above).

Organisation Code	No. Respondents	Mean	SD	R_{wgj}
0IJAB	11	4.90	1.29	0.69
1XGCA	5	6.30	0.32	0.96
3SYAB	7	5.79	0.44	0.90
4KURS	4	5.83	0.78	0.84
7B3S4	7	5.35	1.42	0.72
8DWL8	4	6.37	0.56	0.96
AQU2J	8	6.08	1.11	0.84
BIX5R	4	6.42	0.39	0.96
ENV96	13	5.78	0.93	0.80
HZRPT	5	6.09	0.53	0.92
LRMV2	9	6.58	0.41	0.95
MLTWO	41	5.89	0.78	0.87
0835S	22	5.89	0.89	0.87
PBY0H	10	5.63	1.01	0.82
PIXRH	22	6.04	0.73	0.89
R6294	13	5.71	1.34	0.75
RPVJZ	10	6.04	0.18	0.98
SMFL	18	5.83	1.07	0.81
SQHHK	6	6.27	0.73	0.90
UE6HZ	6	5.93	1.09	0.80
UGA82	5	5.92	0.34	0.96
ULU8V	6	5.27	1.56	0.69
WMMME	10	5.69	1.19	0.75
X3X3X3	8	5.28	1.04	0.82
X5X5X5	7	5.19	0.76	0.77
YJ5M5	10	5.50	0.68	0.88
ZULFS	6	5.77	0.58	0.91

Table A 2: Pair-wise correlations between continuous study variables, using Time 1 dataset (n=299).

	1	2	3	4	5
(1) Tenure	N/A				
(2) Safety Climate	0.10	0.95			
	0.11				
(3) Safety Leadership	0.07	0.83	0.96		
	0.27	0.00			
(4) Safe Machine Behaviours	0.07	0.31	0.31	0.89	
	0.27	0.00	0.00		
(5) At-Risk Machine Behaviours	0.01	-0.09	-0.06	-0.15	0.92
	0.87	0.15	0.32	0.02	

Note: Internal consistency alpha values for each scale are included on the off-diagonal. The p-values associated with each correlation are shown in italics underneath.

Table A 3: Confirmatory factor analysis results (safety climate survey) for Baseline sample (standardised estimates shown).

$\chi^2(89) = 228.28$, p<.01, scaling factor = 1.928, RMSEA = 0.072, 90%CI: 0.06-0.08, p<.01, CFI = 0.92, TLI = 0.90, SRMR = 0.05

Safety Climate Survey Item	Factor Loading
If machine safety needs improving, management will put money towards fixing the issue	0.76
Operators are adequately trained to operate new machines safely	0.81
Management allocates enough money to ensure machine safety requirements are met	0.84
Any unsafe machine operating behaviour is addressed immediately by managers	0.83
Machine safety issues are dealt with quickly by management	0.82
In this organisation we have detailed instructions about how to use machines safely	0.72
There is an emphasis on making sure people are adequately trained to operate machines safely	0.89
Evaluating the safety of new machines (e.g., identifying missing guards) is done before production starts	0.71
Management gives operators enough time to do the job and maintain high safety standards	0.75
Pre-production discussions include safety	0.62
When people here want to stop a machine for safety, they know management will support the decision	0.69
Management actively supports new ideas from operators about how to improve machine safety	0.81
Management gives time and resources to make improvements to machine safety	0.87
There is no pressure to keep operating unsafe or faulty machines in this organisation	0.67
Operators of new machines are closely supervised until they acquire the necessary skills to work safely	0.83

Table A 4: Confirmatory factor analysis results (safety leadership survey) for Baseline sample (standardised estimates shown).

$\chi^2(64) = 162.25$, p<.01, scaling factor = 2.053, RMSEA = 0.072, 90%CI: 0.06-0.09, p<.01, CFI = 0.94, TLI = 0.92, SRMR = 0.04

Safety Leadership Survey Item	Factor Loading
Educate workers on the benefits of working safely with machines	0.75
Verify that machine operators are adhering to safe standards of work	0.88
Explain the reasons why operators need to adhere to machine safety requirements	0.81
Encourage machine operators to share their views on how machine safety should be achieved	0.86
Talk about safety during team meetings	0.73
Ask machine operators for their input into safety procedures	0.84
Gather operators together to talk about machine safety	0.78
Walk around the shop floor observing machine operators' safety	0.83
Interact with machine operators and listen to their concerns about safety	0.89
Participate in workplace safety activities and initiatives (e.g., committee meetings)	0.80
Take the time to develop a positive working relationship with machine operators	0.82
Make it known that machine operators can stop or refuse the job if it is unsafe	0.70
Encourage machine operators to suggest what to do about a safety issue	0.86

Table A 5: Confirmatory factor analysis results (safe machine operating behaviours) for Baseline sample (standardised estimates shown).

$\chi^2(43) = 82.10$, $p<.01$, scaling factor = 1.804, RMSEA = 0.057, 90%CI: 0.04-0.08, p=0.25, CFI = 0.93, TLI = 0.91, SRMR = 0.06

Safe Machine Operating Behaviour Item	Factor Loading
Tell a supervisor if anything about the job seems unsafe (e.g., faulty machine)	0.69
Keep a watch for signs of any problems with machinery and the surrounding environment	0.82
Show concern for the safety of other machine operators	0.76
Report any examples of damaged or missing personal protective equipment	0.73
Make sure all machinery safety devices or controls are working as designed	0.72
Discuss the details of any out-of-the-ordinary machine job with others before getting started	0.67
Follow all workplace safety plans (e.g., SOPs, SWMS)	0.63
Make sure the machine is setup correctly before starting work	0.60
Focus attention on the machine operation task	0.57
Use safe lifting technique for all manual handling tasks	0.41
Wear all required personal protective equipment required for machine operation	0.47

Table A 6: Confirmatory factor analysis results (at-risk operating behaviours) for Baseline sample (standardised estimates shown).

$\chi^2(9) = 25.74$, p<.01, scaling factor = 1.673, RMSEA = 0.09, 90%CI: 0.05-0.13, p=0.06, CFI = 0.95, TLI = 0.91, SRMR = 0.03

At-Risk Machine Operating Behaviour Item	Factor Loading
Reach past a dangerous part of an operating machine to clear a blockage	0.63
Remove any machine guards that stop or slow down production	0.94
Take a guard off a machine to make it work faster	0.94
Move a guard out of the way to access inside the machine and keep it running	0.93
Set the adjustable machine guard to maximum size rather than adjust to suit every piece	0.82
Forget to return a machine guard back to its original position before carrying on with the next task	0.73

Table A 7: Results of structural equation modelling for Baseline sample.

$\chi^2(458) = 936.32$, p<.01, scaling factor = 1.280, RMSEA = 0.06, 90%CI: 0.05-0.06, p<.01, CFI = 0.89, TLI = 0.88, SRMR = 0.06

Pathway	Standardised Coefficent	p-value
Safety climate -> Safe machine behaviours	0.32	<.01
Safety climate -> At-risk machine behaviours	-0.12	0.10

Context for safety leadership

Safety leadership is typically defined as practices that support the prioritisation of safety over other work goals like productivity. Consequently, most safety development programs consist of general leadership behaviours applied to safety contexts, such as setting safety-related goals, establishing and communicating a safety vision, and engaging in safety-related conversations. Although such programs give leaders a solid foundation and wide repertoire of safety-specific skills, arguably there are more powerful ways to improve safety through leadership.

Two ways that safety leadership can be extended include; 1) considering the work situation and the corresponding bundles of practices that apply, and 2) equipping leaders with strategies to help manage competing goals and tensions (e.g., productivity versus safety). The first approach to safety leadership applies the concept of 'situational leadership' and is exemplified by the LEAD model. The LEAD model was developed by Dr Tristan Casey, co-founder of The Culture Effect, and has since been adopted by over 100 companies and endorsed by Workplace Health & Safety Queensland (WHSQ, 2019).

The second approach applies the concept of 'paradoxical leadership', whereby leaders seek to achieve competing goals simultaneously rather than considering them as trade-offs. This approach to safety leadership is more grounded in the practical realities and challenges people face in the workplace, such as when multiple goals or objectives are in conflict. Studies have shown that when leaders think about such goals as simultaneously achievable, rather than being a trade-off, performance is increased. Leaders may be more creative and adaptable when they embrace the paradox rather than avoid it.

Considering safety as an emergent property of a work system means that leaders will benefit more from considering how their decisions, actions, and inactions affect other people and work conditions. This is because safety leadership does not occur in a vacuum. Organisational context, and in particular, culture, shapes safety leadership practices in ways that either contribute to or detract from safety capability. To truly understand safety, we must shift the focus to the macro- or systems-level and treat safety leadership as an emergent property that involves multiple people interacting across and between levels, making decisions, and both influencing and being influenced by contextual factors like organisational culture.

From this macro-systems perspective, successful safety leaders are ‘culturally competent’ in the sense that they are perceptive of and empathetic to the affects that their actions, inactions, and interactions with other actors and objects, have on organisational culture. A part of becoming a

competent and capable safety leader is developing this nuanced awareness and sensitivity to the environment and the impact one has on others, and how leaders operating between and within different levels can interact synergistically to produce safety.

A powerful way of building cultural competence in leaders is story-telling. Stories often work as a catalyst for perspective-taking, helping people to apply different ideas and appreciate different points of view (Casey & Hanley, 2019). Emotional intelligence and empathy are other key skills that contribute to developing cultural competence. Essentially, when a leader knows the 'nuts and bolts' of how leadership is demonstrated (the behaviours) and combines this with a deep appreciation and understanding of how actions and inactions affect others, and indeed, the culture of the organisation, they become a much more powerful force to drive safety.

In the manufacturing environment, safety leadership is best described as general leadership applied in safety-specific contexts. General leadership of relevance for safety is typified by engagement with staff, consultation, empowerment, and generally being visible and acting as an advocate for workers (Donovan et al., 2016). This 'grass roots' combination of different leadership styles (i.e., empowering, transactional, transformational, authentic, and servant) is likely to increase safety performance by encouraging good quality information flow throughout the organisation and building genuine commitment to safety among workers. In manufacturing, an exclusive focus or emphasis on transactional leadership styles is likely to lead (at best) to externally-motivated safety performance (i.e., compliance) and limited safety proactivity.

Context for safety performance

Griffin and Neal (2000) were the first researchers to explicitly examine safety performance and its determinants. Drawing on the general job performance literature, they identified that safety performance is comprised of both compliance and participation. In turn, these performance constructs are predicted by safety motivation and safety knowledge. Interestingly, this basic model has dominated over the past 20 years, with little research done to examine more nuanced safety performance models.

Only a few studies have explored safety performance in more detail. A study by Burke et al. (2006) conducted a qualitative study of manual labourers in the power industry and noted that safety compliance is made up of several dimensions such as usage of personal protective equipment and upholding rights and responsibilities for safety. However, the generalisability of these performance dimensions is questionable.

Research by Hu et al. (2018) expanded the notion of safety compliance into several dimensions: surface, adaptive, deep, and non-compliant. Surface compliance is a form of mindless compliance that involves stepping through tasks with little thought or effort. It is akin to presenting a 'show' to others that compliance is being achieved. In contrast, deep compliance is participating fully and effectively in the compliance task and thinking deeply about how to best apply the procedure or rule. Adaptive compliance is improvising where necessary, such as when a procedure does not exist or does not quite fit the work situation.

A study by Hofmann et al. (2003) expanded safety participation into a broader concept of 'safety citizenship'. Safety citizenship represents a wide array of proactive and self-starting safety behaviours that range from speaking up about ideas to improve safety, to whistleblowing behaviours. A key idea of safety citizenship is that blind 'rule following' or mindless compliance is ineffective to ensure a safe and sustainable organisation. Employees need to actively contribute to safety through participating in exercises designed to achieve learning and continuous improvement, as well as drawing attention to suboptimal and rule-violating practices.

Taken together, it is apparent that the nature of safety performance is much more complex than simple compliance and participation. There are clearly different levels and types of compliance. Further, compliance is only partially effective because workers need to adapt and employ flexibility to cope with disruptions and disturbances (Hollnagel, 2014). Finally, safety performance elements may differ according to industry, such as manufacturing.

Additional qualitative analyses: Entity and affect analysis

The affect analysis looks at the interrelationships between entities found in the workplace, assessing affects that enable or limit safety capabilities in the organisation.

Table A8 shows the entities that interviewees mentioned during their interviews. The table is organised from most to least frequent, which gives an indication of the relative importance or contribution of each entity to the manufacturing industry culture for safety. For instance, 'training' was mentioned or described 30 times across the 60 interviews, which suggests that the development, maintenance, and verification of machine operating competence is seen as an important process in manufacturing and contributes to the culture for safety by generally increasing safety capability (where it is done effectively). On the other hand, 'cleaners' were only mentioned by one interviewee, which suggests that either most people were unaware of this entity, or it is only relevant to a small percentage of workplaces.

In this next section, the themes regarding the culture for safety in manufacturing are summarised. Each theme is categorised into whether it increases, maintains, or decreases safety capability. A total of 10 entities (the most frequently mentioned) are summarised here.

Table A 8: Frequency and percentage of entities mentioned during interviews about the culture for safety in manufacturing.

Entity	Frequency	Percentage
Operators	86	21%
Managers	73	18%
Machines	37	9%
Training	30	7%
Supervisors	26	6%
Safety Beliefs	23	6%
Procedures	18	4%
Materials	14	3%
Toolbox Talk	14	3%
PPE	11	3%
Physical Work Environment	10	2%
Customers	8	2%
Fitters	6	1%
Manufacturers	6	1%
Leaders' Safety Meeting	5	1%
Safety Officers	5	1%
Discipline	4	1%
Isolation	4	1%
Risk Assessment	4	1%
SOPs	4	1%
Government	3	1%
Metrics	3	1%
Pre-Start Check	3	1%
SWMS	3	1%
Suppliers	3	1%
Cranes	2	0%
HSRs	2	0%
Observations	2	0%
Cleaners	1	0%
Committee	1	0%
KPIs	1	0%
Stop-Work Meeting	1	0%

Operators

Operators contribute to increased safety capacity primarily through personal factors such as an unrelenting wariness and vigilance to unexpected or strange signals (e.g., machinery vibrations or noises). To be safe, operators believe that they must be consciously alert and in-tune with their machinery. Operators must also demonstrate a form of 'chronic unease' or pessimism toward the integrity of critical controls. Conversely, failing to anticipate safety consequences was identified as a phenomenon among operators that can decrease safety capability. Another theme that was apparent in the results pertains to co-worker support and proactivity. In these data, peer pressure in the form of social norms around challenging others' unsafe behaviours, was important to maintain effective safety in manufacturing settings.

Increasing safety capability

- Helping co-workers to achieve safety (mateship): Stepping in to assist co-workers with tasks that carry risk (e.g., manual handling) and keeping watch over their safety as work activities are undertaken.
- Never forget to be afraid: Maintaining an almost pessimistic attitude towards the integrity of controls for critical risks (e.g., suspecting that a suspended load could fall and reminding others of the dangers).
- Vigilance to signs of trouble: Remaining vigilant to signals from machinery that could be signs of deeper trouble such as poor maintenance or an emerging problem (e.g., hearing a strange noise and reporting it to management).
- Taking pride in their work: Engaging in pre-job planning and good workspace preparation (e.g., organising tools and resources prior to starting the job). Considering how human-task-machine interaction will occur and reorganising the environment to reduce ergonomic problems, where possible.

Maintaining safety capability

- Learning the limits of machines: Following the purchase of new machinery, there is a period of learning how far they can be 'pushed' within safe operating limits. Over time, this knowledge becomes proceduralised as work instructions and operating procedures.
- Developing deep knowledge and expertise: Workers recognise that long-term employment within the same company results in a critical build-up of expertise that helps to maintain safety performance. Workers draw on each other to leverage different sources of safety expertise.

- Holding each other to safety standards: Developing social norms that make it acceptable and expected that protective equipment violations will be respectfully challenged by anyone, regardless of experience or position in the organisation's hierarchy.

Decreasing safety capability

- Fear of job loss: Concern among operators about raising machine safety issues out of fear of negative repercussions (i.e., being fired by management), which results in continued operation of dangerous and at-risk machinery.
- Untrained people create hazards: Acknowledgement that a lack of machine-specific knowledge, created through absent or inadequate training, can result in a highly hazardous situation.
- Failure to anticipate consequences: A perception that some operators inadvertently put themselves in harm's way through reaching into machinery or manipulating moving loads manually without using appropriate aids or tools.
- Self-imposed production pressure: An observed behaviour among (particularly new) operators that is inferred as a self-imposed production pressure, which much be challenged to reduce risk. There is a perception that some machine operators come from prior workplaces where a production mentality has been reinforced through signals sent by managers and supervisors.

Managers

The most prevalent and important finding regarding senior management was the belief that good safety results in good business, through mechanisms such as supporting efficiency, quality, and customer attraction and retention. When this fundamental belief or 'logic' is held by managers, it seems to drive a host of associated safety leadership behaviours, such as allocating adequate resources proactively to ensure safety, leveraging new employees to spot signs of poor or inadequate safety, and including safety within project budgeting proposals.

Increasing safety capability

- Safety is good for business: Recognition among managers that investment in safety is repaid through higher business performance.
- Machines are 'black snakes' ready to bite you: Managers' use of analogies to drive greater safety awareness and safer behaviours among machine operators (e.g., comparing a dangerous machine to a snake that is ready to strike).
- Drawing on fresh eyes: Managers value the input and feedback of new staff members who may have a unique take on the safety of a workplace, so there is encouragement to share their perspectives on what can be improved.

- Willingness to allocate safety resources: Managers' willingness to invest in safety improvements and control measures in response to concerns raised by workers, such as working from heights or heavy lifts. A perception among operators that management will support any reasonable request to improve safety.
- Budgeting for safety at the proposal stage: Allowance for safety during project budgeting and proposal drafting.
- Designing safety into the job: Adopting a prevention-focussed approach that eliminates the potential for at-risk machine operating behaviours (e.g., reorganising a workspace to eliminate the need for overstretching or bend-and-twist movements).

Maintaining safety capability

- Injury management: A willingness among management to allow adequate time for injured workers to recover before returning to their job—a lack of pressure to recover quickly.
- Engaging regularly with workers: Management visibility on the shop floor, engaging with workers in productive and fruitful conversations about health and safety.
- Visible commitment to safety: The presence of a documented health and safety policy that is supported by visible behaviours and actions by all levels of leadership.
- Flexible production targets: Management's flexibility and tolerance towards production targets, particularly where safety requirements result in lower than expected achieved tonnage or throughput.
- Money lies in people: The belief among managers that investment in training and development of personnel, particularly with a view to long-term retention of staff, results in better safety and the ability to allocate resources elsewhere in the organisation (i.e., avoiding unnecessary expenditure on retraining and supervision).

Decreasing safety capability

- The 'real' becomes 'abstract': Some managers are unable to fully understand or appreciate safety requirements because they are unfamiliar with the machinery and/or operating context.
- Safety costs money: A belief among management that safety detracts from productivity and so leads to reduced investment and dismissal of safety concerns raised by staff. Results in a perception among workers that management "doesn't care about safety".
- Cavalier attitude: Blatant disregard for safety requirements and directing workers to engage in risky workarounds or fixes that have the potential to cause major incidents (e.g., welding additional brackets onto a crane to increase its lifting capacity).

- False sense of security: Complacency among managers that leads to a sense that safety incidents are unlikely to happen (largely based on a good track record in the past achieved through luck or chance).

Machines

Machines themselves contribute to safety capability and performance in both expected and unexpected ways. For instance, machines can cause operators to step back and consider how to best approach a task to ensure safety (i.e., if the task is seen as new or different to usual). Alternatively, machines can 'invite' tampering and removal of guards through the use of securing devices that are able to be removed without tools (e.g., wingnuts).

Increasing safety capability

- Thinking through 'different' jobs carefully: New machines or different tasks on the same machine cue a sense of risk and the expectation that the job will be carefully considered and planned out before commencement to ensure safety is achieved. Reluctance to allow new or different machines to be used immediately without thinking through how they will be used appropriately.
- Interlocks must not be tampered with: Interlocks are widely seen as 'untouchable' and must never be altered or adjusted without firstly consulting management.
- Machines that 'look dangerous' increase vigilance: Where machines include exposed rotating, crushing, or sharp parts, there is a sense among operators that they must treat the machine with caution and vigilance.
- Machine guarding can always be improved or extended: Scepticism that machine guarding is ever adequate enough, which can inspire workers to identify additional protections that go beyond the manufacturer's specifications.

Maintaining safety capability

- Adequate guarding that prevents reaching inside: The presence of machine guarding and blocking mechanisms (e.g., a steel grate or feeder chute) convey to operators that hands or other limbs should not be inserted.
- Emergency stops: Automatic machine stopping systems are widely seen as important safety functions and are relied upon by operators to protect them if they attempt a risky action (e.g., mistakenly opening a machine door while it is operating).
- Large, noisy machines increase vigilance: Some operators believe that noisy and visible machinery increases their risk awareness and overall alertness.

Decreasing safety capability

- Assumptions about imported machinery: Imported and unguarded machinery is seen by some managers and operators as permissible and safe; there is a belief that if guarding was required, it would have been specified by the importer and/or customs (e.g., "they believe they bought it that way, therefore it's okay").
- Old equipment cannot be guarded: The belief that older machines are difficult or impossible to guard, or require unreasonable expense to retrofit and add protective features.
- Safe machinery can be out of reach: Some management are unable to purchase safer machinery due to prohibitive costs (e.g., automatic stop bandsaws) compared to less safe alternatives.
- Unclear machine labelling: Unclear, misleading, or absent labelling on machinery functions, including automatic stop functions.
- Bandsaws are inherently dangerous: The widespread perception that bandsaws are dangerous machines, so their usage is usually restricted and the risk managed by only allowing experienced operators to use them (however, in some workplaces the low frequency of bandsaw use may result in eroded skills, even among experienced operators).
- Machine guards interfering with production: Poorly designed guards are often removed because they obscure a clear view of the product, or cutting or moulding process, and so can reduce quality or efficiency.
- Guards that can be removed without tools: Operators are tempted to remove guards where they are secured with devices that are easily defeated or even encourage hand operation (e.g., wingnuts on protective panelling).

Training

The results presented below showcase some of the training practices that may contribute to increased safety performance, which would otherwise be impossible to discern from prior studies that simply ask whether safety training of any type has been implemented. For instance, use of expert demonstrations and ongoing supervision, feedback and support are strategies that align with Bandura's (1988) socio-cognitive learning theory. Formal assessment of competence following training promotes consolidation of knowledge structures and facilitates training transfer and application (Krauss et al., 2014). Verification of competence by supervisors ensures practices are applied appropriately and signals that the organisation is concerned with how operators use their learning on the job, creating a more positive safety training transfer climate (Grossman & Salas, 2011). Therefore, the mere existence of a safety training program is a necessary but insufficient condition for high safety performance in manufacturing. Organisations must consider how such training is

delivered to maximise learning and application of knowledge and skills when back in the workplace.

Increasing safety capability

- Formal evaluation of competence: Many manufacturing workplaces reported using a formal (often written) evaluation of learned knowledge to ensure operators retain important information and achieve competence on specific machines.
- Rich and meaningful training: Expert demonstration of specific machine operation, combined with ongoing support and supervision to ensure consolidation of skills.
- Commitment to continual training: Delivering training to operators whenever new machines are purchased or changes are made to existing machines. A realisation that continual refreshing and thought about how machines should be used will create safety capability.
- Drawing on experienced personnel: Using competent and highly experienced personnel to 'induct' new operators onto specific machinery and teach effective and safe machine operating behaviours.
- Graded competence system: Using a level system to allocate operators a specific rank that correlates with supervision and training requirements (e.g., a level zero requires constant supervision and support, whereas a level three means the operator can work largely unsupervised).

Maintaining safety capability

- In-field verification of competence: Ensuring machine operators are competent in relevant aspects of their craft through targeted questioning and observation of operating practices. Comparative evaluation of observed practices against standards and procedures set by the company.
- Setting up for success: Instilling in machine operators the important of workspace preparation and thorough machinery pre-start checks.
- Training is needed to use a machine: A preference for purchasing machines that require intensive training and complicated sequences to start-up and operate as a way to prevent untrained personnel from operating them.

Decreasing safety capability

- Non-user-friendly training: Where training is seen as unreasonably long or irrelevant to the user, it is generally considered less effective by operators (e.g., where lock-out tag-out training does not refer explicitly to the machines that the operator will be using in the workplace).

- Shortcutting the training: Relying on previous training received at educational institutions (e.g., TAFE) as the basis for deeming an operator is competent to work on a given machine. This practice also conveys to operators that management is production-oriented and unwilling to invest the necessary time to ensure a high level of competence.
- Failing to train about the consequences: Operators are safer when taught explicitly about the potential severity of injuries that can be sustained when interacting with specific parts or aspects of machines.

Supervisors

An important theme discovered across several manufacturing workplaces was the supervisor practice of threatening operators with job loss for reporting safety issues. Job insecurity is generally associated with decreased safety performance, including increased violations and work-related injuries. Increased stress resulting from job insecurity decreases the cognitive resources that operators can direct towards multiple work goals, and they tend to focus on meeting only one goal effectively (i.e., productivity).

Increasing safety capability

- Supporting operators to manage risk: Supervisors assisting operators to conduct risk assessments and implement appropriate controls in ways that support a collaborative approach to safety management (e.g., operators perceive that they are "never alone" when it comes to dealing with risks).
- Find the supportive supervisors: Operators seek out supervisors who are generally committed to safety as observed by a diligent approach to safety paperwork and risk management practices. Operators perceive that such supervisors know intimately what is happening onsite and are a vital source of information about safety.
- Safety increases efficiency: A belief among some supervisors that a high standard of safety results in greater efficiency, which results in greater safety commitment among workers and safer operating practices (e.g., waiting for two people to move a heavy component).
- Informal coaching: Supervisors providing on-the-job instruction and training on how to work safely in response to observed practices among operators. This practice gives operators the sense that supervisors genuinely care about their wellbeing and safety.

Maintaining safety capability

- Reinforcing machine isolation procedures: Preventing operators from inadvertently accessing dangerous aspects of machinery or reminding operators to follow lock-out tag-out procedures.
- Noticing signals of stretched capacity: The ability among supervisors to observe implicit cues regarding the capacity of the team to handle incoming production demands, stopping work to reassess the situation as a group, and regain situational awareness and focus (e.g., noticing a build-up of delivery trucks, and increased work pace).
- Phased approach to performance management: Dealing with suboptimal safety or work performance using a graded approach, beginning with education and feedback, consultation with other supervisors, and finally disciplinary action.

Decreasing safety capability

- Between a rock and a hard place: Supervisors often feel torn between management and workers, with contrasting requirements creating pressure and goal conflicts. Workers may interpret a lack of action on raised safety issues as a supervisor issue. However, supervisors often lack support from management to fix the issue due to cited production requirements.
- Supervisors threaten job loss: A perception among some workers that supervisors will threaten jobs if safety issues are raised with senior management.
- Absent supervision: In some workplaces, supervisors spend minimal time in the field, and so are seen as detached and distant to shop floor safety (e.g., supervisors are seen to spend too much time in the office away from operators).

Safety beliefs

Evidence of numerous shared beliefs about safety were identified, which paint a picture of the industry-level culture for safety across manufacturing. Noteworthy beliefs that may act to increase safety capability include safety and quality go together (i.e., that safety efforts are compatible with and reinforce quality efforts), stop-the-job authority (even where profits may be impacted), and a shared responsibility for safety (that both owners and workers must accept their individual responsibilities for safety). Interestingly, beliefs regarding the nature of safety itself likely influence how people practice safety activities, and which models, frameworks, and practices they draw on to create safety in their work operations. For instance, the belief that safety is best measured as the absence of negatives creates a focus on lagging indicators and a reactive approach that has diminishing returns. Alternative and supplementary beliefs extend traditional ideas about safety to include a focus on positive events such as successes, and to learn from what makes work successful

(Dekker, 2019). Another belief about safety discovered was that safety must be designed to accommodate the least capable or competent worker. This belief may result in unnecessary constraint and restriction of workers to prevent injuries from occurring, leading also to reduced engagement and job dissatisfaction.

Increasing safety capability

- Safety and quality go together: A belief that safety and quality are mutually reinforcing and synergistic (i.e., that creating higher quality will also create higher safety).
- Machines have no sympathy: Machines will not stop operation for a human limb so extra care and caution is warranted.
- It's OK to stop the job: Even where stopping the job results in lost profits, the belief that it is better than experiencing an injury or other safety incident tends to drive a higher safety commitment.
- People will not work in an unsafe workplace: The safety reputation of a workplace is tied into their ability to attract and retain good machine operator talent.
- Safety at work and at home: A genuine safety commitment is all-encompassing; not only must it be shown at work but also carry over into home life as well.
- Everyone is responsible for safety: All workers must contribute to safety through recognising and accepting their individual responsibilities.
- Being unsafe is socially unacceptable: Changing societal attitudes and beliefs have increased the priority of safety across the industry; there is a belief that it is no longer acceptable for manufacturing workplaces to have major injuries.
- Safety supports customer satisfaction: A belief among some managers that effective safety practices support and grow the organisations' customer base; a belief that an organisation cannot grow commercially without a high level of safety.

Maintaining safety capability

- Safety pessimism: Some operators and leaders believe that zero harm is not possible, and that it is more helpful to anticipate where things can and will go wrong.

Decreasing safety capability

- 'She'll be right': Among some operators, there is a belief that where it is quicker or easier to engage in a shortcut, the safety risk is often downplayed or ignored, particularly where the likelihood of an incident being experienced is low.

- Safety is for the lowest common denominator: Designing for safety is akin to anticipating where the least competent person may interact with the work environment and using this as the basis for safety improvements. A belief that safety is achieved when people are restricted, controlled, or otherwise prevented from making mistakes or non-compliance.
- Absence of negatives: The complacency that is introduced in workplaces where safety is measured as the absence of negatives, which means a long stint of zero incidents creates a false sense of security.

Procedures

Themes discovered in this manufacturing sample support the importance of balancing prescription with freedom to improvise and adapt, as well as the role of procedures in supporting the development of capability and competence. A prevalent theme was involving operators in the design and revision of safety procedures.

Increasing safety capability

- Streamline and simplify: Operators value a safety management system that is comprehensive, but also designed with the end-user in mind so that bureaucratic paperwork requirements are not overwhelming.
- Developing capability: Operators develop their capability through procedures and checklists that are adequately detailed and outline major steps throughout each task they must complete (e.g., setting up for the job, hazards, handover to next shift or section).
- Specificity: Specifying limits and boundaries for safe operation in terms that operators will understand and find practical to achieve (e.g., maintaining a 120mm separation between hand and cutting blade).

Maintaining safety capability

- Adapting and improvising: Where no procedure or work instruction exists, work is stopped and operators consult with supervisors or managers to develop a suitable process until the task can be analysed and an appropriate formalised procedure put in place.
- Procedures as a point of reference: Rather than being a prescription for how work should be done exactly, some workplaces use procedures as a point of reference of 'best practice' against which individual methods can be evaluated.

- User centred design: Where problems with work are discovered, some managers indicated that best practice is to firstly examine whether training and procedures are an issue, with an emphasis on providing additional training and reviewing procedures to ensure they are relevant and helpful to operators.

Decreasing safety capability

- No documentation: Poor workplaces, in terms of safety performance, are typically characterised by an absence of formalised documentation around work processes. Safework NSW inspectors stated that, in such workplaces, there is an *ad-hoc* approach to safety.
- Adapting without thinking: Risk is increased when operators proceed with adaptations or improvisations without stopping the job and either consulting or appropriately considering the risk implications for their adaptations.
- Surface compliance: Some workers believe that the management engages in superficial or surface compliance just to satisfy contract requirements, resulting in a system that is largely paper-based and not implemented in practice.

Materials

Evidence was found that the raw materials involved in creating products affect safety capability in dramatic ways. Of particular importance were themes relating to steel coils. These coils store significant kinetic energy and when released, can cause deep cuts and lacerations to operators. To increase and maintain safety capability, operators used past incidents as story-telling devices that result in an increased vigilance toward such coils. Heavy materials used in manufacturing were also identified as a significant hazard that contributes to safety capability. In workplaces where the approach to controlling manual handling involved hazard elimination, this contributed positively to safety capability. In other workplaces, operators' peer pressure to move heavy loads short distances likely decreases safety capability and may result in increased incidence of musculoskeletal disorders.

Increasing safety capability

- The memory of steel coil incidents: Numerous operators reported stories of injuries sustained due to the kinetic energy stored within steel coils that are used in production processes (i.e., when cutting open the coils, this releases the stored tension and can cut into unwary operators). Operators share these stories with each other to increase safety capacity and teach new operators about risk.

- Decreasing the risk of manual lifting: Manual handling is widely seen as a significant risk in manufacturing, and some workplaces have invested significant effort to eliminate or otherwise reduce the risk of heavy manual lifts (e.g., bringing materials to operators using forklifts).
- Vigilant to jammed materials: Experienced operators are constantly alert to signs that a material is about to or has become jammed, which enables them to be more proactive (i.e., throttling back the machine, reinserting or adjusting the material) rather than reactive (i.e., reaching into the machine to unjam it).
- Suspended loads create extra awareness: Use of cranes with heavy loads was another critical risk identified by experienced operators. Stories are typically shared by these operators to increase team vigilance and alertness.

Maintaining safety capability

- Securing steel coils: Operators remain vigilant to the potential for steel coils to spring apart and cause serious injuries, so tend to devise a range of improvised methods aimed at securing them.
- Avoid manual handling where possible: A prevalent belief among operators was that manual handling should be avoided or eliminated wherever possible as it is an inherently dangerous activity when dealing with heavy raw materials and finished components.

Decreasing safety capability

- Temptation of manual handling for short distances: When manual handling cannot be avoided or there is a small distance to carry the load, some operators can exert pressure on themselves and others to move the load using risky lifting procedures.
- Steel straps and falling bars: Raw materials carry a lot of risk, particularly when coiled or stored under tension (e.g., a load of steel bars). Operators reported a number of examples relating to injuries sustained when handling raw manufacturing materials of this nature.

Safety-Related Meetings (e.g., Toolbox Talks)

Regular safety meetings that concentrate on developing shared mental models of operational requirements, work conditions, and safety requirements tend to be seen favourably by operators and contribute to increased safety capability. Operators prefer safety meetings where there is opportunity to have input and two-way discussion to share safety concerns and ideas.

Increasing safety capability

- Driving safety and productivity: Regular pre-task discussions are widely perceived as beneficial to both productivity and safety as they enabled operators to develop a comprehensive understanding of tasks and operating requirements.

- Regular talks to share daily safety information: End-of-shift team discussions to discuss the day's events and specific safety implications were widely valued by operators.
- Talks to consult with staff and identify issues: Safety meetings were seen as particularly beneficial by operators when they included an opportunity for two-way discussion and permission to raise safety issues or ideas to improve.

Maintaining safety capability

- Safety shares to confirm commitment: Operators are encouraged to share safety-related experiences during meetings, which has the effect of bolstering the workplace's safety commitment and keeping safety as an important agenda item.

Decreasing safety capability

- No themes were identified.

Personal Protective Equipment

Protective equipment is the last line of defence against safety incidents and so should not be relied on exclusively to control hazards assessed as significant risk (Safe Work Australia, 2018). Nevertheless, protective equipment can act as a 'slice' within the 'defences in depth' approach to ensuring the safety of work activities. Defences in depth is a term made popular by James Reason (1997) that refers to multiple overlapping controls that mitigate against the threat of an accident sequence triggering harm or loss. Thus, protective equipment forms the last line of defence that can reduce the severity of injury if all other controls simultaneously fail. Findings suggest that operators deemed to be exemplary in their safety tend to wear protective gear at times where it is not mandated and at a minimum, comply with all rules and procedures relating to personal protection. Some manufacturing workplaces in this sample invested significant time and effort to develop customised protective gear where conventional products were found to be inadequate.

Increasing safety capability

- Wearing non-mandatory protective gear: Some operators will wear additional protective equipment or at times when not required to reduce the risk of minor injuries even further.
- Developing specialist protective gear: Examples were raised of organisations investing in custom-designed personal protective equipment in response to injuries or near-miss incidents (e.g., developing special wrist guards to protect against metal grinders).

Maintaining safety capability

- Wearing all required protective gear: Operators were seen as safe when they complied with all protective gear requirements regardless of the situation.

Decreasing safety capability

- Absence of gear: Operators interpret a lack of protective gear as a sign of poor safety commitment among managers and a threat to their personal safety.