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Product Safety Culture: A Preliminary Study in the UK Manufacturing Industry

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Abstract

Do accidents where users are injured or killed by unsafe products reveal underlying weaknesses in the safety culture of the responsible organisations? While manufacturing firms have long been concerned with organizational culture factors that relate to product quality, there has been much less attention to the relationship with consumer safety. Product safety culture can be defined as the attitudes, norms, beliefs and behaviours of staff in manufacturing organisations that affect the integrity of a product in relation to the well-being of its users. There has been limited research into this type of safety culture, with the exception of several studies from the food industry. This exploratory study in one large company adopted a qualitative approach to identify the dimensions of product safety culture in the manufacture of engineered products. Study 1 consisted of phone interviews (8 managers, 2 workforce). Study 2 was on two UK manufacturing sites where interviews and focus groups were conducted (46 participants in total: 7 managers, 39 workforce). The transcriptions were coded using inductive thematic analysis to identify the main components of product safety culture. The findings indicated six principal dimensions: management commitment to product safety, communication, safety systems, trust, understanding of safety systems and product safety ethic. These are well-established components of culture relating to worker and process safety. The last dimension appears to be a distinctive component (compared to other types of safety culture) relating to an employee's moral and ethical stance toward product safety, where user well-being is considered during product manufacture. This ethical component is a more novel feature which suggests that fostering concern for unknown product users may be an additional facet of product safety culture worth investigating in the effort to reduce the risks to consumers.

Key words: product safety culture; management commitment; communication; safety systems; product safety ethic; product users

1 Introduction

In March 2019, aviation authorities around the world grounded the *Boeing 737 Max* aircraft after two crashes involving *Max 8* planes which killed 346 people. Investigations indicated that the pilots had difficulties controlling the planes due to problems with the flight control software: Questions were then raised about managers' prior knowledge of these issues and the nature of Boeing's corporate culture (*Telegraph,* 2019).

According to a recent briefing paper for the UK parliament on product safety and recalls, *'a safe product is one that provides either no risk or a minimum acceptable level of risk, taking into account the normal or reasonably foreseeable use of the product and the need to maintain a high level of protection for consumers'* (Conway, 2019, p1). As it explains, despite required compliance to regulatory safety standards for all types of goods (e.g. European Medicines Agency, see Aronson et al, 2020; European Machine Directives, see Bagagiolo et al, 2017), product safety failures that have jeopardised user wellbeing are not uncommon. They include fire risks, poisonings due to contaminated food or faulty medical implants, as well as injuries or deaths caused by equipment malfunctions. In 2016, the electronics company *Samsung* announced a global recall of 2.5 million *Galaxy Note 7* phones, due to the risk of faulty batteries that could overheat and cause fires or explosions (BBC 2017). In the UK, 500,000 Whirlpool washing machines were recalled because of the risk of them catching fire (Guardian, 2019). There are multiple cases of car failures that have caused harm, such as the *Ford Pinto* (Gioia, 1992); the *Takata* air bag (NHTSA, 2017); *Toyota's* unintended acceleration issues (FBI, 2014); *Ford's* recall of cars due to loose steering wheel bolts (Reuters, 14 March 2018) and *Honda's* recall of 900,000 Odyssey minivans due to a fault in the rear seat (USA Today, 2017). Reports of product defects which can lead to user injuries or death raise important questions relating to the corporate management of risk: How much do manufacturing companies care about the safety of their consumers? Do accidents where users are hurt by unsafe products reveal underlying weaknesses in the safety culture of the responsible organisations? Manufacturing firms have long been concerned with product quality and the associated corporate culture (e.g. Naor et al, 2008; Wu et al, 2015). However, less attention has been devoted by researchers to the specific relationship between the aspects of organizational culture which affect one specific aspect of product quality which is product safety (i.e. the wellbeing of product users). These cultural factors are what is meant by product safety culture and this concept is particularly relevant to certain types of safety-critical products which have the potential to cause serious harm to users (e.g. vehicles, medical devices, pharmaceuticals, foods).

In this paper, we examine the concept of product safety culture and attempt to identify constituent factors by interviewing managers and workers in one manufacturing company. In the absence of a well-developed literature on the subject, we propose a definition of product safety culture based on the broader safety culture concept which typically relates to worker safety or process safety (Health and

Safety Commission, 1993). Thus, product safety culture can be defined as the attitudes, norms, beliefs and behaviours of managers and workers that affect the integrity of a manufactured product in relation to the well-being of its users. Notwithstanding ongoing theorising on the nature and practical value of safety culture (Bisbey et al, 2019; Le Coze, 2019) and continuing debate about safety climate vs. safety culture (Pettita, Probst & Barnabelli, 2017), we have adopted the latter term which was being used in the participating organisation.

There is an extensive literature on safety culture in relation to worker safety and process safety (e.g. Beus et al., 2010; Frazier et al., 2013) and in relation to the consumers of certain services, such as air traffic control (Kirwan et al, 2018) or healthcare (i.e. patient safety culture, e.g. Waterson, 2014). Leaver and Reader (2019) examined the dimensions of safety culture which were found in prominent empirical studies and literature reviews in the last twenty years. Their list consisted of Management Commitment to Safety (e.g. perceptions of staff for the managerial expectations on risk-related behaviours), Risk handling (e.g. responding to error, risk-taking behaviours), Rules and Regulation (e.g. safety protocols), Systems (e.g. policies, incident reporting) and Collaboration (e.g. communication, teamwork on safety). It is likely that a similar set of dimensions are applicable to product safety culture and this is beginning to be examined in the food industry.

'Food safety culture' focuses on the safe manufacture, storage, handling and delivery of food to avoid foodborne illnesses (Jespersen et al, 2016; Yiannas 2009) and to date, the studies have tended to base their investigations on the cultural dimensions mentioned above. Griffith, Livesey and Clayton (2010) reviewed the literature on worker/process safety culture and suggested that a food safety culture consisted of six dimensions: Leadership, Commitment to food safety, Communication, Risk perception, Food safety management systems (and style), Food safety environment. Powell, Jacob and Chapman (2011) examined the organisational culture of manufacturers responsible for three food contamination cases and found that management commitment and communication were both important dimensions for maintaining good food handling practices. Neal, Binkley and Henroid (2012) conducted a culture survey of food service employees in the USA and reported that management commitment to safety and their consistency regarding handling practices were valued by employees. In a study of butcher shops in Belgium, De Boeck et al. (2016) measured food safety climate using a questionnaire, focussing on factors such as leadership, communication and risk awareness and found a positive relationship with hygiene and safety status. Overall, in the food studies, there has been a focus on examining management commitment to safety and how it impacts workplace practices and whether appropriate procedures (safety systems) are followed. In addition, there was an emphasis on communication between the management and employees facilitating learning and sharing of information. One of the few studies of safety culture relating to a non-food product is Zhu et al.'s (2016) questionnaire survey of juvenile product manufacturers in China, US, Europe, Japan, Australia. They too concluded that management commitment to safety had a strong impact on design for safety and product safety.

While the above studies have explored the corporate culture associated with user safety for food or other products, they have tended to rely on the dimensions already identified as protective for worker or process safety. But what is distinctive about a product user, as opposed to a worker or a service user (e.g. a patient in healthcare), is that the product user will be remotely located from the manufacturing organisation and may not be using the item until months or years following its production. Therefore, while it is probable that cultural dimensions such as management commitment or safety systems will be components of product safety culture, it cannot be assumed that the cultural composition will be equally applicable when the outcome is the safety of the users of manufactured products. Product safety culture, which concerns the safety of individual product users who are external to the organisation, might have some idiosyncratic components. Therefore, the aim of this study was to conduct a preliminary exploration of that proposition by using a qualitative approach to identify the main dimensions of product safety culture in a manufacturing company that produced engineered goods.

2 Method

The study was based in a large UK multinational engineering company which had a product safety manager in each business unit and manufactured safety-critical products. Ethical approval was obtained through the university's research ethics procedures. Following a pilot study with ten managers to check the interview schedule, Study 1 was conducted to gain an overall perspective on product safety culture by interviewing a sample of managers and workers. Study 2 was based on two manufacturing sites in the UK and consisted of interviews and focus groups. Site A manufactured large transportation vehicles and had a higher number of engineers working throughout the organisation, whereas site B made small single-use products and had engineers mostly employed as design and technical authorities. It is not possible to provide more specific details of the company or the products due to the client confidentiality agreement for the study.

2.1 Study 1 – Preliminary interviews

Interview Schedule

A semi-structured interview schedule was designed to explore attitudes and actions relating to product safety culture and was informed by the product safety literature. This was first pilot-tested by conducting phone interviews with 7 product safety managers and 3 managers in related roles, resulting in minor modifications. The resulting interview schedule (see Appendix 1) had 22 questions.

Procedure

Recruitment of participants was facilitated by the organisation and 28 employees (16 of whom were managers) were invited to take part. The intention was to interview those in roles related to product safety, both from managerial and non-managerial positions. The interviews (avg. length 55 mins.) were conducted by telephone, recorded, transcribed and analysed.

Participants

The interviewees who volunteered to take part were 8 operational managers and 2 from non-managerial positions related to product safety, sampled from 3 different sites. No other demographic details were collected to preserve anonymity.

Analysis

Inductive thematic analysis was used to extract dimensions from the data (Smith, 2007) using NVivo 11 (QSR International, 2016). The initial open coding identified concepts of interest, which were inspected and labelled. Axial and pattern coding helped identify conceptual relationships and subcategories (Miles, Huberman & Saldana, 2014; Strauss & Corbin, 1998). All nodes in NVivo were examined to establish whether the developed categories were suitably identified. A second researcher coded five interviews and Cohen's $k = 0.83$, indicated acceptable inter-rater reliability (Fleiss, 1981).

Results

Ten dimensions of product safety culture were identified: management commitment to safety, safety systems, risk mitigation (safety systems sub node), understanding (safety systems sub-node), communication, trust, product safety ethic, economy and productivity, time pressure and reputation. As this was a small sample (and mainly managers), it was decided to gather a larger sample with more members of the workforce. The dimensions were used to revise the interview schedule for study 2. The coding material from study one was subsequently integrated with the findings of the second study. Respondents' quotations from study 1 are labelled below as S1 Ix.

2.2 Study 2 – Interviews and focus groups at two manufacturing sites

Participants

On site A, six participants were interviewed: two shop floor workers, an inspector, a team leader, a training leader, and an operational manager. On site A, convenience sampling was used due to time constraints.

On site B, there were 46 participants (shop floor workers, team leaders, middle and upper managers), of whom 5 were interviewed, 35 were in seven focus groups of 4 or 5, six groups had workforce members and one additional group had 6 managers. The excerpts from study 2 are labelled S2 Ix for the interviews and FG 1-6 for the focus groups. The sampling used was stratified, where the attempt was to collect interviewees across the organisational hierarchy, with a focus towards shop floor workers. In total for study 2, 7 managers and 39 members of the workforce (from varying roles) participated.

Procedure

The 11 interviews either took place on the shop floor or in meeting rooms and lasted 30 to 45 minutes. A digital recorder was used with participants' permission. The interviews were semi-structured and had slightly different schedules for management, team leaders and shop floor workers (See Appendices). They collected demographic information (job role, business unit, product experience, length of employment) and had 22 questions based on the ten dimensions of product safety culture, identified in Study 1. Coding in NViVo (v11) used a thematic analysis approach (Braun & Clarke, 2006), with coding based on the ten dimensions.

The use of focus groups enables feedback from participants as they listen to different perspectives (Carlsen & Glenton, 2011). The interview schedule was used to guide the discussions, in some cases not all issues could be covered due to time constraints. The focus groups were recorded and transcribed, with the exception of the first one, where participants declined to be recorded (notes were taken). The coding method was the same as described above. Six transcripts were second coded and the kappa value was 0.7 (moderate Landis & Koch, 1977; and acceptable, Fleiss, 1981).

3 Results

The findings from sites A and B in study 2 were considered together as the same ten dimensions were replicated from the first study. During analysis, some dimensions did not emerge frequently and therefore did not contribute significantly on a conceptual level. For example, 'reputation' was dropped due to low frequency of occurrence. Due to low frequency and conceptual overlap, 'time pressure', 'productivity', and 'risk' were subsumed as aspects of 'management commitment' as they were often referred to within a management context. These changes resulted in six remaining dimensions identified overall. These were: safety systems, understanding of product safety systems, communication, management commitment, product safety ethic and trust (Table 1 shows frequencies and indicative components).

Insert Table 1 here

The frequency data have only been shown to illustrate how often particular topics were raised and were not used for further quantitative analysis. The nature of each of the six dimensions of product safety culture that emerged from the coded interview data is described below.

3.1 Safety Systems

This appeared to be a broad dimension, at an organizational level, encompassing the company's policies, procedures and practices related to product safety, such as recording identified risks.

> "*There is also the proactive approach to defining product safety issues so it could be around the potential hazards or the risks around product safety and those logs are then maintained and regularly reviewed by the project and the design authority*." (S1 I10)

The dimension included company training relating to product safety behaviours (e.g. tool handling, safety protocols, awareness courses) required for correct product design, assembly, servicing and maintenance. A key aspect to achieving good product safety involved the development of standard operating procedures (SOPs) for specific processes and job roles. These included detailed outlines of what employees could do in terms of their job (or other roles if on job rotation) and their training needs.

> "*When it comes to product safety I think we try and remove all the sources of noise by getting all the things I mentioned before right. Identifying those critical features, putting automation in where it's required, putting checks in where they're required, putting good procedures in where it's required so that, got to be polite here, without overly training people. You don't need experts to run a lot of the processes. So you can train people up to a base level but a good training then the product safety will just flow out of it providing you perform the tasks.*" (S2 I4)

Product safety issues could be recorded on notice boards, which allowed for shift leaders to take appropriate actions. They were also logged in product safety reporting databases (e.g. supplier issues or product faults) which provided an easy access to records and provided users with the latest product safety standards (S1 I3). Reporting behaviours were frequently mentioned and on one site, employees were required to submit one report a month, which was felt to make the reporting more target-driven and some respondents felt that due to the number of reports produced by demand, larger issues could be overlooked.

Safety systems also referred to peoples' work practices relating to product safety, as well the application of the company's policies and procedures in mitigation of risk. It also encompassed managerial responsibility for safety (McDonald et al., 2000), which shares some common ground with the dimension of management commitment. The development of product safety culture in this organisation involved the introduction of a safety management system (SMS). It appeared from the responses that there had been a cultural change on-going for several years, where the importance of product safety was gradually being elevated and incorporated into workplace practices. Overall, the introduction of an SMS was a move towards placing a greater emphasis on product safety, and therefore elevating its visibility within the workplace. The SMS was designed to create accountability among management and to introduce a top-down approach in resolving product safety issues.

Safety systems was a prominent dimension in this examination of product safety culture and is commonly found in studies of worker and process safety culture (Beus et al., 2010; Flin et al., 2000;

Leaver & Reader, 2019). Frazier et al. (2013) viewed an SMS as a core concept of worker safety culture and this relates to the findings here, suggesting that it was an element undergoing integration that would allow for better management of product safety issues. This is in line with studies of food safety culture, e.g. Yiannas (2009) regarded a food organisation's safety systems as integral to its culture (see also Griffith, 2006; Neal et al., 2012).

3.2 Understanding of Product Safety Systems

The second dimension was labelled 'understanding of product safety systems' and this is at the level of the individual. It covers comprehension of concepts relevant to product safety, including the individual's knowledge of relevant training, policies and procedures that may impact on the state of product safety. It also refers to an appreciation of the level of product safety applied in the person's job, and how that could be potentially improved, or how one's actions could impact on the state of product safety. Respondents mentioned the need to be aware of the training that each employee received, and its suitability for specific jobs. They generally appreciated that their workplace behaviours could have an impact on the user's well-being, but according to some interviewees, did not always completely understand all aspects of the product and its inherent risks.

> "*But I think there is a bit of a disconnect when we hand that over to ops to manufacture, we've then got no direct involvement on a day to day basis. And perhaps, whether it's our fault, their fault - it's not always the understanding of what they're making, and the practicality of what they're making. So even though they might, with the best will in the world, want to make safe product, they might not understand how to*." (S2 FG4)

Another aspect of understanding of safety systems was that product safety and other expertise could be tacit, essentially a "*black art*" within the organisation. That is safety knowledge that had been obtained through experience over the years had not always been formally documented – e.g. in the SOPs or training material and this could be lost to new generations of workers. The understanding of product safety systems could also be reduced where younger employees changed jobs more frequently, and had different attitudes and values (see Gibson, Greenwood & Murphy, 2009), resulting in higher turnover affecting awareness of product safety.

The design and technical authorities were considered to be the most knowledgeable figures on product safety, as they were involved in the design of the product and issuing of the work standards required for its manufacture. Sometimes, complete understanding of safety systems may not be reached, as some product safety failures (e.g. from the design phase) can occur only once the product has been in the user's hands, suggesting that product use is a definitive way to determine its safety (S2FG5). Managers with appropriate engineering experience were regarded as more likely to appreciate the issues related to product safety in terms of technical scope and more knowledgeable managers tended to show more buy-in for product safety. This type of safety understanding in workers and managers has been

previously referred to as safety knowledge (Neal, Griffin & Hart, 2000; Neal & Griffin, 2002). It may be derived from lessons learned from previous product safety events and could be described as a form of "*sense-making*" (Weick, 1995; Zohar, 2010), where the individual proactively considers future safety issues that they may create or eliminate, based on their expertise.

This dimension - Understanding of product safety systems - is similar to one in the worker/ process safety literature, called 'safety knowledge'. Neal et al. (2000) found that safety knowledge was an important determinant of safety performance in worker safety. They also suggested that safety behaviour and safety performance were linked, and that knowledge and skills were important in shaping the safety behaviours. A similar notion was raised by Christian et al. (2009) in their cultural meta-analysis of antecedents of safety behaviour and safety performance.

3.2 Communication

This dimension encompassed references to any type of communication relating to product safety, such as reporting concerns and potential risks.

> *"I think that continuous informing of people that are directly involved in product safety activities, making sure that they have the awareness of the governance, of the processes that are there and making sure that they understand the specifics of their business unit or their projects*." (S1 I10)

Respondents mentioned that typically communication on product safety occurred in different kinds of meetings (e.g. team meetings, toolbox talks, site managers' quarterly reviews). Generally, workers used face-to-face communication to notify their supervisor in the case of a product safety issue that would then be passed onto the management, depending on the severity of the situation. Dissemination of knowledge after product safety events was regarded as very important for raising awareness of safety issues. In general, the exchange of safety knowledge and ideas was regarded as crucial, as this helped to inform better practices and also spread awareness as to the on-going situation regarding product safety. Communication was also relevant in reporting concerns about product integrity and then receiving feedback from management in terms of how the issue had been resolved. Littlejohn, Lukic and Margaryan (2014) identified such behaviours as important to learning from safety issues.

Typically, communication is considered an important dimension of worker/process safety culture (Beus et al., 2010; Guldenmund, 2000; Zohar, 1980), as well as of food safety culture (Powell et al., 2011; Yiannas, 2009).

3.3. Management commitment to safety

This organisational level dimension refers to management (including supervisors and team leaders) taking an active role in encouraging product safety practices, or general attitudes of management towards product safety.

"*So, the best way is leading by example. So, the management teams often go out and talk to people as well, engage with the staff. Our head of [XXXX] programme has a regular blog where basically, he videos himself for two minutes talking about something relevant to the business to keep them engaged, instead of just giving them a written piece of paper that's read out like someone else. He'll physically take a video*." (S1 I3)

Management could show their commitment to product safety in various ways, such as showing interest, making appearances on the shop floor, participating in inspections. They could ensure that production staff had undergone product safety training, understood the situations occurring on the shop floor and were able to respond appropriately. It was felt that management should encourage safe behaviours, along with operational goals, to ensure that production was not viewed as a higher priority than safety (see also Frazier et al., 2013). This was achieved as an aspect of the communication between management and the workforce, where workforce would specify if certain tasks required longer completion times due to potential product safety issues. The interviewees mentioned they felt comfortable doing this, as the management was approving of considering product safety carefully.

Management commitment was also shown to be manifested through holding safety talks within the production area and participants remarked that if management did not hold these, it decreased their perception of management commitment. A presence of management on the shop floor was important in encouraging safe behaviours and provided an opportunity for the employees to observe them "*walking the talk*" (I2), which enhanced perceptions of management commitment to product safety.

"*I think it's about clearly articulating that it is a priority, but then exhibiting the behaviours that back that up and visibility."* (S2 FG6)

Respondents (FG4) mentioned that if management said one thing and did another, this could decrease the workers' perception of the manager's commitment, especially in cases of raising product safety concerns. Participants spoke about the differences between upper and middle management, where middle management may be seen to be less focused on product safety due to their drive to achieve sufficient production numbers.

In terms of raising the product safety profile, management was considered as able to influence the awareness within the workplace through their commitment. Zhu et al. (2016) suggested that management commitment was important for product safety. The worker safety culture literature also places a strong emphasis on management commitment (Beus et al., 2010; Mearns et al., 2004) and this can also include balancing competing demands relating to adherence to safety/procedures versus cost/time (Zohar, 2010). Despite good intentions, there may be limited understanding of certain issues

in the workplace from the management perspective, and this might be a result of low involvement of management to encourage learning and sharing of knowledge. An example of limiting the knowledge and awareness of product safety involved situations where management would be shown particular things – e.g. they were not shown the full extent of the issue once it had been resolved but rather what had been done to address it – leading the management to potentially assume that everything was fine regarding safety on the shop floor. Due to this potential cyclical behaviour – where management assumed everything was fine, and issues were not reported openly, the sharing of knowledge and workers' own understanding of product safety could be affected, as a result of knowledge gaps.

This demonstrates the two-way interaction that relates to trust, where management would take the messages conveyed by the workforce at face value. While management should be seen to be proactive, their behaviour is shaped by the communications received from the shop floor. As a result, in situations where knowledge is not communicated fully, a certain degree of complacency may be created at the management level through lack of awareness. This may be underpinned by insufficient 'chronic unease' about ever-present risks (Fruhen, et al., 2013). However, the ability to influence the workers to come forward and report issues remains as a facet of trust-building behaviour within management. Awareness of product safety was also considered to be a result of effective management that builds on sharing of knowledge. Perceiving product safety in a positive light creates a different set of priorities, and such attitudes could be achieved from proactive, positive questioning – e.g. "*What did we do right?"* – and thus adopting a transformational type of leadership focusing on an ethic of care (Simola, Barling & Turner, 2010). Ethic of care relates to the interest in demonstrating commitment towards correct organisational practices and a translation of this could be applied to product safety.

The responses from the two worksites indicated that product safety concerns and practices were primarily shaped by middle management. This echoes the work of Rezvani and Hudson (2016) who discussed the necessity of middle management in functioning as a "*soft alarm system*" in safety management. While the senior management is involved in creating expectations of the type of culture present in an organisation, middle management can be considered a vital part of executing the expectations through their actions. As such, middle management was regarded as a mediator between the workforce and senior management and this may be useful. However, it may also pose risks. For example, there may be the issue of conflicting priorities (product safety versus financial profits/time pressure) that may create inconsistent messages from different layers of management. There were references to the importance of production schedules and cost control.

"In some areas it's still production, production, production. In other areas, as I said, the more mature areas, recognise that they need to have that safe product. So, if there is impact to production because of a product safety issue, you pretty much move heaven and earth to fix that issue. You still want to make the production deadline." (S1 I3)

The references to time/ economy/ production pressure were made in relation to managers and so these dimensions from the original set of ten were incorporated into management commitment.

3.5 Product safety ethic

This individual level dimension refers to personal attitudes towards product safety. This could be a moral or ethical standing in relation to resolving safety issues or pre-empting them and it also refers to personal opinions about the standard of work to which workers hold themselves accountable.

> "*[…] I take pride in my work and I want to make sure that the product that I am providing to the world, .. I want to make sure that that does what it says on the tin and it actually does the correct functionality at the end of the day and doesn't put anybody's life at risk*." (S1 I2)

> "*When nobody's looking, we actually want people to do the right thing*." (S1 I8)

> "*The team and I are embedded in the business, we are here all the time, so we're accustomed to conscience really*." (S1 I9)

Specifically, respondents mentioned that product safety ethic primarily manifested itself in doing what was considered good practice, for example stopping a manufacturing process in the case of an issue. Product safety ethic was related to accountability, where employees would sign off completed tasks, and therefore created a traceable paper trail that allowed the business to observe the actions carried out and who was responsible for them. Respondents felt that while some of this may have been influenced by management commitment to safety and workers' trust in management, some of the determination and willingness to do what was right also stemmed from their own personal beliefs and 'moral compass'.

> *"There's a very strong feeling of right and wrong, and professional ethics, for our part of it."* (S2 FG4)

For example, one interviewee pointed out that there were employees in team leader positions that would stop a process despite instructions from a manger to do otherwise, due to their awareness of a product safety issue and the need to resolve it. It was mentioned that for workers to have a higher product safety ethic commitment, the safety and quality directives they received needed to be tailored to their particular worksite and products.

This ethical component appears to be based on the individual's concern over the well-being of a user during the product's use, and therefore reflects on an individual's ability to think ahead, and to consider the impact of his or her work on another person's safety. Willingness to speak up about product safety is affected by trust (which was coded as a separate dimension). Employees were less likely to speak up if they had low trust in management (Conchie & Donald, 2008) and feared personal or professional consequences (Kish-Gephart et al, 2009). One interviewee commented on possessing a certain degree of resilience in order to be able to justify product safety issues to management, with the knowledge that

they need to adopt a certain type of communication to express their concerns in a valid, constructive manner. Another instance where product safety ethic may manifest was in the case of reporting which ensures that the issues are raised and that their visibility is maintained within the organisation. The ability to imagine and worry over user safety was described as, "*putting myself in their shoes*" and "*I think of my family using this product*". This ethical stance required regarding product safety as relevant to the employee's job and going out of his or her way to ensure it is maintained (even if no-one was looking). It also includes taking responsibility for good working product safety practices (for self and for others – e.g. the ability to correct or help colleagues if required).

Neal et al. (2000) proposed that safety knowledge influenced workers' motivation. As such, motivated workers were more aware of what practices could improve product safety and could thus consciously shape their behaviour within the workplace. This would be especially effective combined with a high product safety ethic which also stems from safety knowledge. Those workers with higher safety knowledge and motivation to deliver a safe product (ethic) may hold themselves to higher standards of accountability.

3.6 Trust

This individual level dimension refers to any mention of trust or openness and to individuals being comfortable in their actions especially when making issues known without the fear of repercussion, being confident in recognising that product safety issues need to be resolved and communicating product safety concerns.

> "*Also how we report up to each other and how we communicate is a manner that, if anyone has any issues, they would readily report them. The environment is that they're comfortable to do so*." (S1 I5)

> "*Yes is the answer to the question with training and education awareness and encouraging an environment where there are no repercussions for people holding their hand up and saying by the way I have been doing this wrong, so making sure there is not retribution in terms of encouraging people to be open and honest*." (S1 I6)

Operators mentioned that they relied on other people (e.g. design engineers) to ensure that the products they were manufacturing were safe. They acknowledged that workers had an impact on product safety, through following appropriate procedures (written by engineers). As such, their trust was placed in their colleagues who they believed to have sufficient awareness and knowledge of product safety. The most prominent topic with regard to trust was workers stopping the manufacturing process in the case of a risk. Participants (FG6) mentioned that there may have been instances where people felt worried about stopping a process, as they felt it could have made them seem as trouble-makers, despite encouragement from management. It was mentioned that after raising a concern with management, there may not always be the opportunity for the employees to obtain feedback (FG3).

One aspect of culture that straddles the dimensions of communication, trust and perceived management commitment related to the key behaviour of speaking up about product safety. The studies showed that workers who felt that management was dedicated to product safety were highly motivated to share their concerns about potential product safety risks. Speaking up therefore identified and mitigated product safety risks that may have been potentially missed. Worker/process safety culture studies have shown that employees who felt listened to and supported by their management were more likely to speak up when safety issues would occur (Burns, Mearns & McGeorge, 2006; Conchie, Taylor & Charlton, 2011). If the management was able to fulfil the expectations of the workers (e.g. maintaining visibility, giving rapid feedback), higher levels of trust and a better attitude towards product safety could be expected, as trust was considered to improve positive safety attitudes in worker/process safety (Donald & Young, 1996).

3.7 Product Safety Behaviours

Behavioural actions, such as speaking up about product safety, emerged throughout the interviews. While not systematically coded, these behaviours included identifying and raising product safety issues; empowering other employees to speak up about product safety concerns; offering assistance when difficult product safety issues arose; stopping the process; completing work without ignoring the risks; following rules and procedures.

4 Discussion

The first study indicated ten cultural dimensions which were subsequently refined to six, based on the analysis of the data in the second study collected from the two manufacturing sites, where the sample consisted primarily of workforce. Overall, the results show consistency with dimensional findings from the worker/process safety culture literatures (e.g. Leaver & Reader, 2019; Bisbey et al, 2019) and the food safety culture literature outlined earlier. A good product safety culture appears to be related at an organizational level to the function of the safety management systems, communication processes and management commitment to safety. At an individual level, the understanding of safety systems is key, acquired through training, experience and most importantly, communication and interactions with the management. Trust in management is also important. Both these dimensions have emerged in similar forms in previous safety culture studies.

The novel component was product safety ethic which described an attitudinal orientation that maintained a concern and prioritisation for the product user during the manufacturing process. This refers to an empathetic approach where employees imagine themselves or members of their family in the user's place to ensure the product has good integrity. Simola et al. (2010) referred to an ethic of

care, however it relates only to transformational leadership. While necessary in shaping worker perceptions on the importance of product safety, the concept of product safety ethic also refers to the individuals' own work attitudes (e.g. holding their work quality to higher standards). Work ethic is discussed in research on vocational behaviour, where it can be considered self-rewarding, in that a good work ethic is often attempted to assure career recognition and progression within the workplace (Blau & Ryan, 1997). Rollenhagen (2010) suggested that the moral dimension of safety was under-theorised in the context of safety culture research (see also Kastenberg, 2014). Employees may not be able to make this empathetic connection at all times, and so a goal for companies striving for product safety culture is to ensure such attitudes become ingrained, so that they influence workforce and managers' routine behaviours.

It is only recently that this moral aspect of safety culture has been emerging in empirical studies. Pettita et al (2017) examined an individual level factor in safety culture that predicts the under-reporting of worker accidents which they call 'moral disengagement' and appears to be of the opposite stance to 'product safety ethic' as discussed here. Leaver and Reader (2019) examined safety culture in financial trading companies by analysing regulatory investigation reports of trading 'mishaps'. They found a typical set of cultural dimensions relating to the organization but there was no evidence of an ethical dimension leading them to conclude that *"This counters narratives focusing on traders as unethical 'rule breakers' and instead emphasises the influence of social environments upon behaviour in financial institutions."* (p478). An alternative explanation would be that the absence of a cultural factor which promoted an ethical concern in traders for the buyers of the financial products had in fact contributed to the behaviours that resulted in the regulatory breaches.

While this study provides a preliminary indication of a possible set of dimensions of product safety culture, additional investigations would be required to provide a deeper analysis and an exploration of external validity, as well as predictive value. As with other types of safety culture measurement and related interventions used in industry and healthcare, this approach is not without limitations (e.g. Antonsen, 2009) and should be regarded as only one aspect of product safety management. In addition, there are external drivers influencing corporate concern regarding product safety, such as product safety regulations (see Conway, 2019), the influence of insurers, consumer representation, concerns about corporate liability and reputation and even sustainable development goals (e.g. the seventeen pillars, United Nations, 2015). It is important to understand how organisations implement high-level standards into tangible outcomes for specific products, and to determine the processes by which they affect employees' attitudes and behaviours thus influencing the organisational safety culture. The influence of regulators and other external agencies on culture was not the focus of this study but their role for product safety culture certainly merits future consideration.

4.1 Limitations

In terms of limitations, the design of the two studies was influenced by the access constraints in a busy manufacturing company, which resulted in sample sizes being smaller than desired and restricted time for interviews and focus groups. Only one manufacturing organization was studied and so replication in other companies would be required. All the data were based on self-report which has limitations but was deemed an appropriate method for this stage of the investigation. The inter-rater agreements of the thematic allocation of the extracted codes were acceptable but not high which underlined the conceptual overlap of the dimensions. As indicated above, portions of text involved the interaction of multiple dimensions that were difficult to isolate for coding purposes, Jespersen and Wallace (2017) discuss this problem in relation to food safety culture.

Product safety culture was a relatively new concept in this organisation. It was suggested by several respondents that the SHE culture (worker safety, health and environment) had been better developed than the product safety culture. Although other interviewees suggested that management paid "*lip service*" to SHE while focusing on product safety. In some cases, product safety was not fully conceptualised within the workforce, indicated by participants referring to worker safety who then had to be prompted to consider product safety. This implied the respective functions of product safety versus worker and process safety within the SMS still required clarification.

5. Conclusion

The concept of product safety culture is beginning to be used in industry but has received limited academic attention to date. In this exploratory study, a qualitative approach was taken to identify the principal dimensions of product safety culture relating to the manufacture of engineered goods. These were found to be safety management systems, communication processes, management commitment to safety, understanding of safety systems, trust and product safety ethic. The first five dimensions are well-established components of culture relating to worker and process safety (Leaver & Reader, 2019) but the ethical component is more novel and suggests that fostering concern for unknown product users may be an additional facet of product safety culture worth investigating in the effort to reduce the risks to consumers.

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Appendices (could be set as Supplementary material)

Appendix A. Product safety Culture: Interview schedule for study 1

1. How long have you worked for XXXXX?
2. What is your job position?
3. Which Business Unit are you based with and which Products do you have experience with?
4. What do you understand Product Safety to be?
5. Why is Product Safety important to you (and the company)?
6. How is Product Safety perceived at the management level?
7. How is Product Safety perceived by the workforce?
8. In what way do your responsibilities and actions in the workplace affect Product Safety?
9. Can you influence the perception of Product Safety among the workforce? If yes, how? If no, why not?
10. What does the workforce think about Product Safety, in your opinion?
11. How do you apply Product Safety in your job?
12. To what extent is Product Safety important when compared with occupational safety or process safety? (ie individual or organizational accidents).
13. What are the challenges in balancing Product Safety with productivity demands?
14. How do you identify Product Safety risks/hazards? Can you give me examples?
15. How do you address such risks/hazards?
16. In what way do you encourage Product Safety practices?
17. Can you describe the culture in your workplace when it comes to workers reporting Product Safety failures or incidents?
18. How do you communicate any ideas or concerns you might have about Product Safety to other employees?
19. What do you think are key features of Product Safety Culture?
20. Why are these features important?
21. Is Product Safety Culture influenced by specific factors in your Business Unit? If so, how?
22. If you could change anything about the Product Safety practices, what would it be?

Appendix B. Supplementary interview questions for study 1

Safety Systems

1. What equipment do you use during the manufacture of a product in your job position?
2. What practices are there in place for the safe use of equipment during product manufacture?
3. How is the safety of equipment used in manufacture determined?
4. What does your safety training involve? How often?
5. To what extent is training and proper work equipment relevant to the safety of your job?
6. In what way does this affect the safety of the product for the user?
7. To what extent is the safety of equipment important when taking production pressures into consideration?
8. To what extent is there an emphasis on the knowledge of the tools and equipment used in the production process?
9. What types of procedures are involved in determining the safety of a product?
10. To what extent are such procedures followed to ensure safety of a product for whom?
11. Can you tell me how important these procedures are to you?
12. To what extent are product safety policies adhered to in your workplace?
13. How do you apply the company policies within your workplace/in your specific job role?
14. How would you rate your understanding of the company's product safety policies? Why?
15. What types of training did you have to complete in order to be able to carry out and assess product safety within your workplace?
16. To what extent are you involved in determining acceptable product safety?
17. To what extent are you involved in assessing product safety?
18. How are product safety assessments carried out in your job role/workplace?

Communication

19. How do you communicate Product Safety issues when they occur? Who do you notify first?
20. To what extent is communication about safety concerns for the user of product important in relation to other safety practices (i.e. wearing appropriate work equipment)?
21. What is important in communicating safety issues appropriately?
22. What do you do if you feel that your message did not come across to others effectively when there is a concern for product safety (i.e. for users of your product)?

Appendix C. Interview schedule for study 2

Impact of Product Safety Culture Further Interviews (Managers)/(Team Leaders)/(Workforce)

1. How long have you worked for XXXX?
2. What is your job position?
3. Which Business Unit are you based with and which Products do you have experience with?
4. What do you understand Product Safety to be?
5. Why is Product Safety important to you (and the company)?
6. ***How is Product Safety perceived at the management level?*** / How is Product Safety viewed by the supervisors/team leaders? How do managers show their commitment to Product Safety?
7. ***How is Product Safety perceived by the workforce?*** / How is Product Safety perceived by your work group (your colleagues)?
8. ***In what way do your responsibilities and actions in the workplace affect Product Safety?*** / How do you make sure you are following the Product Safety standards at your job?
9. ***Can you influence the perception of Product Safety among the workforce? If yes, how? If no, why not?***
10. ***What does the workforce think about Product Safety, in your opinion?***
11. ***How do you apply Product Safety in your job?*** / What is the first thing you do before you start your work for the day? What is the last thing?
12. To what extent is Product Safety important when compared with occupational safety or process safety? (ie individual or organizational accidents).
13. What are the challenges in balancing Product Safety with productivity demands?
14. How do you identify Product Safety risks/hazards? Can you give me examples? / Can you describe your and your colleagues' attitudes towards handling Product Safety risks? How does this affect your behaviours in the workplace?
15. ***How do you address such risks/hazards?*** / How do the managers/supervisors address Product Safety risks? Can you describe their attitudes and approaches?
16. In what way do you encourage Product Safety practices?
17. Can you describe the culture in your workplace when it comes to reporting Product Safety failures or incidents? / **To what extent are you involved?** / How would you evaluate it in terms of its effectiveness/usefulness?
18. How do you communicate any ideas or concerns you might have about Product Safety to other employees
19. What do you think are key features of Product Safety Culture?
20. Why are these features important?
21. Is Product Safety Culture influenced by specific factors in your Business Unit? If so, how?
22. If you could change anything about the Product Safety practices, what would it be?

Note: Questions in italics were used for management only, bolded questions were used for interviewing team leaders, underlined questions were used for workforce. The remainder of the interview was used for everyone.

Table 1: Thematic analysis of six product safety culture dimensions (in order of frequency).

PRODUCT SAFETY CULTURE DIMENSION (total n)	NUMBER OF TIMES CODED (STUDY 1)	NUMBER OF TIMES CODED (SITE A)	NUMBER OF TIMES CODED (SITE B)	EXAMPLES OF DIMENSION COMPONENTS
SAFETY SYSTEMS (456)	277	71	298	▪ Using reporting tools (e.g. databases) to raise product safety issues ▪ Knowledge and adherence to procedures for product safety ▪ Monitoring measures of product safety (e.g. safety matrices)
UNDERSTANDING PRODUCT SAFETY (326)	97	43	186	▪ Knowledge of how to use training for product safety ▪ Understanding the impact of job roles on product safety ▪ Experience-based knowledge of product safety ▪ Appreciation of product safety issues and their scope
COMMUNICATION (325)	134	65	126	▪ Sharing information about product safety (e.g. monthly product safety meetings) ▪ Management quarterly meetings to discuss site issues ▪ Sharing concerns related to product safety ▪ Reporting issues to superiors (e.g. team leaders, design/technical authorities, quality department)
MANAGEMENT COMMITMENT (208)	94	53	61	▪ Maintaining workplace visibility (e.g. product safety inspections, encouraging good product safety behaviours) ▪ Maintaining constant commitment to product safety (e.g. leading by example) ▪ Placing emphasis on giving information about product safety (e.g. leading safety talks) ▪ Sharing priority of product safety across management levels
PRODUCT SAFETY ETHIC (157)	69	29	59	▪ Imagining the user as a recipient of the product ▪ Worrying over user safety ▪ Dedication and drive to maintain product safety ▪ Ensuring product safety training is up to date ▪ Proactive approach toward product safety ▪ High standard of product safety practices
TRUST (77)	33	15	29	▪ Acting without fear of repercussion (e.g. stopping the manufacturing process) ▪ Trust in teammates and supervisors (e.g. to carry out their work to standard) ▪ Belief in follow-through of reported issues (e.g. feedback, actions taken)