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Designing safer working interventions through a literature review using a mechanisms-based approach

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Abstract

The explanation for what safety interventions work in any particular circumstance remains elusive, resulting in many work-related fatalities and injuries every year. We propose a shift in perspective from a preoccupation with safety interventions and their effects to an elucidation of the generative mechanisms underpinning safety and its contiguous context. Using an analytical framework based on contexts, interventions, mechanisms and outcomes (CIMO) we were able to review 43 empirical studies of safety interventions deployed by leaders in organizations. This motivated the development of 10 design propositions; 5 related to accident and injury reduction and 5 to changing safety behaviours. Greater understanding of the mechanisms by which interventions exert their effects will lead to the design of more context appropriate safety interventions thereby enhancing individual and organizational safety in the future and the development of evidence-based safety.

Keywords:

Safety practices, literature review, CIMO logic, Design propositions

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1. Introduction

Globally, an estimated 2.3m people die from work-related accidents each year, and a further 313m suffer work-related injuries (ILO, 2014). The global social and financial cost is enormous. Combined annual costs for the US, EU and Australia exceed an estimated $350bn (European Agency for Safety and Health at Work, 2009; Leigh, 2011; Safe Work Australia, 2015), while in the UK estimated costs of workplace injury exceeds £5bn annually (HSE, 2018). Furthermore, costs of ill-health attributed to, or exacerbated by, work approach £10bn annually (HSE, 2018). Yet organizations in the UK are legally obliged to provide safe working conditions for their employees (Health and Safety at Work Act, 1974) and there is extensive guidance available to leaders in organizations on how this might be achieved from the UK's Health and Safety Executive. For example, INDG275 (HSE, 2008) identifies five steps to managing safety that have universal applicability. Similarly, Hale et al. (2010) provided a framework to categorise organizational interventions that contribute to improving safety, with each main category containing a number of interventions. Their main category, "Monitoring, feedback and learning systems" for example, included supervision; task checking and monitoring; incident analysis; inspection; and review and feedback, while from the same framework, the category of "safety management systems" embraced the presence of a safety committee; specialist advisory service; safety officer and risk assessment. In addition, Shannon et al. (1997) in their review identified some of these same interventions, but also highlighted good housekeeping, amount/duration of training, conducting safety audits and delegating safety activities. Yet despite the diversity of safety interventions available to ensure safe working conditions and extensive guidance on their implementation, accidents and injuries still occur. Recently, Nordlöff et al. (2017) observed that companies struggle to have functioning systematic occupational health and safety management systems.

The question of what safety interventions work in any particular circumstance and why still evades practitioners and academics alike.

Noy et al. (2015: p.543) observe that "safety is an emergent property of sociotechnical processes within organization". One explanation therefore for the continued occurrence of large numbers of injuries and accidents in the workplace may be the implementation of inappropriate or situationally ineffective safety interventions. We suggest that to understand the efficacy of safety interventions it is necessary to explain how safety is achieved, first by identifying which interventions are undertaken and then explaining how these lead to safe outcomes. However, according to Mullen (2004) and Griffin and Neal (2000, pg. 347), "few studies have elaborated the mechanisms through which organizational factors influence individual safety behaviour at work". Whilst concerning, this is, perhaps, unsurprising given that practitioner and scholars of safety are often preoccupied with interventions and the outcomes they produce and underplay the critical importance of context and mechanisms (Denyer et al. 2008). Denyer et al. (2008) term this dominant paradigm 'IO logic'; the concern is primarily with the extent to which an intervention (I) (e.g. a safety intervention) will result in a particular outcome (O) (e.g. no accidents or injuries or changes in safety behaviour). However, Denyer et al. (2008) argue that the IO logic is overly deterministic and downplays the critical role of context (C) and fails to explain the mechanisms (M) that produce the effects. A singular preoccupation with IO logic makes it very difficult to ascertain why specific safety interventions work in certain contexts but not in others. The diffusion and mindless adoption of so-called 'best practices' coupled with a failure to appreciate the interactive complexity of the components of a safety system may lead to more accidents and injuries (Robertson et al., 2015). Denyer et al. (2008) argue for a shift from IO

to CIMO logic to better understand in what contexts (C), specific interventions (I) trigger certain mechanisms (M) to produce outcomes (O).

An understanding of the interplay between context, interventions, mechanisms and outcomes not only advances academic understanding but also provides the basis for evidence-informed practice (Briner et al., 2009). Such prescriptive knowledge permits the development of design propositions, which offer "a general template for the creation of solutions for a particular class of field problems" (Denyer et al., 2008: p.395). By following 'CIMO-Logic' (Denyer et al., 2008) the design propositions capture what to do, in which situations, to produce what effect whilst also offering some explanation of why this happens. This approach, when applied to safety, may help managers and other practitioners' better design, or implement more effectively, safety interventions to ensure safe working in a specified context drawing on the wealth of existing evidence noted above.

The aim of this paper therefore is to develop design propositions that enable organizational leaders to achieve safe working by a process of induction from results of empirical studies captured through a systematic review of the literature. To achieve this we deployed a systematic literature review methodology (Tranfield et al., 2003) to identify academic safety literature that empirically investigated safety interventions deployed by leaders in organizations and the experience of these same interventions by workers. From this selection of empirical studies we identified the contextual circumstances, the interventions deployed and the theoretical explanation for their impact on safety outcomes. These studies allowed us to answer four review questions:

i. What interventions do organizational leaders deploy to achieve safety outcomes?
ii. What safety outcomes are achieved by these interventions?

iii. In which contexts are these interventions applied?

iv. How do these interventions achieve their effects?

2. Methodology

A systematic literature review methodology developed for management and business studies (Tranfield et al., 2003; Denyer and Tranfield, 2009) was deployed. The steps in the review process are explained below.

2.1 Searching and screening

In order to identify interventions deployed by leaders in organizations to ensure safe working by employees, we developed a series of key words (Table 1) including synonyms and alternatives to the terms of primary interest, namely safety, leadership and practice.

INSERT TABLE 1 NEAR HERE

These keywords were combined to make strings using the Boolean character 'OR' and these strings were combined using the Boolean character 'AND' as shown in Table 2 and applied to five different electronic databases (ABI-Proquest, EBSCO Host - Business Source Complete, SCOPUS, Science Direct and PsychInfo) in March 2017. Table 2 indicates the number of items appearing at that time in scholarly peer reviewed academic journals in the different databases in relation to the search string combination.

INSERT TABLE 2 NEAR HERE

An initial screen of these titles permitted a substantial reduction in apparently relevant articles (Table 2). Titles were excluded on the basis of perceived relevance. These exclusion criteria included book reviews and non-English language articles. Other topics or themes warranting exclusion developed for articles identified for the 'Safety + Leadership + Role' string are shown in Table 3.

INSERT TABLE 3 NEAR HERE

After the removal of duplicates occurring in each of the databases, the string for 'Safety + Leadership + Role' was reduced from 167 to 83. A three member panel then reviewed the abstracts of each of these 83 articles for relevance in addressing the question: what interventions do organizational leaders deploy to achieve safety outcomes. Once consensus was reached 34 articles remained. Using these as a foundation, the reference lists of these 34 articles were scanned for additional potentially relevant articles. The citations of these 34 articles were also reviewed. A further 29 articles apparently relevant to this study were identified. However, a number of these were excluded from data extraction on the basis that they were either literature reviews and therefore did not contain empirical details of interventions and outcomes in a particular context (e.g. Gyeke, 2010; Clarke, 2003, 2006; Hofmann et al., 1995; Shannon et al., 1997) or they contained insufficient information about context, interventions, outcomes and/or possible mechanisms (e.g. Beaumont, 1981; Beaumont et al., 1982). In total 16 papers were excluded for these reasons leaving 43 for review.

2.2 Data extraction

These academic articles were read and the following information was extracted from each of them (author, title, year of publication, context, interventions, suggested mechanism(s) and outcomes).

2.2.1 Context

Porter and McLaughlin (2006) identify seven major components of organizational context, although they acknowledge that many studies report only a few of them, and therefore the others need to be inferred. Here most studies gave details of the people. They also directly gave some information regarding processes (e.g. technology used) and structures (including firm size and hierarchical relationships) and allowed indirect inference of degree of standardization and formalization. Organizational culture could be inferred from this information and was classified into one of four types using a framework developed by (Pilbeam et al., 2016a) and derived from Denison and Spreitzer (1991). For example, Evans et al. (2005) report the importance of productivity for the organization and the empirical case in this study was therefore classified as having a rational culture. The remaining two components of organizational context, the state or condition of the organization and its goals, were never reported in any of the 43 studies.

2.2.2 Interventions

Managers (or leaders) in organizations have at their disposal interventions to influence behaviour. Denyer et al. (2008) illustrate this by reference to leadership style, planning and controls systems, training and performance management, and note “that it is necessary to examine not just the nature of the intervention but also how it is implemented, pg 397”. Only interventions that were reported to have a statistically significant effect were captured from the 43 empirical studies. The interventions were categorized subjectively by the authors into

three separate domains according to a framework for axiomatic design in ergonomics (Karwowski, 2005) that ensures a more complete consideration of all the interacting factors that influence safety within a complex socio-technical system (Robertson et al., 2015) drawing on physical, cognitive and organizational (or macro) ergonomics. The three conceptual domains of axiomatic design, functional (dealing with human capabilities and limitations), physical (dealing with human-system interactions and work design) and process (dealing with the management to achieve acceptable performance), capture the interactive effects of factors in work settings that leaders of organizations must integrate to achieve safety outcomes. They also align with the five practical steps for managing safety outlined by the Health and Safety Executive, UK (HSE, 2008) which are widely used to guide practice (See Table 4).

2.2.3 Mechanisms

Mechanisms "consist of entities and activities organized in such a way that they are responsible for the phenomenon" (Illari and Williamson, 2012, p.120) and provide a theoretical explanation for what "makes [a phenomenon] happen", what "produces", "generates", "creates" or "determines" it or, more weakly, "what enables or leads to it" (Sayer, 2000: p.104). They are not variables or attributes and thus not always directly measurable. In fact, they may be invisible (Hedström and Swedberg, 1998). For example, gravity may be unobservable but it does not prevent us from understanding, appreciating and researching its effects (Hedström and Swedberg, 1998).

Social mechanisms differ from other forms of mechanisms, such as biological or physical ones, in that they must consider human volition and choice if they are to explain why individuals act as they do (Hedström, 2008). Beliefs, whether individual or shared, provide

reasons for action (Hedström, 2008). People hold beliefs about safety and those beliefs are the basis for activities, which produce safety outcomes. Safety interventions do not work passively, rather they work actively, offering actors reasons and resources to alter their behaviour. And whether they work to accomplish safe outcomes (or not) depends on how actors choose to respond to the choices on offer. Given that safety interventions are generative (Pawson, 2000) in this way, it is necessary for researchers to delve into the mechanisms of an intervention and to investigate the processes that actually shift the reasoning and behaviour of actors (Pawson, 2000). When people intervene in a situation they often do so with a plausible cause map of assertions about how their actions may produce consequences (Weick and Bougor, 1986). Hedström (2008, p.61) notes that this perspective "makes no assumption that actors act rationally; it only assumes that they act reasonably and with intention". Safety related mechanisms can include desires (beliefs about what is desirable about safety), values (beliefs about what is right or good safety), and motives (beliefs about reasons to engage with safety).

The findings from each paper included in this review are used to generalize from experience and observation to theory. Suppose we have one study which says that to be successful a safety intervention must be deployed in a specific manner in a certain situation. This allows us to develop an initial CIMO model for safety. Let us now suppose we have another study that offers a case of an organization that departed from this initial CIMO model, but nevertheless the results were a positive safety outcome. We need to revise the CIMO model. Tsoukas (2009) refers to this process as analytical refinement. The prime function of a mechanisms-based synthesis (Denyer et al., 2008) is to federate diverse substantive empirical observations by abstracting away from the concrete instances to a generic conceptual framework (Merton, 1968) enabling a move beyond the description of empirical regularities

to a level that is "sufficiently abstract to deal with different spheres of social behaviour and social structure" (Merton, 1968, p.68). Mechanism-based explanations enable us to generalise beyond a-theoretical descriptions but without making indefensible claims about universal laws (Stinchcombe, 1998).

Mechanisms record theories or explanatory frameworks that are offered either explicitly or implicitly by the author(s) of the paper to frame their model designs or explain their results. In 20 of the 43 papers these explanations were stated explicitly by the author(s) (Table 5). For example, the papers by Conchie and her colleagues (Conchie and Donald, 2009; Conchie et al., 2012) focus on trust as an explanation for the relationship between the safety interventions of leaders and safety outcomes. Perceived Organizational Support (POS) was an explicit construct in the models used for example by Credo et al. (2010), by Hofman and Morgeson (1999) and by Mearns and Reader (2008). However, in some articles the mechanism were implicit but nevertheless could be discerned from the text. For example, Kelloway et al. (2006) stated that "organizational leaders are important models of safety behaviour, pg. 79" while Lindgard et al. (2012) talked about "powerful role models, pg. 35". Both of these suggest that role modelling is a potential mechanism. In other articles possible mechanisms were implicit either in the wording of the hypotheses developed in the particular study (e.g. awareness and competence in Parker et al., 2001) or in the overarching research question proposed (e.g. whether high quality relationships can protect workers, implying trust; Yagil and Luria, 2010: pg. 729). But, sometimes it was much less clear. In these cases we made tentative inferences based on our reading of the text. For example, we inferred trust from Hofman et al.'s (2003) discussion of social exchange and the items included in their questionnaire. In a few studies (n=8) it was impossible to identify a possible mechanism to explain the outcome.

2.2.4 Outcomes

Two categories of safety goals were identified in the reviewed literature, namely accident reduction and changing safety behaviours.

2.3 Data synthesis and reporting

The data from each of the four categories (CIMO) were separately analysed and then aggregated within each category across the 43 studies. Each category is reported separately in the findings section. In the discussion we use an explanatory approach to the synthesis of the aggregated data from these four categories (Rousseau et al., 2008). This allows us to develop design propositions. These provide possible explanations for why a stated safety intervention achieves particular safety outcomes in a specified context, which can subsequently be tested empirically.

3. Findings

3.1 Context

A majority of studies were conducted either in the UK (n=10) or USA (n=18). Many of the remainder (n=12) came from developed countries (Australia, Norway) with few (n=6) from developing countries (Malaysia, India). The industrial sectors were primarily energy (oil or gas), manufacturing and some construction. The studies typically investigated large, single organizations. Manufacturing organizations were often located on a single site, whereas energy organizations might operate numerous drilling sites. A corollary of these observations is that these studies were focused on organizations that were technologically sophisticated operating according to standardised procedures. Moreover, culturally they were defined as

rational, focusing on either productivity or performance (n=20), or hierarchical, focusing on achieving coordination and motivated by control (n=10), or a combination of these two (n=9).

An overwhelming majority of respondents to the questionnaires used in these studies were male, typically aged between 30 and 50 years and with significant (i.e. >5 years and frequently more than 10 years) work experience, reflecting the technical demands of the organization. They were mainly employed full-time as front-line workers. In some studies, particularly those exploring relational characteristics (e.g. trust, Conchie and Donald, 2009; Zohar, 2002b), supervisors were included in the sample. These were also males who had a slightly older age profile and longer working experience. Only a few studies investigated managers (e.g. Antonsen et al., 2012; Prussia et al., 2003). A smaller number of studies focused on the hospitality sector (restaurants, bars and hotels) (Barling et al., 2002; Kelloway et al., 2006). These studies investigated mainly younger (<30 years old), part-time workers, and showed a more equitable gender balance.

3.2 Interventions

Not surprisingly, a wide range of interventions were identified as significantly affecting safety outcomes (See Table 4). These interventions were aggregated into three broad domains of ergonomic design (Physical, Functional and Process – Karwowski, 2005) onto which the HSE Steps in Safety Management (HSE, 2008) can be mapped each with their particular interventions (Table 4). There were more interventions investigated that fell into the functional domain than into either the physical or the process domain. The functional domain emphasized various interventions to support cooperation and communication in particular. These are interventions associated with a transformational leadership style, and contrast with the rewards (and discipline) associated with a transactional style.

INSERT TABLE 4 NEAR HERE

3.3 Mechanisms

Table 5 identifies the individual theories either explicitly or implicitly adopted by the authors to explain the effects of the particular interventions on the specified outcomes under investigation. How the enactment of these theories may influence the choice of particular interventions, or alternatively how different interventions may exert their effects are illustrated below with references to individual empirical studies.

INSERT TABLE 5 NEAR HERE

3.3.1 Coordination/control.

Employers who believe that uniform and consistent interventions can be executed more safely that those that are not uniform or consistent (Antonsen et al., 2012) will develop procedures and processes that change the organization of work to remove hazards (e.g. Bentley and Haslam, 2001) or increase worker visibility (Luria et al., 2008).

3.3.2 Awareness.

Employers who believe that being attentive to the circumstance of one's workplace reduces the likelihood of accidents or injuries will encourage employees to pay greater attention to the conditions of their work environment (Evans et al., 2005), and to their own performance and that of others (Parker et al., 2001). This was only identified implicitly (see Table 5).

3.3.3 Trust.

Employees who believe that another will act in their best interest, either because they are competent and able to do so (cognitive-based trust; Lewicki et al., 2006) or because they will show care and concern for the individual (affect-based trust; Lewicki et al., 2006) will accept designations of hazard and risk, wear PPE, support each other and maintain safe working conditions through good housekeeping (Clarke and Ward, 2006; Conchie et al., 2012).

3.3.4 Competence.

Employees who believe that developing their own skills is critical for safe working will show greater participation in, and commitment to, safety (and other) training, allowing them to perform better and work more safely (Griffin and Neal, 2000; Parker et al., 2001).

3.3.5 Contingent rewards.

Employees who believe that their actions result in consequences will alter their safety related behaviours when they receive feedback that it is rewarding, reinforcing or punishing (Kapp, 2012; Zohar, 2002b).

3.3.6 Role Modelling.

Employees who believe that others (particularly managers and supervisors) work safely will, through processes of observation, imitation and role modelling (Bandura, 1977) adapt their safety-related behaviours to mimic others (e.g. Dahl and Olsen, 2013; Kelloway et al., 2006; Lingard et al., 2012).

3.3.7 Perceived organizational support.

Employees who believe that they are valued by their organization and that it is committed to them (i.e. a high POS) develop an implied obligation for future reciprocity that benefits the

organization (Eisenberger and colleagues 1986; 1990) generating greater safety communication, participation and performance (e.g. Credo et al., 2010; Hofmann and Morgeson, 1999; Mearns and Reader, 2008; Tucker et al., 2008).

3.4 Outcomes

Two broad categories of outcome are the focus of most of the empirical research. The first category relates to the occurrence of accidents or injuries (e.g. Zohar 2002a; Varonen and Mattila, 2000; Rinefort and Van Fleet, 1993). Often the purpose of the empirical research was to investigate the nature of the relationship between a particular intervention and accident or injury rates, or similar proxy. Typically the studies show a negative correlation (i.e. accidents or injuries decline as the intervention increases).

The second category relates to individual safety behaviours (e.g. Conchie and Donald, 2009; Clarke and Ward, 2006; Hofman and Morgeson, 1999; Kapp, 2012), typically either safety compliance or safety participation. According to Neal et al. (2000: p.101), safety compliance is "adhering to safety procedures and carrying out work in a safe manner", while safety participation involves "helping co-workers, promoting the safety programme within the work place, demonstrating initiative and putting effort into improving safety in the workplace". Some authors differentiate safety voice from safety compliance, defining safety voice as "communication motivated toward changing perceived unsafe working conditions that have implications for individual and organizational health" (Tucker et al., 2008: p.320). Communication may be both formal and informal and directed towards a wide variety of stakeholders. Interventions are assessed for their impact on improving each of these behaviours.

A smaller set of studies investigated the impact of an intervention on both accident rates and safety behaviours simultaneously (Antonsen et al., 2012; Barling et al., 2002). The results from these studies supported the findings of those studies investigating either accident reduction or changes in safety behaviours, showing no interaction effects of the two outcomes combined on the interventions used.

4. Discussion

4.1 Developing design propositions for safe working

Drawing on the information extracted from the 43 articles according to the four categories (context, intervention, mechanism (or proposed theoretical explanation) and outcomes) that were presented separately above, we can summarise the findings of the literature review in the following way. We note that contextual variation in the identified studies was limited. Studies were focused mainly on a single hierarchical organization using relatively sophisticated technology with full-time male employees who have significant work experience. Similarly, outcomes were of two types only. Studies investigated either reductions in accident or injury rates or improvements in safety behaviours. In contrast the range of interventions indicated in the papers was numerous. Some like communications and feedback, training and managerial commitment appeared to be ubiquitous effecting both reductions in accident rates and changes in safety behaviours, which makes it difficult to discern how precisely they might create these outcomes. Others, such as designing work places and specifying role descriptions and the provision of PPE were associated only with reductions in the number of accidents and not with improvements in safety behaviours. In order to aggregate this diversity of interventions we clustered the data according to the three domains of ergonomic design (Karwowski, 2005; Table 4). Seven different theoretical explanations (mechanisms) for why safe working occurs were identified in the reviewed studies. Some appear to have unequivocal outcomes. Control and awareness influenced

accident rates only, while trust and POS effected safety behavioural change only. The effects of the other mechanisms were less clear cut potentially affecting both outcomes, although it seems that role modelling and rewards tend to reduce accident rates, while competence tends to affect safety behaviours.

CIMO-logic suggests that these four categories may be combined as in Figure 1. Leaders in this single organizational context used a wide variety of interventions to elicit either a reduction in accident or injury rates or an improvement in safety behaviour through the operation of one of seven different mechanisms. Where the mechanism has two or more citations linking it to a particular outcome it is indicated by a solid line in the figure. Dashed lines in the figure denote a single reference linking the mechanism to the outcome. The data suggested that interventions such as identifying hazards, assessing risks, providing PPE, developing procedures, designing workplaces and providing job descriptions, which we classified in the physical domain reduced accident rates by increasing awareness of safety hazards and by providing a greater degree of control and coordination over workplace activities. Interventions comprising the process domain (including housekeeping, monitoring, investigating, reporting, reviewing, auditing and inspecting) tend to reduce accidents by providing the opportunity to reward or discipline employees, and also by offering a greater degree of control. The interventions in the process domain may also influence role modelling, which reduces accident rates and may also change safety behaviours. Functional interventions (such as communication, feedback, training, management commitment, selection) promote changes in safety behaviour by increasing trust, POS and competency. They may also reduce accidents by providing positive role models and permitting rewards and discipline. Finally, it should be noted that communication in particular appears to mobilise every mechanism,

achieving both outcomes. Consequently it may be considered an insufficiently discriminating intervention.

INSERT FIGURE 1 NEAR HERE

Synthesizing this information we suggest the following design propositions related to either the reduction of accident and injuries or the improvements of safety behaviours in large hierarchical centralized organizations in manufacturing / process or energy industries employing full time experienced males.

To reduce the number of accident and injuries in these organizations leaders can:

i. Identify hazards, assess risks, design workplaces, develop procedures and job descriptions, provide PPE, monitor, investigate, report and review to improve levels of coordination and control;
ii. Raise awareness of safety by identifying hazards, assessing risk, provide PPE, develop procedures and design jobs;
iii. Monitor, investigate, report, review, audit and inspect to reward or sanction safety performance levels;
iv. Role model house-keeping, reporting, execution of policies, commitment, team working and information sharing;
v. Select and train, provide feedback, encourage team working, and give advice to improve competency.

To improve safety behaviours leaders in these organizations can:

i. Reward appropriate behaviour through monitoring and investigating, reporting, reviewing and inspecting, and providing feedback and discipline;
ii. Role model team working, commitment and good housekeeping;
iii. Ensure competence through selection, training and giving advice and feedback;
iv. Enhance perceptions of organizational support by showing commitment, providing training and advice, encouraging team working, investigating, inspecting and reporting;
v. Build trust by encouraging team working, showing commitment, giving advice, providing training, monitoring and investigating, reviewing and reporting.

4.2 Developing a research agenda

Each of the 10 propositions by which particular interventions deployed by organizational leaders result in one or other or both of the observed safety outcomes have been developed inductively according to 'CIMO-logic' from a review of existing empirical literature. Like all theoretically based explanations they offer a statement of the relationships between concepts accompanied by a set of boundary constraints (Corley and Gioia, 2011). In this case the relationship between intervention and outcome is explained by a mechanism operating within the specific context of large hierarchical centralized organizations in manufacturing / process or energy industries employing full time experienced males.

This particular organizational context explicit in the empirical investigations incorporated in this review indicates limitations in our current understanding of ways organizational leaders can intervene to improve safety outcomes. The limited scope of these studies suggests four different sets of context in which to investigate how interventions reduce accidents or change employee safety behaviours. First, much of the current research investigates high hazard

environments, but most people in developed countries like the UK work in low hazard service sector organizations (Office for National Statistics, 2013). The transferability of the design propositions from high to low hazard environments, or manufacturing to service environments needs to be tested. Secondly, existing studies focus on experienced workers employed on a full time basis. Temporary workers are more prone to accidents and injuries (Underhill and Quinlan, 2011) and so different design propositions may be required for this particular group of workers. A greater emphasis on training and coordination may be required to ensure appropriate and safe working interventions. It may also be necessary to consider the potentially adverse effect of reward structures on safe working amongst these temporary workers. Thirdly, and similarly, existing studies do not consider professional workers or those working in flat, non-hierarchical organizations. We suggest that mechanisms of control in these forms of organization may be different to those in the centralized, hierarchical organizations considered here. As a consequence, design propositions may also differ. This remains to be tested. Fourthly, gender differences in the enactment of safety have also not been investigated extensively (Jensen et al., 2014), and yet we know that there are gender differences in risk-taking behaviours and in seeking support (Stergiou-Kita et al., 2015). Both of these may influence the outcomes of the safety interventions, and the design propositions which are currently based almost exclusively on responses from males.

Denyer et al. (2008) argue that design propositions like those outlined here require several stages of testing to further refine theoretical ideas on intervention–outcome relations. We propose two forms of testing, conceptual testing and field testing. Alvesson and Sandberg (2011) suggest that the robustness of an explanation and therefore its utility should be tested by challenging the assumptions of the theory. A process they describe as problematization. Through the identification of these assumptions the limitations of the propositions can be

identified. This indicates circumstances where the proposed intervention would not work, and simultaneously reveals directions for future research. Here we provide a brief challenge to each of the mechanisms identified in the review of empirical studies. For example, coordination and control assume that the operation of uniform and consistent processes reduces accidents. In unexpected circumstances that require improvisation interventions designed to ensure coordinate and control will be ineffectual. Similarly, company policies or regulatory guidelines may restrict the opportunity to offer rewards or apply sanctions limiting the effectiveness of contingent rewards as a mechanism to reduce accidents or change safety behaviours. Alternatively opportunities to improve safety behaviours based on perceived organisational support may be limited where there have been recent redundancies or outsourcing of activities. Role modelling assumes that there is an accepted way of working. Where new technologies demand new interventions or working arrangements this mechanism may be ineffectual at least initially. Likewise awareness presumes a familiarity with the workplace and the task. Where these are new or unfamiliar then awareness may not provide a satisfactory safeguard. Trust assumes enduring relationships. Where there is a transient workforce this is inevitably limited and trust will be an ineffective mechanism for achieving safety outcomes.

Van Aken (2004) suggests that design propositions that explain intervention-outcome relationships should be field tested in a range of different contexts. Alpha-testing is conducted by the original investigator, followed by Beta-testing by third parties. Drawing on Pettigrew (2012) we suggest three essential analytical features of safety research that would permit safety interventions to be unequivocally linked to outcomes. The first requirement is to conduct comparative studies of safety interventions with variation in the outcomes. This would permit the examination of why and how variation in the mobilization of safety

mechanisms creates variation on safety outcomes. The second is to identify matched pairs of organizations in the same sector and in the same political and economic context. The third is to ensure that the operational definition of the outcome variables is constant across the studies, specifically whether the outcome variable represents some intermediate safety effect (e.g. reduction in errors), or some final safety effect (frequency of accidents). Pettigrew (2012) notes that studies exhibiting these three features are rare. An alternative approach to these stringent empirical requirements would be to employ Qualitative Comparative Analysis (QCA) to examine the conjuncture of variables and their inter-relationships and how these affect outcomes (Fiss, 2007; Ragin, 2014). The technique uses the basic principles of Boolean algebra, developed in mathematics to analyse set-theoretic relationships to identify, simplify and compare the combinations of conditions leading to a particular outcome (Fiss, 2007; Ragin, 2014). As such, QCA could distil safety interventions from multiple cases in order to derive key features whose role in generating safety outcomes could be systematically examined across a larger population.

4.3 Implications for practice

Here we sought to identify the mechanisms by which specific interventions achieve identifiable safety outcomes in a restricted set of circumstances. However, in practice, interventions are often bundled together as for example in INDG275 (HSE, 2008). This bundling may contribute unwittingly to the failure of safety interventions to prevent accidents and injuries and to completely protect workers. Each intervention in the bundle may draw on a different mechanism. So it is of particular practical concern whether the mechanisms, and therefore the interventions, are additive or multiplicative or even conflicting in their effects on desired safety outcomes. Combinations of mechanisms that are additive in their effect may arise when interventions characteristic of different stages of the safety culture maturity model

(Parker et al., 2006) are combined. For example, interventions based on standardizing work processes, or rewards and sanctions, or on affective trust are influential at different stages of their model and consequently may combine to cumulatively reinforce safety. Others, like trust and POS, that operate at similar stages in the model may be multiplicative. In safety research trust and POS have been used as complementary explanations for their effects on safety. Others may conflict, one reducing the effect of another. For example, disciplinary actions using negative rewards may undermine trust or POS. Alternatively, standardization of working interventions might reduce the impact of competence. Understanding the effects of bundling of interventions in this way would provide greater clarity in the choice of interventions and potentially greater precision in their application. It would also reveal which interventions may be swapped without loss of impact because they operate in the same way to stimulate the same outcome.

Design propositions ought to have practical application. While those developed here apply in centralized manufacturing and process industries caution should be exercised if they are applied in less-hierarchical or service-sector organizations. They may not translate from one organizational context directly into another, and may require adaptation. This militates against the simple mimicry of the successful interventions of one organization by another in response to the pressures of mimetic isomorphism (DiMaggio and Powell, 1983), although there is some evidence that safety interventions in retail/service environments resemble those from high hazard environments (Pilbeam et al., 2016b).

5. Conclusions

By scrutinizing more closely the mechanisms reported in published literature through which safety may be promoted by leaders in an organisation we have developed a more granular

understanding of how two different types of safety outcome (reduced accidents and improved safety behaviours) might be secured using a wide variety of safety interventions. Furthermore it has also allowed us to more clearly align particular interventions with an explanation of how they might exert their effect, where this has not been possible before. Consequently we have been able to identify 10 design propositions that explain how particular interventions generate specific safety outcomes in a specified set of circumstances. Following developments in other fields, like medicine and management, this suggests the need to develop evidence-based safety. Greater understanding of the mechanisms by which interventions exert their effects will lead to the design of more context appropriate safety interventions thereby enhancing individual and organizational safety in the future.

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Table 1: Keywords used to create search strings

Main term	Additional terms
Safety	safety OR security OR sure* OR safeguard OR protect* OR reliab* OR resilien*
Leadership	Leader* OR manage* OR advisor OR director OR supervisor OR facilitator OR officer OR superintendent OR chief OR commander OR expert OR coach OR specialist
Practice	activity OR action OR role OR function OR skill OR enact OR do OR conduct OR routine OR practi?e

permits alternative extension to stem, e.g. protect = protects or protection or protecting; ?=accommodates alternative spellings, e.g. practice or practise.

Table 2: Number of items discovered by applying a search string to an electronic database, and reduction through stages.

Database					
Search String	**ABI**	**EBSCO**	**SCOPUS**	**Science Direct**	**PsychInfo**
Safety AND Leadership AND Practice	90 (12)	100 (21)	480 (37)	134 (18)	66 (24)
Potentially relevant after initial screen	167				
Remaining after duplicate removal	83				
Remaining after panel screening	34				
Addition through snowballing from 34	29				
Exclusion through lack of data	16				
Total reviewed	43				

Table 3: Topics and themes excluded in a title screen of results from a search string

Search String	Primary Topic or Theme	Subsidiary Topic or Theme
Safety AND Leadership AND Practice	Cyber Security	IT systems/Networks, data security
	Health and Patient Safety	Medicine, mental health
	Financial Security	Pensions, stocks, fund management, loans, credit, investment, Tax, bankruptcy
	Food safety/security	
	Environmental safety	Environmental protection, climate change, marine, agriculture
	Psychological safety	
	Technical safety	Engineering
	Business performance	Production, litigation, law
	Transport safety	Driving, air transport, vehicle safety
	Modelling	
	National security	
	Family	Child protection, community, Mothers and adolescents
	Schooling/education	
	Energy security	
	Chemical safety	
	Product safety	

Table 4. Interventions that contribute to safety outcomes aligned to domains of ergonomic design and the steps in safety management derived from a review of 43 papers.

Domains of Ergonomic Design (Karwowski, 2005)	Steps in Safety Management (HSE, 2008)	Interventions	References (First author only, year)
Physical	Set Policy	Identify Hazards	Bentley, 2001; Burt, 2008; Varonen, 2000
		Provide PPE / Resources	Bentley, 2001; Evans, 2005; Huang, 2004; Luria, 2008; Prussia, 2003; Yagil, 2010
		Develop Procedures / SOPs	Antonsen, 2012; Dahl, 2013; DeJoy, 2004; Luria, 2008; Mearns, 2003; Mearns, 2008; Subramaniam, 2016; Taufek, 2016; Vinodkumar, 2010; Yagil, 2010
		Prioritize Tasks	Antonsen 2012; Hofman, 2003
		Write Job Descriptions	Barling, 2002; Dahl, 2013; Huang, 2004
		Establish Safety Committee	Huang, 2004
Functional	Organize Staff		
	-Competence	Select	Smith, 1978; Vredenburgh, 2002
		Induct	Vredenburgh, 2002
		Train	Arboleda, 2003; Chew, 1988; Dahl, 2013; DeJoy, 2004; Griffin, 2000; Horstmanshof, 2002; Probst, 2010; Smith, 1978; Subramaniam, 2016; Taufek, 2016; Varonen, 2000; Vinodkumar, 2010; Vredenburgh, 2002; Yagil, 2010; Zohar, 2003
	-Control	Supervise	Bentley, 2001; Chew, 1988
		Discipline	Huang, 2004; Yagil, 2010
		Reward	Clarke, 2006; Huang, 2004
	-Cooperation	Support	DeJoy, 2004; Parker, 2001
		Encourage participation / team-working	Ali, 2009; Burt, 2008; Clarke, 2006; Dahl, 2013; Vinodkumar, 2010

		Involve management	Arboleda, 2003; Donald, 1996; Smith, 1978; Subramaniam, 2016; Taufek, 2016; Thompson, 1998; Varonen, 2000; Vinodkumar, 2010
	-Communication	Communicate	Ali, 2009; Bentley, 2001; Burt, 2008; Clarke, 2006; Credo, 2010; DeJoy, 2004; Dunbar, 1975; Griffin, 2000; Huang, 2004; Lindgard, 2012; Parker, 2001; Probst, 2010; Tucker, 2008; Vinodkumar, 2010; Watson, 2005; Yagil, 2010; Zohar, 2002b
		Give Advice / Information	Clarke, 2006; Huang, 2004; Vinodkumar, 2010; Yagil, 2010
		Provide feedback	Ali, 2009; DeJoy, 2004; Hofman, 1999; Huang, 2004; Kapp, 2012; Lindgard, 2012; Luria, 2008; Vinodkumar, 2010; Watson, 2005; Yagil, 2010; Zohar, 2002b; Zohar, 2003
Process	Plan and Set Standards	Demand housekeeping	Chew, 1988; Dunbar, 1975; Evans, 2005; Smith, 1978
		Plan and budget	Dahl, 2013; Donald, 1996; Parker, 2001; Prussia, 2003; Rinefort, 1993
	Measure Performance	Monitor	Dahl, 2013; Hofman, 1999; Kapp, 2012; Luria, 2008; Watson, 2005; Yagil, 2010; Zohar, 2003
		Investigate	Bentley, 2001
		Report	Bentley, 2001; Burt, 2008; Taufek, 2016; Yagil, 2010
		Execute	Dahl, 2013; Huang, 2004; Lingard, 2012; Mearns, 2003; Mearns, 2008
	Learn from Experience	Audit	Yagil, 2010
		Review	Dahl, 2013; Yagil, 2010
		Inspect	Griffin, 2000

Table 5: Studies identifying explicitly or implicitly mechanisms that explain the safety outcome from safety interventions deployed by leaders in organizations derived from a review of 43 papers

Mechanism / Theory	Explicit (First Author only, year)	Implicit (First Author only, year)
Reward	Ali, 2009; Kapp, 2012; Luria, 2008; Probst, 2010; Zohar, 2002a; 2003	Donald. 1996
Control	Antonsen, 2012; Huang, 2004; Rinefort, 1993	Bentley, 2001; Evans, 2005
Trust	Clarke, 2006; Conchie, 2009; 2012; Watson, 2005	Burt, 2008; Hofman, 2003; Yagil, 2010
POS	Credo, 2010; Hofman. 1999; Mearns, 2008; Thompson, 1998; Tucker, 2008	DeJoy, 2004; Dunbar, 1975
Competence	Griffin, 2000	Parker, 2001; Vredenburgh, 2002
Awareness		Bentley, 2001; Parker, 2001
Social learning (role modelling)	Vinodkumar, 2010	Dahl, 2013; Donald, 1996; Kelloway, 2006; Lingard, 2012; Mearns, 2003

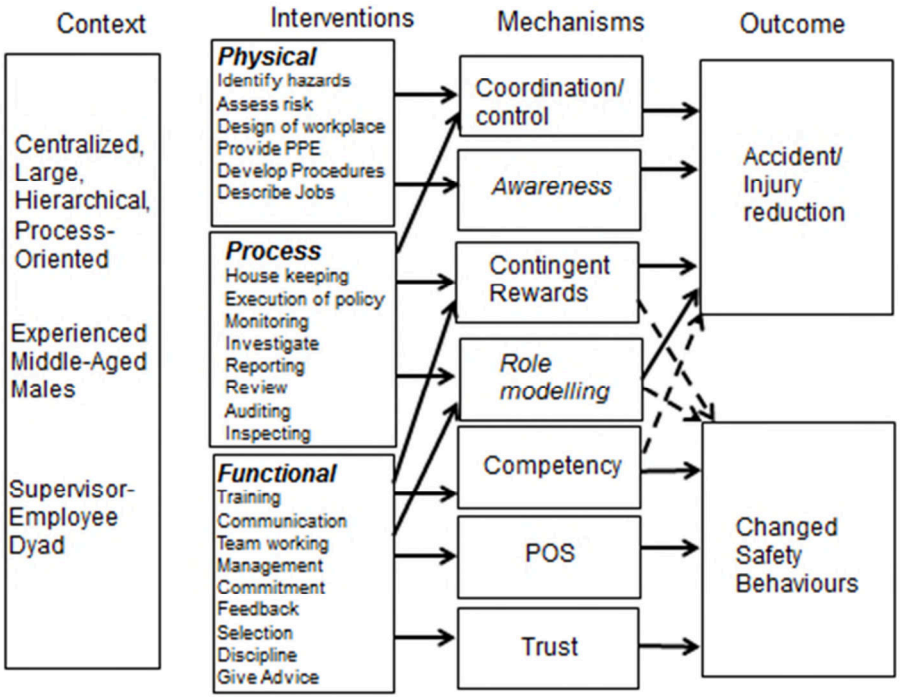

Figure 1. Alignment of the findings of a review of safety literature with a CIMO framework.