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Review

Failure to learn from safety incidents: Status, challenges and opportunities

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ABSTRACT

For effective and efficient learning to occur from safety incidents, certain factors and conditions related to the organisation, the actors or agents of learning, the learning process and the incidents themselves must be considered. Learning from incidents is not automatic and requires conscious and systematic steps to ensure it happens. Retaining the lessons learnt in the organisational memory to ensure continuous usage during the lifetime of the organisation is critical because personnel and learning agents change. To understand where breakdowns in learning from incidents are occurring, a bowtie analysis was used to organise the literature on failure to learn from safety incidents in a way that informs researchers and practitioners of priority areas. Additionally, the analysis aimed to test the validity of the bowtie method to filter failure to learn literature to identify key areas that could maximise learning. Using the bowtie analysis method led to the grouping of the issues identified in the literature on learning from safety incidents into three themes, namely, ***threats*** to failure to learn, ***consequences*** of failure to learn, and ***controls*** for overcoming failure to learn. This approach allows a summary representation of how and why failure to learn continues to occur together with potential practical strategies on how to overcome failure.

1. Introduction

All over the world safety incidents with diverse consequences continue to occur despite the investments organisations make into safety management (Drupsteen and Guldenmund, 2014; Drupsteen and Wybo, 2015). The recurrences of the same or similar incidents suggest a failure to learn from previous events. Learning from incidents (LFI) refers to the ability of a business to obtain useful experiences and understanding from past incidents and transfer them into practices and behaviours that prevent future events, contributing to the overall improvement in safety (Jacobsson et al., 2011). A failure to learn from incidents refers to the inability to obtain, retain and utilise the right lessons from past incidents to prevent future recurrences of same or similar events. A failure to learn suggests one of two things. Either lessons were not learned from previous incidents or the lessons learned were not effectively implemented, monitored and maintained over time.

Much has been written about the failure to learn from safety incidents. Early research in this field was conducted by cognitive systems engineers Rasmussen and Vicente (1989), Woods and Cook (2002), Hollnagel et al. (2007) and others. Pioneering work was also conducted by high reliability organisation researchers including Rochlin et al. (1998). In addition, Donald Schön and Chris Argyris developed the concept of single-loop and double-loop learning and offered explanations on how these translate into different models of organisational learning systems (Argyris and Schön, 1978). Trevor Kletz also impacted the field of process safety significantly, particularly with his emphasis on the need to undertake root cause analysis to identify key lessons that normally might have been overlooked (Kletz, 2001). All these researchers reached a consensus that for organisations to achieve high levels of safety, they must improve their ability to learn from incidents and accidents.

In addition, reviews on the subject of learning from incidents have been carried out with different aims, objectives and emphases including work by Drupsteen and Guldenmund (2014), Le Coze (2013), Lindberg et al. (2010) and Lukic et al. (2010). These reviews, together with other works, have contributed to the advancement of the still developing LFI subject. However, a systematic review that considers the threats to learning or why organisations fail to learn, the outcomes of failure to learn and how failure to learn from incidents can be avoided has not been completed. A systematic review is needed to further develop understanding of the LFI subject and to assist organisations in identifying the critical decisions they need to take to maximise learning from incidents and ensure that an organisational memory of lessons learnt is retained and used.

Causes and conditions contributing to the failure to learn from incidents need to be identified and understood. It is only when these

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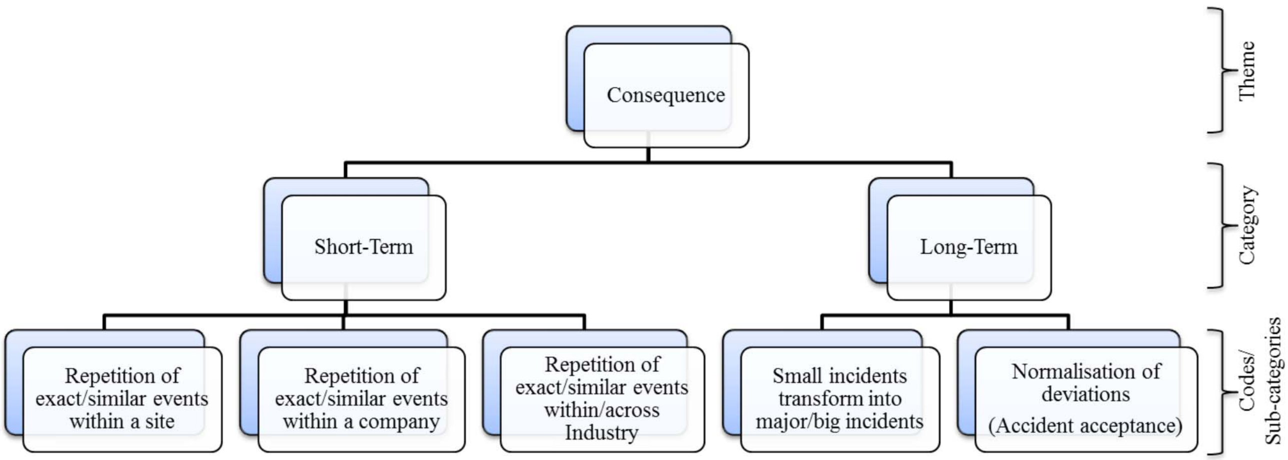

Fig. 1. Final coding structure for the consequence theme.

causes and conditions are systematically determined that specific sustainable solutions can be offered not just to overcome failure to learn but most importantly to maximise learning from incidents. One possible method for conducting such a systematic analysis of failure to learn in order to identify causes, consequences and solutions is bowtie analysis.

The bowtie analysis (BTA) was developed by coupling a fault tree and an event tree connected to an unwanted (initiating) event in the early 1970s (Nielsen, 1971). While some authors describe how the method can be implemented (Cardwell, 2008; de Dianous and Fiévez, 2006; Duijm, 2009; Ferdous et al., 2013; Jacinto and Silva, 2010; Lewis and Smith, 2010; Pitblado and Nelsone, 2013), others focus on specific aspects such as evaluating the characteristics of controls (Guldenmund et al., 2006; Hollnagel, 2008; Rowe and Taylor; Sklet, 2006). As identified by Pitblado and Weijand (2014) there exist several descriptions of the method including the EU ARIMIS project (Salvi and Debray, 2006), a risk management project by Shell to the European Union (Zuijderduijn, 2000) and the Norway BORA project (Aven et al., 2006). Most descriptions highlight that the BTA method consists of elements such as, a hazard, an unwanted event, threats, consequence and controls (mitigating and preventing), all arranged to form the shape of a bowtie. The technique has been extensively used in safety critical domains such as the petrochemical and chemical industry (Chevreau et al., 2006; Pitblado et al., 2015; Pitblado and Weijand, 2014) and mining industry (Burgess-Limerick et al., 2014; Dodshon and Burgess-Limerick, 2015; Hassall and Burgess-Limerick, 2016). Chevreau et al. (2006) have demonstrated that the technique does not only assist in effective analysis of incidents and risks but can also be utilised as an effective tool for communicating safety issues.

This review used the BTA approach to organise LFI related literatures into three broad themes or topics namely;

- threats to learning,
- consequences of failure to learn and
- the interventions required to prevent or mitigate the failure to learn from incidents.

By adopting the bowtie analysis method, the review aimed at answering the question "***Can bowtie analysis help in distilling failure to learn from safety incidents literature in a way that informs decision makers on how to maximise learning?***"

2. Methodology

2.1. Collection and analysis of literature

The search methodology used in this review is consistent with that of Drupsteen and Guldenmund (2014) and Lukic et al. (2010). Four major databases namely, Scopus, Science Direct, ProQuest and Ingenta Connect were searched using various search strings related to various stages of the LFI process. The search string used was *learning* and (*failure to learn)* and *incidents or accidents*. Additional search strings specific to some aspect of the learning process were also used such as *incidents or accident investigation or analysis* and *planning and implementation of investigation recommendations*. The search was restricted to titles, keywords and abstracts of peer-reviewed papers that were published from 2000 to 2016. Apart from the selected peer-reviewed articles, some selected books were also included in the review. Two of such books are, *Prevention of Accident through Experience Feedback* by Kjellén (2000) and *Organizational Learning: A Theory of Action Perspective*, by Argyris and Schön (1978). These two books were considered particularly important for the review due to their significance and influence on the LFI subject.

A total of 45 of the identified papers were selected for detailed analysis. The selected articles were those that were very specific to workplace safety related learning such as learning from disasters, accident and incidents. Each article was analysed thematically and coded using an integration of deductive and inductive approach. Through the deductive approach, the articles were categorised into three predefined themes derived from the BTA method of risk assessment. The three themes are ***threats*** to failure, ***consequences*** of failure, and ***controls measures*** for overcoming failure. The collected articles were sorted into these three broad topics after each article was read through as a whole. After the broad categorisation, the articles were reread and coded through an inductive approach. The inductive process of coding involve dividing text of an article into "chunks" of words, paragraphs and sentences and assigning each chunk with summary words or phrases that described the meaning of the text. This was an iterative process and involved going back to originally coded articles to check and compare codes. The process was repeated for all the articles and codes were constantly compared and refined until a final coding structure applicable to all the articles under a particle major theme was developed. As a result the inductive coding process produced for each theme, overarching categories and subthemes that comprised group similar codes. An example of the coding structure is shown in Fig. 1, which is the final coding structure for the consequence theme. The final coding structure was then arranged to form a bowtie using the BTA method as explained in the next subsection.

2.2. Development of bowtie

The basic structure of the bowtie is shown in Fig. 2. The centre (knot) of the bowtie describes the unwanted event, which for this analysis is the ***failure to learn*** from incidents. The hazard refers to

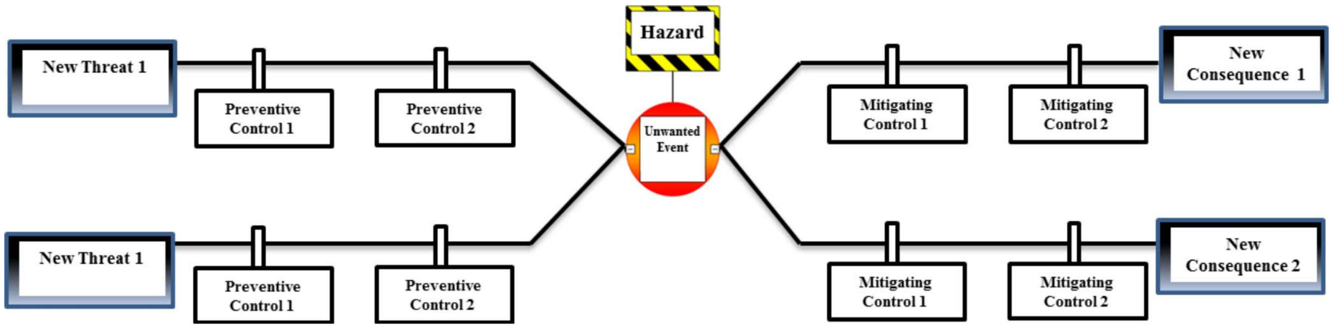

Fig. 2. Generic bowtie.

either a condition or material which could lead to the unwanted event if control is lost. Thus, loss of control of the hazard directly gives rise to the unwanted event (Pitblado et al., 2015). In this analysis, the hazard refers to the ***safety incidents***. On the left side lie the threats capable of causing the failure to learn from incidents. The outcomes or consequences of the unwanted event are shown on the right of the knot.

By inductively coding the articles that fell under the threat theme and constantly comparing and refining the emerging codes, four overarching categories each with subcategories emerged. The four overarching categories with subcategories were arranged as threat lines The four overarching categories are below:

- Learning inputs (Choularton, 2001; Cooke and Rohleder, 2006; Drupsteen et al., 2013; Drupsteen and Hasle, 2014; Einarsson and Brynjarsson, 2008; Huber et al., 2009; Jacobsson et al., 2012; Körvers and Sonnemans, 2008; Lindberg et al., 2010; Lukic et al., 2010; Ramanujam and Goodman, 2011; Rasmussen et al., 2013; van der Schaaf and Kanse, 2004)
- Learning process (Cedergren and Petersen, 2011; Cooke and Rohleder, 2006; Drupsteen et al., 2013; Drupsteen and Wybo, 2015; Harms-Ringdahl, 2009; Hollnagel, 2008; Hovden et al., 2011; Jacobsson et al., 2011, 2012, 2009, 2010; Katsakiori et al., 2009; Lampel et al., 2009; Lindberg et al., 2010; Lukic et al., 2012; Lukic et al., 2010; Lundberg et al., 2009; Russell Vastveit et al., 2015)
- Learning agents (Baumard and Starbuck, 2005; Cannon and Edmondson, 2005; Cedergren and Petersen, 2011; Drupsteen and Hasle, 2014; Drupsteen and Wybo, 2015; Geller, 2014; Huber et al., 2009; Lundberg et al., 2009, 2010; Manuele, 2011; Manuele, 2014; Sanne, 2008; van der Schaaf and Kanse, 2004)
- Learning context (Baumard and Starbuck, 2005; Bourrier, 2011; Cannon and Edmondson, 2005; Catino and Patriotta, 2013; Cedergren, 2013; Cedergren and Petersen, 2011; Choularton, 2001; Cooke and Rohleder, 2006; Drupsteen et al., 2013; Drupsteen and Guldenmund, 2014; Einarsson and Brynjarsson, 2008; Hovden et al., 2011; Huber et al., 2009; Le Coze, 2013; Lukic et al., 2012, 2010; Lundberg et al., 2012; Manuele, 2014; Russell Vastveit et al., 2015)

The learning inputs refer to the incidents themselves and encompassed threats associated with not or underreporting of incidents and as a result there is no opportunity to learn from incidents. The learning process refers to the LFI process and threats associated with this category include issues with the selection, investigation and analysis of incidents. Learning agents refer to the people involved in the learning process. Threats associated with this category include limitations and weakness in the knowledge, expertise and competencies of the individual actors. Finally, the learning context refers to the organisational and political context within which learning occurs. Effective learning from safety incidents can only occurs when the right organisational factors exist.

After identifying the threats, the next step of the bowtie analysis was to determine the consequences of the unwanted event. Two overarching categories of consequences were determined after the inductive coding approach was applied to the articles grouped under the consequence. The categories are:

- short term (Bourrier, 2011; Cannon and Edmondson, 2005; Huber et al., 2009) and
- long term (Bourrier, 2011; Cooke and Rohleder, 2006; Huber et al., 2009; van der Schaaf and Kanse, 2004) consequences.

Short term consequences are observable within the shortest possible term. Subcategories of short term consequence include repetition of similar events. Long term consequences require an incubation period. One subcategory of long term consequence is when small failures are left unattended, they gradually develop into big failures whose outcome is only visible in the long term. Another subcategory is the long term acceptance of accidents as normal business.

Control measures lie between the threats and the knot (preventive controls) and the knot and the consequences (mitigating controls). In identifying controls for overcoming failure to learn, a combination of inductive and deductive coding was applied. This method was adopted because certain code types were considered useful in developing certain forms of output. Thus, the analysis was undertaken such that it was sensitive and attentive to what was emerging from the articles in addition to capturing other relevant controls which were not mentioned in the collected articles. The controls that not mentioned in the collected articles emerged from the authors experience and their knowledge on risk management, change management and organisation learning. The controls that emerged from the literature review are shown in Fig. 4 and discussed in further in the results section.

One important aspect highlighted as important in the literature but not represented in the BTA was single and double-loop learning proposed by Argyris and Schön (1978). This is because when a control is applied such that it challenges the organisation's assumptions and functions in relation to LFI, then the control helps ensure double-loop learning (Argyris and Schön, 1978). However, when the control is applied such that it does not question the organisation's underlying beliefs and assumptions required to achieve double-loop learning, then the controls will only achieve single-loop learning (Argyris and Schön, 1978). Thus, the proposed preventative and mitigative controls may elicit single-loop or double-loop learning depending on how they are practically implemented in the field. The type of learning elicited – single-loop or double-loop – is therefore potentially a measure of the effectiveness of a control.

3. Results

The results of the analysis conducted on the content of the articles are shown in Fig. 3, Table 1 and Fig. 4. Fig. 3 shows the number of articles that was coded to each category and the themes. Some of the articles addressed more than a single theme. Table 1 provides details of the categorisation of the selected articles used for this review. Fig. 4

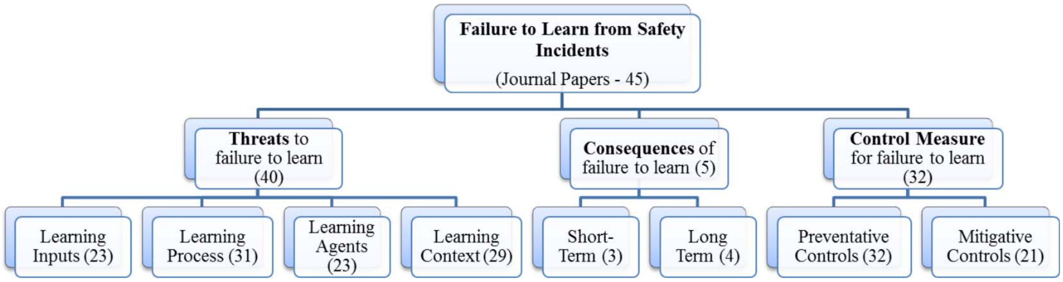

Fig. 3. Overview of themes and categories on failure to learn from safety incidents.

summarises the articles into the bowtie framework. The number of articles addressing a particular theme, category and subcategory as they emerged from the content analysis is shown brackets in Figs. 3 and 4. In addition to the themes, categories and subcategories that emerged from the selected journal papers, others subcategories were deductively identified from other sources. These subcategories not mentioned in articles were indirectly inferred from the articles or identified from authors' experience and from other literature on risk management, change management and learning in organisations. These subcategories have an article count of zero as can be seen in Fig. 4. The detailed analysis of the threats, consequences and controls comprising the bowtie is provided in the following subsections.

3.1. Threats and controls to prevent failure to learn from safety incidents

It can be seen in Figs. 3 and 4 that 40 of the articles (89% of the total articles) contained explicit information on different aspects of the threats that confront LFI. Furthermore, 32 (71%) of the articles had information on how the threats can be overcome, though not all were explicit. Fig. 4 also highlights 32 (71%) of the articles had information on preventative controls that addressed the threats and 21 (47%) of articles had information on mitigation controls to address the consequences. From the analysis it can be observed that the literature contained detailed information on why failure from incidents continues to occur as well as some practical control strategies for overcoming failure. One of the key aims of the analysis carried out in this research was to identify from the literature specific and practical solutions that address the threats that cause failure to learn from incidents. The analysis, as shown in the bowtie (Fig. 4) has highlighted that each of the threats has at least one specific control that addresses each particular threat and subsequently ensures LFI occur. Details and examples of each of the threats together with their corresponding controls have been provided in the next subsections.

3.1.1. Learning inputs – non-detection and non-identification of reportable incidents

Several authors describe reporting as the initial and fundamental stage of the LFI process (Drupsteen et al., 2013; Jacobsson et al., 2011; Lindberg et al., 2010). This is because reporting provides the necessary inputs required for the commencement of the LFI process. Without the detection and subsequent reporting of safety incidents, there will be minimal to no opportunity to learn from such events. Drupsteen and Hasle (2014) observed that difficulties in reporting incidents were due to the lack of clarity on what constitutes a reportable event. They observed disparity among different work groups such as operators and engineers of the same organisation on their interpretation of what qualifies as a dangerous situation worthy of reporting especially when there were no negative consequences associated with the event. Sanne (2008) made similar observations when some technicians stated "it is difficult to know what constitutes an incident if nothing happens". This situation makes the determination of reportable incidents very subjective and obviously hinders the utilisation of the learning potential of some incidents. Lindberg et al. (2010) acknowledged that the determination of reportable events depends on the definition of accidents as adopted by an organisation.

The control to address this threat is having well-defined objective criteria that clearly distinguish what should be reported from what may not be reported as shown in Fig. 4. For an incident to be reported, it must be noticed and identified as relevant and worth reporting. Therefore, the threshold of the reporting criteria should be as low as possible (Cooke and Rohleder, 2006; Jacobsson et al., 2011, 2012) and must be effectively communicated to the entire workforce. The literature shows that although studies on incident reporting abounds, some specific areas still require research attention. An example area is evaluating the information and communication processes organisations use to ensure that workers are adequately empowered and equipped to determine what to report and what not to report. Little is known about the criteria adopted by different organisations to differentiate reportable cases from non-reportable cases. An earlier recommendation made by Lindberg et al. (2010) concerning the possible conflict existing between quality and promptness of reporting and the need to evaluate incidents reporting from these viewpoints still remains unattended to and presents an opportunity for further work.

3.1.2. Learning inputs – underreporting of detected incidents

Many authors have identified inadequate reporting of detected incidents as one of the major causes of failure to learn from safety incidents (Cannon and Edmondson, 2005; Choularton, 2001; Cooke and Rohleder, 2006; Dekker, 2009; Drupsteen et al., 2013; Drupsteen and Hasle, 2014; Einarsson and Brynjarsson, 2008; Geller, 2014; Huber et al., 2009; Jacobsson et al., 2011, 2012, 2009, 2010; Körvers and Sonnemans, 2008; Lindberg et al., 2010; Lukic et al., 2012, 2010; Manuele, 2014; Russell Vastveit et al., 2015; Sanne, 2008; van der Schaaf and Kanse, 2004). Prominent among those who offer reasons on why underreporting and non-reporting of detected incident continue to occur is van der Schaaf and Kanse (2004). They identified six things (namely; afraid/ashamed, no learning, not applicable, recovery, no remaining consequences and others) as possible reasons why recoveries from self-made errors go unreported. In a study to analyse the learning from incidents processes in selected Dutch organisation, Drupsteen et al. (2013) observed that the main bottlenecks were associated with the reporting stage. The reason for these bottlenecks was largely due to the complexity of the reporting and registration system (Rasmussen et al., 2013).

A large portion of the literature (20 (44%) articles, see Fig. 4) identifies the safety culture of an organisation as the single most important factor affecting reporting of safety incidents. Sanne (2008), Drupsteen and Hasle (2014), Geller (2014) and Lukic et al. (2012) all found that reporting an incident was associated with negative consequences such as shame, blame, punishment, scolding, threat of prosecution and extra work rather than positive consequences such as attracting rewards and encouragement. These negative outcomes are usually adopted as a means of deterring people from committing errors. However, research has shown that these are ineffective means of correcting "human error" since they do not deter employees from making mistakes but rather from reporting them (Dekker, 2009). Cannon and

Table 1
Overview of failure to learn from safety incidents literature, classified by themes.

Author	Year	Journal	Title	Themes
Baumard	2005	Long Range Planning	Learning from failures: Why it May Not Happen	Threats & Consequences
Bourrier	2011	Journal of Contingencies and Crisis Management	The Legacy of the High Reliability Organization Project	Threats & Consequences
Connon	2005	Long Range Planning	Failing to Learn and Learning to Fail (Intelligently): How Great Organizations Put Failure to Work to Innovate and Improve	Threats, Control Measures & Consequences
Catino	2013	Organization Studies	Learning from Errors: Cognition, Emotions and Safety Culture in the Italian Air Force	Threats
Cedergren	2013	Accident Analysis & Prevention	Implementing recommendations from accident investigations: A case study of inter-organisational challenges	Threats
Cedergren	2011	Safety Science	Prerequisites for learning from accident investigations – A cross-country comparison of national accident investigation boards	Threats & Control Measures
Chevreau	2006	Journal of Hazardous Materials	Organizing learning processes on risks by using the bow-tie representation	Control Measures
Choularton	2001	Safety Science	Complex learning: organizational learning from disasters	Control Measures and Threats
Cooke	2006	System Dynamics Review	Learning from incidents: from normal accidents to high reliability	Control Measures & Consequences
Dekker	2009	Cognition, Technology & Work	Just culture: who gets to draw the line?	Threats & Control Measures
Drupsteen	2013	International Journal of Occupational Safety and Ergonomics	Critical Steps in Learning From Incidents: Using Learning Potential in the Process From Reporting an Incident to Accident Prevention	Threats & Control Measures
Drupsteen	2014	Journal of Contingencies and Crisis Management	What Is Learning? A Review of the Safety Literature to Define Learning from Incidents, Accidents and Disasters	Threats & Control Measures
Drupsteen	2014	Accident Analysis & Prevention	Why do organizations not learn from incidents? Bottlenecks, causes and conditions for a failure to effectively learn	Threats & Control Measures
Drupsteen	2015	Safety Science	Assessing propensity to learn from safety-related events	Threats, Control Measures
Einarsson	2008	Journal of Loss Prevention in the Process Industries	Improving human factors, incident and accident reporting and safety management systems in the Seveso industry	Threats & Control Measures
Geller	2014	Professional Safety	Are You a Safety Bully?	Threats & Control Measures
Harms-Ringdahl	2009	Safety Science	Analysis of safety functions and barriers in accidents	Control Measures
Hollnagel	2008	Safety Science	Risk + barriers = safety?	Control Measures
Hovden	2011	Safety Science	Multilevel learning from accidents – Case studies in transport	Threats & Control Measures
Huber	2009	Process Safety Progress	Learning from organizational incidents: Resilience engineering for high-risk process environments	Threats & Consequences
Jacobsson	2011	Journal of Loss Prevention in the Process Industries	Method for evaluating learning from incidents using the idea of "level of learning"	Threats & Control Measures
Jacobsson	2012	Journal of Loss Prevention in the Process Industries	Learning from incidents – A method for assessing the effectiveness of the learning cycle	Control Measures
Jacobsson	2009	Journal of Loss Prevention in the Process Industries	A sequential method to identify underlying causes from industrial accidents reported to the MARS database	Threats
Jacobsson	2010	Journal of Loss Prevention in the Process Industries	Underlying causes and level of learning from accidents reported to the MARS database	Threats & Control Measures
Lampel	2009	Organization Science	Experiencing the Improbable: Rare Events and Organizational Learning	Threats
Katsakiori	2009	Safety Science	Towards an evaluation of accident investigation methods in terms of their alignment with accident causation models	Threats & Control Measures
Körvers	2008	Safety Science	Accidents: A discrepancy between indicators and facts!	Threats & Control Measures
Le Coze	2013	Safety Science	What have we learned about learning from accidents? Post-disasters reflections	Threats & Control Measures
Lindberg	2010	Safety Science	Learning from accidents – What more do we need to know?	Threats & Control Measures
Lukic	2012	Safety Science	A framework for learning from incidents in the workplace	Threats & Control Measures
Lukic	2010	Journal of Workplace Learning	How organisations learn from safety incidents: A multifaceted problem	Threats
Lundberg	2009	Safety Science	What-You-Look-For-Is-What-You-Find – The consequences of underlying accident models in eight accident investigation manuals	Threats & Control Measures
Lundberg	2010	Accident Analysis & Prevention	What you find is not always what you fix—How other aspects than causes of accidents decide recommendations for remedial actions	Threats & Control Measures
Lundberg	2012	Accident Analysis & Prevention	Strategies for dealing with resistance to recommendations from accident investigations	Threats & Control Measures
Manuele	2014	Professional Safety	Incident Investigation Our Methods Are Flawed	Threats and Control Measures
Manuele	2013	Professional Safety	Preventing Serious Injuries & Fatalities: Time for a Sociotechnical Model for an Operational Risk Management System	Threats & Control Measures
Manuele	2011	Professional Safety	Reviewing Heinrich: Dislodging Two Myths From the Practice of Safety	Threats
Pitblado	2015	Process Safety Progress	A method for barrier-based incident investigation	Threats & Control Measures
Ramanujam	2011	Safety Science	The challenge of collective learning from event analysis	Threats and Control Measures
Rasmussen	2013	Safety Science Monitor	Can we use near-miss reports for accident prevention? A study in the oil and gas industry in Denmark	Threats
Rollenhagen	2010	Safety Science	The context and habits of accident investigation practices: A study of 108 Swedish investigators	Threats
Vastveit	2015	Safety Science	Learning from incidents: Practices at a Scandinavian refinery	Threats
Sanne	2008	Safety Science	Incident reporting or storytelling? Competing schemes in a safety-critical and hazardous work setting	Threats

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Journal	Title	Themes
Sonnemans	2010	Journal of Loss Prevention in the Process Industries	Accidents in "normal" operation – Can you see them coming?	Threats & Control Measures
van der Schaaf	2004	Safety Science	Biases in incident reporting databases: an empirical study in the chemical process industry	Threats & Consequences

Edmondson (2005) observed that although workers are willing to learn from the errors of their colleagues, most workers involved in incidents develop a natural antipathy for reporting their errors. This is because the disclosure process sometimes erodes the positive impression of the reporters. The literature also shows that there is usually a decline in reporting when employees observe that reported incidents are treated unfairly (Dekker, 2009). Geller (2014) introduces the term "safety bully" as a possible cause of failure to learn from incidents particularly in the area of reporting. He notes that the use of punishment as a corrective measure in response to an injury report is a type of bullying. Such punishments may include simple things like harsh words from management which usually decreases the safety commitment of the workforce.

Manuele (2011) notes that some of Heinrich's proposal on accident causation and severity particularly the 300:29:1 ratio relating to the proportion of incidents occurring based on the seriousness of incident presents a threat to current safety practice specifically the LFI process. According to this ratio, for a single major accident that occurs, there should have been 29 minor incidents and 300 no-injury cases. This ratio made Heinrich (1941) conclude that "reducing accident frequency will equivalently reduce severe injuries". When this viewpoint is strongly upheld, it can result in the adoption of strategies that reduce the number of reportable incidents which might not necessarily be an indication of good safety performance. In recent times, there have been situations where major incidents have occurred in organisations with zero injury events. For example, the Deepwater Horizon explosion occurred on an oil rig which reportedly had 7 years without a lost time injury (Freudenburg and Gramling, 2011; Graham et al., 2011).

The problem with underreporting and non-reporting is that it gives an inaccurate or misleading overview of the risks associated with the site. To encourage reporting, the reporting and registration system organisations use must be as simplified as possible. It should be one that is easily understood by the majority of the workers and should encourage individuals to report willingly. Cooke and Rohleder (2006) however, note that reporting of incidents does not only depend on the willingness of individuals to reports but also on the willingness of management to respond appropriately to reported cases. Addressing reported incidents (Drupsteen et al., 2013; Drupsteen and Guldenmund, 2014; Hovden et al., 2011; Jacobsson et al., 2012; van der Schaaf and Kanse, 2004), providing feedback to the entire workforce and particularly those that reported the incident (Cannon and Edmondson, 2005; Catino and Patriotta, 2013; Geller, 2014) and promoting and encouraging reporting act as controls.

3.1.3. *Learning inputs - lack of focus on small precursor incidents*

Reporting of incidents is not sufficient to guarantee learning especially if the reporting comprises simply the noting of an event. In order to learn there needs to be a focused analysis on incidents – including small precursor events – to fully understand how to prevent future incidents. Research on high reliability organisations (HRO) shows that instead of evaluating and investigating high consequence accidents, much learning can be obtained when organisations proactively study daily operations (Baumard and Starbuck, 2005). Several authors have emphasised that catastrophic accidents can be avoided by focusing on small minor incidents such as near misses (Baumard and Starbuck, 2005; Cannon and Edmondson, 2005; Drupsteen and Hasle, 2014; Jacobsson et al., 2011; Lampel et al., 2009; Manuele, 2013b). This is because most tragic and disastrous accidents are often preceded by minor antecedent incidents and the analysis of this antecedent incident is identified as a control in the bowtie diagram (Fig. 4). The cases of BP Texas City and Westray Mines are clear examples. Small incidents can therefore instigate the wakeup call required to prevent major accidents. By focusing on small incidents, organisations can learn valuable lessons. Small incidents usually have minor or no consequences and their investigations and analyses are usually done in an open and free environment devoid of blame and protection as compared to major

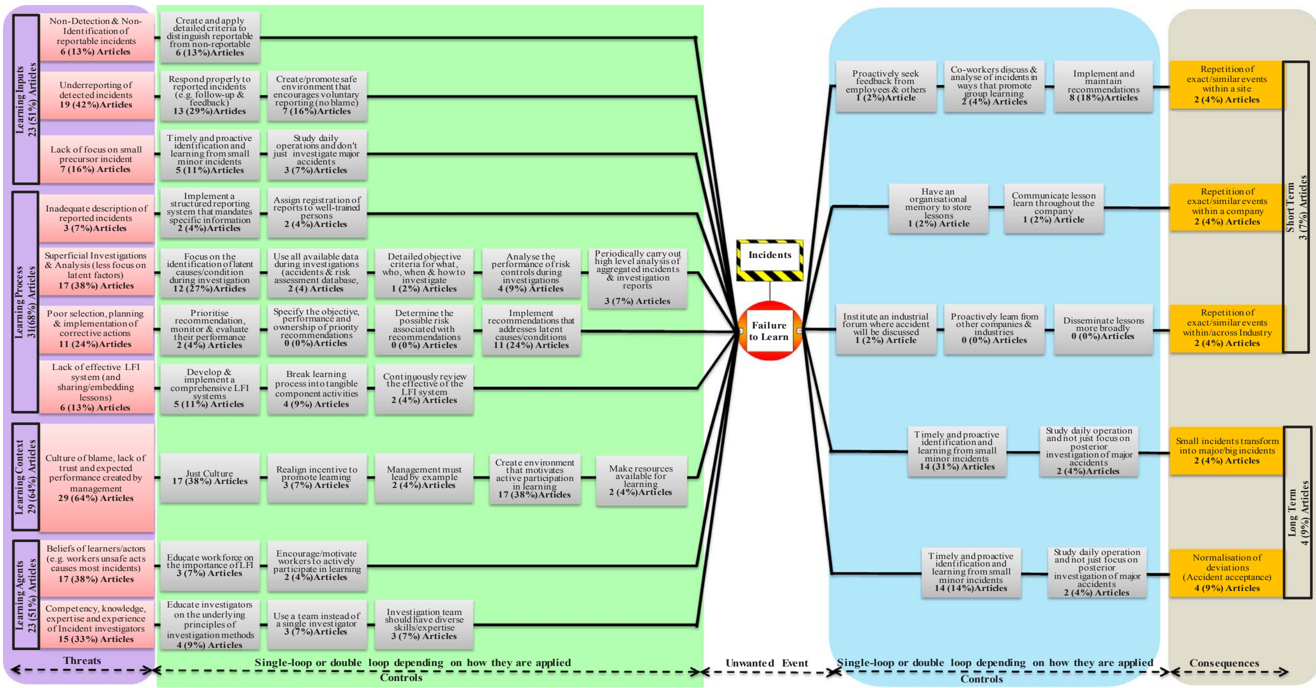

Fig. 4. Failure to learn from safety incidents bowtie.

accidents (Lindberg et al., 2010). Furthermore, as such incidents occur more often than those with major consequences, they can give a representative overview of the site's risk. Effective evaluation of small incidents can expose organisational conditions, equipment failures and human behaviours which under slightly different conditions could have resulted in a disastrous event (Jacobsson et al., 2011).

For organisations to learn intelligently, they must institute a system that proactively identifies and obtain lessons from the smallest incident that can occur. The need to study the daily operations of the organisation to understand the operation and not wait for incidents/accident to happen to investigate is an additional control that was identified in the literature.

3.1.4. Learning process – inadequate description of reported incidents

Little information and narrow descriptions of reported events were identified as factors affecting LFI process (Sanne, 2008). Jacobsson et al. (2010) found that 15% of the cases they studied contained insufficient information for further analysis. In the remaining cases they found weakness in the quality of reporting largely because there was a significant variation in the reports from one country to the other. In addition Lindberg et al. (2010) identified that the promptness of reporting does affect the quality of the report. They stated that enough time is a prerequisite for obtaining a fuller and a comprehensive report and that there is the need to maintain a balance between the promptness and the quality of reporting.

In addressing this threat, two major controls were identified. The first is the implementation of a structured reporting system which requires certain mandatory information. Furthermore, although reporting of incidents can be done by any member of the workforce, the actual registration should be done by specialised well-trained persons.

3.1.5. Learning process – superficial investigations and analyses of incidents

The way investigations are undertaken and analysis completed can minimise learning. Despite the advancement in accident causation models and investigation methods, the majority of the causes of accidents identified during investigation are mostly restricted to the sharp end (Katsakiori et al., 2009). An analysis of railway accident reports by Cedergren and Petersen (2011) shows that substantial attention was paid to micro-level causes such as activities of operators and equipment failure. Little emphasis was given to meso-level causes such as organisational factors and macro-level causes. According to Körvers and Sonnemans (2008) organisational factors usually receive less treatment than technical and human factors. A similar observation was made by Sanne (2012) who stated that causes far from the accident scene usually remain unaddressed. Jacobsson et al. (2011) also observed that causes related to weakness in management often went unreported and unregistered. Drupsteen and Hasle (2014) found problems associated with the investigations stage such as less treatment of organisational and human factors, an emphasis on direct and technical causes and little consideration of the context within which the incidents occur. Sanne (2008) and Lukic et al. (2010) made similar observations concerning the over-focusing on direct sharp end causes as against indirect hidden blunt end causes.

From the review, it seems that regardless of how complex and rigorous the investigation method and accident model used, some factors are significant in determining the quality and effectiveness of investigations and if the investigations are superficial or in depth. These factors are:

- the context of the investigation, the people performing the investigation and the lack of criteria to determine what to investigate and how to investigate (Drupsteen et al., 2013; Drupsteen and Hasle, 2014; Lindberg et al., 2010; Ramanujam and Goodman, 2011);
- little time for investigation (Drupsteen and Hasle, 2014; Lundberg et al., 2009, 2012);
- quick fixes prior to investigation (Drupsteen et al., 2013; Hovden et al., 2011; Lukic et al., 2010; Lundberg et al., 2012); beliefs about accident causation (Cooke and Rohleder, 2006; Geller, 2014; Lukic et al., 2012; Lundberg et al., 2009; Manuele, 2014)
- early stop rules (Drupsteen and Hasle, 2014; Lundberg et al., 2010).

Ramanujam and Goodman (2011) in their study of event analysis in two hospitals observed that variation in the criteria adopted for the selection of incidents for investigation and analysis determined the frequency and quality of investigation and learning. Lindberg et al. (2010) noted that the selection criteria should be one that allows the extraction of sufficient information from the selected event. Drupsteen et al. (2013) and Drupsteen and Hasle (2014) identified through empirical research studies that organisations had difficulty in selecting incidents for thorough analysis due to the absence of comprehensive objective selection criteria. The scope and quality of investigations are impacted by selection criteria and stop rules that govern the sufficiency of information required of investigations. Lundberg et al. (2010) identified several issues among safety practitioners that indicated difficulty in finding a very objective rule that determines when to stop the search for causes during investigations. Drupsteen and Hasle (2014) made similar observations and admitted that investigations stop earlier than expected and thus limit the identification of all causes (both actual and potential).

It was observed in the literature that in some organisations, the occurrence of incidents results in the adopting of quick fixes to address the situation before in-depth investigation begins. The problem with the quick fix approach is that it does not allow for an adequate investigation and hence, system failures and latent conditions that contributed to the incidents are often not identified. Other factors impacting the quality of investigations include a lack of incentive for in-depth investigation (Cannon and Edmondson, 2005), the purpose/aim/focus of investigation as defined by organisations and understood by learning agents (Harms-Ringdahl, 2009; Hollnagel, 2008; Ramanujam and Goodman, 2011) and the narrow use of other databases as learning tools (Lindberg et al., 2010). Specific controls required to address this superficial investigation challenge include making a conscious effort to focus on the identification of latent causes during investigation, implementing detailed criteria that clearly state who, when, what and how to investigate different categories of incidents and using a wide spectrum of data source during investigations.

Since the majority of risk controls are implemented to prevent accidents, it should be a natural aim to evaluate the performance of those specific controls during incident investigations to determine what worked well, what failed, what was present but not used and what was required but absent. From the review, it was observed that the objective of most investigations is to describe the course of event by identifying causes without any purposive attempt to evaluate the performance of controls. Analysis of risk control/safety barriers is barely considered as a key objective of investigation. Therefore, it is proposed as a control that analysis of the performance of failed/absent risk controls should be an integral part of incident investigations.

It was observed that most investigations focus on the actual event without a significant consideration to potential events (Hollnagel, 2008). This limited focus on actual events aims to prevent recurrence of same or similar event without necessarily looking into the future as well as other areas within the organisation to identify potential events. This narrows what is looked for and what can be found and subsequently impact the kind of corrective actions that can be recommended.

Geller (2014) and Jacobsson et al. (2012) stress that organisations must not only investigate incidents but must analyse them and this was identified as one of the controls. Such analysis can be done in two ways. The first approach is to analyse a particular incident to understand the multifaceted web of underlying and contributing factors. The second is to analyse aggregated incidents and investigation reports to determine patterns and trends and obtain a characteristic overview of the site's risk. Such an analysis will help in identifying priority areas with regards to incident prevention. This area of incident analysis was identified as a gap in the literature.

3.1.6. Learning process – poor selection, planning and implementation of corrective actions

According to the LFI process, identification of causes should be directly followed by the planning and implementation of corrective actions. As the nature and quality of the corrective actions proposed depends on the causes identified, when recommendations are made, the axiom *what you can fix depends on what you can find* is typically followed. It is logical to conclude that superficial investigations will result in proposing insufficient remedial actions. It is understandable that if contributing causes and latent conditions responsible for the direct blunt end causes are not detected, optimal recommendations cannot be proposed. Lundberg et al. (2010) acknowledged that incident investigation is not always a rational process where corrective actions are proposed and implemented to address identified causes. In an interview with 22 investigators, they observed that several other factors other than the causes of the accident determine recommendations for remedial actions, causing them to coin the phrase "what you find is not always what you fix" (p. 2132). In one particular instance, they observed that the investigation manual specifically emphasised the need to consider the economic cost of recommendations. In another organisation, although improvement in safety culture was an objective it was deeply contrasted by the better, safer, cheaper perspective that was being promoted. Instances where recommendations were affected by economic factors have been identified by other authors (Baumard and Starbuck, 2005; Cedergren, 2013; Drupsteen and Guldenmund, 2014). In organisation where cost determines remedial actions, the risk is mostly allowed to exist because the cost of changes is deemed to be more significant than the advantages of reducing the risk (Drupsteen and Guldenmund, 2014). The most significant controls required to tackle the above threat are the need to promote a culture that encourages the selection and the implementation of corrective actions that address blunt end causes.

Other factors that affect the implementation of recommendations include delay in implementation (Drupsteen and Hasle, 2014; Hollnagel, 2008; Le Coze, 2013; Rasmussen et al., 2013), lack of prioritisation of corrective actions (Sonnemans et al., 2010), lack of ownership of correction actions (Drupsteen and Guldenmund, 2014; Sanne, 2008), lack of an all-inclusive approach in identifying actions, lack of systematic processes for implementing lessons (Lundberg et al., 2012; Rollenhagen et al., 2010) and limited motivation and drive to perform actions (Cannon and Edmondson, 2005; Geller, 2014; Schöbel and Manzey, 2011). Effective implementation of actions, particularly when several actions are identified, will be affected by the time allocated for implementation and the priority assigned to the action.

The following are proposed as controls to tackle the above issues; recommended corrective actions must be prioritised according to their order of importance and they must be periodically evaluated to determine their effectiveness. Again some specification such as the performance, objective and ownership must be stated for corrective actions. Finally, potential risks associated with corrective actions should be identified and managed.

3.1.7. Learning process – lack of effective LFI system and sharing lessons

How organisations practically ensure that organisation-wide/industry-wide learning occurs and that lessons learnt are shared and disseminated across company and industry was identified as a challenge. In the Texas City refinery disaster, BP failed to learn from previous process safety incidents related to start-ups (Hopkins, 2008). Prior to that incident, several lessons obtained from previous accident analysis were widely available, however, BP failed to heed these warning signs. Although lessons were captured from previous incidents, there were no systematic and specific attempts to embed them within the company (Hopkins, 2008). As noted by Cooke and Rohleder (2006), without an effective learning system, those antecedent incidents were only observable with the benefit of the hindsight that came from the disaster.

For organisations to learn from each other, there must be an avenue to share lessons. In initiating such a move, cues can be obtained from the "Morbidity and Mortality" conferences, where medical practitioners meet to discuss very significant errors and unanticipated death with the objective of learning (Cannon and Edmondson, 2005). This is because it is worthwhile not only to learn from previous internal experience but also to acquire lessons from external sources. Those who get the chance to learn from incidents will have to disseminate their lessons more broadly, within company, within industry and across industry. This was identified as a control gap in the current situation and is an area where researchers should begin to focus to understand how organisations learn from the mistakes of others (both within and across industry), how broadly are lessons communicated and the information processes use to convey lessons at various levels.

Organisations can learn from incidents only when learning systems are available. In this article an incident learning system refers to the set of organisational capabilities and processes used to identify, obtain and extract useful information (lessons) from incidents of all kinds, including near-misses, and to implement the lessons so that an organisation's safety performance improves over time (Cooke and Rohleder, 2006). The LFI system is only one of several management systems that are instituted to enable organisational learning and growth. Several authors have emphasised the importance of having such a system, and recommendations have been made concerning its components (Cooke and Rohleder, 2006; Drupsteen et al., 2013; Jacobsson et al., 2012; Lindberg et al., 2010). According to Rijpma (1997) the LFI system bridges the gap between normal accidents and high reliability theories. Cooke and Rohleder (2006) emphasise that such a system provides an organisational mechanism to achieve high reliability since "normal" accidents are used to reduce accident severity and overcome the underlying conditions that result in accidents. However, research has shown that certain factors can undermine the effectiveness of the learning system (Drupsteen et al., 2013; Drupsteen and Hasle, 2014; Lundberg et al., 2009, 2010; Manuele, 2011). Therefore, there should be periodic evaluation of learning systems to ascertain their efficacy and resilience. As part of the learning system, there should be an objective criteria to assist in determining what to investigate, who to investigate, how to investigate and when to investigate. The use of a learning system which meets the above specification would be an essential control.

3.1.8. Learning context – culture of blame, lack of trust and expected performance created by management

In recent times there have been calls to evaluate the organisational context within which learning from incidents occurs (Lundberg et al., 2010). This call was made based on the premise that the very organisational factors that are usually emphasised in current accident causation models and investigation methods as causes of accidents can impact the investigation process and the learnings (Rollenhagen et al., 2010). Manuele (2014) describes a situation where the action of an investigator was largely influenced by a culture of fear arising from a system of anticipated performance expected by management. Lundberg et al. (2012) identified situations where investigators were scared of critiquing management although that was the right thing to do. Concerning the same issue, participants in an interview conducted by Russell Vastveit et al. (2015) has this to say "no, it is rare to write something about leadership…maybe we do not have a culture for it, so you could say that the incident system largely has been aimed at the operators" (p. 84). In the same study, another participant remarked "it is rare to write [measures] aimed at leadership or the HSSE department; mainly they [the measures that the respondent produced] are technical measures that can be aimed at the maintenance department" (p. 84).

Furthermore, there are instances where management blame incident victims and in some cases punish them for the causes which were identified due to the benefit of hindsight. This culture of blame, seeking culprits and punishment have been identified by several authors as a significant challenge to the LFI process (Baumard and Starbuck, 2005; Bourrier, 2011; Cannon and Edmondson, 2005; Cooke and Rohleder, 2006; Dekker, 2009; Geller, 2014; Hovden et al., 2011) and is rightly captured in the model shown in Fig. 4 as the threat line with the highest number of articles. What this blame culture does is stigmatise people (Catino and Patriotta, 2013) and creates an environment that discourages employees from taking safety initiatives.

Cannon and Edmondson (2005) report on how certain organisational policies, norms, structures, behaviours and procedures can discourage workers from proactively participating in learning. Geller (2014) discusses how certain organisational behaviours may block learning. These include setting high and incorrect safety goals such as the "zero injury goal"; misuse of feedback such as giving negative/corrective feedback more than giving positive/supportive feedback; misuse of incentives and wrong use of behaviour-based safety programmes. The politicised context within which learning occurs together with the secrecy both within and between competing companies can prevent learning from taking place (Cooke and Rohleder, 2006).

The learning context sets the conditions for the other threats as the occurrence of the other threats is determined by the type of culture that prevails in an organisation. Therefore, creating a just culture, where management lead by example, where resources are made available for learning and where incentives realign to promote learning were identified as controls (Cannon and Edmondson, 2005; Catino and Patriotta, 2013; Chevreau et al., 2006; Choularton, 2001; Dekker, 2009; Deverell, 2009; Deverell and Hansén, 2009; Geller, 2014; Manuele, 2013a) which address the learning context threat line and aspects of the other three major threat lines. The learning agents and process threats answer the question of *how/what*. The learning context threats on the other hand answers the question of *why* there has been a failure to learn. For instant, failure to learn occurs when people refuse to report safety incidents; however, refusal to report may have been caused by a culture of blame, shame and stigmatisation. It is therefore only when this culture of blame is fixed that optimum learning can ensue. For learning to occur, organisations must have the culture for it. They must consciously invest in creating an environment that motivates and does not deter people from actively participating in learning. There must be a conscious effort to create a culture that encourages individuals and working groups to enthusiastically look for lessons throughout the working period (Cannon and Edmondson, 2005). Blame culture must give way to just culture. Reason (1997) explains just culture as "an atmosphere of trust in which people are encouraged, even rewarded for providing essential safety-related information – but in which they are clear about where the line must be drawn between acceptable and unacceptable behaviour." A just culture organisation makes resources readily available for learning because safety is seen as a way of life. Management show commitment through leadership by example and there is open communication. In a just culture, trust and openness is strongly upheld and workers are motivated, sometime with rewards when they provide significant safety information (Reason, 1990).

3.1.9. Learning agents – beliefs, experiences and competencies of actors of learning

People who learn from incidents on behalf of the organisation such as incident investigators and management play a significant role in the LFI process. Not only do such people ensure that learning occurs, they also play a key role in ensuring that lessons obtained are completely embedded within the entire organisation and effectively retrieved and utilised. This makes the learning agents critical as a key determinant of the success of the LFI process.

To a large extent, the quality of the lessons obtained will depends on the competency, proficiency, knowledge, training and beliefs of the agents. For example, for an investigator who believes that 95% of incidents are caused by "human error", most if not all the causes of accidents investigated will be restricted to the sharp end regardless of the investigation methods used. Geller (2014) labels such people as safety bullies, stating that such believe shifts focus from the organisational culture and management system to the worker. Lundberg et al. (2012) report of situations where incident investigators made changes in their investigation to suit what they perceived to be preventable causes. After a review of 1800 investigation reports, with a focus on identification of causal factors and remedial action, Manuele (2013a) concluded that majority of the investigations were shallow because the investigators were repeatedly predisposed to choose worker's unsafe act as the cause of the incidents. Manuele (2011) and Manuele (2014) identified that Heinrich's 88:10:2 ratio that relates to the causes of accidents which proposes that 88% of accidents are caused by unsafe acts, and 10% by unsafe machines (with 2% being unavoidable) is strongly upheld by some safety practitioners. When this ratio is espoused, emphasis is placed on correcting the unsafe acts of worker instead of addressing the diverse interrelated causal factors that led to the incident. Therefore, how the learning agents participate in learning such as searching for causal factors relate to their beliefs about incidents causation.

Hovden et al. (2011) in their research on multilevel learning identified that the expertise of the investigators was regarded as an essential condition for learning. Cedergren and Petersen (2011) in an interview study observed that the causal factors often mentioned in investigation reports were a reflection of the experiences and competences of the investigators. Geller (2014) and Manuele (2014) raised questions about the type of training investigators receive. They report on the danger of teaching others what to do without letting them understand why they should do it. Questions about the type of training learning agents received, when they receive such training, when are they applied and the kind of competencies relevant for effective and quality learning are critical research areas.

The learning agents are responsible for initiating learning by identifying and reporting incidents; identifying lessons through investigations and analysis; and storing and sharing lessons through the dissemination of information. Although only some workers are directly responsible for ensuring that learning from incidents occurs, all workers must be encouraged to participate in learning and this acts as a control (Baumard and Starbuck, 2005; Chevreau et al., 2006; Lindberg et al., 2010; Manuele, 2013a). Organisations should train the workforce for this purpose. Apart from this general workforce training, specific actors like incident investigators and other learning specialists must receive specialised training. Ramanujam and Goodman (2011) emphasise the importance of such training by indicating that its purpose should be to assist investigation team member understand learning as "a distinct set of behaviourally-oriented outcomes and process" (p. 87). Other controls include; determination of the composition of the investigation team. Some advise that the team should consist of people with diverse views including those who have technical skills and expertise and factual knowledge about the activity being investigated (Hovden et al., 2011; Manuele, 2013b, 2014). Geller (2014) warns on the danger of knowing how to use an investigation method without understanding its underlying theory. He states that for people to be committed to the use of a particular safety programme they must not just be taught on how to implement but they must rather be educated on the underlying principles, guidelines and theories.

3.2. Consequences of failure to learn from incidents

Although generally within the literature, there was a strong recognition that failure to learn from safety incidents results in some consequences, empirical research that determines specific consequences is sparse. Only a few (5) of the articles contained information that could be coded under the consequences theme as can be seen Fig. 4. In those few articles, three major consequences were identified, namely (see Fig. 4):

- Repeat of same/similar incident (Bourrier, 2011; Huber et al., 2009; van der Schaaf and Kanse, 2004)
- Transformation of smaller incidents into major accidents or disasters (Bourrier, 2011; Cannon and Edmondson, 2005; Cooke and Rohleder, 2006; Huber et al., 2009)
- Normalisation of deviation (accident acceptance) (Cannon and Edmondson, 2005; Cooke and Rohleder, 2006; Huber et al., 2009; van der Schaaf and Kanse, 2004)

During the analysis, it was identified that repeat events are normally the immediate effect of failure to learn from incidents, and can occur at the site, within a company with multiple sites, within industries and/or across industries, although this was not explicitly mentioned in any of the articles. Therefore, the occurrence of repeat events was regarded as an instantaneous consequence of failure to learn and categorised as a short-term outcome. However, when these repeat events which are usually minor incidents are allowed, they can produce two negative outcomes over time, namely:

- a situation where incidents are accepted as necessary consequences of the organisation's operations and
- a situation where minor events left unattended gradually accumulate and result in major accidents and disasters.

These outcomes are usually not immediate, but rather occur in the longer term and were therefore categorised as long-term consequences. Specific examples of such scenarios as found in the literature have been provided in the next paragraphs.

Cannon and Edmondson (2005) explain that refusing to learn from failure does not only result in the repetition of the same or similar failure but also leads to a more serious situation where small failures transform into bigger ones. This was particularly the case in the BP Texas refinery explosion. Hopkins (2008) explains how the organisation was oblivious to major accident risks which were identified from previous accidents analysis. Although the independent review panel advised BP to heed the lessons learnt from that disaster, Hopkins indicates that these lessons were previously commonly available. Although people were aware of the lessons, the company failed to implement them. This is an example of a situation where small incidents unattended to can gradually develop into a tragedy. Cooke (2003) made a similar observation concerning the Westray mines tragedy. Prior to that fatal explosion, the mine had suffered several incidents that had a potential to claim lives but rather resulted in loss of production. Richard (1997) addressed Westray as "a predictable path to disaster".

Cooke and Rohleder (2006) cautioned that when organisations are less sensitive to LFI, deviations from normal operations go undetected and continuously concealing such deviations leads to a situation where they become accepted as normal. Similarly, Bourrier (2011) comments on the possibility that an organisation's response to incidents can create a culture that permits normalisation of deviation. In their results of a resilience engineering safety audit conducted in a chemical company, Huber et al. (2009) observed several situations were minor incident were ignored and considered as normal side-effects of the daily operations. Enquiring about the annual rate of incidents, their respondents stated that major accident were rare, occurring zero to five times a year. However, they unanimously admitted that minor non-consequential incidents occurred regularly. Employees were so used to these incidents that they considered certain type of incidents to be normal even though their potential consequences were high. A specific example was the situation where operators ranked "acid in the eyes or a skin burn" as minor incidents (Huber et al., 2009). The problem with this incident acceptance consequence is that it gives a poor and a weak overview of the risks associated with the site. Additionally, it can result in a situation where deviation from other things such as safety standards, manuals, procedures and goals becomes unwittingly acceptable.

One of the key controls identified to prevent/mitigate these consequences is the need to share lessons more broadly. Organisations must institute a forum where incident which offer major lessons are discussed to provide an opportunity to learn from others. This was identified as a control gap as the literature considered does not include how organisations learn from the experiences of others, either within or across industry. Other controls include; communicating lessons throughout the organisation, encouraging employees to discuss and analyse incidents in a way that promotes group learning and proactively seeking feedback from employees and other business partners, as shown in

Fig. 4. Furthermore, recommendations made during incident investigation and analysis should be implemented (Lundberg et al., 2012; Rollenhagen et al., 2010) and their effectiveness monitored continuously, especially those that address latent causes.

4. Discussion

The limitations in this review can be categorised into two; the sources of materials used and the aspect and type of learning considered. First, the search strings used were limited to only peer-reviewed articles in four major databases. There are learning from incidents related peer-reviewed papers in other databases. Apart from peer-reviewed papers, there are a number of books covering several aspect of learning from incidents which were not the focus of this review. Furthermore, the search years were limited from 2000 and 2016, while there are a number of articles that were published before 2000. Lindberg et al. (2010), Le Coze (2013) and Drupsteen and Guldenmund (2014) have carried out reviews that includes articles dating as far back as 1993. Secondly, this review was very specific to learning from safety incidents, whereas there are other types of learning. A number of authors have indicated that organisation can learn from other sources apart from incidents or failures. Some specifically mention that learning from success and experimental learning are possible (Cannon and Edmondson, 2005). Drupsteen and Guldenmund (2014) have identified that an organisation with the propensity to learn from incidents can learn from other sources as well. Despite these limitations, insights gained from this review can provide useful guidance to those seeking to address failure to learn issues. The insights drawn from the review and from Fig. 4 can provide inspiration and direction for more intensive research in the future.

The review sought to examine the ability of the BTA method to filter literature on learning from safety incidents in a way that identifies gaps in research on learning from incidents and suggests options for further maximising learning. By adopting this method, issues impacting learning from incidents were identified. The literature was categorised into three broad themes, namely; threats, consequences and controls. With this categorisation, areas where future research attention is needed were identified. For instance, as can be seen in Fig. 4, while almost all the 45 articles selected for the review addressed various aspects of the threats, only 5 (9%) tackled some of the likely consequences of failure to learn from incidents. The consequences of failure to learn is a topic which is covered less in the literature. Therefore, the need to initiate more research, particularly field studies to identify specific ways organisations continue to suffer due to their inability to have learnt from previous internal experiences and that of others is critical and one that requires urgent attention.

It can be observed from Fig. 4 that majority of the literature focused on the learning process (31/69%) while the least number of articles were associated with the learning agents and learning inputs (23/51%) threat lines. Two kinds of interpretation can be drawn from this. Firstly, this can give an indication of where an organisation should begin to look at in addressing failure to maximise learning from incidents. Secondly, it could also provide an idea of where emphasis has been in the research. Although the analysis seems to support the second reason, both interpretations are worth exploring and validating with empirical studies.

It is observable from the BTA (Fig. 4) that the learning agents' threat line is an area that has received little research attention. Key questions about that threat line are yet to be answered – such as:

- who are the learning agents?
- what should be the key requirements of the learning agents (such as incident investigators and learning specialists)?
- in what specific ways do learning agents influence the process and outcome of investigations?
- what learning beliefs are strongly upheld by the agents and how do they affect learning?.

The analysis also clarified the point that one of the key determinants of learning is the culture of the organisation. This can clearly be seen in the controls that were proposed to address the threats. From the analysis, the control which was mentioned by most of the articles used for the review was *just culture* (17/38%) and the need to *create an environment that motivates active participation in learning* (17/38%). For learning to occur, the organisation must have the culture for it and must promote a just culture where safety becomes a way of life.

A reoccurring theme in the literature was that a number of investigations fail to identify organisational factors as causal explanations of accidents (mentioned by 17/38% of the articles) even with the advancement of investigation methods. This is quite surprising especially because of the robust and comprehensive nature of current investigation methods. Sharp end causes continue to dominate most investigations. Therefore, it is likely that a number of factors apart from the investigation method influence the quality, adequacy and outcomes of investigations. This finding suggests that there is the need to obtain a broader and deeper understanding of how the organisational context impacts the various stages of the LFI process. The bowtie analysis helps identify some of these factors (i.e. those on the learning agent and learning context threat lines) which could with further research and industry attention be enhanced in ways that improve learning.

Additionally, current investigation methods focus on the identification of causes (mentioned in 38% of the literature); however, the safety literature suggests that in most workplaces, risk controls are implemented to prevent accidents. The ICMM (2015) observed that incidents reoccur not because the cause wasn't foreseen but because the controls needed to manage the cause were not implemented and/or maintained over time. Therefore, evaluating the performance of risk controls should be an integral part of incident investigation. Unfortunately, this is not the case. Only 4 (9%) of the selected articles recognised the need to analyse the performance of risk controls during investigations. Clearly, this is an area that needs focus. It is necessary to identify what controls worked and what controls failed, what controls were available and what controls were lacking, so that recommendations can be made that address the vulnerabilities that failed to prevent or mitigate the incident.

5. Conclusions and recommendation

The review aimed at identifying possible reasons why failure to learn from incidents continue to occur and subsequently offer practical strategies on overcoming failure by applying the BTA method on failure to learn from incident literature. By adopting this method, a pictorial representation that gives a snapshot of the LFI literature has been provided and control gaps (such as the competencies of learners and analysing the performance of risk controls during investigations) have been highlighted.

Results indicate that learning from incidents requires a simultaneous interplay of several factors, ranging from the learning inputs, learning process, learning context and the learning agents. For learning to occur, organisations must institute a systematic well defined learning process, from the collection of incidents through quality investigation and analysis to quality identification and implementation of lessons. The lessons must subsequently be disseminated more broadly and stored in a way which is not dependent on the people, and the workforce should be able to retrieve stored lesson and utilise them effectively when the need be. However, all these cannot occur if the organisation does not have a learning culture. The fundamental requirement underlying learning is the learning context, which is the culture of the organisation. Sagan (1993) describes four factors that limit organisational learning and it is only when these factors are addressed that optimal learning can ensue. These four factors are, the ambiguity associated with feedback, the politically-charged environment within which incident analysis is conducted, superficial reporting from individuals who deliberately want to cover the truth and secrecy as a result of constraints on information flow. Choularton (2001) likens these four factors to Argyris and Schön (1978) Model I behaviour concept which is very defensive in nature. He concludes that when such behaviour dominates an organisation, only single-loop learning is achievable largely because the implementation of double-loop lessons is considered expensive. The results so far strongly support the Model I behaviour. It was observed that several organisations lack the willpower to implement double-loop lessons.

Furthermore, result of the review also highlights the significant role the learning agents play and clarifies the need for education. Such education should cause the learning agents to become self-motivated to act correctly because they understand and believe in the underlying principles and theory behind learning. As Geller (2014) states, they must "develop their own belief system to rationalise their participation". Finally, results indicate that most organisations are more willing to learn from major incidents, largely because of the media, regulatory and other external pressures such incidents create. However, several researches have shown that a number of major accidents were preceded by minor incidents which were not identified as being worthy of examination and learning. To maximise learning, organisations must begin to see small failures as warning signs and adopt proactive ways of identifying lessons from them to avert imminent safety risks (Sonnemans et al., 2010). Moreover results from HRO studies also highlight the advantages of examining daily operations as against a retrospective analysis of tragic incidents (Bourrier, 2011).

All incidents regardless of their consequences must be seen as potential opportunity to learn. If lessons can be obtained from incidents, stored and shared throughout the organisation to prevent or mitigate future events, then the original incidents will have benefited the organisation. Incidents must not be seen as disappointments but rather as free lessons, an opportunity to focus attention and to collectively learn. It is particularly recommended that there should be field studies to evaluate the promptness of reporting and/or investigating incident against the quality of the reports. Furthermore, this literature review should be complemented with empirical and case study analysis to understand what is actually happening in the field. Combining both analyses will allow the gaps that researchers and practitioners need to address to be determined.

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