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Improving Organizational Health and Safety Performance: Theoretical Framework and Contemporary Approaches

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Abstract- *This article reviews accident causation, prevention and occupational health and safety (OHS) management as an opportunity for improving organisational performance. A theoretical framework based on a periodization scheme is introduced first. This is then used to examine developments in two inter-twined areas of research; accident causation and OHS management, associated with the first era. According to this five age/three era framework; six theories and models have been used for explaining accident causation, and three approaches commonly used for managing OHS. The key premises of accident causation theories and models are that accidents can be associated with single factors, mostly caused by unsafe acts of humans, and the sequence of events which lead to them occurring involves a linear sequence of events. The three main strategies for managing OHS in this era included technical, regulatory and behavior-based safety; with only one of these being informed through research on accident causation. Limitations and implications for practice of these are discussed, together with some identified gaps in research and practice.*

Keywords- *Occupational health and safety; accident causation; contemporary safety; integrative; ages of safety*

1. INTRODUCTION

The management of occupational health and safety (OHS) is a significant issue throughout the world. This is because 2.3 million workers die from work-related accidents and 474 million experience occupational injuries and fatalities every year[1]. The situation is more pronounced in some countries than others. For example, 4 679 workers died in 2014 in United States, equating to a fatality rate of 3.3[2]. This is about twice that experienced in Australia and about eight times when compared to the United Kingdom[3][4]. Recent workplace fatality statistics for these three countries are shown in Table 1.

Table 1. Workplace fatalities in selected countries

Country	Fatalities	Fatality Rate
Australia (2013/14)	196	1.70
United Kingdom (2013/14)	133	0.44
United States (2014)	4 679	3.3

The financial costs of these injuries and fatalities are also very high, with current estimated at AUD$62 billion, £14.2 billion and US$250 billion[3][5][6]. These costs are expected to increase even further as a result of rapid advancements in technology; globalization; changing societal views regarding accidents, safety and risks; introduction of new regulations; and increasing complexity of organisations[7][8]. Apart from injured workers and society, these costs are also borne by companies. As OHS is depended on management philosophy and policies of firms; this will ultimate impact on organisational performance[9]. For this reason more effective approaches and strategies for managing organisational OHS continues to be a significant cause of concern among safety practitioners, policy makers, researchers and leaders; and call for a re-think about how these can be addressed. Specifically, what do we know about the causation of work-related accidents and injuries? How has an understanding of such causation informed OHS management practice? What are strengths and weaknesses of these approaches and strategies? Answering some of these questions is an important first step in developing a nuanced understanding of what we need to do better to improve organisational OHS performance in the future. This article aims to answer some of the above research questions through an integrative review of the published literature. In doing this it seeks to advance research in this area previously published by Swuste, et al. [10][11]

2. RESEARCH METHOD

The research method used in this article involves an integrative review. Such reviews summarise previous research, draw conclusions, highlight unresolved issues and provide directions for future research[12]; hence are considered scholarly work on their own right. The review employed a thematic analysis of peer-reviewed published literature and key policy papers. The efficacy of such forms of documentary analysis as a research method has been previously demonstrated[13]; in studies of history, organizational culture [14] and construction OHS risk management[15]. This paper integrates developments in theory and practice across three main areas of research; (i) accident causation and prevention, (ii) management, and (iii) OHS management. The next section discusses the theoretical framework which informs this study.

3. THEORETICAL FRAMEWORK

It is only by having a good understanding of what has been used in the past that we can be better informed about what changes are necessary for effective organisational OHS management over a period of time. Periodization, which has its roots in history, provides an important theoretical framework for understanding such change over time[16]. Periodization is interwoven with historical theory, can be elaborated upon and refined for use in other disciplines; hence provides an excellent framework for investigating developments in accident causation, prevention and OHS management.

3.1 Periodization in Management

A number of periodization patterns have been used in the management research. A popular one based on American developments includes four periods[17]. The first included Early Management, the second Scientific Management, the third Social Management and the fourth Modern Management. Early Management appears to be part of practice from the Industrial revolution of 1750s until the early 1900's. A key practitioner during this period was Smith [18] who is known for his work on division of labour. Scientific management emerged in the early 1900s and is closely linked with Taylor[19]. His approach included breaking jobs into their component parts, allocating each component to different workers, training and giving them autonomy over the way they conducted the work, and using financial incentives to achieve results. Social management, which emerged in the mid-1990s, is closely associated with Gilbreth, Maslow and McGregor[20][21][22]. These were largely about behaviors and incentivisation of work. Modern management, which gained prominence in the late-1990s, is closely associated with Drucker, Deming and Senge[21][23][24]. Drucker introduced the notion of management by objectives and self-control and is regarded as the founder of Modern management. Deming is credited for developing and introducing a continuous improvement, quality assurance and total quality management systems; while Senge is noted for his work on organizational learning.

A different scheme has been suggested from the UK[25][26]. These authors saw until 1870 as pre-classical, the second, from 1870s to the 1950s as its 'scientific management,' the 1960s and 1970s as one of change and strategy, and the 1980s and 1990s managerial capitalism. They also distinguished between three key schools of thinking: classical (1880s-1960s), comprising Taylor, Weber, Fayol and Follett; humanistic (1930s-1980s), which included Mayo, Maslow and Simon; and management-science (1950s to present) with Drucker and Senge being key proponents. Fayol was instrumental in identifying the 14 key principles of management, while Weber is credited for his work on bureaucratic management[22]. The humanistic approach gave rise to the field of organizational behaviour; while the management science led to systems, quality control and assurance, operations management and organisational learning.

A third scheme covering 1900 to 1992 has been suggested; including scientific management (1900-1923), welfare capitalism/human relations (1923-1955), systems rationalism (1955-1980) and organizational culture (1980-1992). And another alternative to this sees the first (1900-1940) as scientific management, the second (1940-1960) humanist / behaviorist; the third (1960-1980) as strategic management; the fourth (1980-2000) as popular and individualized management; and the fifth (since 2000) as critical management[27]. The authors acknowledged there were no clear demarcations between their periods in the sense that management practices of one period were not completely abandoned at any stage as new beliefs, concepts and practices often established themselves gradually. As such these demarcations can best be seen to represent beginnings of progressive development in thinking and practice in the field of management.

3.2. Periodization in OHS Management

A number of periodization schemes for OHS management have also been proposed. An early one of these was suggested by Petersen[28]:

- since 1911 – physical conditions,
- since 1931 – industrial hygiene and unsafe acts,
- since 1950s – audits and management,
- since 1954 – noise control,
- since 1960s – systems safety,
- since 1971 – regulatory standards, ergonomics, 'safety programs', environmental, total quality management, and behavioural.

This scheme attempted to capture the progress following industrial revolution of the 19th century experienced in Europe and America. A second scheme which considered these developments more globally suggests that OHS management has evolved over five ages; the first being technical, the second human error, the third socio-technical, the fourth organisational, and the fifth as adaptive [29] or resilience . A third scheme presents these somewhat differently; with suggestions the second age was about behavioural and human factors, the third management and culture[30]. Another variation to the second and third ages has been suggested[31], with safety management systems seen to be part of the second, and behaviours with the third age. This scheme makes no reference to culture. A fifth scheme, by the Australian Radiation Protection and Nuclear Safety Agency (ARPNSA) places these into four ages[32]; the first with technology, the second with humans, the third with organizations and the fourth with systems. An attempt has been made to unify the five ages into three different eras;

contemporary, advanced and sophisticated[33]. The contemporary era includes the technological and behavioural/human error approaches (consistent with the first and second ages); advanced era included socio-technical and cultural approaches (consistent with the third and fourth ages), and the sophisticated era includes adaptive and resilience approaches (consistent with the fifth age). The salient lines of distinction between these eras is characterised by the predominant understanding of how work-related accidents and injuries were caused (and therefore prevented) and strategies for managing OHS.

The reminder of this article examines the contemporary era of OHS management. The advanced and sophisticated eras will be the subject of future articles.

4. THE CONTEMPORARY ERA OF OHS MANAGEMENT

Contemporary era of OHS management is closely linked with the period of industrial revolution. Smiths' division of labour and Taylor's scientific management theories were seen as a panacea for driving efficiencies and improving productivity. DuPont were one of the first to realize the latter, together with the fact that both teamwork and safety were important in driving such efficiencies[34]. According to the author, "…managers quickly realized that there was a direct relationship between efficiency and safety: efficient methods of production could promote safety, and the waste resulting from unsafe conditions was inefficient." However, when it was alleged that efficiency methods had been a factor in two explosions, safety and efficiency came into conflict, and Du Pont's managers resolved that safety was more important than efficiency [34]. While safety practices in the workplaces developed sporadically during the 19th Century, the underlying theoretical assumptions were not articulated until Hugo Munsterberg's (1863-1916) research on industrial psychology[35]. His ideas of selecting 'street motormen' and ship's officers, who were deemed less likely to have accidents, together with training and development, have become standard practices in many industries.

4.1 Accident Causation in the Contemporary Era

The contemporary era spanned the first two ages of safety. The first was associated with Industrial / technology, and the second with behaviours and human error. A number of theories and models were used to explain how accidents were caused in this era; prominent among these included *Acts of God*, Accident proneness, Dominoes, Human factors, Accident-incident theories, Energy-exchange and Time-sequence models.

4.1.1 Acts of God

An early thinking about accidents were that these were random *Acts of God[36]*. The phrase, however; has an older, legal tradition which can be traced to Roman law, and which had a significant influence on English law[37]. As the author notes; accidents, as captualised in the early 1400s, embraced ideas such as injuries, property losses, unexpected events and unintended results; and the absence of any scientific tools to investigate causation during that period meant many of these being associated with the phrase an *act of God*. The first breakthrough in moving away from this line of thinking was when people started conceptualising what happened, relinquishing the need to refer to luck, good or bad, in favour of understanding[38].

4.1.2 Accident proneness

The theory of accident proneness can be traced to the work of psychologists such as Arbous and Kerrich [39]] and Paterson[40]]. Theoretically defined; "accident proneness is the sum of personal qualities and activities which render a person unable to make the requisite and adequate response in a moment of danger"[40]. The author such individuals had a reasonably poor degree of sensory-motor coordination so were unable to react. He also distinguished between accident potential individuals (those had personalities structures which enabled them to be displaced beyond the social thresholds of specific levels of social acceptance into groups where they became accident prone under stress); and accident liable individuals (those who showed a history of recurrence of accidents, either as a result of proneness or potential proneness, or both). Arbous and Kerrich [39]] suggest this was linked to a minor group of individuals who were responsible for the majority of industrial accidents because of their personalities. Some attempts have also made to provide scientific explanations of accident proneness among those entering hazardous occupations[41][42]. A recent study by Wåhlberg and Dorn [43]] has also provided support for this proposition.

However, the theory has been refuted by a authors such as Weinerman [44]]and Froggat and Smiley [45]], who linked variations in human performance with personal and environment factors, and associated accidents with biological conditions and environment. More recent studies also suggest that people who were more psychologically stressed were more likely to have a work-related accident because they were more susceptible to cognitive failures[46].

4.1.3 Dominoes Theory

Dominoes theory was first suggested by Heinrich, based on his work in the insurance industry. According to his reasoning; "an injury is almost invariably preceded by (i) a cause and (ii) an accident. An employee wilfully indulges in unsafe practice-that is a cause; as a result he collides with a fixed object-that is the accident; he sustains a broken arm-that is the injury"[47]. Preceding the accident was a sequence of events, some of which resulted in an injury. He extended these ideas into the Dominos theory. His five original dominoes included (i) ancestry and social environment, (ii) fault of person, (iii) unsafe act or mechanical/physical hazard, (iv) accident, and (v) injury. The first domino in the sequence, social ancestry and social, included undesirable human traits (such as greed, recklessness and stubbornness) deemed to have been genetically inherited, or things such as alcoholism and drug dependency) which developed from a person's social environment. These impacted on the second domino, fault of person, making them an unsafe person. The third domino, which he labelled as unsafe act or mechanical of physical hazards; was the direct cause of incidents and included such factors as starting machinery without warning, and absence of rail guards. Heinrich felt that unsafe acts and unsafe conditions played an essential role in the causation of incidents, a process which he likened to lifting one of the dominoes out of the line; thus a combination of the first three dominoes caused accidents, some of which could result in an injury. A number of variants of the Dominos theory were also proposed, including the Loss-causation model (LCM) suggested by Vincoli[48], illustrated in Figure 1.

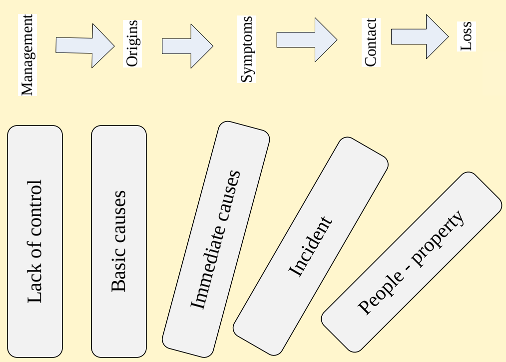

Figure 1: Loss Causation model

This introduced two new dominoes, management control and losses; resulting in the five dominoes being relabelled as lack of control, basic causes, immediate causes, incidents and losses. The author associated lack of control with the management function; the basic cause as an origin and the immediate cause as symptoms. He did not distinguish between any levels of management; arguing that irrespective of where they were in the management hierarchy they were still responsible for the four basic functions expected of any managers (planning, leading, organizing and controlling); and incidents were more likely to occur amidst organizational environments where management allowed the symptoms to continue unchecked. More recently a generalized domino theory which integrates these models comprised of the following has been proposed:

(i) lack of management controls,
(ii) unsafe acts,
(iii) unsafe conditions; and
(iv) loss [49]

The Domino theory saw people as being this most single factor, so holding them responsible was an accepted norm for many decades. However, it is only after World War II that increased efforts were devoted to developing a more nuanced understanding of people's behaviour in work and accidents, under the broader field of human factors.

4.1.4 Human Factors Theory

Human factors (HF) is concerned with the way in which environmental, organisational, job factors, together with human and individual characteristics; influence unsafe acts which can impact health and safety[50]. HF theory brought home the message, that while technological advancements brought significant improvements in production and safety; they also reduced workers skills about the work they were required to do, the time required to do that job; the monotony of their jobs impacted on their attitudes as well as mental well-being, and these factors combined together to increase their potential to err. So while this theory posited that accidents were ultimately caused by human error, they were more likely to be due to the combined effects of overload, inappropriate response and inappropriate activities[51].

Overload represented an imbalance between a person's mental and physical capacity at any given time and the load that person was expected to carry in any given state; and was the product of his or her natural ability, training, state of mind, fatigue, stress and physical condition; while load comprised of the tasks he/she was responsible for, and the added burdens arising from environmental factors (such as noise, distractions etc.), internal factors (such as personal problems, stress, worry) and situational factors such as degree of risk, clarity of instructions [51]. Workers could also be 'set up to fail' by the way the human brain process information, through the design of equipment and procedures and even through the culture of the organization they worked for[52]. Accidents could also be caused or prevented by how people respond to any given situation. For example, if a person noticed a hazardous condition or threat but did nothing to correct or report it, this could be deemed to be an inappropriate response. Ignoring safety procedures and rules that have been provided for people's use is another example [51]. People were also capable of making catastrophic decisions even though they are aware of the risks [52]. Inappropriate activities included performing a task without the necessary training, or misjudging the degree of risk that may be involved with a particular task[51].

The initial ideas arising from HF theory were closely associated with behaviours and unsafe acts[53][54]. Later, these were developed into the broader notion of human error, a generic term used to describe unsafe acts where a planned sequence of mental or physical activities failed to achieve desired outcomes, but when these could not be attributed to a chance agency[55]. Under this theory, unsafe acts of people can be caused through errors or violations. An error is unintentional, while violations are intentional. Errors were further classified into skill-based errors (which included things such as slips of action or lapses in memory) and mistakes (which could be rule-based or knowledge based); while violations could be routines, situational or exceptional. Slips occur when an action does not go as planned, and they are potentially observable, e.g. slips of performance or slips of the tongue. Lapses represent a more covert form of error forms, largely involving failures of memory but which do not manifest in actual behaviour; hence they may only be apparent to people who experience them. Mistakes include deficiencies in the process of making judgements or inferences, where people take the wrong action but believe it to be right[56]. They are more complex and less well understood than slips; for that reason they constitute a greater degree of danger and are much harder to detect. Mistakes can arise at two levels, rules or knowledge[57]. Rule-based mistakes occur when a person's action is based on remembered rules or familiar procedures, and results from their strong tendency to use familiar rules or solutions even whey they may not be most convenient. Knowledge-based mistakes result from misdiagnosis and miscalculations when dealing with unfamiliar circumstances. Violations represent a further type of human error[58]. In general, they are deliberate and intentional acts which breach regulations, policies, directions, instruction or commonly accepted ways of working. The intention, however, may not to damage the system. Deliberate intention to harm is sometimes described as sabotage. Violations may be routine, situational or exceptional. Authors such as Petersen [28]have suggested the incidence of human error varies considerably, and differs between individuals. Moreover, the propensity of the individuals to err varies with time and situation, and this can be due to a large number of factors, both internal and external to the individual. He also proposed that the degree of people errors could be placed on a continuum, ranging from being completely error free to negligence, deliberate destruction, thefts and arson, as illustrated in Figure 2. The broken lines are used to demonstrate that the different types of errors cannot be clearly delineated.

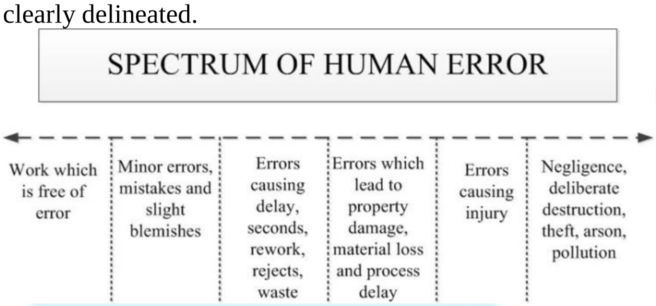

Figure 2: The human error spectrum

4.1.5 Accident/Incident Theory

Another explanation involved the Accident/Incident theory (AIT), which included an extension of HF theory, but also integrated new knowledge about o0rganisational systems. According to this theory, error by humans could be associated with overload, ergonomic traps arising from the design of work stations; and decision to err[51]. Ergonomics is about the compatibility of the man-machine interface[59]; the decision to err could be due to tasks being misjudged, group norms, measures and rewards; while methods used for selection and training; and the requirements to complete documents processes such as job safety analysis (JSA) or job hazard analyses (JHA) could all cause overload and unsafe behaviour amongst workers[51], as illustrated in Figure 3.

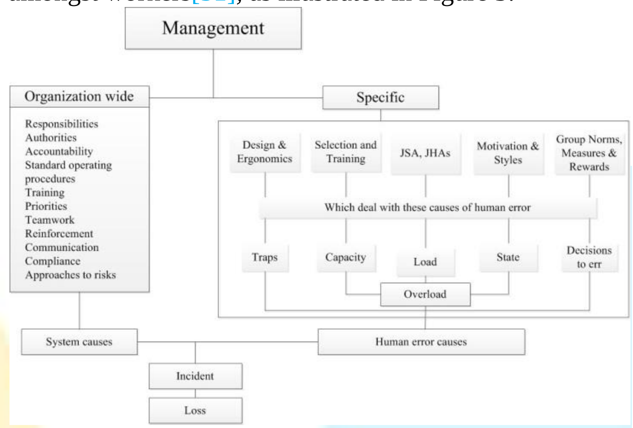

Figure 3: Extended AI Theory

An important contribution of the AI theory involved the introduction of 'systems' element and highlighting the potential for a causal relationship between management behaviors and safety; thus bringing to the fore managements' role in the causation and prevention of accidents. According to this theory management contributed to failures, for example, by not (i) establishing or implementing a comprehensive safety policy, (ii) clearly defining accountabilities, responsibilities and authorization for safety actions and improvements, (iii) giving adequate attention to measuring, monitoring, investigations and corrective actions[60].

AIT played an important role in extending our understanding about common sources of human error. Beyond the theory, however, there has been little research published on the topic.

4.1.6 Energy-exchange model

The basic principles of this model were based on the premises that injuries (which arise from accidents) involved the transfer energy [61][62]and these injuries could be placed in two groups. The first comprised of caused by interference with normal whole body or local energy exchange (such as suffocation, drowning, strangulation, carbon monoxide inhalation, and cyanide poisoning); while the second comprised of those in which the damage was caused by the delivery to the body of amounts of energy in excess of the corresponding local or whole body injury thresholds (such as bullets, hypodermic needles, knives and falling objects), and those produced when the moving body collided with relatively stationary structures (such as falls, plane crashes, and auto crashes bums; electrocution [62]Haddon posited that most injuries were caused by abnormal energy transfer, with mechanical energy being most common. His work, however, has been more commonly used in Road safety, although there are some proponents of his approach in OHS practice. In Australian one of these include[63], who proposed that there were three key principles involved in this model.

1. Energy is required produce injury and damage,
2. The process develops sequentially in time, and

3. Uncertainty is involved.

These principles were used to develop one of two models. The first of this comprised of hazard, hazard control mechanisms, space transfer mechanisms, recipients and recipient's boundary. The model starts with a consideration of the energy involved; which represents the hazard. Hazard control mechanisms are normally put in place to prevent the energy from escaping and being transferred to a recipient. The original energy will likely change its form in the transfer process. For example, a build-up of pressure may cause an explosion and fire. The explosive force is transmitted through air pressure (acoustic energy) or by fire (thermal energy) of various types or pieces flung from the machine (kinetic energy). If any of these are intense enough to overcome the recipient's boundary threshold limit, damage will be caused to the recipient. According to this model, injuries could be prevented by stopping the transfer of energy in some way, by things such as training, safe systems of work, or having a back-up system.

4.1.7 Time-sequence model

The Energy exchange model explained that the damage and energy develops over a period of time. Haddon argued that this development, onset and treatment entailed three key phases, "Pre-event, Event and Post-event"[61]. The pre-event phase included all those factors which increased the likelihood of a person being exposed to a particular hazard. In road safety for example, this phase involves factors that determine whether potentially damaging energy exchanges will take place-that is, whether vehicles will crash. The event phase involved the interaction of the human with the agent. There were three distinct activities at this phase; an initiating event, the event itself and an outcome. The post-event phase was when the damage or loss had taken place, following which salvaging any damage done would commence, with the aim of reducing the likelihood of death, disability or disease.

Building on these ideas, a Generalized Time-sequence Model breaking up the series of events into three zones was proposed [65]. In *Time Zone 1*, the preconditions for an accident become manifest and, under normal conditions the usual prevention systems will circumvent its occurrence. An event is then initiated at the beginning of *Time Zone 2*, occurrence, which is the period immediately surrounding the event. In *Time Zone 3*, the consequences start with damage, which could result injury, fade out or enable recovery. The opportunity to exert control over the event and energy transfer only exists if the risk is recognized in the first instance. The prerequisite for this countermeasure is the existence of a *supervisory system*, which is capable of identifying risks, recognizing the existence of potentially damaging conditions and circumstances and taking effective control measures. In *Time Zone 2*, there is an opportunity for active control of the occurrence, while in *Time Zone 3* such opportunity is lost, but replaced with damage control and rehabilitation. Sklet [64]used different terms to explain a similar sequence of events when discussing safety barriers and functions; an initial phase, the concluding phase, and the injury phase. Sklet thus saw the preconditions (Time zone 1) as the initial phase, the occurrence (Time zone 2) as the concluding phase, and the consequence (Time zone 3) as the injury phase.

An understanding of how accidents (and injuries) are caused is also intrinsically linked to ways and methods of preventing them; usually as part of the broader strategy for managing OHS adopted in organisations. The next section examines commonly used approaches that have been used.

4.2 OHS Management In The Contemporary Era

The main approaches for managing OHS in the contemporary era differed between industries and regions. While there are many in the mix; they can be summarised into three main ones; technical, regulatory and behaviour-based safety.

4.2.1 Technical approaches

OHS management approaches in the early 1960s, for example, focused on addressing technical and mechanical faults with structures, plant and machines[65]. An example of this was illustrated by DuPont. At the time it introduced Taylorism, DuPont's core business involved the manufacture and sale of explosives. Because these products were inherently dangerous, the company followed a loose policy in terms of safe design, with the sequence of production being carried out in number small buildings, each of which were separated by distancing and barriers to isolate them from being impacted by an explosion at any of them[34]. This represented an early example of managing OHS risks by separation, an engineering solution. In effect, this was about separating the dominoes sufficiently apart so that the impact of an incident could be contained within the one plant, without impacting on the others. How far they were to be separated were largely governed through technical standards and rules. The range of methods and approaches developed exponentially in the 1970s, following the development of nuclear power plants and establishment of regulatory agencies for environmental and safety protection.

4.2.2 Regulatory approaches

Early regulatory approaches for managing OHS were based on 'Factory-style' Acts and Regulations. Most of these were derived from the British system of common laws, were largely prescriptive, included a mass of detailed and technical rules, and were aimed at particular industries, workplaces (such as factories, shops and mines) or hazards (such as lead, asbestos)[66]. These sought to control things such as the number of hours worked, restricted the entry of children into mills, and provide guarding for dangerous parts of machines [67]The laws also prescribed safe systems of work (SSW), in the form of safety rules, work instructions, procedures and permit-to-work systems[49]. They also provided for remedial actions to be taken without enforcement, rules, penalties courts or involvement of Inspectors. For example, in the US these included research to aid the development of new methods for dealing with OHS problems, the exploration of ways to discover latent occupational diseases, medical criteria to assure that no one will suffer diminished health or life expectancy because of his job, and training programs to increase the number and competence of personnel in the field of OHS[68]. Over time the prescriptive standards were further progressed into performance-based, duty of care, process-based and systems requirements[69][72].

4.2.3 Behaviour-based safety

In addition to technical and regulatory approaches, behaviour-based safety (BBS) approaches were also a common method for managing OHS. These drew heavily on human motivation and incentives to bring about modifications in human behavior[55][73]. BBS was first introduced around the 1970s in the US, followed by the UK a decade later[74]. Since its introduction it has undergone a series of evolutionary changes [75]Between the 1970s to mid-1980s it was largely a supervisory, top-down-driven process, where supervisors observed how workers behaved, gave feedback and provided some form of positive or negative reinforcement. In the early 1980's, this changed more towards employee-led process; and later to one involving managerial and employee partnership in the 1990s. Employees monitored behaviour of members of work-groups, while managers monitored their own safety-related leadership behaviors. All three approaches are widely used around the world [60][75]

5 DISCUSSION

This research sought to examine how work-related accidents and injuries are caused; how such understanding has informed OHS management practice; and strengths and weaknesses of these approaches. Sections 4.1 to 4.6 sought to provide some answers to the first research question through six models and/or theories that were common in the contemporary era. The ensuing section seeks to provide some answers to the remaining research questions.

There is very little published research linking *Acts of God* with any of the OHS management strategies discussed here over four decades. This is largely due to the realization that, in order to qualify as an *Act of God*, an accident needed to be due to natural causes without human intervention [37]Accident proneness, on the other hand; has been the subject of some recent research published from industries such as railways [76] and air force [77]The results, however, are inconclusive; with some evidence that some people may be accident prone in given situations. Recent reviews, however, suggest a number of weaknesses with this theory; including low correlation between test results and accident figures, a realization that correlation was not a proof of causal relationship; the studies being retrospective and dependent on accident registration by companies; reliability of registration information; vagueness of definitions used, and variations in its operationalization [10][78]. Earlier reviews have similarly concluded that, in order for accident proneness to be accepted as a stable personality characteristic, it needed to be measured reliably proven to be a valid predictor[79]. Employees more likely to experience cognitive failures if they are under stress or experiencing fatigue, and this can easily be mistaken for being accident prone [46]Moreover, the few published studies have failed to make any links between these two theories and technical, regulatory or BBS OHS management strategies. For these reason organizations which develop their accident prevention and OHS management initiatives on these theories are unlikely to see any tangible improvements in their overall OHS performance.

The Dominoes theory has similarly been the subject of some research in the chemical sector[80][81]. These theories are useful in explaining abrupt, unexpected onset of accidents[82]. Moreover, they are relatively easy to understand. When investigating for causes under these models, one can continue to ask *why* type of questions until such time when all contributory factors around the first three dominos have been exhausted. In the LCM these questions can also be directed at the key management functions of planning, leading, organizing and controlling. Small and medium-sized organisations which generally operate with very few processes or deal mass-produce a small range of goods and products may find Dominoes a useful approach.

However, they are also limited because they seek to suggest that

1. organizations were linear in structure;
2. the sequence of events leading to injury also followed a similar pattern, and
3. accidents were caused by single factors [60][82]

Hence dominoes reinforced a misunderstanding that accidents have a single root cause which can be found by searching backwards from event through the chain of causes that preceded it, and that the chain of events occur in a linear fashion. Moreover, they suggest that accidents can be prevented by disrupting the linear sequence by removing the domino, or by spacing the dominoes sufficiently apart such that they were unlikely to be impacted by the preceding domino[60]. However, reports of organizational disasters such as the Columbia shuttle disasters pointed towards 'gradual losses in safety barriers and defenses' [83]These could not be explained by the linear sequencing proposed under the dominoes theory. Boyle also makes this point, arguing that one domino was rarely involved in a given accident; instead, there are various causes which contribute to the fall of the domino[49]. On a more pragmatic level, there are no domino pieces waiting to fall in organisations; although “there may be precariously poised systems or subsystems that suddenly change from normal to an abnormal state, but that transition is rarely as simple as a domino falling”[82]. For this reason large organizations and those which have multiple and complex processes should not rely on Dominoes theory to develop their accident prevention and safety management initiatives.

In relation to the second research question, this review suggests that although the above models/theories have been in the literature since the early 1930s; they have not played a role in informing OHS management research and/or practice consistent with the first age of safety; i.e. technical or regulatory approaches.

Invariably, any accident can be linked with some aspect of human behaviour. Forgetfulness, inattention, poor motivation, carelessness, negligence, and recklessness are all common; and the associated countermeasures aimed at reducing this-poster campaigns, writing another procedure (or adding to existing ones), disciplinary measures, threats of dismissal and/or litigations, retraining, naming, blaming, and shaming, are all attractive options[84]. For this reason BBS; which is most closely related to human behaviour, has a greater appeal to many practitioners, scholar and policy makers. It offers a number of advantages. Among these include (i) a focus on human aspects of safety, (ii) levels of safe and unsafe behaviors being established upfront, and (iii) employees and supervisors both being involved in the process[60][85]. Experience with BBS strategies they are useful in reducing injuries and behavioural changes in both statistic and dynamic work settings; using a mix of one-to-one and workgroup-based approach for observing; and three to four feedback mechanisms[75]. Organisations which use these as the basis of developing their accident prevention and OHS management strategies may experience improvements in safety performance.

However, such approach has also been criticized because it (i) reinforces the notion that people are the sole cause of incidents and accidents, (ii) focuses on behaviors only, while problems could lie elsewhere; such as values, attitudes and perceptions, (iii) denies the importance of power structures, (iv) isolates safety and production into two different parts of an organisation, and (v) masks the true causes of accidents and incidents [60][85]Research from a number of industries have revealed that safety-related behaviour is not necessarily under the control of individual workers but can be associated with organizational processes, management decisions, workplace conditions, supervision, training, lack of safety awareness, a culture of being 'tough', work pressure, attitudes of co-workers and a range of organizational, economic and psychological factors[86][87]. For that reason simply linking accidents to human error is a very simplistic, if not naive, approach. Errors are simply fact of life[88][89]. Furthermore, treating errors as a:

i. cause blocked learning by masking some of the more prominent causes and factors that affected human and system performance;
ii. synonym for harm gave a false sense of feeling of progress being made; when , in actual case, there may be none; and
iii. deviation from a model of 'good' process was as odds with the acknowledged acceptance that all human behaved differently[90].

Safety rules, as a component of SSW, are generally incomplete as models of expertise and success. This is because it was not possible to identify all possible hazards and risks, the procedures / rules written to address them will invariably be limited in their application [56]. In addition, safety rules by themselves do not reduce risks, nor do extortions to follow rules more carefully enhance safety[91]. Rules can also create unnecessary regulatory burden on organisations[92]. Organisations which use SSW for controlling and managing unsafe behaviour with the above mindset are unlikely to experience any visible improvements in safety performance.

In spite of these, human error and safety rules continue to be subject of interest; with recent research suggesting that flexibility in the applications of such rules are critical to their success[93]. In the construction industry for example, such flexibility has been suggested, for example; in safe work method statements (SWIMS) being reserved for tasks that are out of the ordinary instead of every-day construction work, used as a cognitive artefact, and as a tool for social interactions[94][95]. However, the extent to which such flexibility are likely to reduce work-related incidents, accidents; or improve safety performance; are yet unknown. More empirical studies are needed to investigate the linkages between such SSW on accident prevention and OHS management strategies.

The Damaging energy-exchange and Time-sequence models advanced work on accident causation by integrating and drawing on research from diverse fields such as physics and medicine. However, they still continued to associate accidents and injuries with a linear chain of event. Qureshi[96], for example, suggests these sequential models assume that the cause-effect relation between consecutive events were linear and deterministic; hence they could not comprehensively explain accident causation in modern organisational systems where multiple factors combined in complex ways to cause system failures. Authors such as Lehto and Salvendy[97] have also argued that the energy models neglected accidents such as those involving blockage of energy and material flows. Many of these accidents, according to the authors, could also be modelled in ways analogous to Haddon's model; such as the exposure to toxic materials seen as a flow from some source to a susceptible host. In addition, there is very little published on energy exchange or time-sequence models from traditional and contemporary industries such as manufacturing, construction, transport, mining or healthcare. More empirical studies are needed to investigate the efficacy of these models in these industries, and the role they play in organisational OHS management.

6. CONCLUSION

The five age/three era periodization scheme used to develop an understanding of accident causation, prevention and OHS management in this review provides a useful framework because it places progress and advancements in accident causation and OHS management research and practice along a continuum of improvements. According to this framework, six main theories or models have been used to inform accident and injury causation in the first era. The main limitation of these models lies in associating accidents and injuries with singular causes; and the linear sequencing of events and factors. The three main approaches for managing OHS in this era were based on technical, regulatory and BBS. Apart from BBS, which draws on theory on human behavior and errors, there is little evidence that any of the six theories and/or models of causation have been used to inform OHS management practice. BBS strategies are gaining popularity in terms of practice and research. What is unclear, however, is the role that these play in reducing accidents and/or injuries; or in improving OHS performance.

This review has also shown that accidents need to take into account other, broader factors (such as organizational and environmental) beyond the human element. This requires delving into the advanced era of OHS, and will be the subject of a future review.

7. REFERENCES

[1] J. Takala, P. Hamalainen, K. L. Saarela, Y. Y. Loke, K. Manickam, W. J. Tan, et al., "Global estimates of the burden of injury and illness at work in 2012," Journal of occupational and environmental hygiene, vol. 11, pp. 326-337, 2014.

[2] Bureau of Labor Statistics, "Revisions to the 2013 census of fatal occupational injuries (CFOI) counts," Washington, DC2015

[3] Health and Safety Executive, "Health and safety statistics - Annual report for Great Britain," London2015.

[4] Safe Work Australia, "Key work health and safety statistics, Australia," Canberra, 2015.

[5] Safe Work Australia, "The cost of work-related injury and illness for Australian employers, workers and the community: 2012-2013," Safe Work Australia, Canberra 2015.

[6] R. Eisenbury. (2013, 6 Jun). Workplace injuries and illnesses cost U.S. $250 billion annually. Available: http://www.epi.org/publication/workplace-injuries-illnesses-cost-250-billion/

[7] E. Hollnagel, "The changing nature of risk," *Ergonomics Australia Journal*, vol. 22, pp. 33-46, 2008.

[8] R. Hudson, "The costs of globalization: Producing new forms of risk to health and well-being," Risk Management, vol. 11, pp. 13-29, 2009.

[9] B. Fernández-Muñiz, J. M. Montes-Peón, and C. J. Vázquez-Ordás, "Relation between occupational safety management and firm performance," *Safety Science*, vol. 47, pp. 980-991, 2009.

[10] P. Swuste, C. van Gulijk, and W. Zwaard, "Safety metaphors and theories, a review of the occupational safety literature of the US, UK and the Netherlands, till the first part of the 20th century," *Safety Science*, vol. 48, pp. 1000-1018, 2010.

[11] P. Swuste, C. v. Gulijk, W. Zwaard, and Y. Oostendorp, "Occupational safety theories, models and metaphors in three decades since World War II, in the United States, Britain and the Netherlands: A literature review," *Safety Science*, vol. 62, pp. 16-27, 2014.

[12] R. Whittemore, "The integrative review: updated methodology," Journal of Advanced Nursing, vol. 52, pp. 546-553, 2005.

[13] G. A. Bowen, "Document analysis as a qualitative research method," Qualitative research journal, vol. 9, pp. 27-40, 2009.

[14] A. Hopkins, "Studying organisational cultures and their effects on safety," Safety Science, vol. 44, pp. 875-889, 2006.

[15] M. Pillay and M. C. Jefferies, "A revised framework for managing construction health and safety risks based on ISO 31000," in CIBWO99 International Health and Safety Conference, Benefitting Workers & Society Through Safe(r) Construction, Belfast, Northern Ireland, 2015, pp. 467-477.

[16] W. A. Green, "Periodizing world history," History and Theory, vol. 34, pp. 99-111, 1995.

[17] D. A. Wren and A. G. Bedeian, "The emergence of the management process and organization theory," in The evolution of management thought, D. A. Wren and A. G. Bedeian, Eds., ed Hoboken: John Wiley & Sons, Inc., 2009.

[18] A. Smith, An inquiry into the wealth of nations, 1776.

[19] F. W. Taylor, The principles of scientifc management. New York: Harper & Brothers Publishers, 1911.

[20] M. Krenn, "From scientific management to homemaking: Lillian M. Gilbreth's contributions to the development of management thought," Management & Organizational History, vol. 6, pp. 145-161, 2011.

[21] D. M. McGregor, "The human side of enterprise," in Readings in Managerial Psychology, L. H. J, L. R. Pondy, and D. M. Boje, Eds., Third ed: The University of Chicago Press, 1980, pp. 310-321.

[22] S. Robbins, R. Bergman, I. Stagg, and M. Coulter, Management, 4th ed. Frenchs Forest, Australia: Prentice Hall, 2006.

[23] A. H. Maslow, "A theory of human motivation," Psychological Review, vol. 50, pp. 370-396, 1943.

[24] H. Mintzberg, "Managerial work: analysis from observation," Management Science, vol. 18, pp. B97-B110, 1971.

[25] J. F. Wilson and A. Thomson, *The making of modern management: British management in historical perspective*. Oxford: Oxford University Press, 2006.
[26] J. Wilson and A. Thomson, "Management in historical perspective: stages and paradigms," *Competition & Change*, vol. 10, pp. 357-374, 2006.
[27] S. Keulen and R. Kroeze, "Introduction: The era of management: a historical perspective on twentieth-century management," *Management & Organizational History*, vol. 9, pp. 321-335, 2014.
[28] D. Petersen, "Human error: a closer look at safety's next frontier," *Professional Safety*, vol. 48, pp. 235-32, 2003.
[29] D. Borys, D. Else, and S. Leggett, "The fifth age of safety: The adaptive age," *Health & Safety Research & Practice*, vol. 1, pp. 19-27, 2009.
[30] A. R. Hale and J. Hovden, "Management and culture: the third age of safety. A review of approaches to organizational aspects of safety, health and environment," *Occupational injury: Risk, prevention and intervention*, pp. 129-165, 1998.
[31] J. C. Le Coze and M. Dupre, "The need for 'translators' and for new models of safety," in *Resilience engineering perspective: remaining sensitive to the possibility of failure*. vol. 1, E. Hollnagel, C. Nemeth, and S. W. A. Dekker, Eds., ed Burlington, USA: Ashgate Publishing Company, 2008, pp. 11-27.
[32] Australian Radiation Protection and Nuclear Safety Agency. (2014, 20Aprl 2016). *History of safety*. Available: http://www.arpansa.gov.au/regulation/Holistic/history.cfm
[33] M. Pillay, "Accident causation, prevention and safety management: a review of the state-of-the-art," *Procedia Manufacturing*, vol. 3, pp. 1838-1845, 2015.
[34] R. R. Stabile, "The DuPont experiments in scientific management: efficiency and safety, 1911-1919," *The Business History Review*, vol. 61, pp. 365-386, 1987.
[35] P. B. Petersen, "Early beginnings: occupational safety management 1925-1935," *Journal of Managerial Issues*, vol. 2, pp. 382-405, 1990.
[36] P. L. Bernstein, *Against the gods: The remarkable story of risk*. New York: John Wiley, 1996.
[37] H. Loimer, M. Druir, and M. Guarnieri, "Accidents and Acts of God: A history of terms," *American Journal of Public Health*, vol. 86, pp. 101-107, 1996.
[38] P. Hudson, "Accident causation models, management and the law," *Journal of Risk research*, vol. 17, pp. 749-764, 2014.
[39] A. G. Arbous and J. Kerrich, "Accident statistics and the concept of accident-proneness," *Biometrics*, vol. 7, pp. 340-432, 1951.
[40] T. T. Paterson, "The theory of social threshold: The social aspect of accident causation," *Sociological review*, vol. 42, pp. 53-68, 1950.
[41] G. E. Bates and J. Neyman, "Contributions to the theory of accident proneness. 1. An optimistic model of correlation between light and severe accidents," *University of California Publications in Statistics*, vol. 1, pp. 215-254, 1952.
[42] G. E. Bates and J. Neyman, "Contributions to the theory of accident proneness. II. True or false contagion," *University of California Publications in Statistics*, vol. 1, pp. 255-276, 1952.
[43] A. A. Wåhlberg and L. Dorn, "Bus driver accident record: the return of accident proneness," *Theoretical Issues in Ergonomics Science*, vol. 10, pp. 77-91, 2009.
[44] E. R. Weinerman, "Accident proneness: a critique," *American Journal of Public Health*, vol. 39, pp. 1527-1530, 1949.
[45] P. Froggat and J. A. Smiley, "The concept of accident proneness: a review," *British Journal of Industrial Management*, vol. 21, pp. 1-13, 1964.
[46] A. J. Day, K. Brasher, and R. S. Bridger, "Accident proneness revisited: the role of psychological stress and cognitive failure," *Accident Analysis & Prevention*, vol. 49, pp. 532-535, 2012.
[47] H. W. Heinrich, "Relation of accident statistics to industrial accident prevention," *Proceedings of the Casuallity Activity Society*, vol. 16, pp. 170-174, 1930.
[48] J. W. Vincoli, *Basic guide to accident investigation and loss control* vol. 1. New York: John Wiley & Sons, 1994.
[49] T. Boyle, *Health and safety: risk management*, Third ed. Leicestershire: IOSH Services Limited, 2012.
[50] C. D. Wickens, A. S. Mavor, and J. P. McGee, *Flight to the future: Human factors in air traffic control*. Washington, D.C.: National Academy Press, 1997.
[51] D. L. Goetsch, Occupational safety and health for technologists (8th edition). Sydney: Pearson, 2015.
[52] Health and Safety Executive, *Reducing Error and Influencing Behaviour*. London: HSE Books, 1999.
[53] P. Slovic, B. Fischhoff, and S. Lichtenstein, "Behavioral decision theory perspectives on risk and safety," *Acta Psychologica*, pp. 183-203, 1984.
[54] D. H. Taylor, "Accidents, risks, and models of explanation," *Human Factors*, vol. 18, pp. 371-380, 1976.
[55] J. Reason, *Human error*. Cambridge: Cambridge University Press, 1990.
[56] J. Reason, D. Parker, and R. Lawton, "Organizational controls and safety: The varieties of rule-related behaviour," *Journal of Occupational and Organizational Psychology*, vol. 71, pp. 289-304, 1998.
[57] Health and Safety Executive, *Reducing error and influencing behaviour*. Sudbury, Suffolk: Health and Safety Executive, 2007.
[58] S. J. Alper and B.-T. Karsh, "A systematic review of safety violations in industry," *Accident Analysis & Prevention*, vol. 41, pp. 739-754, 2009.
[59] W. Karwowski, "Ergonomics and human factors: the paradigms for science, engineering, design,

technology and management of human capital systems," *Ergonomics*, vol. 48, pp. 436-463, 2005.
[60] M. Pillay, "Taking stock of zero harm: A review of theory on contemporary health and safety management in construction. ," in *CIB W099 International Health and Safety Conference*, Lund, Sweden,2014, pp. 75-85.
[61] W. Haddon Jr, "Approaches to prevention of injuries," presented at the American Medical Association Conference on Prevention of Disabling Injuries, Miami, Florida, 1983.
[62] W. Haddon Jr, "A note concerning accident theory and research with special reference to motor vehicle accidents," *Annals of the New York Academy of Sciences*, vol. 107, pp. 635-646, 1963.
[63] D. Viner, Accident analysis and risk control: VRJ Delphi, 1991.
[64] S. Sklet, "Safety barriers: Definition, classification, and performance," *Journal of Loss Prevention in the Process Industries*, vol. 19, pp. 494-506, 2006.
[65] J. Hovden, E. Albrechtsen, and I. A. Herrera, "Is there a need for new theories, models and approaches to occupational accident prevention?," *Safety Science*, vol. 48, pp. 950-956, 2010.
[66] M. Quinlan, "Occupational health and safety: a review of developments in 1987," *Asia Pacific Journal of Human Resources*, vol. 26, pp. 55-70, 1988.
[67] R. Schilling, "Developments in occupational health during the last thirty years," *Journal of the Royal Society of Arts*, vol. 111, pp. 933-984, 1963.
[68] M. E. Gross, "The Occupational Safety & (and) Health Act: much ado about something," *Loloya University Chicago Law Journal*, vol. 3, pp. 247-269, 1972.
[69] N. Gunningham and R. Johnstone, *Regulating workplace safety: system and sanctions*: Oxford University Press, 1999.
[70] R. Johnstone, E. Bluff, and A. Clayton, *Work health and safety law and policy*, Second ed. Sydney: Law Book Co., 2004.
[71] M. Pillay, "Harmonisation of construction health and safety laws in Australia " in *CIBWO99 Safety and Health in Construction*, Brisbane, Australia, 2013, pp. 97-109.
[72] M. Tuck and M. Pillay, "Harmonization and standardization of risk management of underground ventilation in Australia," in *14th U.S./North American Mine Ventilation Symposium*, University of UTAH, 2012, pp. 31-38.
[73] A. R. Duff, I. T. Robertson, R. A. Phillips, and M. D. Cooper, "Improving safety by modification of behaviour," *Construction Management and Economics*, vol. 12, pp. 67-78, 1994.
[74] Institution of Occupational Safety and Health, *Behavioural safety: improving performance*. Leicestershire: Institution of Occupational Safety and Health, 2015.
[75] D. M. Cooper, "Behavioral safety interventions: A review of process design factors," *Professional Safety*, vol. 54, pp. 36-45, 2009.
[76] G. C. Gauchard, J. M. Mur, C. Touron, L. Benamghar, P. Perrin, and N. Chau, "Determinants of accident proneness: a case-control study in railway workers," *Occupational Medicine*, vol. 56, pp. 187-190, 2006.
[77] K. E. Rani and S. Chaturvedula, "Accident proneness of pilots in Indian Air force: An empirical analysis through selection criteria," *Indian Journal of Aerospace Medicine*, vol. 53, pp. 36-44, 2009.
[78] E. Visser, Y. J. Pijl, R. P. Stolk, J. Neeleman, and J. G. M. Rosmalen, "Accident proneness, does it exist? A review and meta-analysis," *Accident Analysis & Prevention*, vol. 39, pp. 556-564, 2007.
[79] M. D. Rodgers and R. E. Blanchard, "Accident proneness: a research review," vol. DOT/FAA/AM-93/9, F. C. A. Institute, Ed., ed. Oklahoma: Office of Aviation Medicine, 1993.
[80] F. I. Khan and S. A. Abbasi, "Domifect (DOMIno eFFECT): User friendly software for domino effect analysis," *Environmental Modelling & Software*, vol. 13, pp. 163-177, 1998.
[81] R. M. Darbra, A. Palacios, and J. Casal, "Domino effect in chemical accidents: Main features and accident sequences," *Journal of Hazardous Materials*, vol. 183, pp. 565-573, 2010.
[82] E. Hollnagel and D. D. Woods, "Epilogue: resilience engineering precepts," in *Resilience Engineering Concepts and Precepts*, E. Hollnagel, D. D. Woods, and N. Leveson, Eds., ed Aldershot, England: Ashgate Publishing, 2006, pp. 347-358.
[83] D. D. Woods, "Creating foresight: How resilience engineering can transform NASA’s approach to risky decision making," *US Senate Testimony for the Committee on Commerce, Science and Transportation*, 2003.
[84] J. T. Reason, "Human error: models and management," *BMJ Qual Saf*, vol. 320, 2000.
[85] E. S. Geller, "Behavior-based safety and occupational risk management," *Behavior modification*, vol. 29, pp. 539-561, 2005.
[86] R. M. Choudhry and D. Fang, "Why operatives engage in unsafe work behavior: Investigating factors on construction sites," *Safety Science*, vol. 46, pp. 566-584, 2008.
[87] J. Mullen, "Investigating factors that influence individual safety behavior at work," *J Safety Res*, vol. 35, pp. 275-85, 2004.
[88] L. T. Kohn, J. M. Corrigan, and M. S. Donaldson, Eds., To err is human. Washington, D.C.: National Academy Press, 2000.
[89] S. W. A. Dekker, "Accidents are normal and human error does not exist: a new look at the creation of occupational safety," International Journal of Occupational Safety and Ergonomics, vol. 9, pp. 211-218, 2003.

[90] D. D. Woods and R. I. Cook, "Mistaking error," in Patient safety handbook, B. Youngberg and M. J. Haitely, Eds., ed Burlington, USA: Jones & Bartlett, 2004, pp. 95-108.
[91] S. W. A. Dekker, "Failure to adapt or adaptations that fail: contrasting models on procedures and safety," Applied ergonomics, vol. 34, pp. 233-238, 2003.
[92] A. Hale, D. Borys, and M. Adams, "Safety regulation: The lessons of workplace safety rule management for managing the regulatory burden," Safety science, vol. 71, pp. 112-122, 2015.
[93] A. Hale and D. Borys, "Working to rule, or working safely? Part 1: A state of the art review," Safety Science, vol. 55, pp. 207-221, 6// 2013.
[94] D. Borys, "The role of safe work method statements in the Australian construction industry," Safety Science, vol. 50, pp. 210-220, 2012.
[95] M. Pillay, "Resilience engineering, gaps and prescription of safe work method statements part 1: The view of organisational outsiders," in Advances in Safety Management and Human Factors vol. 491, P. Azeres, Ed., ed. Switzerland: Springer International Publishing, 2016, pp. 261-272.
[96] Z. H. Qureshi, "A review of accident modelling approaches for complex socio-technical systems," in Proceedings of the twelfth Australian workshop on Safety critical systems and software and safety-related programmable systems-Volume 86, 2007, pp. 47-59.
[97] M. Lehto and G. Salvendy, "Models of accident causation and their application: review and reappraisal," Journal of Engineering and Technology Management, vol. 8, pp. 173-205, 1991.

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