Investigations

Core Body of Knowledge for the
Generalist OHS Professional

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The Manager, OHS Body of Knowledge

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See also the companion volume to this chapter – *OHS Body of Knowledge* 12.6.2 Guide to Effective Investigations.

Investigations

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Members of the Topic-specific Technical Panel were selected on the basis of their demonstrated specialist expertise. Panel members were not remunerated; they provided input and critical comment as part of their contributions to the OHS profession and to workplace health and safety, but the final text was at the discretion of the authors.

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Core Body of Knowledge for the Generalist OHS Professional

Investigations

Abstract

Incident investigation is an essential element of workplace safety and a core function for many generalist OHS professionals. However, reports suggest that significant investigation skill deficits exist. An overemphasis on analysing the actions of individuals results in findings of human error without adequate inquiry into the underlying systemic factors that led to those errors. This chapter and the accompanying Guide to Effective Investigations are designed to enhance the investigatory capability of OHS professionals. This chapter explores the influence of investigator lenses, biases and perceptions on the collection and interpretation of evidence and the role, benefits and limitations of causation models and methods. The investigation process is outlined, logic-based analysis is explained, and the development of recommendations and the investigation report is discussed. This chapter and the accompanying guide are based on the premise that, for generalist OHS professionals, the primary objective of investigating incidents should be organisational learning for future prevention.

Keywords

investigation, incident, accident, event, safety, evidence, analysis, witnesses, methods, models

Contextual reading

For context, readers should refer to *OHS Body of Knowledge* 1.2 Contents, 1.3 Synopsis of the OHS Body of Knowledge, 2 Introduction, and 3 The OHS Professional: International and Australian Perspectives.

Terminology

Depending on the jurisdiction and the organisation, Australian terminology refers to 'Occupational Health and Safety' (OHS), 'Occupational Safety and Health' (OSH) or 'Work Health and Safety' (WHS). In line with international practice, this publication uses OHS with the exception of specific reference to the Work Health and Safety (WHS) Act and related legislation.

Jurisdictional application

This chapter includes reference to Australian model work health and safety legislation. This is in line with the Australian national application of the *OHS Body of Knowledge*. Readers working in other legal jurisdictions should consider these references as examples and refer to the relevant legislation in their jurisdiction of operation.

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1 Introduction

Incident investigation is a core function for many generalist occupational health and safety (OHS) professionals (INSHPO, 2017). The generalist OHS professional role may involve leading an investigation, advising or supporting others conducting an investigation, or acting as part of an investigation team. Irrespective of incident severity and outcome complexity, the primary objective of all investigations should be to enhance organisational learning to prevent future events, reduce risk, and improve the safety of workers and others more generally. The aim should not be to apportion blame or determine liability as such outcomes do not address true safety improvement (e.g. Cikara, 2022; Shufutinsky, 2019).[1] To this end, generalist OHS professionals require the knowledge and skills to conduct OHS investigations that are evidence-based, effective, rigorous, ethical and supportive of learning to improve the safety and health of any persons impacted by the work. However, research has shown that there is a gap between the need for investigations of this nature and the typical investigatory capability of OHS professionals.

Lederer (1988, p. v) referred to incident investigation as “both a science and an art.” Indeed, the investigation of events with actual or potential negative outcomes is a contested space with different ‘schools of thought’ informing conceptual approaches. This chapter is based on the principle that, while a range of causation models and analytical tools can inform the collection of evidence, it is the logic-driven process of formulating and testing proposed explanations (or hypotheses) against the evidence, that is the key to rigorous, valid and reliable investigation outcomes. With its focus on the conceptual knowledge that should underpin all investigations, this chapter presents the ‘science’ of investigation relevant to generalist OHS professionals while the companion Guide to Effective OHS Investigations provides practical advice and checklists.

The need for improved OHS investigation capability is addressed below followed by an explanation of the chapter’s terminology and scope, and the introduction of an incident case study that is referred to in subsequent sections of the chapter. Section 2 considers the imperatives for systematic investigation of incidents and factors that impact learning outcomes. Section 3 explores some influences on how investigators interpret evidence that can impact their objectivity and the fidelity of investigation outcomes. The investigation process is summarised in section 4 and addressed in more detail in the accompanying guide. Section 5 presents a logic-based analysis process that should be applied in all investigations to determine defensible descriptions of causation sequences irrespective of the underpinning theoretical causation model or analytical methods or tools used. Section 6 focuses on the development of investigation conclusions, recommendations and reports. Quality assurance and the link between investigations and organisational learning are

[1] Satisfying legislative/regulatory requirements may be an additional objective but this should focus on prevention of future accidents and address necessary safety action.

discussed in sections 7 and 8, respectively. Section 9 focuses on implications for OHS practice and presents a set of principles to guide all incident investigations and an approach to investigation of incidents perceived as ‘minor’. The chapter concludes with a summary.

1.1 The need for improved investigation capability

Although serious workers’ compensation claims in Australia decreased by 13% in the decade from 2009-10 to 2019-20, with a total of 130,195 serious claims in 2020-21 (SWA, 2022) and 169 worker fatalities in 2021 (SWA, 2023b), incidents, injuries and fatality rates remain unacceptably high. There are many reasons for these statistics; however, it has been acknowledged that the substandard nature of investigations and associated actions contributes to the ongoing occurrence of injuries and deaths (Cikara, 2022; Dell & Toft, 2011; Huang et al., 2017).

Ferry (1988, p. 3) observed that:

> Most accidents are investigated by persons without any investigative background who have no particular approach to the task. They usually have minimum resources to meet minimum company or government regulations. This has placed us in a situation of getting little benefit from most investigations.

More recently, an analysis of investigations in the construction industry found no evidence of improvement:

> Overall, the results demonstrate that the accident analysis in construction has not moved beyond a human error focus and does not presently identify multiple actors and contributory factors or the interaction between them (Woolley et al., 2018, p. 297).

Furthermore, some investigation findings are unreliable due to poor data quality and analysis (Cikara et al., 2021; Drury & Brill, 1983) and many are affected by the assumptions inherent in the models or tools that investigators apply when looking for causes, reflecting the ‘what-you-look-for-is-what-you-find’ phenomenon (Dekker, 2006; Lundberg et al., 2009, 2010). A survey completed by more than 200 incident investigation practitioners across a range of industries confirmed that opportunities exist for improvement in investigation processes, including level of investigator training and competence (Dodshon & Hassall, 2017). Interviews of 20 incident investigators revealed that one of the most prominent adverse influences on heavy vehicle crash investigations was that investigators lacked the skills necessary to focus on organisational/industry learning rather than blame (Cikara et al., 2021). As argued by various authors (e.g. Cikara, 2022; Shufutinsky, 2019), this focus on blame is counter-productive and does not address true safety improvement.

The aviation industry provides an exemplar for improvement in OHS investigations. Although aviation is now recognised as one of the safest forms of transport (IATA, 2018; Savage, 2013), that has not always been the case (Braithwaite, 2012). As commercial aviation grew exponentially in the years following the Second World War, incident rates became unacceptably high and, with the advent of jet-powered aircraft, the number of fatalities from crashes increased with the size and capacity of aircraft (Matthews, 2014). In 1951, the International Civil Aviation Organization (ICAO), an agency of the United Nations, adopted a standard investigation methodology. 'Annex 13', which contained the Standards and Recommended Practices for Aircraft Accident and Incident Investigation was adopted by all 52 nation signatories to the 1944 Convention on International Civil Aviation (ICAO, 2020). All signatory nations were then required to enact legislation to standardise the approach to aviation incident investigation. Importantly, Annex 13 provided that:

> 3.1 The sole objective of the investigation of an accident shall be the prevention of [incidents]. It is not the purpose of this activity to apportion blame or liability. …
>
> 3.2 A State shall establish an accident investigation authority that is independent from State aviation authorities and other entities that could interfere with the conduct or objectivity of an investigation. (ICAO, 2020, p. 28)

In 1959, there were about 50 accidents per 1 million commercial jet airplane flight departures worldwide; by 2022, this had reduced to 1-2 incidents per 1 million flight departures (Boeing, 2023).[2] There were various reasons for this improvement, but the standardisation and independence of incident investigation were pivotal (Braithwaite, 2015; Lederer, 2006; Matthews, 2014). While differences between workplace investigations and aviation should not be discounted, there are lessons for OHS investigations that can be drawn from aviation.

1.2 Terminology

Precise and consistent use of terminology in conducting and reporting investigations is essential for clarity and shared understanding. Also, terminology and language used by investigators and others influences the culture within which investigations are conducted.

Terms such as 'hazard', 'risk', 'barrier' and 'control' are discussed in several chapters of the *OHS Body of Knowledge*.[3] Relevant to this topic of investigations, the word 'accident' can trigger much discussion. Some authors suggest that 'accident' implies the notion of chance, luck or act of God, and that for those who subscribe to this interpretation, accidents could be seen as inevitable with commensurate negative pressure on the need for and benefit of preventative arrangements (e.g. Hasle et al., 2009). In transport industries, concern about this has sometimes led to substitution of the word 'accident' with the word 'crash' since crashes are generally accepted to be caused. Obviously, use of the word 'crash' in the OHS

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[2] 'Accident' in this context refers to 'airplane accident' defined as: "An occurrence associated with the operation of an airplane that takes place between the time any person boards the airplane with the intention of flight and such time as all such persons have disembarked, in which: the airplane sustains substantial damage [or] death or serious injury results from: being in the airplane, direct contact with the airplane or anything attached thereto, direct exposure to jet blast" (Boeing, 2023).

[3] See *OHS BoK* 15 Hazard as a Concept, 31 Risk, and 34.1 Prevention and Intervention.

failure context is problematic as it implies some type of collision; toxicological or electrical failures, for example, would not be accurately captured by such terminology. In this chapter, the word ‘accident’ is not used so as to avoid this controversy. However, it should be noted that in Australia, and internationally, the term ‘accident’ is still extensively used in literature and in practice in many domains.

The following terminology is used in this chapter:

> *Incident* – any unexpected, undesirable or unplanned event or circumstance that led, or could have led, to a fatality or injury, ill health, or damage to property or environment; it is used generically to include dangerous occurrences and near misses[4]
>
> *Cause* – the factors, conditions or mechanisms of failure that led to an incident
>
> *OHS investigation* – an investigation into an incident as defined broadly above
>
> *Recommendations* – the outcomes of an investigation; used in preference to ‘corrective actions’ as it protects the independence of the investigation, placing the responsibility for determining and implementing action with line management. Recommendations can include other safety actions established through the investigation even if not directly related to incident causality.
>
> *Causal sequence(s)* – the pathway(s) to an incident; used in preference to ‘root cause’, which (like ‘probable cause’) is often used in the singular implying single-factor causation, which is almost never the case. (If ‘root causes’ is used by investigators or others, then it should always be in the plural or qualified by a note if an industry software package does not allow for the plural.)

1.3 Scope

The objective of an OHS incident investigation is to discover the systemic deficiencies and underlying causes for the purposes of preventing or mitigating event reoccurrence and improving safety outcomes (SA, 2006). As previously stated, this chapter focuses on investigation methods for gathering information about incidents as a basis for organisational learning to improve health and safety for all who may be impacted by workplace operations. These investigations may occur alongside investigations by police and regulatory bodies, which typically have quite different objectives (e.g. determining whether a prosecution is to occur), and may take many months or years to be completed and the findings published. The conduct of police or regulatory investigations does not negate the need for in-house investigation. Table 1 identifies key differences between criminal and OHS investigations.

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[4] This definition has been developed to avoid the confusion that can be created by definitions that distinguish between ‘accidents’ (which cause actual harm) and ‘incidents’ or ‘dangerous occurrences’ that have similar causation and may have high potential for injury or damage and so should have rigorous investigation (e.g. HSE, 2004).

Table 1: Differences between criminal and OHS investigations

Criminal investigations	Effective OHS investigations
Formal examination to identify facts to substantiate evidence for prosecution	Systematic examination of factors leading to an incident, systems failures or weaknesses, including those of OHS management systems
Focus on identifying blame of an individual(s) or organisation(s) based on 'proofs' of shortcomings against the law	Do not focus on blame or liability; focus on what failed in a system and how and why it failed
Tunnel-visioned and offender-centric, focus on individuals/groups, often not systems-based	
Adversarial in conduct and nature	Examine the interconnections between individuals, equipment, software, environment, processes and organisations
Require interviews and interrogation	Require fact finding; include interviews of those involved and other workers, systematic examination of systems, equipment, processes and data
Persons of Interest obliged to answer questions	No obligation to answer questions
Must establish breach of elements or an offence for prosecution to commence	Focus on prevention and risk reduction rather than prosecution unless there is a deliberate violation or intent, or the deviation is such that it has a catastrophic consequence
Build evidence to establish offending	
Forensic examination of equipment, crime scene, etc., to establish evidence to support a prosecution	Systematic examination of systems to identify weaknesses that need to be mitigated to improve health and safety for those involved in the work

1.4 A case study example

This chapter draws on the following case study to illustrate aspects of the incident investigation process.

Worker falling through grid-mesh opening of the floor in boiler building

A worker (X) fell through an opening in the floor on level 4 of a boiler building. The incident had the potential for serious injury or fatality.

Circumstances

At the time of the incident, boiler refurbishment works were underway. Having been removed previously for maintenance-access purposes, the grid-mesh flooring of level 4 was being replaced but was incomplete – a section of grid-mesh (approximately 400 mm x 700 mm) was missing.

A hard barrier with warning signage attached had been erected across the stairway up to level 4 to prevent workers not involved in the grid-mesh replacement from accessing the area. A short time before the incident, this hard barrier had been removed to allow the two workers involved in the grid-mesh replacement safe access to level 4 while manually handling the heavy sections of grid-mesh floor up the stairway. The barrier was removed by a third worker who had been working in an adjacent area and had observed the two workers involved in the grid-mesh replacement struggling to lift some of the heavy grid-mesh sections over the hard barrier across the stairs. Having replaced some, but not all, of the sections of the grid-mesh flooring, the two workers involved left the level 4 work site without replacing the barrier across the stairway. This left the opening in the level 4 floor unprotected.

The two workers proceeded to ground level to retrieve the remaining sections of flooring from where they had been stored. During this activity, they were asked to inspect scaffolding in another area of level 4 and proceeded to that area via their work site. Worker X accompanied the two workers up from the ground floor in the lift to level 4, overheard their conversation and decided to tag along to look at the scaffolding. He did not inform the other two workers of his intent but followed along behind. He reported that when they arrived on level 4 (via the staircase with the hard barrier removed), he did not see the other two workers "step over the grid-mesh that was removed" and he was not looking at the walkway when he fell into the hole.

Internal investigation

An internal investigation was undertaken; this examined factors under the headings of people, environment, equipment and materials, methods of work, and organisation. The resultant sequence of events identified as leading to the incident focused almost solely on the perceived behaviour and decisions of the workers involved, including the assumption that the injured worker did not see the hole because he was not wearing his prescription eyeglasses. 'Corrective actions' focused on the workers and included "appropriate action" taken against the workers who had been installing the grid mesh and the worker who removed the hard barrier, and disciplinary action against the injured worker.

External investigation

Subsequently, an external investigation was undertaken; this took a systems approach with the conclusions linked to the evidence by logic-based analysis. The findings of this second investigation disproved the assumption that the failure to wear prescription eyeglasses was a causal factor, instead identifying procedural conflicts, gaps in the risk assessment and permit-to-work and isolation processes, issues with the work planning, excessive administrative workload for supervisors that limited their time in active supervision, and communication breakdowns leading to lack of awareness of certain procedures and requirements.

2 Investigation as an OHS essential

Investigations are an essential element of an OHS management system or program (ISO, 2018).[5] This section describes the imperatives for systematic investigation of OHS incidents and locating them in a sociotechnical system[6] context, and identifies factors that can optimise learning outcomes.

2.1 Imperatives for systematic investigation of incidents

Although there is no statutory requirement for organisations to investigate incidents in Australia, there is a regulatory obligation for organisations to protect as far as reasonably practicable the health and safety of workers and others, which makes learning from incidents

[5] See *OHS BoK* 12.2 OHS Management Systems.

[6] See *OHS BoK* 12.1 Systems and Systems Thinking, and 12.2 OHS Management.

that occur implicit as part of OHS programs and any associated OHS management system. Also, incident investigation is a sustainability imperative with substantive need for the protection of people driven by moral and financial reasons to improve health and safety and prevent injury.

2.1.1 Regulatory obligations

Organisations have a regulatory requirement to notify certain types of incidents (WHSA, ss 35-38; see SWA, 2023a)[7] and may have regulatory obligations to investigate certain types of incidents. As different events may require different investigation approaches and varying resource allocations, some organisations classify incidents using a risk-based approach.

OHS regulators have finite resources. While they invariably attend and investigate serious incidents, particularly those that result in fatalities or serious injuries, they are unable to attend and investigate all reported incidents. Regulators, through their inspectors, may require an organisation to conduct an investigation and forward the findings and intended actions to the regulator for review. There is an imperative for organisations to be accurate in their investigations and scrupulous in collecting evidence – focusing on facts not opinions, and presenting appropriate findings, conclusions and recommendations. Consequently, organisations require an understanding of how to effectively conduct investigations.

2.1.2 Organisational learning

As indicated in section 1, and reinforced by various authors (Brathwaite, 2012; Cikara, 2022; Hopkins, 2003; Kletz, 2001; Larsen, 2004; Lederer, 1988; Newnam & Goode, 2015; Salmon et al., 2012), the main purpose of incident investigations is organisational learning to prevent event reoccurrence. Hopkins (2003, p. 13) defined OHS investigation as "a reactive technique that aims to prevent future [incidents] by learning from the events of the past." One of six guiding principles outlined in the Canadian Standard *Z1005:21 Workplace Incident Investigation* (SCC, 2021, p. 8) is that:

> …effective investigations analyze all possible potential contributing workplace factors and analyze how those factors influenced the outcome and present findings and recommendations as an opportunity to learn and prevent further occurrences or to improve the practices and processes within the organization…

More than three decades ago, Lederer (1988, p. v) stated that incident prevention "depends to a large degree on lessons learned from [incident] investigation" and Ferry (1988) pointed

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[7] For reporting requirements under other legislation, see for example: *Rail Safety National Law* reg 57 (https://classic.austlii.edu.au/au/legis/nsw/consol_reg/rsnlnr2012425/s57.html), *Transport Safety Investigation Regulations (2022 Amendment)* s11A-D and s12 (https://www.legislation.gov.au/F2022L01354/latest/text).

out that safety investigations are a small but essential part of OHS management if organisations are to learn from the failures, errors and omissions that have resulted in losses. Also, investigations can reveal issues not directly involved in an incident, and corrective and preventive actions implemented as a result may prevent other situations/hazards or weaknesses in hazard controls previously missed.

Learning from incidents is not organic. A conscious, systematic process needs to be consistently applied to gain a thorough understanding of all relevant factors, so that appropriate conclusions and recommendations for OHS improvement can be identified and implemented (Kletz, 2001; Moura et al., 2017; Stemn et al., 2019). An organisational learning culture – driven by leaders who reinforce a culture that removes blame and encourages an environment where employees feel safe to report failings – is an important element of such conscious and systematic processes (Edmondson, 2011).

2.1.3 Moral and financial obligations

There are moral and financial imperatives for organisations to look for effective solutions to prevent work-related incidents. Safe Work Australia (SWA, 2015) estimated that, in 2012-13, 77% of the cost of incidents was borne by the workers and their families, 18% by the communities in which they lived, and only 5% by the organisations in which they worked. Of course, not all costs associated with incidents are financial; the consequences for victims and their families can include the loss of a loved one, long-term illness and incapacity, permanent injury, reduced physical capability, reduced earning capacity and increased cost of living (Dell, 2019a). Dell (2015, p. xv) observed that:

> Despite more than a century of effort by governments and industry to prevent accidents, they continue to occur in epidemic proportions. Given the acclaimed benefits of years of science and technological developments to society, it is a travesty that the failure to effectively manage risk continues to cause untold misery and loss. Despite technical advances, lives are still being cut short or irreversibly affected, and the loved ones of those killed and injured are left to cope with their memories and loss.

In 2015-16, "Injury was the third highest area of health care spending in Australia at $8.9 billion" (AIHW, 2020). The cost of work-related injuries and illness in Australia in 2012-13 was estimated at $61.8 billion (SWA, 2015). Employing a different methodology, Deloitte Access Economics (2022) estimated that the 6.9 million work-related injuries and illnesses that occurred between 2008 and 2018 (an average of 623,663 per year) resulted in a productivity loss of 2.2 million FTEs,[8] health system costs of $37.6 billion, and other employer overheads (workers' compensation claims and hiring/training new staff) of $49.5 billion.

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[8] FTE refers to 'full-time equivalent' – "an employee's scheduled hours divided by the employer's hours for a full-time workweek" (SHRM, 2023).

These statistics highlight the necessity to ensure that rigorous and effective investigations occur following incidents, to maximise lessons learned, prevent future incidents and reduce impacts on workers and their families, communities and society. In many organisations, the costs of incidents are hidden or not effectively tracked and, while it is not possible to investigate all events and issues equally, classifying incidents using a risk-based approach can prioritise cost tracking and investigation resourcing.

2.2 Sociotechnical system context

Effective incident investigation requires an understanding of the complexity of sociotechnical systems within which incidents occur (Cikara, 2022; Klockner & Toft, 2018; Newnam & Goode, 2015; Toft, 2016).[9] Salmon and Read (2019, p. 612) defined complexity science as:

> …the discipline concerned with understanding and responding to problems that are dynamic, multi-dimensional, unpredictable and comprise various interrelated components. In relation to safety, it seeks to understand systems in terms of their components and interrelations and how behaviour (e.g. accidents) emerges from these relationships.

This complexity of the sociotechnical systems of modern organisations presents a major challenge to effective investigation of incidents (Klockner & Toft, 2014). Much has been written about the drawbacks of simplistic, linear, cause-and-effect relationship theories of failure leading to incidents and claim superiority of concepts of multifaceted, simultaneous interrelationships of factors that influence outcomes (e.g. Dekker, 2011; Hollnagel, 2008a,b; Viner, 2015). However, neither can answer questions of causation without respect for both cause and effect relationships and regard the complexity and simultaneous interrelationship of factors. Modern incident investigation must be able to contend with system complexities to identify opportunities for improvement.

Even in simple workplace settings, interrelationships within and among internal and external components of the sociotechnical systems – people, the organisation, work practices, working environment, equipment, government, industry bodies and society – influence performance and outcomes. These influences should be considered in any investigation to ensure that no factors leading to the incident being investigated are overlooked. This can present its own challenges as investigation, by its very nature, is an attempt to deconstruct the complexity of factors leading to an incident to understand what happened and why and, importantly, what to do to improve health and safety.

To understand and investigate sociotechnical systems we need to consider, at a minimum, the people, equipment, other engineered components of the system, organisational

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[9] See *OHS BoK* 12.1 Systems and Systems Thinking and 12.2 OHS Management Systems.

structures, and software used. An understanding of the following aspects of sociotechnical systems is required:

- *The nature of work* – what is work, expectations, goals, how work is conducted and why[10]
- *The nature of organisations* – what they look like, their functions and goals[11]
- *The nature of systems* – their characteristics, types of systems, hardware and software systems, how they operate and interoperability with adjacent or other remote and/or critical systems[12]
- *The interactive relationships* – of the system and subsystem components and how sociotechnical systems operate holistically.

Investigation of a sociotechnical system is not complete without consideration of every stage of the life cycle of the system from concept through to decommissioning and beyond.

Hollnagel (2008a) and others (e.g. Dekker, 2011) advocated shifting the focus of investigations from learning what went wrong in a system that led to an incident to what went right at times when an incident did not occur. These authors proposed that more can be gained by studying the relationship dynamics of the various system components when they were working normally, or as intended, and what worked well, possibly mitigating an event. Indeed, it may be impossible to understand what went wrong, or what changed in the lead-up to an incident, without developing a concurrent view of what should have happened had things gone as intended or as had been the norm. Hollnagel (2014) described this contrast as 'Safety I vs Safety II.' There is a need to not only contrast what happened in the lead-up to an incident with what was intended (e.g. what was written in the operating procedures and other documentation), but also to compare with normal practice. This is particularly the case when documented practice has deviated over time to become a new norm prior to the sequence of events leading to the incident in question. A thorough systems investigation requires an understanding of both what should have gone right and what went wrong.

The 'socio' in sociotechnical system refers to individuals, groups, organisations and society in general. The sociotechnical element is multifaceted, nonlinear and complex (Pumpuni-Lenss et al., 2017; Roberts et al., 2016) as an organisation interacts with its dynamic environment (Rasmussen, 1997). People are part of a system along with their interrelationships individually and collectively, and their interactions with system 'hardware' and 'software'. The human factors element of an investigation requires understanding the goal or purpose of the human(s) in the system, what task(s) they were there to fulfil, what this task would look like if completed successfully and what, if any, changes occurred that

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[10] See *OHS BoK* 4 Global Concept: Work (in development at time of writing).

[11] See *OHS BoK* 10.1 The Organisation.

[12] See *OHS BoK* 12.1 Systems and Systems Thinking and 12.2 OHS Management Systems.

impacted the normal or expected mode of operation. It is important to not only look at the task in terms of human actions but to look at the design of the system itself (i.e. the interaction between system elements, including the interface between system elements and the human, and human expectations and capabilities (Day et al 2011, Howard & Toft, 2003; Toft et al, 2003; Toft, 2017). Such an approach will help to uncover latent errors that may have laid dormant in the system and to address the challenging issues of design-induced operator error (Toft et al, 2003).

An investigation finding of 'human error', frequently linked with a mantra of 'blame and retrain', is the result of a limited understanding of the holistic science of human factors (Hawkins, 2006). Investigations should seek the genesis of the 'error', which often can be found in the system or equipment interface design (Toft, 2016; Toft et al, 2003). Put more simply, it is more important to understand the reason(s) for the error than the error itself as the sources of errors are often systemic factors. Instead of blaming and retraining an individual, this provides the opportunity for recommendations with greater potential for improving health and safety for many.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)
The internal investigation stopped when it reached the worker-focused conclusion of worker blame and resulted in corrective actions directed at worker behaviour. In contrast, by applying a sociotechnical systems approach that considered the complexity of the organisation, the work and the dynamics of the interactions between people, the environment, equipment and work processes at the time, the external investigation disproved some of the worker-focused conclusions and identified systemic factors. Such systemic factors included procedural conflicts, gaps in the risk assessment and permit-to-work and isolation processes, issues with the work planning, excessive administrative workload for supervisors that limited their time in active supervision, and communication breakdowns leading to lack of awareness of certain procedures and requirements.

2.3 Optimising learning outcomes

As emphasised throughout this chapter, the key objective of OHS investigations is organisational learning to prevent future incidents and to reduce the risks to the safety and health of workers and others. Three factors that can impact such learning are: the investigation culture, the impact of related processes such as learning teams and the ethics of an investigation process and its investigators. A fourth factor, legal professional privilege, can either stop an investigation occurring or impact the outcome and/or inhibit the sharing of lessons learned.

2.3.1 Investigation culture

The concept of organisational culture is explored in *OHS Body of Knowledge* chapters 10.2.1 Organisational Culture: A Search for Meaning and 10.2.2 Organisational Culture: Reviewed and Repositioned. Investigation culture may be considered a subset of organisational culture. As identified in chapter 10.2.1, although there is no agreed definition of safety culture, Schein's (2010, p. 18) definition of organisational culture as "a pattern of shared basic assumptions [as they apply to and impact incident investigations]" is useful. More specifically, three of Reason's (1997) four interlocking subcultures that make up an informed culture can impact the investigatory process and outcomes: reporting culture, just culture and learning culture.

Reporting culture

Fear of negative repercussions and underappreciation of the benefits of reporting are significant impediments to the reporting of incidents by workers (Sentis, 2018). Workers are more likely to report incidents, near-misses and other safety issues, and so enable initiation of investigation processes, when they do not fear retribution and managers have created an atmosphere of trust. This may take years to develop and is something that organisations should constantly strive for and encourage.

Just culture

"A Just Culture is one in which all employees are encouraged to provide, and feel comfortable providing, safety-related information" (CANSO, 2016). A just culture has been described as "A system of Natural justice that reflects…human infallibility" (Henderson, 2016). It creates an atmosphere of trust and an environment in which people are clear about where the line must be drawn between acceptable and unacceptable behaviour (Reason, 1997). An organisation's approach to a just culture will impact its reporting culture just as an investigator's mental model of 'human error' and 'blame' influences their approach to collecting evidence, interviewing witnesses and analysing evidence (Cikara et al., 2021; Dekker, 2016).[13] Where there is a culture of blame (the opposite of a just culture), investigators may be more likely to focus on attributing responsibility to specific persons rather than on controls, and there may be a narrow dissemination of investigation findings (Stemn et al., 2019).

Interestingly, recent research revealed that no-blame ideology in incident investigation in the US construction industry (Sherratt et al., 2023) can have unintended consequences, including:

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[13] Some academics and organisations differentiate between a restorative just culture and a retributive just culture (e.g. Dekker, 2016). In this chapter, the concept of a just culture is aligned with that sometimes described as 'restorative' because the blame elements in a retributive approach inhibit effective investigation for organisational learning.

- Trust between the organisation and workers can be damaged if promises of no blame are not fully adhered to during the investigation.
- Investigators can become "reluctant to unpack and challenge the people in the process and instead focus on things that can be blamed without consequence such as inanimate objects, materials, protocols, and paperwork. …[This] often results in the collection of limited information [and] organisational learning is also limited." Sherratt et al. (2023) called this 'new blame'.

Clearly, while a just culture is vital to effective and ethical investigation outcomes, creating such an environment is not simple and investigators and others should be mindful of their language and potential unintended consequences (Sherratt et al., 2023). In a just culture, it is recognised that individuals should not be held accountable for system failings over which they have no control. It is acknowledged that many errors represent predictable interactions between human operators and the systems in which they work, and that competent professionals make mistakes. Fundamental to a just culture is how the story of an event is told and who tells the story (McHugh & Klockner, 2020).

Learning culture

In a learning culture, information gained through reporting and investigation leads to organisational learning and systemic, rather than local, adjustments. Where an organisation is not focused on learning and is resistant to change, the investigation process may be:

- Undermined as investigators may adjust their data collection methods, analysis and design of recommendations in response to what they perceive they will be able to achieve, rather than what were the most critical factors (Lundberg et al., 2012)
- Inhibited by availability of resources, including staffing and equipment, and the imposition of time pressures
- Task-based, with a 'tick and flick' approach taken by investigators
- Influenced by a 'quick fix' mentality.

In organisations not focused on learning, investigators may adjust their recommendations to cope with resistance to change, the available resources, and how they perceive the receiving organisation or individual managers will respond (Lundberg et al., 2012). At the implementation stage, managers may select from the identified causes rather than implement them all (Carroll, 2006) or suppress conclusions identifying shortcomings of individual managers or higher-level organisational factors such as inadequate resources. Of course, even if an organisation is focused on learning, sharing complex lessons across potentially hundreds or thousands of people from different backgrounds and in different contexts is challenging.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)
The internal investigation focused on the behaviour of individuals and ignored the more complex issues. The combination of worker focus and a simplistic response as evidenced by "appropriate action" taken against the workers was indicative of an organisational culture not focused on learning.

2.3.2 Related processes

There is much OHS discussion about the role of 'learning teams' in organisational learning. As described by Conklin (2016):

> A Learning Team is a facilitated means of engaging with workers to understand and then learn from the opportunities that are presented by everyday successful and safe work as well as learning from events or incidents. … Involving workers is crucial to gaining this understanding. In essence, Learning Teams are a worker-focused engagement approach to problem identification, and problem-solving issues, conditions, environments, opportunities and threats in organizations to support continuous improvement of operational excellence.

Incident investigation and learning teams are complementary processes albeit with different perspectives. While drawing on a range of sources of information, investigators work directly with people involved in an incident to understand the event and what led to it. A learning team, or focus group activity, convened to understand and learn from an incident will comprise workers who understand the work. They will be briefed on what happened (based on the investigation data gathering) but their process, questions and outcomes are independent of the investigation process as is the investigation independent of the learning team process.

Learning teams and focus group discussions may support an investigation by identifying potential lines of enquiry that the investigation team can test and validate as part of their analysis (section 5). However, the potential for 'group think' (section 3.2.2) in learning team processes should be identified and considered in the analysis. A key issue for objective investigation is the 'contamination' of witness recollection (section 4.5.2); depending on the timing and activity, learning teams may potentially exacerbate witness contamination. Organisational learning from incidents is optimised when the outcomes of both the objective investigation and the learning team are considered by organisational decision makers.

2.3.3 Ethical investigations

Typically, OHS investigators are drawn from professions with espoused codes of ethics.[14] Beyond a formal code of ethics, ethical investigators will direct their investigations to the improvement of health and safety. This requires that they:

- Ensure that their language, actions and demeanour support a just culture

[14] See *OHS BoK* 38.3 Ethics and Professional Practice.

- Strive to be impartial and do not attempt to falsify, cover up, destroy or contaminate evidence or misrepresent facts pertaining to an investigation
- Strive to objectively determine the facts during investigations, ensuring that, as far as practicable, facts are checked for validity
- Avoid speculation, except when offering proposed explanations for testing, remain open-minded and react positively to the pursuit of new lines of enquiry and new evidence that may arise
- Within the scope of systems investigation and good practice, pursue all lines of enquiry that could reasonably be expected to inform the establishment of the facts and determination of the causal sequence
- Recognise that other parties (including senior leaders) may have vested interests, and avoid being influenced by, or releasing private or other unauthorised information to, such parties
- Ensure that findings, conclusions and recommendations are derived from the facts and evidence and are determined logically, avoiding biases or value judgements based on personal experience and unsupported preconceptions
- Be cognisant of the limitations of their knowledge and experience, and seek the best available assistance and expertise as appropriate to assure investigation integrity
- Prepare investigation reports that:
    - Clearly describe the evidence, facts, conclusions and recommendations in language that can be understood by an intelligent layperson without specialist technical knowledge of the industry, workplace or area in which the incident occurred
    - Where appropriate, use language that aligns with the industry or organisation, dependent on the target audience for the report and bearing in mind members of the public, government agencies and others who may not be familiar with industry jargon and abbreviations
    - Provide sufficient supporting information, documentation, sources and references to enable the findings, conclusions and recommendations to be validated or checked by others.

2.3.4 Optimising investigations within legal professional privilege

Legal professional privilege (LPP) is a common law legal tenet that forms part of the ideal that everyone has the right to independent legal representation without prejudice. It is intended to allow free and frank communication between a lawyer and their client without fear of disclosure. LPP protects the advice given by a lawyer to a client and their enquiries from the discovery process pertaining to actual or contemplated court proceedings or litigation. LPP can be waived but only by the client or “if the client does (or authorises) something which is inconsistent with the confidentiality which the privilege is intended to protect” (IPC, 2020, p. 2).

Until an organisation contacts a lawyer to seek legal advice or assistance with regards to an incident, all documentation, incident investigation reports, procedures, policies, photographs, forensic evidence and any materials associated with the incident are not likely to be subject to LPP. The regulator is entitled to access and obtain such documents relevant to an investigation. However, once the organisation has contacted a lawyer regarding a specific incident, all communications with the lawyer become privileged between the organisation and the lawyer. This means that any running sheet, document or material evidence, created, captured or identified becomes confidential between the lawyer and the client (usually the organisation).

Incident investigation fidelity problems sometimes arise when an investigation is commissioned by lawyers, on behalf of their client, as a part of their preparation for a case or an anticipated case. Such problems inhibit organisational learning and may include:

- Where incident investigations conducted within LLP begin to reveal information considered potentially prejudicial to an individual executive or manager within a company and where a legal case might be anticipated, the fidelity of the investigation may be affected by the manager or others claiming privilege
- Where an investigation begins to reveal, or is suspected to potentially reveal, information that may prejudice the client's legal case, the investigation may be terminated to prevent that information becoming known
- If lawyers ask that information be given verbally, rather than in writing, to circumvent disclosure requirements (however, the lawyer's notes of such conversation *could* be discoverable)
- If incident investigators commissioned by lawyers on behalf of their clients may be expected to sign a confidentiality agreement before the investigation commences to ensure that information discovered by the investigation is contained within the confines of the LPP
- Where the client pleads guilty to the charges in a prosecution case, evidence from both sides of the case is unable to be put before the court and so remains unknown outside of the legal case
- Reports of investigations conducted under LPP are usually not widely circulated with at best only small factual summaries made available.

From the lawyer's perspective, these examples provide evidence that LPP protects the interests and rights of the client. For OHS incident investigators, however, they can create conflicting ethical issues. When investigations are terminated prematurely, or information is suppressed as part of the legal process, opportunities for learning lessons from those incidents are often lost. Consequently, the incident investigator can find that their professional objectives conflict with those of the lawyer, even though both may consider they are acting in the best interests of the client organisation and/or individual executives/managers involved. Often the only course of action available to an OHS investigator whose work is terminated or suppressed when LPP is applied is to appeal directly to organisational management for the investigation to be completed and/or its lessons considered and effective recommendations implemented. Actions beyond that might directly open the OHS investigator to litigation for breach of confidentiality or contract.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)
Documents such as job safety analyses, barrier plans, risk assessments, safe work method statements, toolbox meetings, prestart meetings, training material, worker records and design specifications captured in the investigation prior to obtaining legal advice are unlikely to be privileged. Documents relating to the incident created after commencement of legal communications may become privileged between the organisation and the lawyer, who will probably provide directions with regards to the investigation process.

3 Lens, bias and reasoning

While different investigators may have access to the same evidence and view themselves as objective, undoubtedly there will be differences in interpretations. Investigator interpretations of evidence will be influenced by personal factors such as the lens through which they view the evidence, their conscious and unconscious biases, and their view of the contextual reality. Also, interpretations of the evidence will be influenced by the analysis tool(s) used and application of inductive and deductive reasoning (Figure 1).

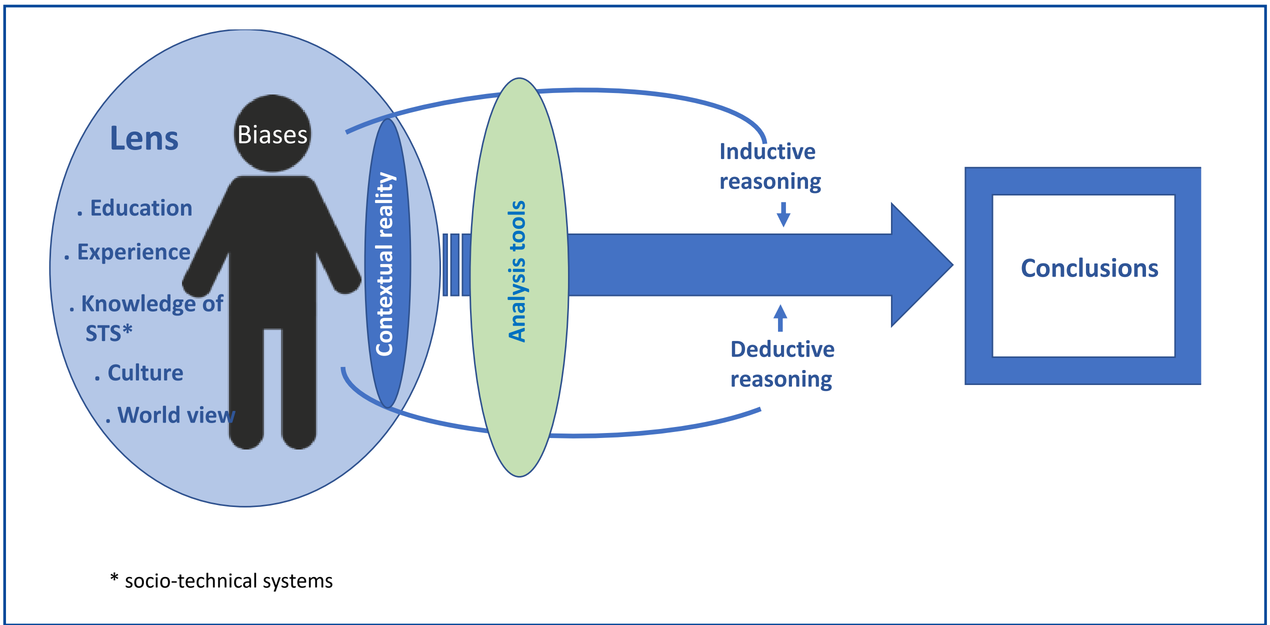

Figure 1: Factors influencing an investigator's logic and reasoning

3.1 Lens

Every investigator should be self-aware (reflexive) and cognisant of the lens they use while investigating and its limitations, and challenge that view of reality. Every incident investigation is influenced by the investigator's personal development through their life and career, including their education, experience, understanding of sociotechnical systems, cultural factors and the way they view the world.

Education

An investigator who has been trained in a particular discipline will bring that training to an investigation. For example, someone educated in the engineering discipline may visualise the internal workings of a piece of equipment and consider the procedures governing the safe use of the equipment as a given, while someone with a more traditional OHS education may focus on the way the equipment was used and question any deviations from procedures, the efficacy of the procedures and which parts of the system might have led to any procedural deviations. Both investigators may ultimately reach similar conclusions; however, without a heightened awareness of their personal lens, the engineer might finalise the investigation with a conclusion of human operator error due to evidence that the operator deviated from the defined procedures, while the OHS-trained person might conclude that the system administrative arrangements for validating procedures were inadequate without ever considering where equipment might have deviated from normal operational parameters. Furthermore, it is possible that neither investigator would question the interface design of the equipment from a user's perspective – a line of enquiry that would be considered by an investigator with human factors engineering training or experience.

Experience

Substantial industry experience may blind an investigator to assumptions made within that industry in relation to practice. This is evident when a practice that has been handed down and accepted as a 'norm' within an industry remains unquestioned even when there is little evidence to support it. For example, during the coronial investigation and inquest into the 1998 wildfire at Linton, Victoria, the 'normal' practice taught to protect the firefighters and their appliance in a wildfire was tested in a laboratory and found not to afford protection in the way it was expected (Johnstone, 2002).

Knowledge of sociotechnical systems

An investigator with limited exposure to complex sociotechnical systems may concentrate on drilling down a particular line of enquiry but miss important questions about the interoperability of parts of the system. For example, the Longford Royal Commission (Dawson & Brooks, 1999), which investigated the 1998 Esso Australia gas plant explosion and fire at Longford, Victoria, found that (in addition to technical issues related to equipment and training) the decision to centralise engineering personnel offsite contributed to the incident by removing the opportunity for informal discussion of queries that operators might have raised in the presence of staff they knew.

Culture
Cultural norms may be misinterpreted. For example, an investigator might not fully appreciate the mental model that an operator has developed in another industry, using different equipment or working internationally and so might miss important cues as to what triggered the user's response. Also, the investigator's own cultural norms might lead them to apply their cultural bias to the interpretation of the actions of others.

Worldview
How an investigator views the world – including their values, beliefs, political orientation and philosophical perspective – can influence their interpretation of evidence.

3.2 Bias

Bias is the most common factor influencing an investigator's interpretation and analysis of evidence. Biases can be conscious or unconscious (i.e. deliberate or inadvertent). They can manifest in most, if not all, aspects of the investigation process and have the potential to skew investigation outcomes meaning that investigations can differ based on who conducts them (Wachter & Yorio, 2014).[15]

3.2.1 Conscious bias

Not all people and organisations involved in investigations have common objectives. In the worst case, some parties may not want an investigation conducted at all or may not want certain facts to come to light. This can lead to unscrupulous, unethical or illegal behaviours (e.g. deliberate tampering with evidence, misleading investigators, lying to interviewers).

While OHS professionals may have a common interest in finding the facts about causation to enable effective recommendations, it would be a mistake to assume that everyone has the same vision. Others may have outwardly aligned but different objectives. For example:

- Lawyers in common law countries such as Australia, England and the USA operate in an adversarial system and, while the processes of the courts are intended to provide fairness, some behaviours of lawyers, motivated by their professional desire to act in the best interests of their clients, can be interpreted as an attempt to influence or restrict investigations.

[15] The Canadian Standards Association online course *Understanding the Impact of Bias in a Workplace Incident Investigation Using CSA Z1005,* particularly the evaluation tool, may provide a discussion stimulus for members of investigation teams (https://www.csagroup.org/store/standards-support-tools/occupational-health-and-safety/understanding-the-impact-of-bias-in-workplace-incident-investigations/).

- Some company executives or managers might not be comfortable accepting that their decisions or actions, or lack of decisions or actions, contributed to an incident, due to concern about potential impact on their image or career.
- Some OHS professionals might not want any shortcomings in their work, or in the OHS systems they oversee, to come to light.
- Some OHS professionals might suppress information or fail to include information in an investigation to protect their employer.
- In cases where there are multiple organisations or agencies involved, vested interests of the various parties might lead to attempts to prevent information from coming to light.
- Media representatives, operating on the worthy premise that people have the right to know, might go to considerable lengths to scoop a story or be the first to reveal 'new' information about an investigation and in doing so may prejudice the investigation.
- Investigators from other agencies claiming jurisdiction in relation to an incident investigation might wish to test the parties involved against some regulatory obligation for the purposes of establishing liability or prosecution for breach of the law.
- In high-publicity cases, regulatory authorities are under pressure to apportion blame to an organisation or individuals, a situation that cannot be underestimated as a source of bias.

Where possible, investigators need to take action to bring conscious bias to attention and/or limit its influence. Actions that can limit the potential for deliberate interference with investigations will depend on where in the investigation process the interference occurs or is attempted. For example, to help prevent:

Evidence being destroyed or lost in the field	Protect the incident scene from persons not involved in the investigation by establishing scene perimeters, controlling the access of people not involved in the investigation and escorting visitors on the site.
Items of evidence being misappropriated or deliberately contaminated	Employ robust methods of securing evidence from the time it is collected until the time the investigation is complete, or until any subsequent related court actions are completed.
Witnesses misleading an investigation by making false verbal or written statements	Corroborate witness accounts with other sources such as physical evidence from the scene, documentation and records, and compare with accounts from other witnesses.
Analyses being skewed or altered by vested interests to avoid specific adverse findings that might reflect badly on one party or another	Ensure, where possible, multiple parties are involved in the analysis and/or peer review of the analysis.

Investigation reports omitting key information, evidence or findings	Ensure appropriate peer and stakeholder review of draft investigation reports.

3.2.2 Unconscious bias

Investigators are subject to unconscious biases that may skew their thinking. (See section 4.5.2 for comment on interviewee biases.) Awareness of biases is vital in developing strategies to counteract such thinking and optimise objectivity. For example:

- *Confirmation bias* occurs when investigators' preconceptions about the causes of an incident can result in potentially contradictory evidence being ignored or downplayed, or premature termination of an investigation to avoid contradictory evidence.

- *Outcome bias* occurs when an outcome is already thought to be known or is desired/expected and taken as fact without validation, and may be used to coerce others to accept or proffer the same outcome.

- *Cognitive dissonance* occurs when a person experiences tension because of conflict between their beliefs and their actions and they need to minimise the dissonance by, for example, trivialising the importance of a behaviour, selectively processing information to support earlier biases and actions, or increasing commitment to a position.

- *Process bias* occurs when overreliance on a familiar or preferred investigatory method or tool may lead to gaps in thinking or methods applied with flow-on gaps in findings, analyses or conclusions.

- *Blind-spot bias* occurs when investigators subconsciously assume that they are accurate, fair and unbiased when assessing the actions or decisions of others.

- *Expert bias* occurs when investigators unquestioningly accept at face value the views of eminent experts in their field without robust discussion, proof or validation.

- *Groupthink* occurs within an investigation team when a proposition is accepted as being correct because the rest of the team thinks so.

- *Hindsight bias* occurs when people with outcome knowledge exaggerate the extent to which the event was predictable beforehand (see for discussion Henriksen & Kaplan, 2003).

Combating bias is most challenging when investigating alone, as many people have difficulty with effective unbiased self-appraisal. Furthermore, we may not be aware of our deep-seated biases and their manifestation. In an investigation team environment, particularly where open communication exists, it is possible for team members to assist each other in identifying individual biases and in guarding against the incipient impact of biases in the actions and decisions of individuals or the team.

Persons charged with the conduct of an investigation should be independent of all parties involved in the incident under investigation. This will minimise the influence of vested interests, assist in avoiding conscious and unconscious bias, and provide the basis for a fair analysis of events. It is good practice for investigation team members to try to disprove individual or team theories and conclusions. Investigators must be mindful that their biases may influence both the original theories or conclusions and attempts to disprove them. Cognitive processes such as 'Six Thinking Hats'[16] may be useful in addressing biases in investigations. Also, testing the links between evidence and proposed explanations with logic-based analysis (section 5) can help protect against the biases of investigators and others.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)

The in-house investigators had earlier interactions with the injured worker that included discussions about the need for him to wear corrective eyeglasses, which he resisted. They exhibited:

- *Confirmation bias* in their finding that not wearing corrective lenses contributed to the worker not seeing the hole and was thus a 'cause' of the incident
- *Hindsight bias* in determining that the injured worker should have seen the hole (even though the level of lighting and colour of the metal grid made the hole difficult to discern)
- *Process bias* in the use of the investigation tool that focused on the actions of the workers, resulting in 'corrective actions', including disciplinary action.

3.3 Contextual reality

From the investigator perspective, there are two aspects of understanding the contextual reality of an incident – the reality of those involved in recalling the incident and the reality of the work, which is often described as work-as-done as opposed to work-as-imagined (Hollnagel, 2015).

An investigator views the scene of an incident through their personal 'lens', which, as indicated in section 3.1, is affected by their education, experience, knowledge of

[16] See, for example, The de Bono Group (https://www.debonogroup.com/services/core-programs/six-thinking-hats/)

sociotechnical systems, culture and worldview. The investigator's perception of the scene is further impacted by the circumstances of the incident, such as pre-planning activities, site access, any early media coverage and the investigation model/methodology used. Also, the investigation model used can influence the investigation process, including factors identified as causative (Huang et al., 2017; sections 3.4 and 5.2).

In every incident there are multiple people involved, each with their own lens and biases that will impact the way they interpret what happened in the lead-up to and during an event. The investigator also needs to be aware of personal factors that might inform an individual's context or perception of the reality of the event. Examples of such factors include:

- Familiarity with the environment (e.g. seeing what they expect to see rather than appreciating that change has occurred)
- Previous exposure to potential hazards (e.g. if they had previously experienced multiple exposures to a particular hazard with minimal adverse outcomes, they might not perceive the gravity of this particular exposure)
- Personal thoughts (e.g. an event outside of work might influence their perception of what is happening or distract them from the task at hand)
- Personal health (e.g. visual capability, individual health response to an exposure, reduction in smell or other sense)
- Organisational priorities (i.e. pressures from within the business to identify a predetermined outcome favourable to the organisation's best interests)
- Wishing to be seen as trying to do the right thing for the organisation (to the detriment of the investigation).

A challenge for the investigator is to understand the contextual reality for those who were involved in an incident and how it may have influenced their actions in the lead-up to and during the event. Retrospectively, it may be clear what each actor should have understood (hindsight bias) but this is by no means a given before or during the event. For example, Leveson (2011, 2012) suggested that to avoid hindsight bias it is necessary to shift from the rationale of 'what did the operator do wrong?' to 'why did it make sense for the operator to act the way they did?'

The investigator must listen to each person involved and understand what made sense to them at the time rather than what seems logical to the investigator post-event. Importantly, the investigator needs to ask 'why' to drive their understanding.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)
The workers undertaking replacement of the grid-mesh had completed the risk assessment and job safety and environmental analysis (JSEA) and signed the required permits as per procedures. However, while the risk assessment and the JSEA focused on the risk of falls, neither considered the manual handling risk. The worker who removed the hard barrier to facilitate handling of the heavy grid-mesh considered they were assisting their workmates in their task. Effective investigation requires that the investigator understand the reality of the work at the time and that procedures may not always address the variations in work demands.

3.4 Analytical tools

Investigators systematically analyse the evidence to establish links and validate facts to arrive at justifiable, useful and repeatable conclusions. They may use a model or 'tool' (i.e. a standard process) that provides a conceptual representation of incident causation to inform their thinking and drive their understanding of the event (section 5.2). However, as noted by Dekker (2006, p. 81):

> …that model is also constraining. After all, if the model tells you to look for certain things, and look at those things in a particular way, you may do just that – at the exclusion of other things, or at the exclusion of interpreting things differently.

While the use of a model can provide consistency in approach that supports trend analysis (section 9.2), process bias (section 3.2.2) related to chosen analytical tools can blind an investigator to the rich context of an event. Process bias can be created (or exacerbated) by concentrating on specific elements of the context (e.g. using a tick list or some categorisation investigation methods) rather than appreciating the holistic context of the event, ultimately leading the investigator to a diminished understanding of what made sense to each person involved as the event unfolded.

3.5 Reasoning

Reasoning involves:

- Formulating an *argument*, i.e. "the reasons for your opinion about the truth of something or an explanation of why you believe something should be done"
- Making an *inference*, i.e. "a belief or opinion that you develop from the information that you know"
- Drawing a *conclusion*, i.e. "the opinion you have after considering all the information about something." (Cambridge Dictionary, 2023)

Abductive, deductive and inductive reasoning are applied in incident investigations. As uncertainty in the outcome decreases, reasoning moves from abductive to deductive and inductive. Investigators should be aware of when they are using which type of reasoning and the strength of the outcome of each type.

Abductive reasoning

Abductive reasoning involves forming a 'best explanation' based on the information that is known at the time (which may be incomplete). Abductive reasoning may be part of formulating an explanation (hypothesis) that must be tested to provide further information. While abductive reasoning has some relevance in the early stages of investigation, if not rigorously tested against the evidence, including any contrary evidence, it can lead to false assumptions and conclusions.

Deductive reasoning

Deduction is "the process of reaching a decision or answer by thinking about the known facts, or the decision that is reached" (Cambridge Dictionary, 2023), i.e. an inference from a general claim to a particular conclusion (e.g. *All snails eat lettuce, this thing is a snail, therefore this thing eats lettuce).*

> Arguments where the goal (to achieve valid arguments) is to provide conclusive evidence for the conclusion; the nature of the inferential claim is such that it is impossible for the premises to be true and the conclusion false. (Valid or Invalid) (Pine, 2011, p. 110).

Deductive reasoning is applied when certainty is required in the conclusion by logically working through the facts to get an irrefutable outcome. The emphasis in deduction is on testing facts; if the facts are true, it is impossible to reach any other conclusion. An example of a deductive argument is:

> *(1) all workers are union members Fact 1; (2) Sam is a worker Fact 2; (3) therefore, Sam is a union member If both facts are proved and true then the conclusion must also be true.*

The only two outcomes from this type of reasoning are that the deductive argument or reasoning is **valid,** or it is **invalid**. Deductive reasoning is used in many settings, but the most recognisable use is in a court of law.

Inductive reasoning

Induction is "the process of discovering a general principle from a set of facts" (Cambridge Dictionary, 2023), i.e. an inference drawn from many particular claims to a general claim, or to other particular claims (e.g. *This snail eats lettuce, this snail eats lettuce, this one too, etc., therefore all snails eat lettuce).*

> Arguments where the goal (to achieve strong and reliable beliefs) is to provide the best available evidence for the conclusion; the nature of the inferential claim is such that it is

unlikely that the premises are true and the conclusion false. (Strong or Weak) (Pine, 2011, p. 110).

Inductive reasoning occurs when the highest probability (belief) in a conclusion is sought to predict what comes next from what is already known. The emphasis in induction is that it is argued on the belief that the sample population, situation, research or assumptions that underpin the argument are representative of the conclusions to be drawn.

The outcomes from this type of reasoning are that the inductive argument or reasoning is **strong**, or it is **weak**. Inductive reasoning is used in many settings, but the most recognisable use is in scientific journal articles where research is carried out on a sample population or circumstance, and it is concluded that the sample population is likely representative of the whole population or cohort. The investigator must 'prove' deductive 'facts' and, when relying on research or assumptions for inductive conclusions, each argument must include the basis for each assumption.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)

The initial explanation of the event was that the actions of the injured worker were the 'cause' of the incident (abductive reasoning – best explanation based on the information available at the time). This proposed explanation was proven false when the assumption was tested against the evidence. As the external investigation progressed, the facts were tested (deductive reasoning), resulting in identification of systemic factors, including procedural conflicts, gaps in risk assessment and permit processes and issues in work planning (inductive reasoning – inferences made by drawing on the best available evidence to make generalised statements).

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4 Investigation process

In this chapter, and in the accompanying Guide to Effective Investigations, the investigation process is described under the headings:

- Investigation preparation
- Investigation management
- Incident scene
- Evidence
- Witnesses
- Analysis
- Conclusions, recommendations and reporting

- Post-investigation review.

This section introduces some key points in each of these steps, with analysis and conclusions, recommendations and reporting explored further in sections 5 and 6, respectively. The accompanying guide outlines actions required at each of these steps in the investigation process.

4.1 Investigation preparation

Appropriate preparation prior to accessing an incident scene is essential for effective investigation outcomes. Investigation preparedness begins well before any incident occurs and sets the basis for event-specific planning. Some aspects of the planning phase may have general applicability (e.g. compilation of a core investigation kit), while others may change from scene to scene, requiring specific effort (e.g. site- and situation-specific risk assessments).

In an ideal world, all incidents that led, or could have led, to fatality, injury, ill health, or damage to property or environment would be investigated, with the investigation starting as soon as practicable after the incident. There are several reasons for this:

- There is a real possibility that the circumstances that led to an incident continue to exist after the incident occurred, such that there is a risk of further incidents if appropriate remedial actions are not taken promptly.
- Some evidence is perishable and needs to be collected quickly or it may be lost. Failure to collect perishable evidence may have a substantial impact on the fidelity of an investigation. Also, it may result in lost opportunities for learning and factors that could lead to incidents remaining undetected and dormant until another set of circumstances triggers another incident.
- Evidence from eyewitnesses may be adversely affected the longer the time between an incident and eyewitness interviews.
- The risk that recommendations for remedial action will be flawed increases the longer the delay in commencing an investigation.

There are always limitations on the resources available for an incident investigation and, inevitably, not all incidents can be subject to a full investigation. Even major investigation agencies, such as the Australian Transport Safety Bureau and OHS regulators, have insufficient resources to investigate everything within their legislative domains and, accordingly, need guidelines to determine which incidents are to be fully investigated (ATSB, 2022).

Table 1 in the accompanying guide (guide section 2.4) provides advice for determining the appropriate level of investigative response, noting that seemingly minor events may have complex causation justifying in-depth investigation and analysis. As explained in section 2 of the guide, event-specific investigation planning addresses:

- Initial collection of information
- Response planning
- Scoping the investigation
- Preliminary risk assessment
- Convening the investigation team
- Collecting the required equipment
- Planning for evidence collection
- Addressing logistical requirements
- Liaising with regulator and other investigation agencies.

4.2 Investigation management

Various management activities are vital to ensuring valid investigation outcomes. Section 3 of the guide provides advice on these management activities, including:

- Team briefings and site inductions
- Record keeping (investigator notes, logs and running sheet)
- Progress tracking (lines of enquiry and progress reporting)
- Managing the media.

4.3 Incident scene

Important initial actions on arrival at an incident scene as described in section 4 of the guide include:

- Statutory body liaison
- Working to a plan that addresses:
    - Scene access
    - Ongoing risk assessment
    - Task allocation and investigator health and safety
    - Resource allocation (PPE and investigation equipment)
    - Logistics
    - Agency liaison
    - Communications

- Evidence collection
- Time frames

- Maintaining (defining, securing, preserving) the scene
- Mapping the scene (sketch map, final map, technology-assisted mapping).

4.4 Evidence

Evidence has been defined as "the available body of facts or information indicating whether a belief or proposition is true or valid."[17] Use of the term 'evidence' is sometimes seen as legalistic or related to blame, fault finding or prosecution, with preferred terms being 'information' or 'data'. This chapter uses the term 'evidence' to emphasise the required rigour in establishing facts for analysis as part of an effective, objective investigation that requires a systematic evidence-based methodology to gain a thorough and comprehensive understanding of causation. Advice and checklists related to evidence – including preservation, collection, continuity and scene photography – are provided in section 5 of the accompanying guide.

4.4.1 Types of evidence

Different types of incidents and incident scenes will have different characteristics that determine the types of evidence potentially available to aid an investigation.

- *Physical evidence* constitutes items or artefacts that are materially linked to an incident process or to the plant, persons or places involved in the incident process (e.g. discrete objects such as debris and equipment, and transient artefacts such as tyre marks and equipment settings).

- *Documentary evidence* includes hard copy as well as digital/electronic versions that provide information regarding an incident or the circumstances leading to the incident (e.g. work specifications, rosters, equipment manuals, risk assessments, job safety analyses, safety data sheets, training records, meeting minutes, contracts).

- *Photographic evidence* includes photographs of an incident scene taken by investigators and any other photographic or video media (e.g. CCTV) that captures information relevant to the incident or the circumstances of the incident or the lead-up to it (e.g. pre-incident site photographs can show the configuration of equipment prior to the incident).

- *Witness evidence* typically consists of information regarding an incident gathered from eyewitnesses, but also can include information relating to the context and circumstances of the incident (e.g. establishing typical operations or historical information) (section 4.5). Also, expert witness evidence is sometimes sought from

[17] Google English dictionary - Oxford Languages

specific subject matter experts who do not have a connection to the incident but can provide insight into potential causation pathways based on their experience and expertise in the relevant field (section 4.5.3).

Also, evidence may be categorised according to availability:

- *Perishable evidence* that may change over time or be affected by environmental conditions or in the emergency response phase (e.g. vehicle skid marks). Some recorded data may be considered perishable, especially if it can be overwritten if not promptly collected. Also, witness recall could be considered perishable; the longer the time taken to capture information from witnesses, the more they may be likely to rationalise and try to make sense of what they saw/experienced and alter the information they provide. Consequently, it is important to collect witnesses' initial descriptions of what they saw/experienced as soon as possible after an event.

- *Retrievable evidence* that can be recovered from the incident scene for off-site examination (e.g. data recordings, CCTV, software, instrument/machinery settings, equipment, vehicles, tools, photographs).

- *Available evidence* that can be obtained later (e.g. policies/procedures, management structure and delegations, workplace consultation arrangement, OHS management system, OHS officer due diligence record, training and relevant medical records, risk assessments and controls, past incident documentation, inspection and audit record, safe work method statement, contracts).

4.4.2 Preservation of evidence

The presentation of cases in court is governed by extensive rules set out in evidence Acts specific to the jurisdiction in which a case is being tried.[18] While these rules are important for lawyers, of relevance for OHS investigators are the requirements for preservation and continuity of evidence. Even where legal action is unlikely, it is best practice to treat the collection of evidence as though it may be required in court, as this high standard of reliability can protect the integrity of the investigation. Such a standard is achieved by collecting, transporting and storing evidence in a way that avoids interference, contamination or degradation while documenting continuity of the evidence.

Impairment of physical evidence can occur as a result of exposure to weather or accidental contamination. Collection of perishable items such as physical and photographic evidence that is likely to be vulnerable to degradation or interference (section 4.4.1) should be prioritised. Incident scenes can become high-traffic areas because of investigation activities and may remain active worksites with the movement of personnel and equipment posing a

[18] See, for example, *Evidence Act 1995*, updated 2021 (https://www.legislation.gov.au/Series/C2004A04858).

threat to evidence integrity. Also, items of evidence must be protected from deliberate or inadvertent interference (WHSA, s 39; see SWA, 2023a) should an attempt be made to destroy the usefulness of an item. Deliberate interference without malice may occur when an item of evidence is a piece of equipment that is returned to use prematurely without its contribution to causation being appropriately assessed by the investigator.

4.4.3 Collection of evidence

Principles for collection of evidence include:

- Priority of safety and health of investigators
- Priority of considering the perishability of evidence
- Maintenance of continuity of evidence, including when evidence is handed to other persons/agencies.

Arrangements for evidence collection begin in the planning stage and address collection from two perspectives: initial on-site collection prioritising perishable items and items likely to change such as lighting and meteorological conditions, and ongoing collection throughout the investigation.

4.4.4 Continuity of evidence

Continuity of evidence refers to proof that an item used to provide investigative insight or information is the same item that was collected from the incident scene (or other relevant location). Achieving continuity requires keeping an unbroken, auditable record of the security of each item of evidence, known as the continuity record (or the ‘chain of evidence’ or ‘chain of custody’). The cost of doing so needs to be balanced against the actual or potential significance of the investigation.

4.4.5 Scene photography

Incident scene photography provides a permanent record of the circumstances of the scene, the relationships between the various components of the scene, and the positions of items of evidence. It can record the state of perishable evidence and ensure its subsequent usefulness, support understanding of pre- and post-incident configurations, provide a record of how evidence was collected and by whom, and help investigators to refresh their memories of circumstances of the scene or items of evidence.

Scene photographs can help stakeholders who did not attend the scene to establish an overview or mental model of the scene and the disposition of the wreckage and items of evidence that might not be expected from written or verbal descriptions alone. Also, they can assist with understanding the perspectives of eyewitnesses (with photographs taken from the witnesses' point of view). Walk-through scene videos (from which still shots can be taken) are increasingly being used.

Although most people can use a camera, it does not follow that most people can take useful photographs of incident scenes and evidence. As with the collection of evidence and scene mapping, incident scene photography requires specific protocols (guide section 5.4). Where it is considered appropriate to engage the services of a skilled photographer, unless that photographer is an experienced investigator, they will need supervision and guidance on what to photograph, what features of artefacts or the scene need to be showcased in the photographs, and from what angles to take the photographs. Also, they may need briefing on, or assistance with, photographic log keeping.

A photographic log (guide section 5.4.2) records details of all photographs taken. (A digital voice recorder is useful, but transcription may be necessary to support reporting of the investigation.) While each investigator/team may have separate working photographic logs, particularly if working at different sites, there should be a single composite photographic log for the investigation.

4.4.6 Testing 'usefulness' and 'truth' of evidence

Investigators may access research, technical or industry information to assist them to understand the causative sequence that led to an event. However, in a world of ubiquitous information, it is the investigator's responsibility to test the currency and trustworthiness of sources. Some questions to assist in evaluating information are:[19]

- Is the author qualified to write on the subject? (e.g. check author qualifications, affiliations, experience)
- Does the publisher stand behind the information? (e.g. check the processes used by the publisher to verify the information, promotion of information, peer review)
- Is the information too old to trust? (e.g. try to find information that has been published within the previous five years; however, also be aware of seminal information sources/papers that lay the foundation for later papers)
- Is the information biased or objective? (e.g. check whether there is involvement by funding agencies with agendas that could potentially bias the outcomes; consider the language used and whether superlative or emotive terminology is used)
- Do experts respect the information? (e.g. have other reputable authors linked to the information or cited it in their work?)

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[19] See *OHS BoK* 39 The OHS Professional as a Critical Consumer of Research.

- What clues do links provide? (e.g. follow links from the information to assess the way the information is used and whether linked sites are reputable)
- Is the information accurate? (e.g. consider the assumptions the author relies on, the type of scientific reasoning used, the strength of the argument and the validity of the findings or probability of accuracy)
- Does the evidence support the author's claims? (e.g. is there a direct link between the evidence provided, the analysis of that evidence and the claims made by the author?).

4.5 Witnesses and specialist input

Witnesses, especially eyewitnesses, are a valuable source of evidence in any investigation. While they can often provide a first-hand account of what led to, and what happened in, an incident, they may be reluctant to give information, and investigators without regulatory powers cannot compel them to participate. Where investigation agencies (e.g. OHS regulators, ATSB, coroner's court) are involved, compulsion powers are balanced by protections. For example, a compulsion to provide answers to questions from a regulator will mean that the information witnesses provide cannot be used against them; however, it can be used against others (e.g. their organisations). In such cases, workers have no choice but to cooperate with the investigation; failure to do so can be seen as a serious offence by the regulator. Where regulators do become involved, it is always advisable to seek legal advice and support for those required to give evidence. Checklists and advice relevant to identifying, managing and interviewing witnesses are available in section 6 of the guide.

4.5.1 Types of witnesses

There are three types of witnesses:

- *Eyewitnesses*, who observed or were involved in an incident and can give their observations in an interview or a statement.

- *Material witnesses*, who did not observe an incident but can provide other evidence such as standard operating procedures at the incident site or information on a similar incident(s) involving the same plant at a different location.

- *Expert witnesses*, who have specialist knowledge and are appropriately qualified and experienced to provide specialist advice to an investigation. When providing evidence in court, these witnesses are allowed to present their opinions as evidence based on their expertise in the relevant area.

Also, witnesses may be considered based on their level of independence. An *independent witness* is one who has no vested interest in the outcome of an investigation and typically no connection with the persons or organisations relevant to the incident (e.g. a bystander).

Other persons who may provide useful information to an investigation may not be considered independent, including:

- Persons who were involved in the incident or may have contributed to its causation
- Persons associated with the organisation involved or the site of the incident, including workers, employers, managers, owners, etc.
- Friends or family members of persons injured or killed in, or involved in the causation of, the incident
- Representatives of regulatory agencies or other investigating bodies, such as state OHS regulators, industry safety/investigation bodies (e.g. ATSB, CASA, ARPANSA), state police, federal police, etc.
- Representatives of unions or other interested parties.

The role of a witness in any incident investigation is to provide honest testimony of their knowledge about the incident. Evidence obtained from non-independent witnesses can be extremely valuable to an investigation. While most non-independent witnesses will provide honest testimony despite having a connection to the incident, the evidence should be considered in light of this connection; even a person who is cooperating with the investigation and intending to be helpful will bring their own lens and biases that may affect their testimony. The evidence of independent witnesses is often given more weight, as their lack of connection to the incident should minimise the potential for specific bias or vested interest.

Specialist advice should be sought in the rare cases where an eyewitness to a workplace incident is under 18 years of age. Such witnesses should be treated as a special category of witness as their age will affect the way in which incident investigators can and should interact with them.

4.5.2 Limitations to witness evidence

Given the imperfect nature of human memory, it is unlikely that witnesses will have perfect recall of an incident or the events that led to it, even if they personally observed the entire process. While recall can be impacted by factors such as time elapsed since the incident and age of the witnesses, several other factors that impact recall are discussed below.

Witness observational skills and ability to relate their experience of an incident

Generally, witnesses who have been trained in observational techniques (e.g. police officers, security guards) can recall more detail with greater accuracy than untrained witnesses who, taken by surprise by an incident, may be able to remember only broad strokes or general information about an incident and the events that led to it. The practice in some organisations of handing witnesses blank statement forms and telling them to write down what they saw without explaining the process and objectives, questioning or providing support, can lead to poor results, including misunderstanding, mistrust and skewing of the information obtained. Also, the proficiency of a witness's verbal and writing skills can impact the efficacy of results.

Witness expectations and bias

Influenced perhaps by their experiences or unconscious biases, witnesses may unintentionally fill in the blanks in their recall of an incident or the events that led to it. This memory 'editing' to fill in gaps with what they may have expected under those circumstances can be difficult to identify and address, and is one reason why independent corroboration from other witnesses is valuable.

Witness contamination

Related to the concept of witnesses filling in memory gaps, is the idea of witness contamination, in which recall may be affected by hearing what another witness recalls of the same event. In some instances, witnesses sharing their perceptions of an incident can affect how they remember it taking place; this can be overt, where someone is convinced by another person that they 'remembered it wrong', or subtle, where someone's perception is subconsciously overridden with the details discussed.

Fatigue

Witness fatigue can impact recall and the level of detail provided. Witness fatigue may be increased where rescue operations have taken considerable time or the interview has been delayed by other factors, or as a result of repeated questioning by different agencies.

Mental and emotional state

The mental and emotional state of a witness can make a profound difference to their experience of an incident and how much detail they are later able to recall. Witnesses who are severely affected or traumatised by what they have experienced may have difficulty recalling specifics, or may be able to remember only that which they found most shocking. Being involved in the investigation can exacerbate this emotional reaction, as they may be asked to essentially relive the experience. It is vital that investigators are mindful of the emotional and mental state of victims, family members and others, and have a planned approach to dealing with situations that may arise (e.g. pausing or delaying interviews). In addition to the ethical implications, if consideration of victims, family members and others is not managed effectively, then the evidence gained may be limited, skewed or unusable (guide section 2.11).[20] Also, a witness may have a physical or mental illnesses or condition that impairs their ability to provide useful or reliable information.

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[20] See also *OHS BoK* 35 Mitigation of Health Impacts (sections 7.8 and 7.9).

Effect of alcohol or drugs
Specific circumstances may arise where witnesses are intoxicated, potentially impairing their ability to accurately form representational memories or recall details. If intoxicated at the time of an incident, a witness may never be able to provide useful or reliable statements or testimony. If a witness becomes intoxicated following an incident, they may be able to provide useful information once they have 'sobered up'. This effect of intoxication is not limited to deliberately self-imbibed/ingested recreational substances; certain medications have similar effects on memory storage and recall that may need to be taken into consideration when evaluating witness usefulness or reliability.

In conducting witness interviews there may be a trade-off involved. For example, an inebriated or drug-affected eyewitness may not be capable of giving fully coherent testimony of an incident, but also may not be able to remember details of the incident once they have sobered up; a distressed eyewitness may not be in an appropriate mental state immediately following an incident to be questioned about what they have observed, but delays in conducting the interview can result in forgotten details and increase the potential for memory contamination if they speak with others involved in the incident. Cognitive interviewing techniques (guide section 6.2.3) have been developed to minimise the impact of limitations on witness recall and optimise the value of witness evidence.

4.5.3 Specialist input

Depending on the education and experience of the OHS professionals conducting an incident investigation, specialist expertise may be required to ensure appropriate investigation outcomes. The role of specialist investigators (also called expert witnesses) is to provide relevant, impartial, unbiased and objective evidence in their area of expertise that relates to the incident investigation. While they are often used in legal cases (either prosecution or civil case), they also may provide vital information to ensure the effectiveness of in-house investigations.

A broad range of subject matter experts may be called upon to provide specific information or analysis for an investigation (e.g. forensic, mechanical, structural, chemical and electrical engineers; medical specialists; psychologists; human factors specialists; occupational hygienists; and environmental specialists). The range of skills may vary depending on the industry – oil and gas, aviation, rail, maritime, chemical, mining, road safety, industrial, health. Specialist expertise most likely to be applicable to workplace investigations may include human and organisational factors, forensic engineering and fire investigation.

- *Human factors* investigations consider the interrelationships between the system and the humans who are required to interact with it, individually and collectively, and with each other. They may consider physical, cognitive or organisational aspects, but ideally all aspects holistically. The goal of a human factors investigation is to look beyond the human error paradigm to the genesis of the error, which frequently can be found in the system or equipment interface design.

- *Forensic engineering* investigations may be required when investigating:
  - Equipment or mechanical failures
  - Materials or structural failures
  - Chemical, physical or electrical energy releases or involvement
  - Fire or explosions.

  In such situations, examination and testing of suspect items or materials requires suitably qualified investigators experienced with the particular technology. Examination and testing may require transport of wreckage and artefacts to a suitable workshop or laboratory. If transport of wreckage is not possible, in situ examination and testing with specialist engineering investigators attending the scene may be required. Some specialist engineering investigation techniques can be destructive, in that the item or material being tested may be destroyed or consumed in the testing process. In such cases, the potential benefit to the investigation of the tests is weighed against the potential loss of the item or sample.

- *Fire investigation* is a specialist area as establishing the origin and cause of a fire requires an understanding of fire chemistry, fuels, ignition and fire propagation. In most jurisdictions, fire-fighting authorities will have the primary responsibility to conduct investigations into major fires. Where there is any evidence or suggestion that a fire was deliberately lit, the scene becomes a crime scene and the police will take control to investigate the arson.

Critical traits for a specialist investigator/witness are knowledge and competence; they must have qualifications and experience in their field of expertise. They should be incorporated into the incident management arrangements, including daily meetings, and scene and evidence preservation and continuity processes. Specialist investigators usually submit a report that becomes part of the final report of the overall investigation.

4.6 Analysis

Having collected evidence and interviewed witnesses, the investigator must analyse the information to identify the incident sequence and contributing factors. While effective investigations require attention to many elements, analysis of evidence to draw conclusions and formulate recommendations is often inadequately addressed. This deficiency was recognised in a 2008 report for the Australian Transport Safety Bureau (ATSB; Walker & Bills, 2008):

> The quality of a safety investigation's analysis activities plays a critical role in determining whether the investigation is successful in enhancing safety. However, safety investigations require analysis of complex sets of data and situations where the available data can be vague, incomplete and misleading. Despite its importance, complexity, and reliance on investigators' judgements, analysis has been a neglected area in terms of standards,

> guidance and training of investigators in most organisations that conduct safety investigations. …
> Many investigators (from most safety investigation organisations) seem to conduct analysis activities primarily using experience and intuition which is not based on, or guided by, a structured process. It also appears that much of the analysis is typically conducted while the investigation report is being written. As a result, the writing process can become inefficient, supporting arguments for findings may be weak or not clearly presented, and important factors can be missed. (pp. vii, 6)

The quality of analysis in OHS investigations is an ongoing issue. For example, in 2022, the Tasmanian Coroner, referring to an ATSB report into an aircraft crash resulting in death, stated:

> In my view, in a general sense, the report lacks much by way of reasoning, is largely speculative and is, from my perspective at least, of little forensic value. …. [T]he report is replete with conclusions, but with no apparent basis… (Cooper, 2022, p. 16)

The problem is not limited to high-profile investigations. A Google search for “incident investigation report form” conducted in August 2022 produced 115,000,000 results with a review of the top 30 responses revealing significant issues with the offered sample templates, some of which were provided by OHS regulators. The forms tended to:

- Address notification rather than investigation
- Focus on injuries rather than the actual event
- Forced event description and perceived causation into categorisations (e.g. Figure 2a)
- Give little or no attention to causation sequence or analysis
- Focus on failures by individuals
- Require listing of corrective actions without linking to any causation sequence (e.g. Figure 2a,b).

(a)

What factors contributed to the incident?			
Environment:		**Equipment/materials:**	
☐ Noise	☐ Layout / design	☐ Wrong equipment for the job	☐ Equipment failure
☐ Lighting	☐ Dust / fume	☐ Inadequate maintenance	☐ Material / equipment too heavy / awkward
☐ Vibration	☐ Slip / trip hazard	☐ Inadequate guarding	☐ Inadequate training provided
☐ Damaged / unstable floor	☐ Other	☐ Other	
Work systems:		**People:**	
☐ Hazard not identified	☐ No / inadequate risk assessment conducted	☐ Procedure not followed / no procedure exists	☐ Drugs / alcohol
☐ No / inadequate safe work procedure	☐ No / inadequate controls implemented	☐ Fatigue	☐ Time / production pressures
☐ Hazard not reported	☐ Inadequate training / supervision	☐ Change of routine	☐ Distraction / personal issues / stress
☐ Other		☐ Lack of communication	☐ Other

Corrective actions:				
Contributing factor (from above list)	**What are we going to do to fix the problem?**	**Who**	**When**	**Completion date**

(b)

Location:	
Date:	Incident Details (How the incident happened, factors leading to the event, and what took place. Be as specific as possible.)
Time:	
Police Notified: ☐ Yes ☐ No	

Incident Causes:	Follow Up Recommendations:

Figure 2: Example investigation forms from Google search[21]

[21] (a) Source: WorkSafe Queensland. (n.d.). (https://www.worksafe.qld.gov.au/__data/assets/word_doc/0025/19429/incident-investigation-form.doc)
(b) Source: Clark, V. (2023). How to write an effective incident report [Templates]. (https://venngage.com/blog/incident-report/)

A dialogue via LinkedIn and email responses from practicing OHS professionals revealed that some organisations striving to improve the quality of their workplace investigations had implemented more detailed forms demonstrating some analysis. However, this analysis was mainly focused on categorisations with few forms indicating relationships between the evidence and the conclusions. It is worth noting that pre-existing databases and forms can lead to investigators exhibiting a ‘pick a box’ mentality and may contain potential confounders or biases of the original investigators, analysts or developers. Also, there may be the issue of the form driving, rather than supporting, the process.

This chapter emphasises the importance of a logic-driven analysis process of formulating and testing proposed explanations against the evidence as the key to effective investigation. Logic-driven analysis processes are discussed in section 5 (and guide section 7).

4.7 Technological representations and re-enactments

Post-event analysis of recorded data can provide an accurate and unambiguous view of what took place during an event and may shed light on what the various components of the sociotechnical system were doing before the event. While event data recorders (‘black boxes’) have provided information on incident sequences since the 1950s (DSTG, n.d.), more recent technological representations of incidents include animation, computer modelling and simulation. There are various safety systems that utilise sensory perceptions, operator behaviours and equipment operations as a way of identifying potential risks (e.g. in-vehicle monitoring systems can detect and record risks such as fatigue, speeding and unsafe driving conduct that can be immediately addressed to prevent the risk from escalating). These systems also provide valuable historical and real-time data for investigators.

4.7.1 Event data recorders

Event data recorders (EDRs; black boxes) are becoming more prevalent across industry to aid post-event understanding. They include crash-protected devices, such as flight data recorders and voice recorders in aircraft, similar data recorders in trains and other vehicles, and non-crash-protected data loggers such as those used in heavy industry control rooms. Increasingly, data from video cameras (e.g. car dash cameras, CCTV) and recorded data stored in computer memory chips (e.g. in-vehicle air bag computers) are providing investigators with reliable data. However, many EDRs are limited in scope; not all parameters of interest may be recorded, and data may be lost due to low fidelity of recordings, data decay or crash damage. Also, recording devices only capture what happened, such as a driver taking their eyes off the road, and not the underlying reasons why. Nevertheless, they provide investigators with a solid grounding for their enquiries and a starting point for the investigation into the factors that led to the event.

Specialist expertise and equipment are usually needed to recover and access recorded data. To avoid misleading interpretations and the influence of biases, the readout and interpretation of recorded data should be conducted by specialists independent of the parties involved in the event.

4.7.2 Animation and computer modelling

Animation and computer modelling are gaining popularity in post-incident analysis applications.[22] Software packages are available that allow investigators to represent circumstances of an incident to inform others about what took place. While some packages accept hard data collected from equipment involved in the incident (e.g. stored data from vehicle airbag computers, aircraft flight recorders and process plant control room data recorders), most packages allow manual construction and animation of incident scenes without validation from any recorded source. Some packages allow a blend of both hard data and manual inputs.[23] However, such modelling software has significant limitations that should be recognised and addressed to avoid misinterpretation or misleading results. For example:

> *A car impacts a pedestrian crossing a road. Computer modelling using the data from the car's airbag computer accurately shows the movement of the vehicle in relation to the road environment. However, the movement of the pedestrian may be based entirely on witness recollection and perception that may be much less reliable. If the witness evidence is inaccurate, the output of the computer modelling presents an image of how the event unfolded that may be seriously skewed and therefore invalid.*

4.7.3 Simulation

While animation is a graphic-like representation of a particular object, scene or activity based on mathematical calculations, simulation is a replication of the real event. Simulations are a useful method of depicting what took place in an incident, particularly for enlightening those who did not observe the event or attend the scene. There is a wide variety of software for generating simulations[24] but, as with animation and computer modelling, there are potentially serious limitations associated with its use:

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[22] Examples of animation software include: Visme (https://visme.co/), Adobe Animate (https://www.adobe.com/au/), Blender (https://www.blender.org/features/animation/), SideFX Houdini (https://www.sidefx.com/products/houdini/) and Unity Animation (https://www.sidefx.com/products/houdini/).

[23] For examples of outputs from animations of accidents, see SafeWork NSW Incident Animations (https://www.safework.nsw.gov.au/advice-and-resources/incident-animations) and NSW Resources Regulator Learning From Investigations videos (https://www.youtube.com/playlist?list=PLK1EiOat4BsVUu4nRMImzCyXNzOtB-bHN).

[24] Examples of simulation and reconstruction tools and software include: Smart Draw (https://www.smartdraw.com/), FARO (https://www.faro.com), Virtual Crash (https://www.vcrashusa.com/), Trimble (https://forensics.trimble.com), Pycrash (open source;

- Underlying assumptions and settings of the software can markedly alter the behaviour of a simulation and subsequent outcomes
- Underlying assumptions of the investigators or persons producing a simulation can be reflected in the behaviour of the simulation and its outcomes, and these assumptions may be difficult or impossible for an observer to discern
- Simulations based on the input of a mix of reliable data from data recorders and ‘soft’ data (e.g. witnesses’ perceptions) or simulations based solely on soft data, may be misleading
- Input of biases and preconceptions when generating simulations may skew outcomes.

Notwithstanding these limitations, simulations have been particularly useful in incident analysis and systems design activities and for understanding and predicting the possible dynamics and outcomes of potential incident and failure scenarios.

4.7.4 Physical reconstruction

Reconstructions can shed light on what happened in an incident, aid investigation and provide a starting point for understanding why it may have happened. Reconstruction can relate to physical wreckage and the incident scene. Physical wreckage reconstruction has been used in aviation and transport for many years. It is particularly useful in identifying any pre-crash damage or failures. Usually, the wreckage is removed from the scene once the field investigation phase is complete with the reconstruction carried out in a controlled environment such as a warehouse or hangar.

4.7.5 Re-enactments

Re-enactments provide an opportunity to confirm event sequences, test understanding of witness observations or perspectives, resolve any anomalies, validate assumptions or other evidence, and/or walk stakeholders through an event. However, unless carefully scripted, re-enactments can carry the risk of repeating the event with a similar injury or damage outcome.

4.8 Conclusions, recommendations and reporting

There is often debate regarding whether an investigator should specify certain actions following completion of an investigation. Where an investigator is independent of a business

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https://pypi.org/project/pycrash/), Hexagon (https://leica-geosystems.com), Accident Reconstruction Professional (https://en.freedownloadmanager.org/Windows-PC/Accident-Reconstruction-Professional.html) and PC-Crash (https://www.pc-crash.com/).

(or part of a business) that suffers an incident, those responsible for the safe operation of that business (or part of the business) have line responsibility for what takes place, making it somewhat inappropriate for an investigator to mandate particular actions. Generally, responses to investigation reports tend to be less controversial when the investigator makes recommendations for safety improvement that line management stakeholders can accept or reject or, indeed, replace with an equivalent, more appropriate or more acceptable course(s) of action to prevent event reoccurrence.

The investigation report is arguably the most important part of the investigation process as it provides the only opportunity for those with an interest in the investigation outcomes, but who did not attend the scene or have access to the relevant data, to understand what took place, why and what needs to be done to improve health and safety. The investigation report must provide a rational explanation of what took place, describing all the facts that came to light in the investigation and all the evidence that enabled investigators to explain why the incident occurred. Drawing conclusions, formulating recommendations and preparing the investigation report are addressed in section 6 (and guide section 8).

4.9 Post-investigation review

Every major investigation should be subject to a review to ensure the investigation met the commissioning organisation's goals. Such reviews have two objectives:

- To evaluate the implementation of learnings and recommendations for improvement in health and safety
- To identify opportunities for improvement in the investigation process.

Organisations with robust OHS management systems will include investigation recommendations in their routine OHS action plans to ensure appropriate and periodical focus to ensure close-out occurs. However, there are many reasons why implementation of investigation recommendations may stall. Limited financial and other resources and the competing priorities of maintaining output versus the operational implications of implementing design or other changes may impact the uptake of recommendations in the short term. Management perceptions of the severity of the actual or potential outcomes and loss of corporate memory can negatively impact the implementation of change in the longer term.

Once a major investigation is complete, the investigation process should be reviewed for opportunities to enhance the conduct of future investigations. Every aspect of the investigation should be scrutinised: investigation preparation; timing of the response; resourcing; management and actions at the incident scene; relationships with regulators, other agencies, and external and internal stakeholders; handling of evidence; and interpretation of data in the analysis phase. Ensuring all investigations are subject to comprehensive review is the basis for continuous improvement in investigation preparedness and fidelity, provided of course that where anomalies or barriers are identified, appropriate actions are implemented. Evaluation of the investigation process as it is applied in more routine investigations should be an integral part of routine review of elements of the OHS management system (guide section 9).

5 Logic-based analysis

> Logic is concerned with reasoning and with establishing the validity of arguments. It allows conclusions to be deduced from premises according to logical rules, and the logical argument establishes the truth of the conclusion provided that the premises are true. (O'Regan, 2017)

The science of logic has a long history, emerging over centuries with the work of ancient luminaries such as Socrates, Plato and Aristotle. The Roman Empire considered logic, as did Arabian cultures. Logic for the purpose of safety and incident investigation started to come into its own with the work of logicians De Morgan (1847) and Boole (1859), and gained influence through the work of Van Neumann and the 'Manhattan' project (the atomic bomb), and the development of set theory (Oliver, 1953). Economist Keynes' (1921) conception of probability as a logical relation between hypothesis and evidence created the premise for the use of logic in incident investigation.

Logic has been formally linked with incident investigation and prevention since the early 1960s when *fault tree analysis* (FTA) was developed at Bell Laboratories by H.A. Watson, under a US Air Force Ballistics Systems Division contract to evaluate the Minuteman I Intercontinental Ballistic Missile Launch Control System (Ericson, 1999). While FTA analysis is a graphically presented logic description of potential causes, *consequence analysis* focuses on the potential for hazardous outcomes to cause injuries, fatalities, and damage to assets and the environment (Basu, 2017). A third type of logic diagram used in describing incident scenarios is the *event tree* – an inductive analytical diagram in which an event, actual or hypothetical, is analysed to examine a chronological series of subsequent events or consequences. It depicts all possible outcomes following the failure of protective systems. Results of event tree analysis (ETA) are event sequences or sets of failures that lead to unwanted outcomes (Zuccaro et al., 2018).

Section 5.6 outlines an application of logic diagramming based on ETA, but as there is variation in the definitions, descriptions and application of these analysis tools the term 'logic diagram' is used.[25] Whatever tool, model or method is used to inform evidence collection, it is the logic applied to uncover the most probable sequences leading to the outcome and to ensure that conclusions are clearly linked to the evidence that is important in ensuring the analysis and findings can be defended under rigorous examination.

5.1 Evidence-informed enquiries

Incident investigation involves systematic analysis of the evidence informed by the investigators' knowledge, reflections and evaluation of their practice (section 3). This is an iterative process usually involving the following steps:

- Gather facts
- Form a proposed explanation (hypothesis) based on the facts available at the time
- Determine whether the proposed explanation is consistent with all available facts
    - If not, then it is an unlikely explanation – reject/review/amend
    - If yes, then go to the next step
- Test or investigate the explanation further by asking questions that may be formulated with the aid of theoretical models of causation
    - Does the explanation withstand further investigation? If not, then reject/review/amend
    - If yes, then gather new data
- Construct a logic diagram that represents the causation sequence indicated by the evidence
- Explain the causation sequence as a narrative
- List the conclusions
- Propose recommendations.

This iterative process (Figure 3) is undertaken throughout an investigation to inform data collection and analysis. It creates internal integrity within the investigation and subsequent findings that enables the findings to be effectively defended.

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[25] While the logic diagrams described in this chapter draw on the event tree format, it is worth noting that the term 'logic diagram' has been broadly interpreted to encompass a range of diagrammatic representations of relationships and reasoning. Some of these approaches are of little use in investigations and, by imposing categorisation, can inhibit logical analysis process.

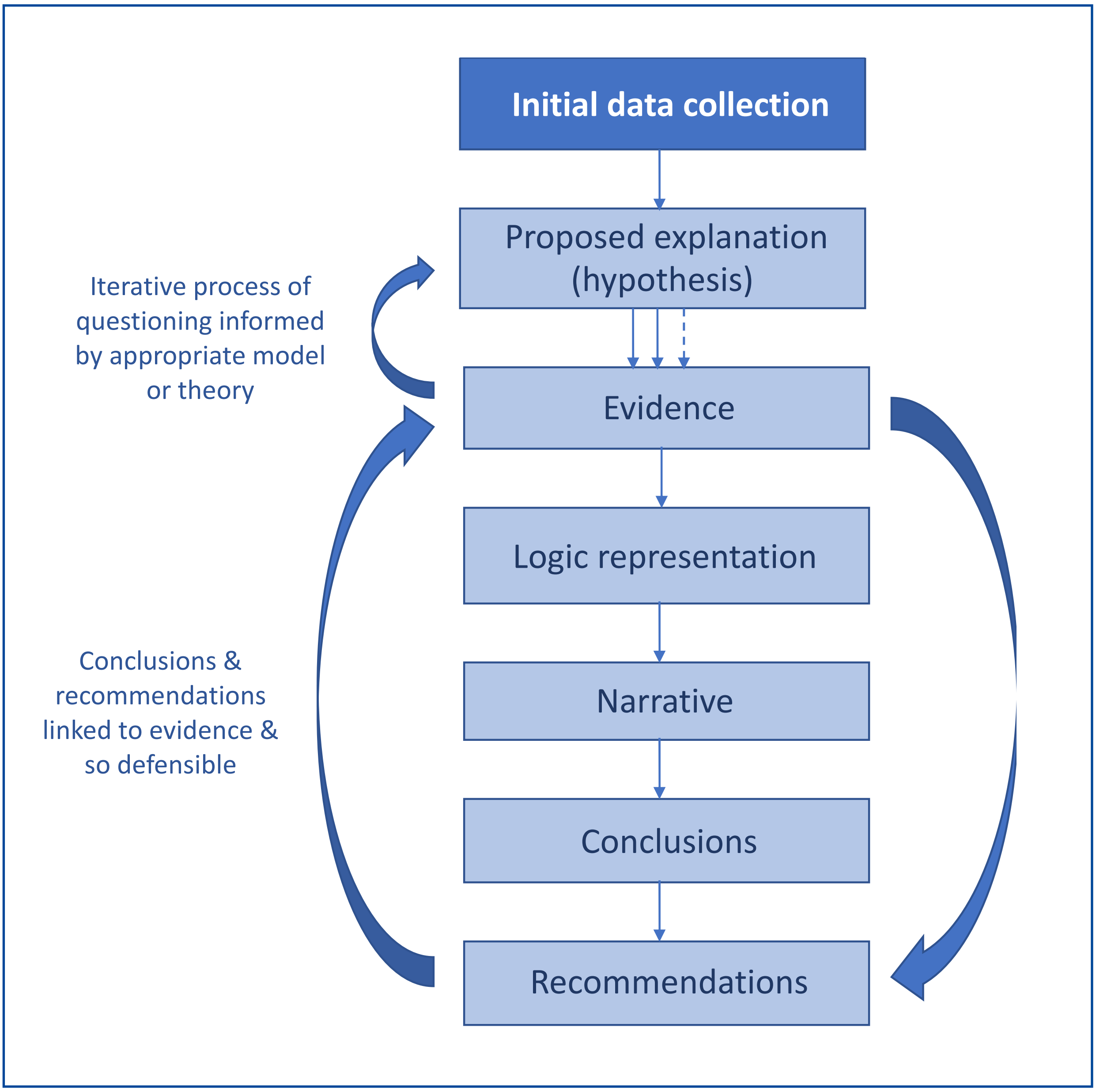

Figure 3: Conceptual approach to evidenced-informed investigations

5.2 Theoretical and analytical models, methods and tools

A theoretical causation model provides a conceptual representation of incident causation that informs an investigator's thinking and drives understanding of an event (Underwood & Waterson, 2013a). Such a model "helps you determine what things to look for. It brings some kind of order into the rubble of failure because it suggests ways in which you can explain relationships" (Dekker, 2017, p. 81). However, models can be constraining: "if the model tells you to look for certain things in a particular way, you may do just that – at the exclusion of other things" (Dekker, 2017, p. 81).

The literature often uses the terms model, method and tools interchangeably, adding to the confusion around the role of 'models' in investigation. 'Theoretical causation models' are taken in this chapter to mean those models that seek to explain how incidents occur (e.g. Reason's swiss cheese model). 'Analytical tools' have been developed by many authors based on one of more theoretical causation models to operationalise the model's application (e.g. Tripod Beta tool). It should be noted that theoretical models can also be directly used to analyse incidents.

Incident causation models have been characterised under three headings:

- Sequential techniques
- Epidemiological techniques
- Systemic techniques (Dekker, 2017; Underwood & Waterson, 2013a).[26]

Table 2 summarises the work of Underwood and Waterson (2013a) and Dekker (2017) on the key assumptions, uses and limitations of these types of investigation models. Given the number and variety of incident causation models and analysis tools and methodologies, any further comparative evaluation is beyond the scope of this chapter. However, various authors have commented on the efficacy of the various types of models; OHS professionals seeking such a comparative evaluation should see, for example, Pirzadeh et al. (2021), who reviewed 36 incident investigation techniques.

Table 2: Summary description, key assumption, uses and limitations of types of investigation models (Dekker, 2017; Underwood & Waterson, 2013a)*

Model type	Description	Key assumption	Uses	Limitations
Sequential Domino theory (Heinrich, 1931)	Describe incidents as the result of a time-order sequence of discrete events (1)	Incidents can be prevented by taking one link from the chain or by inserting a barrier (2)	Work well for losses caused by physical/technical component failures or actions of humans in	Choice of events considered causal to one another is subjective and always incomplete (2)

[26] See *OHS BoK* 32 Models of Causation – Safety (under review at the time of writing) for examples of models in these three categories. Note that chapter 32 lists the models as simple sequential linear accident models, complex linear models and complex non-linear models.

Model type	Description	Key assumption	Uses	Limitations
			relatively simple systems (1) Good at explaining the time period just before an incident and how the events during that time could be related to the outcome (2)	Humans often get painted as the weakest link in the chain (2) Unable to depict cause-effect relationships between management, organisational and human system elements (1)
Epidemiological Swiss Cheese Model (Reason, 1990, 1997)	View incidents as a combination of latent and active failures within a system; analogous to the spreading of a disease via resident pathogens that can lie dormant within a system for a long time (1)	Incidents can be prevented by identifying and knocking out resident pathogens, or by making sure they don't get activated (2)	Encourage probing organisational contributions to failure and seeing human error at the sharp end not as a cause but as an effect (2)	Focus on failures – do not help understanding of people's actions (2) Searches for 'latent pathogens' can quickly become pointless as everything is construed as a possible latent failure inside an organisation (2) Not able to account for the increasingly complex nature of sociotechnical system incidents (1) Similar to sequential models as they describe a linear direction of incident causation (1) (2)
Systemic Systems Theoretic Analysis Model and Process (STAMP) (Leveson, 2004, 2011, 2012) Functional Resonance Analysis Method (FRAM)	View incidents as the result of humans and technology operating in ways that seem rational at a local level but unknowingly creating unsafe	Incidents come from the normal workings of the system; they are a systematic by-product of people and organisations trying to pursue success with imperfect	Focus is on the whole, not the parts (1) (2) Describe losses as the unexpected behaviour of a system resulting from uncontrolled relationships	As systems are increasing in complexity, interactions are difficult to model (2) Resource intensive (1)

Model type	Description	Key assumption	Uses	Limitations
(Hollnagel, 2004, 2012)	conditions within the system (1)	knowledge and under the pressure of other resource constraints (scarcity, competition, time limits) (2)	between its consistent parts (2)	Application requires considerable domain and theoretical knowledge (1) Have not gained widespread acceptance within the practitioner community (1)

* (1) Underwood and Waterson (2013a); (2) Dekker (2017)

When approaching an investigation, the action of an individual or a broken component should often be seen as just one element in a complex system. As noted by Vaughen and Muschara (2011, p. 373):

> The deeper and more difficult to implement actions necessary to prevent an accident from repeating may be missed if the investigation team stops at the individual error, especially if it stops at the operator who last touched the process before the incident occurred.

Systems models apply a macro view that takes into consideration the integration and interrelationships within the system as an inseparable part of understanding an incident (Hollnagel, 2004). This broadens the scope of the investigation process. However, as noted by Leveson (2011, p. 59):

> Most accident analysis techniques identify the proximate chain-of-events and often the conditions underlying those events. They are based on the classic assumption that cause and effect must be directly related. Almost none include systemic factors, often because those factors only have an indirect relationship to the events and conditions. A few attempt to include systemic factors but are severely limited in their success in achieving this goal.

In between are epidemiological models, which may be more-or-less systemic.

Notwithstanding these reservations, there has been a proliferation of theoretical and analytical models, methods and tools – "well in excess of 100" according to Underwood and Waterson (2013a). Hollnagel (2008b, p. 39) provided three reasons for this proliferation: "the inability of established methods to account for novel types of…incidents", "a lack of efficiency, in the sense that recommendations and precautions based on the usual explanations have not led to the desired effects and improvements" and the development of "new theoretical insights." Hollnagel (2008b) proposed that the appropriate method to inform an investigation should be selected based on the system or scenario described in terms of its *coupling* (systems linkages) and *tractability* (management).

Underwood and Waterson (2013a) combined the categorisation of incident analysis models, methods and tools with Hollnagel's advice on selecting an appropriate model based on system coupling and manageability (Hollnagel, 2008b; Hollnagel & Speziali, 2008) (Figure 4).

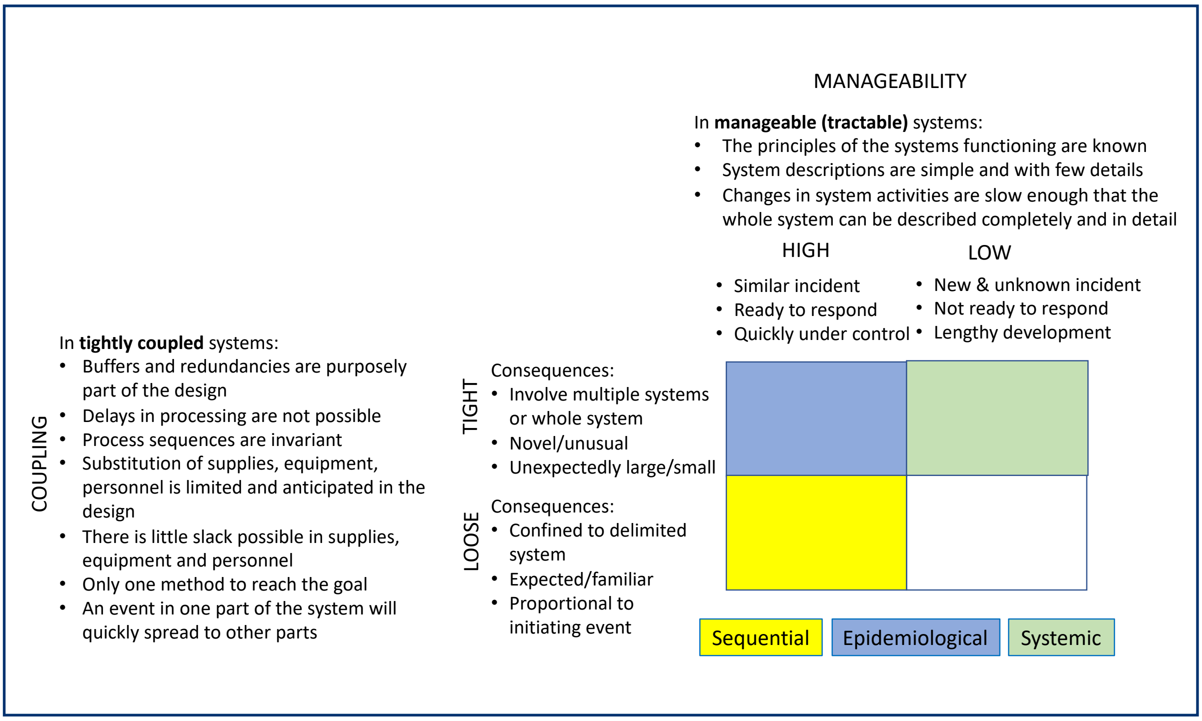

Figure 4: Guide to selecting incident analysis models (derived from Hollnagel, 2008b; Hollnagel & Speziali, 2008; Underwood & Waterson, 2013a)

However, it may not be a simple matter of just selecting what is seen to be the most appropriate analysis model or method. Pirzadeh et al. (2021) and others (e.g. Underwood & Waterson, 2013b) found that linear/sequential models are widely used in practice while systemic models are mainly used in the academic domain. This is of concern for reasons cited in Table 2, and as observed by Pirzadeh et al. (2021, p. 3):

> …studies have suggested that these [linear/sequential] techniques do not effectively capture how human, management and organisational elements combine and contribute to accidents and can lead to identification of easy-to-find causes and ignore less evident organisational (latent) factors that contribute to accidents.

Many factors may interact to influence the selection of an analysis model or method. Underwood and Waterson (2013a,b) interviewed 42 safety professionals across 10 countries and found that awareness, adoption and usage of models and methods can be hindered by factors including:

- Awareness
    - Resistance to change by safety professionals committed to their current approach
    - Level of training of investigators
    - Perception that some analysis models are seen as too conceptual and providing little practical benefit
- Adoption
    - Personal preferences
    - Objectives of the investigation (blame/no blame, liability, commercial and legal implications)
    - Reluctance to use a method that does not have a track record of use, and therefore credibility, within the industry
- Usage
    - Available resources, including time and financial constraints
    - Availability and clarity of guidance material and training
    - Ease of graphical output
    - Reliability/consistency of results when a given incident is analysed by different people or re-analysed by the same person
    - Limited access to data required for more complex (e.g. systemic) models
- Organisational and industry influences
    - Whether organisational policies dictate which methods are used
    - Whether resources are available to support learning and use of new analysis methods
    - Whether regulation in the industry is prescriptive with regards to analysis methods. (Underwood & Watson, 2013a)

While acknowledging these limiting factors, Underwood and Waterson (2013a) advised that OHS professionals engaged in incident analysis:

> … should not consider that one technique is necessarily appropriate to analyse every aspect of every accident. The analyst should not force fit evidence into their analysis, or reject it, simply to comply with the application requirements of their chosen method. While a method will guide the analyst to collect evidence and help interpret the data, the analysis should not be constrained by the method. Therefore, it may be necessary to use more than one method so that the strengths of one technique will compensate for the weaknesses of another. (p. 14)

This is supported by Pirzadeh et al. (2021, p. 3), who concluded that:

- Using different techniques during the investigation process can help the investigators to draw on the strengths of different techniques based on the requirements of their organisation and the accident situation.
- Applying multiple techniques can both improve the breadth of the investigation and address the bias that reliance on one perspective can entail.

Furthermore, Gall (2009) suggested that using a specific investigation method can lead the inexperienced and unwary down a false path (having observed that in the chemical industry, investigators relied on their accumulated years of knowledge and experience from conducting investigations and rarely used a specific investigative method). However, models/methods can inform and serve as a template for the gathering of evidence necessary for constructing a logic diagram to record lines of enquiry.

5.3 Lines of enquiry

Creating and following lines of enquiry is a questioning process that may be generated at any stage of an investigation. An initial question is followed by further questions prompted by the answer to the initial question, with each question raised explored until it is answered or all avenues exhausted. The investigation plan should identify the priority lines of enquiry from other lines that cascade from the original line of questions.

The acronym PEEPO (people, environment, equipment, procedures, organisation) is often used to prompt development of initial questions.[27] While these prompts can be useful, investigators should be aware that such a process has the limitations of the models discussed in section 5.2.

Lines of enquiry also may originate from sources within or outside the investigation scope such as:

- Forensic examination of evidence that uncovers something that requires further investigation
- Information provided by external sources (e.g. witnesses) that either supports or conflicts with information discovered.

The questioning process involved in following lines of enquiry produces information that is logically analysed to generate proposed explanations that are tested against the evidence in an iterative process to arrive at conclusions. These conclusions form the basis for recommendations.

[27] See, for example, Safety Wise (https://www.safetywise.com/single-post/2016/08/29/developing-peepo-for-your-incident-investigation)

5.4 Proposed explanations

As depicted in Figure 3, following collection of initial data, a provisional explanation(s) is formulated. This proposed explanation, which may be informed by the selected incident analysis model or tool, leads to further collection of evidence (section 4.4). As further evidence is collected, the proposed explanation may be accepted, rejected or modified.

5.5 Logic representations and narrative development

To interpret the causal sequence of an incident, the information gained from evidence collection should be reduced to a logic diagram. Commonly used in engineering, logic diagrams are based on the binary principles of Boolean algebra (logic gates) and have certain conventions.[28]

In incident investigation, logic diagrams and the determination of whether the elements are dependent (the 'AND' gate) or independent (the 'OR' gate) enable investigators to quickly identify the need to look for further evidence to either prove or disprove a line of enquiry. Through ongoing review, the logic diagram is eventually refined to include only those elements that are directly supported by evidence. That is, there is a causal link between any individual factor and the 'top event' (the incident) being investigated. If a causal link to the top event cannot be established by evidence, then that factor is very likely not causal of the event being investigated. The application of the logic diagram in practice is tested by presenting the diagram as a narrative.

For example, Figure 5 – based on the relatively simple scenario of a worker being struck by a stone while using a lawn mower – is a logic diagram with boxes on the left- and right-hand sides that express the lines of enquiry as a narrative. Figure 5 is addressed further in section 5.6.[29]

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[28] See, for example, Module 5 Logic Diagrams in the US Department of Energy's (1993) *DOE Fundamentals Handbook: Engineering Symbology, Prints, and Drawings Volume 2* of 2 (https://www.standards.doe.gov/standards-documents/1000/1016-BHdbk-1993-V2/@@images/file)

[29] See also guide section 3.3.1.

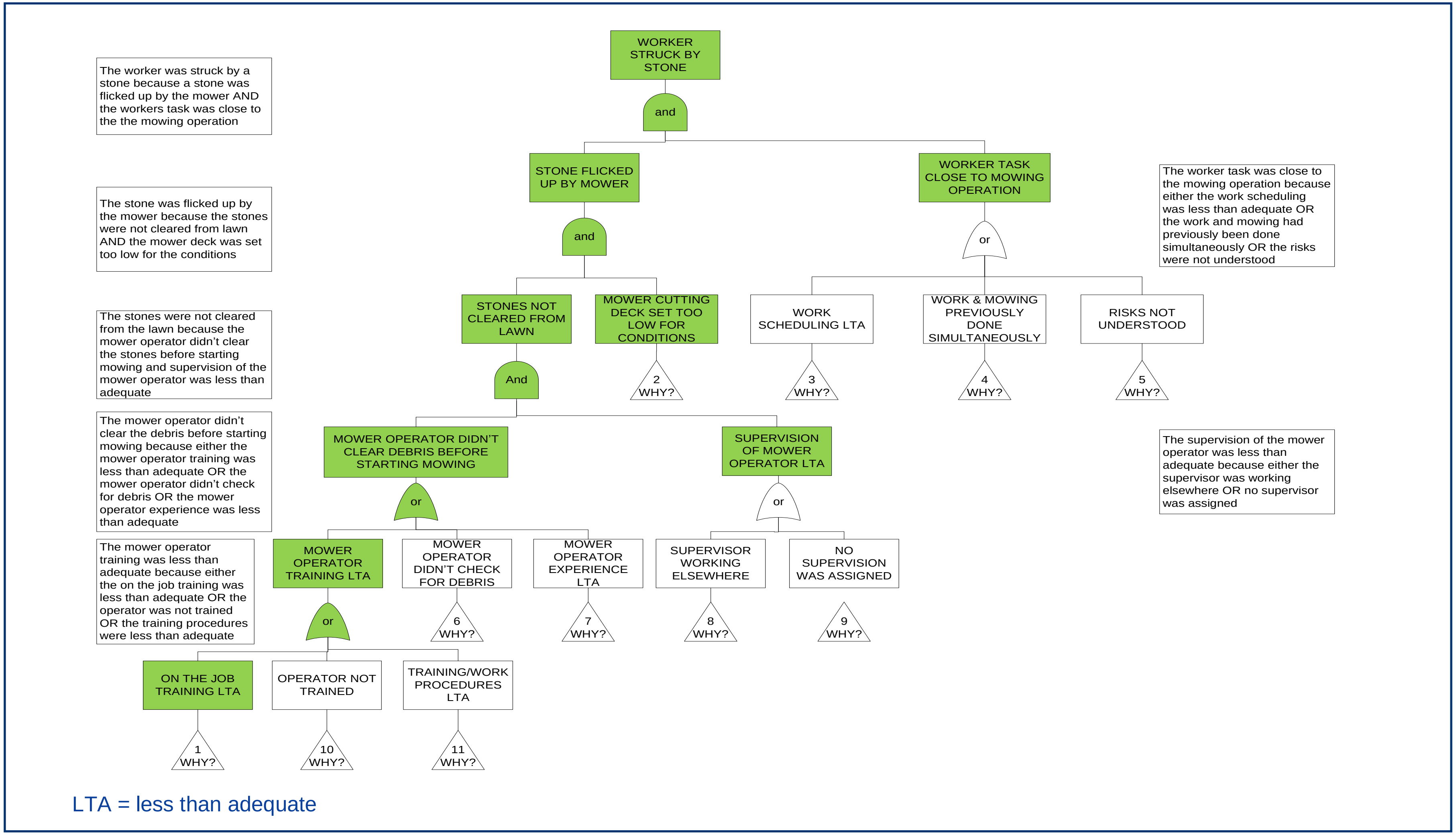
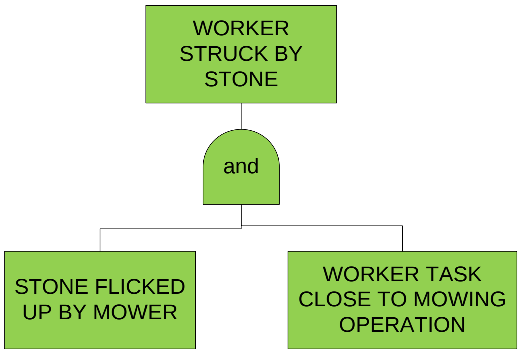


Figure 5: Example incident logic diagram and narrative – worker operating a ride-on lawn mower was struck by a stone

5.6 Testing proposed explanations

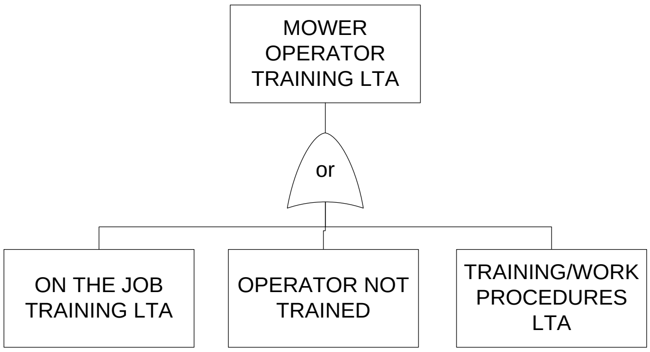
As noted above, proposed explanations are tested against the evidence, and further evidence is collected as indicated by the analysis, resulting in the hypotheses being accepted, rejected or modified. This process of collecting evidence and testing proposed explanations becomes iterative as further lines of enquiry are identified. This is illustrated in Figure 5, which depicts an investigation with 11 lines of enquiry. Only one (highlighted in green) has been investigated beyond three levels (and then only in part). All other conditions (black and white) represent proposed explanations that are yet to be tested and confirmed by evidence. Following the evidence may reveal that additional lines of enquiry need to be added to the logic diagram and to the investigation, or that some hypotheses are not supported by the evidence and need to be removed.

The 'AND' gates indicate that evidence has already been collected, confirming that all the conditions directly connected to the parent condition are proven. For example, evidence already collected confirms that the worker was struck by a stone because the stone was flicked up by the mower AND the worker task was close to the mowing operation.



This would be read: *The worker was struck by a stone because a stone was flicked up by the mower AND the worker task was close to the mowing operation.*

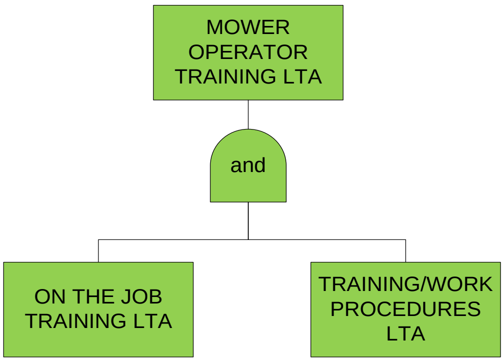
The 'OR' gates indicate that evidence has not yet been collected to confirm that all subsequent conditions directly connected to the parent condition are true. At this stage of the investigation, any or all the conditions directly connected to a parent might be true and evidence gathering must continue to establish which (if any) are true.



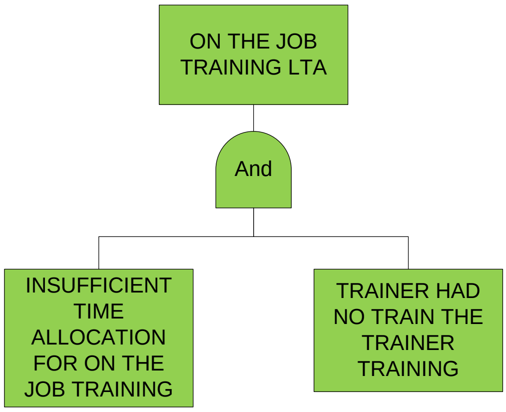
This would be read: *The mower operator training was less than adequate because either the on-the-job training was less than adequate, or the operator was not trained or the training/work procedures were less than adequate.*

Each condition below the OR gate would be the start of a line of enquiry to establish whether one or more of these conditions are true based on the evidence.

When evidence confirms which conditions are true, the OR gate will be changed to an AND gate and those conditions not supported by evidence removed from the diagram. For example, if evidence collection confirms the worker did receive on-the-job training that was inadequate and the training/work procedures were inadequate, then the 'Operator Not Trained' condition would be removed from the diagram and the OR gate changed to an AND gate.



Of course, pursuing these lines of enquiry may reveal evidence that one or more additional conditions existed that led to the mower operator training being less than adequate (e.g. there was insufficient time allocated for on-the-job training and/or the trainer had not received train-the-trainer training). These conditions would be added to the logic diagram.



So, the investigation process goes on, with the investigator forming hypotheses and pursuing evidence to prove or disprove the hypotheses and using the logic diagram to map the causation sequences. In pursuing each line of enquiry, the investigator asks the question 'Why?' (e.g. 'Why was insufficient time allocated for on-the-job training?') and proceeds to find the answer based on the evidence. As a result, the logic diagram changes to map the growth in the investigation. Ultimately, all the conditions supported by evidence remain in the logic diagram, appropriately connected by AND gates, and all disproven conditions are removed.

5.7 Summary

Following and testing the evidence is an essential element of effective investigations as it minimises the potential for investigator biases and avoids inclusion of issues or conclusions not supported by the evidence.

The use of incident causation models/methods can aid an investigator's understanding of how incidents occur and so inform the lines of enquiry and development of the logic diagram. As all models are based on inherent assumptions and have limitations, investigators and OHS professionals should select a model(s) to suit the incident/situation and not assume that any one technique will be appropriate for all incidents. Nor should they attempt to force fit evidence to a model.

Logic diagrams provide a valuable method of tracking lines of enquiry and mapping causation sequences proven by evidence. By enabling deconstruction of the complexity inherent in most incident scenarios, they aid understanding by highlighting individual cause-and-effect relationships that lead to incidents, while maintaining the imagery and mapping of the big picture of the investigation.

Logic diagrams are not encumbered with categorisations, jargon, naming conventions or preconceptions that are associated with some other methods. As causal factors are directly linked by evidence, time is not spent trying to make evidence fit into categories specified by the model/method. Descriptions of all causal factors are worded to exactly describe the evidence found.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)

The initial proposed explanation – the worker fell through the floor because they were not wearing their glasses – was disproved as a causative factor as a result of logical analysis of the evidence, i.e. even wearing the prescription eyeglasses, the worker would have not been able to see the hole due to the lighting conditions.

Without such testing of evidence and logical analysis, the investigation would have come to erroneous conclusions. In contrast, the external investigation followed the logic to test all possible lines of enquiry and proposed explanations until all OR gates were converted to AND gates or the line of enquiry removed.

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6 Conclusions, recommendations and reporting

While evidence collection and analysis is vital to the fidelity of an investigation, it will all come to nothing unless valid conclusions are drawn, effective recommendations made and a report compiled to stimulate necessary change.

6.1 Conclusions

After determining all the facts and following lines of enquiry using logic-based analysis to test proposed explanations, OHS investigators draw conclusions about what happened and why. Every causal factor identified through the analysis and proven by the evidence should be noted in conclusions that are systematically linked to the underpinning facts and evidence.

Conclusions should highlight aspects of the systems that worked properly or effectively, and as such were not causal, and what failures and shortcomings occurred that were causal. No aspect of the investigation or causal sequences should be left unaddressed, and the listing of conclusions should provide a narrative of the findings that reflects the narrative in the logic analysis. Discussion of, or attention to, ‘root cause’ can be detrimental as such discussions tend to focus on a single cause, leaving other causal factors unaddressed.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)

Conclusions listed as a statement of facts:

- During reinstallation of grid-mesh flooring, a hard barrier with warning signage attached that had been fitted across the access stairs to prevent unauthorised access to the site was removed to allow safe access for manual handling of the grid-mesh panels up the stairs to the work area.
- The workers reinstalling the grid-mesh panels subsequently left the area to collect additional panels and did not reinstate the hard barrier, leaving a hole in the grid-mesh floor unprotected.
- Worker X followed the workers from the area back to the worksite without their knowledge.
- Worker X was unaware of the hole in the grid-mesh. ….

6.2 Recommendations

The implementation of recommendations is what drives organisational learning and improvement in managing OHS. Each conclusion should be linked with a recommendation(s) so that all causative factors are addressed. As indicated in section 1.2, the term ‘recommendations’ is used in preference to ‘corrective actions’ as it protects the independence of an investigation, placing the responsibility for determining and implementing action with line management.

Research suggests that the formulation of OHS investigation recommendations is often inadequate, with issues including:

- Reports focusing on the analysis process with less emphasis on recommendations (Dodshon & Hassall, 2017; Lundberg et al., 2012)
- Recommendations focusing on the quality of risk assessment to the detriment of analysis of the effectiveness of risk controls (Dodshon & Hassall, 2017; Noetic Solutions, 2014)
- Recommendations focusing on what investigators perceive as possible to implement rather than most critical (where likelihood of implementation may be influenced by organisational culture, including resistance to change or available resources) (Lundberg et al., 2012)
- Investigators subjected to pressure from the organisation and/or individuals in the framing of their recommendations (Dodshon & Hassall, 2017).

The importance of overcoming organisational factors that create resistance to change was stressed by Lundberg et al. (2012), who identified some ‘rules of thumb’ (i.e. strategies) that Swedish incident investigators used in their attempts to overcome organisational culture factors inhibiting implementation of investigation outcomes. Table 3 lists these strategies, highlighting that different strategies were used in different organisational cultures.

> As shown in the table, the strategies can also be characterized in terms of ethics (duty, trading-off, orienting) and power. Strategies that mainly rely on *orienting* are those that aim at ‘rational cultures.’ Strategies that rely on *trade-off* aim at resource-weak cultures. Strategies for institutionalising safety standards can also *appeal* to a sense of *duty*. Finally, when it comes to cultures where safety is not a top priority, one strategy is to use *trade-offs* to make recommendations less demanding, or to rely on *power*. (Lundberg et al., 2012)

Lundberg et al. (2012) did not evaluate how widespread the strategies were nor their effectiveness; clearly, this is an area for further research.

Table 3: Strategies used by Swedish investigators versus safety culture (Lundberg et al., 2012)

Strategy/Rule of thumb	Characteristics that the strategies draw on			
	Power	Trade-off	Duty	Orienting
Cultures with institutionalised minimum safety standards				
Back up by law	■			
Suggesting change				■
Resource-weak cultures				
The demand that remedial actions are implemented regardless of cost	■		■	
Leave the cost-benefit decision to the law makers	■	■		
Recommendations that are known to be too expensive and are expected to be turned down by the recipient are nevertheless proposed		■		
Give recommendations regardless of cost and leave the decision entirely to the recipient		■		
Set a price tag on recommendations		■		
Present alternatives with different costs		■		
Too-expensive recommendations aren’t made		■		
Rational cultures				
Inviting fixes				■
Thorough explanations				■
Dialogue with the recipient				■
Knowing the right people	■			
Cultures where safety is not the top priority				

Strategy/Rule of thumb	Characteristics that the strategies draw on			
	Power	Trade-off	Duty	Orienting
Weaker remedial actions		■		
Fewer remedial actions		■		
Adapting follow-up explanations and arguments				■
Aim recommendations at another stakeholder	■			
Publicity	■			

A further factor for consideration when framing recommendations is the psychological impact on those involved. While investigators cognisant of the influence of their lens and biases strive for independence in their evidence collection, analysis and formulation of recommendations, they should be aware of the potential psychological impact of conclusions and recommendations that punish a worker (Heraghty et al., 2020). Such recommendations can occur even in organisations that attest to a just culture where the interpretation of a just culture is one that distinguishes between acceptable and unacceptable behaviour or blame-free (intentional) and culpable (intentional) acts and punishes culpable acts. Such poorly framed, inappropriate or missed recommendations limit organisational learning and prevent improvement in health and safety.

In formulating recommendations, investigators should address the required goal or objective while leaving the specific nature of the corrective action as the responsibility of the relevant manager and other workplace decision makers (guide section 8.2). In developing recommendations for corrective actions the hierarchy of controls[30] should be considered to ensure maximum effectiveness with consideration given to the lifecycle of the recommended controls.

Worker falling through grid-mesh opening of the floor in boiler building (section 1.4)

Review procedural documentation to ensure:

- Requirements under *Permit to Remove Flooring, Handrails or Edge Protection* are not in conflict with the simultaneous need for providing safe access and egress for areas with unsafe flooring
- Requirements under *Barriers and Cordons* procedure address the need for safe access and egress from barriered work areas, especially for manual handling of materials

[30] See *OHS BoK* 34.1 Prevention and Intervention for a discussion on the hierarchy of control.

- Warning signage is such that deliberate or inadvertent removal of a barrier does not also remove all warning signage
- JSEAs are cross-referenced to the relevant permits.

Address work planning arrangements to ensure that:

- Risk assessments, particularly in relation to safe access and egress required for cordoned and barriered work areas, are conducted, documented and inform the planning process
- Safe access and egress are assured (especially in relation to safe materials and manual handling) and evaluated, and effective solutions identified and incorporated into the work processes
- Workers are briefed on applicable JSEA conditions, particularly relevant hazard and hazard-control conditions, and sign on to the JSEA before entering any work area
- Workers are aware of, and empowered to respond to, the need to stop work and immediately advise the supervisor(s) whenever an unexpected, uncontrolled or ineffectively controlled hazard is observed or encountered, so that the associated risk assessments and JSEAs can be reviewed, and revised hazard control and working arrangements can be made to minimise the risk of incidents.

Review supervision arrangements especially in relation to:

- Establishing an appropriate balance between office and 'in the workplace' duties
- Supervision and surveillance of compliance with JSEA procedures and associated sign-on requirements. …

6.3 Investigation report

The investigation report is the culmination of the investigative effort. It is often the only aspect of the investigation accessed by decision makers and so is key to organisational learning and implementation of recommendations.

Heraghty et al. (2018) demonstrated that the framing, language and style of an investigation report can affect the interpretation of the event, with report style tending to:

- Dictate the content of the report. In 'reductionist' approaches, report writing relies on the investigator's "perception and interpretation of 'important' facts [and is] vulnerable to omitted information." In comparison, an organisational system style focuses on the elements of the system that contributed to unmanaged risk, and a storytelling style uses the voices of those involved.
- Influence the focus of recommendations. Recommendations arising from reductionist-style reports focus on human error in the front line, system-style reports result in system-focused recommendations and the storytelling style enables deeper understanding of the human factors.

A storytelling style assists the reader in understanding an event and seeing it from the perspective of those involved (McHugh & Klockner, 2020). Logic diagrams with narrative support a storytelling approach as well as a system focus. In contrast, when a reductionist-style report uses language similar to that of a criminal investigation and gives little attention to background information and underlying causes, the actions chosen are more likely to be human/blame-focused (Heraghty et al., 2018).

The report must accurately represent the event and the analysis, with conclusions and recommendations clearly linked to the evidence (Figure 3). It should describe the same causation sequences as those in the logic diagram and associated narrative. While this chapter does not address investigations conducted for legal purposes, such reports will be defensible so that any challenges from within, or external to, the organisation can be rebutted.

Timeliness of completion of the investigation and the report will impact organisational learning outcomes. Depending on the complexity of an investigation, the number of stakeholders involved, access to information, availability of witnesses, whether the investigation was routine, etc., a final report within 30 working days may be an appropriate target. However, simpler investigations may take less time to complete and complex investigations may take considerably longer. An investigation's outcomes should not be rushed to meet stakeholder expectations or organisational standards if it means that critical information may be missed.

7 Quality assurance

Quality assurance of investigations is an often-missing component of organisations' investigation programs (Drupsteen et al., 2011). Ironically, this is often the case in organisations suffering a lot of safety-related events. If the demand for investigations has an organisation and their investigators under significant pressure, then there may be a need to review the overall performance of the investigation program. However, those in control may feel they are unable to find time or resources to step back, pause and conduct a review. Quality assurance in investigations has two key aspects: audit and review; and ensuring investigator capability.

7.1 Investigation process audits

Periodically, organisations need to schedule investigation quality assurance audits, preferably by including such audits in their annual OHS management system audit programs. Audit of the effectiveness of investigation processes should not be limited to major events but should include the more routine investigation of minor incidents, especially those with potential for more serious consequences.

7.2 Investigator capability

Section 1 explained the need for improved incident investigation capability. In 1988, it was observed that:

> The haphazard nature of accident investigation and analysis provides none of the factors for a base for constructive and positive [incident] prevention policy, although much time and effort is given to collecting information which is not put to constructive use. (Edwards as cited in Ferry, 1988, p. 3)

Since then, multiple authors have recognised the need for improvement in incident investigation capability (Cikara, 2022; Dell, 2019b; Dell & Toft, 2011; Manuele, 2014; Newnam et al., 2017; Read et al., 2021; Toft, 2017; Toft, 2016).

There are some commercial training opportunities available that may influence investigative capability; however, uptake across industry is sporadic and does not always result in better investigations. Investigators need to appreciate and understand investigation as both an art and a science, and not just the application of a proprietary or organisational tool. Some factors for consideration in choosing a training option are that:

- All people who could be expected to participate in investigation teams should undergo relevant training, not just those who will lead investigations.
- Investigator training should include both theory and practice; in addition to theoretical concepts, trainees should be given opportunities to practice investigation skills within the training environment or with on-the-job supervision.
- Investigator training should include theory and practice of analytical techniques required to establish the facts, develop lines of enquiry, use logic to identify causal sequences, draw conclusions and formulate recommendations to effectively improve OHS.
- Trainees should have opportunities to use investigation equipment in the training environment so that they develop familiarity and competency prior to using it in the field.
- Training should be applicable to the trainees' organisational environment and expectations and scaled to the needs of the organisation.

8 Postscript on organisational learning

Except for investigations conducted to identify liability or to underpin a prosecution (which are not the subject of this chapter), all incident investigations have the purpose of organisational learning. However, the failure of organisations to learn from past incidents is widespread. In his investigation of the BP Texas City oil refinery disaster, Hopkins (2008) identified various reasons for the repeated failure of organisations to learn from past incidents, which he called an organisational 'learning disability':

- A risk management approach that de-emphasised critical risks

- Organisational cost-cutting targets imposed without risk assessment or consideration of the impact on safety
- Management incentive schemes that focus on short-term targets
- Decentralisation of organisational structure, resulting in local complacency and lack of capability as major incidents are rare events at any one site
- Management leaders not responsive to indicators of potential failure
- Disciplinary action moving ‘accountability’ to front-line workers, closing off identification of more systemic factors.

The issue of ‘blame’ inhibiting organisational learning has been addressed by many authors (e.g. Debrincat et al., 2013; Dekker, 2006, 2009; Heraghty et al., 2020; Hollnagel, 2014; Larsen, 2004; Newnam & Goode, 2015; Cikara et al., 2020). While the effect of punitive recommendations on organisational culture are well recognised, implementing a ‘no-blame’ approach has its own issues and complexities (e.g. Dekker, 2009; Larsen, 2004). Rather, a just culture where individuals are treated with fairness and compassion after they have suffered an incident is supportive of organisational learning (McCall & Pruchnicki, 2017).

Importantly, whether organisational learning occurs as an outcome of an incident is about more than just a blame/no-blame approach. Organisational bottlenecks in learning from incidents identified by OHS professionals (Drupsteen et al., 2011) include:

Reporting	• Incidents and/or near misses are not reported or reporting is delayed • Process of reporting is not clear • Incomplete or poor-quality reports
Determining scope	• No procedure for determining scope • Scope is determined based on severity or individual judgement
Investigation	• Number and/or depth of investigations carried out • Use of one technique even if it does not apply to all incidents • Inadequate investigator knowledge/competencies
Analysis	• Number and/or depth of analyses carried out • The right people not involved • No method of analysis available
Formulating recommendations	• Short-term • Not specific enough • Only aimed at technical solutions • The right people not involved

	• Inadequate follow-up
Prioritising interventions	• Not performed • Prioritisation based on resource availability (easy to implement or short-term) or image • Differences in interpretation of importance of interventions
Action plan	• No clear owner of the action list • Follow-up not monitored • Involves mainly ad hoc actions, no overview of all separate actions
Communicating interventions	• Only through a system/email[31] • Only top-down • No feedback
Performing actions	• Only based on earlier determined plan • Dependent on costs, time required • Forgotten, not performed
Evaluation	• No evaluation • Only implementation evaluated • No feedback.

Organisations that are genuinely committed to mitigating risk and implementing change, will ask the following two questions as part of the follow-up to any incident investigation:

1. What have we learned from that incident?
2. What has been done to prevent event reoccurrence and reduce future risk?

Sharing information is an opportunity for organisations to help other organisations avoid experiencing the same type of event, and potentially improve industry safety processes on a broader level and/or save lives. Unfortunately, there are many barriers to sharing information from workplace investigations that preserve knowledge deficits (e.g. unwillingness of some companies and individuals to share their failures). Furthermore, some professionals advising industry and management actively discourage openness with a misguided objective of protecting companies and managers from being held to account.

[31] Note Hopkins' (2008, p. 69) observation that "Managers, it seems have little time for reading. This is, no doubt, one of the factors undermining their capacity to assimilate lessons from elsewhere."

9 Implications for OHS practice

While this chapter focuses on the theory behind OHS investigations relevant to compliance with regulatory obligations, supporting organisational learning and meeting moral and financial obligations, the companion document – Guide to Effective Investigations – provides OHS professionals with practical guidance. This section provides key principles for effective investigations together with and advice for investigations of incidents perceived as minor.

9.1 Principles for effective investigations

All incident investigations – irrespective of apparent simplicity or minor potential consequences of an incident – should be carried out according to the following principles.

1. In scoping an investigation, consideration should be given to potential outcomes and learning opportunities, noting that even minor events may have complex causation justifying in-depth investigation and analysis (sections 1, 9.2; guide section 10).

2. Learning from investigations requires a focus on the system; therefore, where the outcome of an investigation focuses on the actions of an individual, the investigation must go further to identify the systemic conditions or environment that led to the non-functioning component or human actions (sections 2.2, 2.3, 8).

3. While objectivity is an idealistic aim, all investigators must actively recognise that how they view the investigation process and interpret the evidence will be influenced by factors such as their background and experience, and conscious and unconscious biases (section 3). Where it is a common practice for supervisors to investigate incidents within their work area, a co-investigator from another work area should provide an independent view to challenge findings and sign-off on the investigation report (guide section 2.6).

4. Investigations must focus on the reality of 'work-as-done' as well as the conditions leading to, and at the time of, an incident, where those conditions include organisational, psychosocial and physical conditions (section 3.3).

5. Basic investigation equipment should be available and used as appropriate for all investigations (guide section 2.7).

6. There should be the capacity to call on technical experts as required (section 4.5.3; guide sections 6.3, 7.2).

7. Collection of evidence should include as wide a range of sources and types of evidence as necessary to enable validation of the information (section 4.4). When collecting evidence, consideration should be given to the broader scene, types of witnesses and limitations of witnesses (section 4.5; guide section 5.2).

8. While a standard investigation form may be useful for reporting investigation outcomes, an investigation should not be driven by a form (section 4.6). Investigators

should keep their own notes as an investigation unfolds, completing such a form to reflect the outcomes of the investigation. Investigator notes (guide section 3.2.1) should include a sketch map (guide section 4.4), items and sources of evidence collected (section 4.4; guide sections 2.8, 5.2), scene photographs as appropriate (section 4.4.5; guide section 5.4) and analysis notes in determining causation sequence (section 5; guide section 7.1).

9. Irrespective of perceived simplicity, analysis should ensure that conclusions and recommendations are defensibly linked to evidence. Lines of enquiry should be documented (section 5.3; guide section 7.1). Logic representations can be useful even in apparently simple situations (section 5.5). Every explanation proven to be causal by logic-based analysis should be matched with a conclusion and a recommendation, with no proven explanations left unaddressed (sections 5, 6; guide section 8).
10. An investigation report should provide an accurate account of the event and analysis (with conclusions clearly linking recommendations to evidence) and be written with the primary objective of stimulating and supporting organisational learning (sections 6, 8; guide section 8).
11. Attention should be given to the language used in an investigation report to ensure that actions are directed to systemic factors rather than to worker-focused attribution of error or blame. This is especially important in the short-form language often used in proforma incident reports. Where proforma documents tend to control and limit the information that can be recorded, investigators should attach an extended report and make a notation to that effect on the proforma report (section 6.3; guide section 8.3).
12. Personal opinions or emotive/aggressive language should not be used in reports; the language must be relevant to the facts supported by evidence identified during the investigation. Proposed explanations that are not supported by evidence should not be included (section 6.3; guide section 8.3).
13. The organisational learning loop should be closed by implementing processes to ensure that the recommendations for every investigation are actioned and their effectiveness evaluated (sections 7, 8; guide section 9).

9.2 Investigation of minor incidents

Depending on their role and the industry in which they work, generalist OHS professionals may rarely be required to investigate major events. Rather, they are more likely to be involved in investigations of the type described in Table 4.[32] The importance of effective investigation of seemingly minor events becomes apparent when OHS performance reviews and incident data reveal a trend in events of similar causation or circumstances.

[32] Table 4 is part of a table included in the accompanying guide (i.e. guide section 2.4 – Table 1: Guide to determining the level of investigative response).

Comparative examination of investigation reports then enables a more in-depth analysis and formulation of recommendations to address what is potentially a more serious organisational or industry risk.

Table 4: Guide to determining the level of investigative response for minor incidents

<table>
<tr><th>Scale of incident</th><th>Level of investigation</th><th>Reporting requirements</th></tr>
<tr><td rowspan="2">Incident that involves minor injuries and/or some property or environmental damage, but had the potential to have more serious consequences</td><td>May be subject to investigation by regulators, or police in the case of transport incidents</td><td>Statutory obligation to report incident occurrence to the relevant regulator or agency</td></tr>
<tr><td>In-house investigation conducted by a trained and experienced investigator(s)</td><td>In-house investigation will usually culminate in a comprehensive report detailing all causal factors and recommendations for action</td></tr>
<tr><td rowspan="2">Incident that involves minor or no injuries and/or little or no property or environmental damage</td><td>In-house investigation may be conducted by a trained and experienced investigator(s)</td><td>In-house investigation will usually culminate in a comprehensive report detailing all causal factors and recommendations for action</td></tr>
<tr><td>Simple investigation conducted by the line supervisor(s) using standard investigation form</td><td>Completed investigation form serves as final report</td></tr>
</table>

Investigations of minor incidents are usually conducted in-house and may be driven by standard investigation forms or protocols. As indicated above, although a minor incident may seem to present minimal risk, a series of minor events can indicate something more serious. Also, some apparently simple events can have complicated causal relationships. Where practicable, every incident should be investigated as the data analysis may reveal a risk that would otherwise remain undetected until a major incident occurs. The principles for effective investigations (section 9.1) should apply to all investigations, including those perceived as minor.

It could be argued that a simple investigation proforma may be adequate for the investigation of minor events. However, use of standard proforma reports can limit the scope of an investigation and inhibit objective analysis by artificially forcing event descriptions and perceived causation into categorisations (section 4.6). Also, they may require listing of corrective actions without linking to any causation sequence. Such shortcomings or gaps in the investigation process will undoubtedly result in shortcomings or gaps in the investigation outcomes and recommendations.

Figure 6 is a process outline to assist OHS professionals who may routinely investigate minor incidents or mentor others in such investigations. The principles espoused in section 9.1 should be considered fundamental to this process.

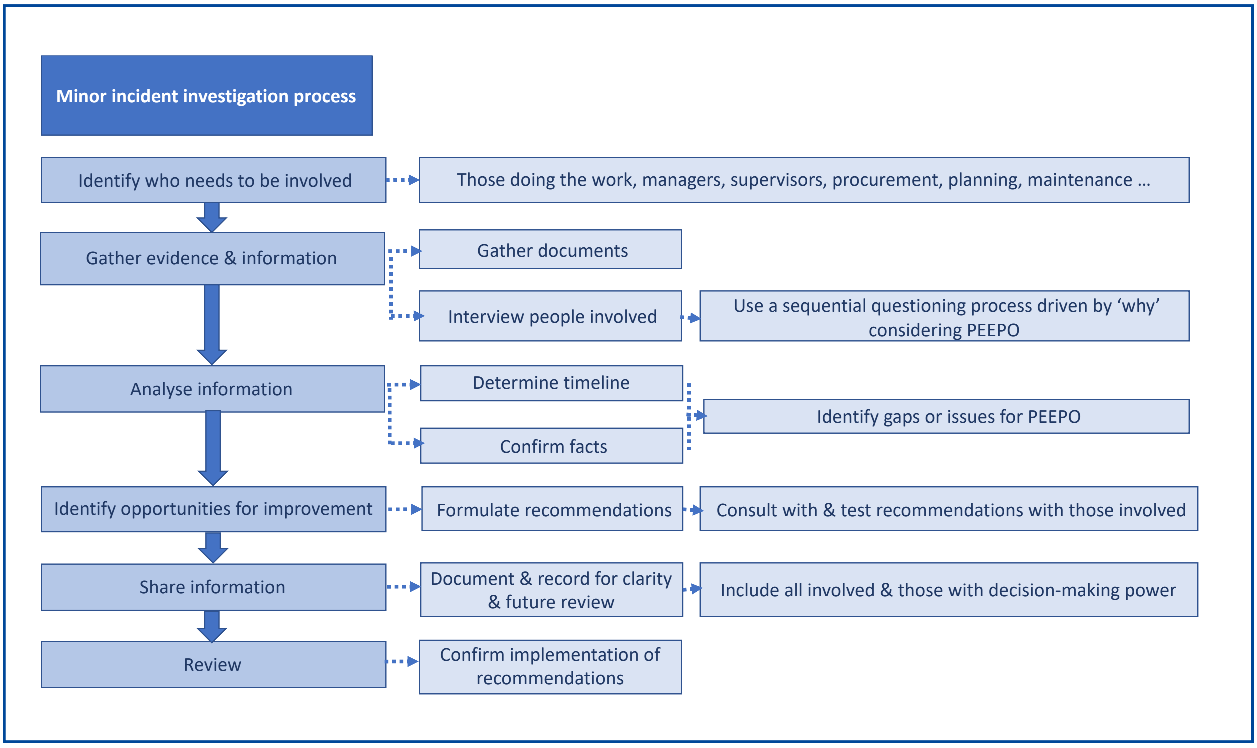

Figure 6: Minor incident investigation process

10 Summary

The *OHS Body of Knowledge* addresses the topic of incident investigation in two documents. This chapter focuses on the conceptual knowledge that should underpin all OHS investigations and a companion document – Guide to Effective Investigations – provides practical advice and checklists. Both documents address recognised gaps in the skills of generalist OHS professionals in investigating workplace incidents. They support a systematic and systemic approach based on the premise that, for generalist OHS professionals, the primary objective in investigating incidents is not to apportion blame or determine liability, but rather to achieve organisational learning to improve health and safety.

Section 1 of this chapter discussed the necessity for improved OHS investigation capability, and flags the post-1950s improvement in aviation safety as an exemplar for more-effective workplace incident investigation. Section 1 also explains the chapter's terminology and scope, and presents an incident case study that is referred to in subsequent sections.

Section 2 reviewed the role of investigation in OHS and identifies relevant regulatory obligations, and organisational learning, moral and financial imperatives. It places investigations within a sociotechnical systems context and considers the influence of organisational culture and structure on investigation outcomes. Also, ethics and legal professional privilege are addressed.

Section 3 explored potentially challenging concepts for investigators, including how their personal lens (determined by education, experience, knowledge of sociotechnical systems, cultural norms and worldview) and various conscious and unconscious biases can influence their thinking and reasoning and so their objectivity. An investigator's understanding of the reality of work-as-done also influences their objectivity.

Section 4 summarised the investigation process, which is covered in more detail in the accompanying guide. Eschewing proforma investigation reports, section 5 explains a logic-based analysis process that should be applied in all investigations to determine defensible explanations. While incident causation models/methods may have a role in informing investigation lines of enquiry, they have significant limitations and OHS professionals are advised that they should not consider any one technique appropriate for analysis of every aspect of every incident, nor should they force fit evidence into their analysis or reject evidence simply to comply with the requirements of a chosen technique. In fact, investigators may find that it is not necessary to use a fixed model.

In section 5 reviewed the logic-based process of exploring lines of enquiry involving an iterative approach drawing on the evidence to propose an explanation and then testing the proposed explanation against the evidence. Lines of enquiry are represented in logic diagrams with AND gates, indicating that the collected data confirms the proposed explanation, while OR gates indicate that the proposed explanation is not yet proven by the evidence. Each logic diagram is accompanied by a narrative.

Section 6 focused on developing conclusions and recommendations and writing reports, and the role of report language in organisational learning is emphasised. Section 7 addresses an often-neglected area of investigations – quality assurance through audit and ensuring investigator capability. Bottlenecks to organisational learning from investigations are identified in section 8. To support generalist OHS professionals in their daily practice, section 9 presented a set of principles to guide investigations irrespective of the level of incident consequence or complexity, and an approach to investigation of incidents perceived as minor.

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