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World Safety Journal

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World Safety Organization

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Articles for inclusion in this journal will be accepted at any time; however, there can be no guarantee that the article will appear in the following journal issue.

All articles shall be written in concise English and typed with a minimum font size of 11 point. Articles should have an abstract of not more than 200 words. Articles shall be submitted as Times New Roman print and presented in the form the writer wants published. On a separate page, the author should supply the author's name, contact details, professional qualifications, current employment position, a brief bio, and a photo of the author. This should be submitted with the article.

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They Say I Can Clearly See – But Can I?

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ABSTRACT

Truck driving requires the application of more advanced skills than driving a standard motor vehicle, and as acknowledged by relevant licensing authorities truck drivers must pass a more stringent medical assessment. Therefore, the vision standards applied by the relevant licensing authorities in the assessment regime would suggest that the truck driver has good vision. However, by examining the standards, it is noted that real world driving conditions are not considered in the true sense of what a driver can actually see working in a highly dynamic environment. The review conducted by various independent agencies found the clinical management guidelines quite complex and difficult to understand, and the depth in information for vision and the importance that vision plays for the truck driver remains scarce. With vision playing an integral component in truck driving any deficits in functioning vision may be the key to a range of serious medical conditions and the trigger to the high number of serious and fatal collisions that involve heavy vehicles, noticeable gaps become evident in what is considered acceptable in safe driving and good vision.

Keywords: Truck drivers, Vision standards, Visual function, Stereopsis, Visual acuity, Accident causation

Introduction

Road transport is large, diverse and one of the worlds' most dangerous occupations (National Transport Commission [NTC] 2016; Transport Workers' Union of Australia 2011; Boyd 2005; Brown 2002), that exposes every truck driver to unrealistic and demanding schedules (Boyd 2005), hostile traffic systems and an array of other hazardous environments (Locke & Romis 2007). With the recent review conducted by various independent agencies found the guidelines that underpin the requirements that focus on a drivers medical fitness to drive are quite complex and difficult to understand. Truck drivers believe their vision is acceptable and any deficits will not adversely impact on their ability to minimize the risk of collision and injury and drive safely (Johnson & Keltner 1983).

This means that the depth of information for vision and the importance that vision plays for the industry remains scarce, as the reliance drivers place on their vision by streaming information accurately to detect objects, is not considered significant in the standards applied by the various licensing authorities. Even though truck drivers must demonstrate the skills that are complementary to normal driving behavior, by predicting the level of risk that appears ahead of time (Stahl, Donmez & Jamieson 2014), to ensure the safety of other road users. These standards overlook key aspects of vision in a highly dynamic working environment, because every truck driver must be able to visually identify vehicle speed of their own vehicle, as well as other road users and ensure the vehicle remains fixed in the desired lane (Lewis-Evans, De Waard & Brookhuis 2011; Fox, Levitt & Nelson 2010).

Vision and Driving

If the foundations of driving any vehicle is the same and '*good vision is essential to operating a motor vehicle'* (Austroads 2014, p.116); then vision and visual function plays a significant role in driving a commercial heavy vehicle (Vasudevan et al. 2012). Up to 80% of all impressions are perceived by means of sight (Barg et al. 2009) and every situation experienced by the driver in the truck is in an environment that is continuously and simultaneously stationery or in motion, while surrounded by objects that are stationery or in motion. This would mean that if a drivers' vision is interrupted or compromised the normal information-decision-action sequence (Clark et al. 2008) will also be compromised.

Whilst potentially increasing the risk of an accident, as the driver will experience a disruption to their visual field, deficits in functional vision have not been evaluated during any post-accident investigations (Whillans 1983). Even though, truck drivers can safely estimate the relative distance, position, speed and direction for all objects encountered (Morgan & Hancock 2009) by visually cataloguing every object in the immediate environment, in order to determine what actions are appropriate and ensuring these actions are consistent with what is going on around the vehicle (Stahl, Donmez & Jamieson 2014). It has been indicated that truck drivers are hyper-sensitive to the initial condition as it is witnessed and processed at that very moment (Vasudevan et al. 2012), as their vision enables them to assimilate all information being streamed (Tsimhoni & Reed 2007) prior to drawing the appropriate interpretations (Goodale & Milner 2013).

This would mean that when the truck driver instantaneous captures lane changing and acceleration behaviors of all other road users, the middle and lowest tactical levels are integral in the information-decision-action sequence (Spiers &Maguire 2007). However, if the truck driver misprioritises or diverts their vision away from the primary line of sight (Beanland et al. 2013), this sequence is prone to being corrupted by the design of the vehicle or the environment (Pitchipoo et al. 2014). Therefore the truck driver still needs to focus on the object, prior to making any further decisions or assumptions that are cued from their auditory, biomechanical, physical and cognitive functions (Ghazizadeh & Boyle 2009).

Vision Testing

Licensing authorities have adopted numerous policies and practices to ensure that all drivers have good vision. However, with sight being the physical sensory experience of light that refracts shapes and objects allowing the eyes to focus on this light (Shaheen & Niemeier (2001) and vision is how the mind interprets the images (Horowitz 2004), truck drivers may not understand the difference between vision and sight. The guidelines are written in such a way that drivers, licensing authorities and medical practitioners are expected to understand how a medical condition is likely to negatively influence a drivers' ability to safely operate a motor vehicle and the risk they present to other road users.

With the inclusion of vision in these guidelines, all authorities and health professionals should be able to report that every driver is able to interpret what is being seen, which is supported by the driver passing a standardized test that is designed to measure their visual function (Decina & Staplin 1993). This means that when a person witnesses an event under normal driving conditions, their vision will help them understand the significance it has in the road traffic system (Goodale & Milner 2013). Therefore, the mechanisms that underpin these principles that drivers have good vision will quantitatively measure a person's ability to see an in-focus image at the minimum distance-value (Colenbrander 2002; Colenbrander 2008) to determine their visual acuity.

Conceptual errors can be found in the test platforms (Fritz & Musial 2016), because the mandated minimum required distance between the test and the driver, is not always achievable. While this can be mimicked with mirrors to give the illusion that the test platform distance is accurate (Ferris et al. 1982; Bach 1996; Krueger et al. 2007), the test platform only evaluates static or photopic visual acuity and overlooks key elements of dynamic visual acuity. Therefore, these standardized test platforms are not an adequate predictor in how truck drivers discriminate fine details in a moving target (Brown 1972); even though they meet with the required visual standards for safe driving.

Vision Difficulties

Approximately one half of the global population legally allowed to possess a driver's license have been diagnosed with low visual acuity or loss in functional vision (Danermark & Hanning 2012), consequently difficulties in driving in demanding situations may be common. Even though a high percentage of truck drivers at an age where poor visual acuity is likely (Bohensky, et.al. 2007; Duke, Guest & Boggess 2010), most only require corrective or prescription lenses to restore sight to within normal range. Therefore the licensing authority or health professional must be able to correctly interpret the risk presented to all other road users, if the truck drivers' vision is found to be below the minimum standards applied in the guidelines, even if corrective lenses have been prescribed.

Colour Deficiencies

Because no two people are able to interpret the same colour in the same manner (Mullen 1985), vision of the drivers that have some form of colour vision deficiency (Vision Eye Institute 2016) or will experience difficulties in correctly interpreting and understanding the specific frequency or wavelength of the light that is reflected into the retinal cones that form colours (Valberg et al. 1983) is not considered detrimental (Cole 2004). Because people that experience issues with interpreting colours in driving and the wide range of occupational tasks, leisure pursuits and other everyday tasks (Steward & Cole 1989) will adopt strategies to minimize the inconvenience or embarrassment that an incorrect interpretation of colour may cause.

While these strategies may include limiting driving to daylight hours (Galpin, Underwood & Crundall 2009), colour deficient drivers are unlikely to recognize and respond to all of the overlapping colours that are commonly found in road signage or traffic signals and any misinterpretation of these will increase the risk of a motor vehicle collision (Owsley & McGwin 2010; Whillans 1983). This may have been the reason for Austroads (2006) to include the recommendation that drivers with an increased number of collisions at stop lights should be referred for a red hue assessment; however, this was removed from later revisions, because of improvements in road engineering (Austroads 2014).

Binocular Vision and Stereopsis

Ideally all truck drivers must have adequate binolcular or stereoscopic vision to retain or apply for a heavy vehicle licence, with some considerations given for drivers with monocular vision, showing vision capabilities over 110^0 on the horizontal plane (Austroads 2014). Some uncertaintities exist in terms of the effects that monocular vision has for truck driving; even though stereoscopic vision is the technique where the two distinct images captured by both eyes, are rapidly merged together to give any object a three-dimensional appearance. This infers that all truck drivers must have stereoscopic vision to accurately identify all objects that are being looked at across the entire horizontal visual spectrum (Read 2015; Bertozzi et al. 2006; Matuszyk et al. 2004; McKnight, Shinar & Hilburn 1991).

Changizi and Shimojo (1988) support this notion, stating that any person with normal binocular vision will have the ability to target and track objects that are hidden by one eye, which may aid the driver in focusing on smaller vehicles and pedestrians during normal driving. However, Coday et al. (2002) contends that a person without stereoscopic or binocular vision can obtain a three-dimensional structure with acquired monocular vision, supporting the view held by many health professionals that, most conditions that result in complete single ocular visual deterioration, will infill the information that is missing from the eye that no longer functions, to reflect what is assumed to be the external environment. As the monocular driver can mimic most aspects of stereoscopic vision; however, noticeable deficits to depth perception and tracking will be experienced, as the visual center-line will be slightly skewed from the eye that is no longer receiving visual input.

Contrast sensitivity

If the baseline for assessing vision of all truck drivers replicates normal or photopic visual acuity (Wood & Owens 2005), it begs the question of how visual function is adequately assessed for an industry that mostly operates in low-light conditions. Because truck drivers that experience difficulties in visually identifying pedestrians and other road users, as well increasing the potential risk of injury when working near the vehicle in these low-light conditions, may have poor contrast sensitivity or deficits in scotopic visual acuity (Barlow 1962). Therefore, the photopic visual acuity examination used to determine a truck drivers visual function test, does not consider the risk to all road users, for drivers that operate in low-light or overnight.

This shows that for all truck drivers to safely operate in low-light environments that is not limited to fog, glare and overnight, when the contrast between objects and the background is reduced, they require above average contrast sensitivity (Atkin et al. 1984). Deficits to a truck drivers scotopic visual acuity could also indicate to the health professional a number of ophthalmic medical conditions or diseases, including; cataracts, glaucoma or diabetic retinopathy, which will negatively influence a driver's capacity to make the judgements necessary to performing their normal duties (Owsley & McGwin 1987). In addition to these concerns, Woods and Owens (2005) point out that drivers will experience dramatic or permanent reductions in vision in these environments where reduced illumination is commonly experienced for extended periods.

Driver Manipulation

There is considerable evidence to support the fact that the risks that most medical conditions pose to other road users, and to link deficits in functioning vision have to illness and other diseases with life threatening consequences (Blanco 2002; Horowitz 2004; Hood et al. 2014). There is no evidence to support or dispel the assumption that any disruption to a truck drivers' vision increases the risk of a collision (Whillans 1983; McKnight, Shinar & Hilburn 1991). Because the relationship vision has between drivers with poor vision and contributing to an accident, is more subtle than other medical conditions (Dong, et.al, 2015), which must be addressed by health professionals to preserve the integrity of all other road users (Owsley & McGwin 1999).

However, as all truck drivers rely on their license for employment, and are prone to manipulate their own behavior (Lajunen & Summala 2003) to ensure that what is seen, or how they respond to a series of questions will not result in their license being suspended. This implies that unless the licensing authority understands all of the complexities involved in driving (Lajunen & Summala 2003; Runcie 1969), they may not realize that the results found in the assessment is not an accurate representation of a truck drivers' visual function and functioning vision (Bailey & Sheedy 1988). The consequence is that the truck driver will use the complex, antiquated and ambiguous phraseology applied in the guidelines and associated legislation (Austroads 2017; NTC 2017; Hunt 2003), to manipulate their responses and misrepresent their actual vision.

Conclusion

Road transport is an intractable environment which exposes all truck drivers to numerous hazardous situations and every licensing authority has implemented similar practices to ensure that all drivers comply with the principles documented in the various clinical management guidelines that addresses vision and visual function. This implies that the assessment allows the truck driver to demonstrate that their vision is adequate, and in order to retain their driving license, the anthropometric measurements of the driver and the geometry of the road (Pitchipoo et al. 2014), to safeguard all road users must be considered. However, with a number of vision issues being identified as an indicator of secondary health concerns, it is recommended that the measurement, monitoring and reporting of a truck drivers' vision must include assessments that go beyond the current vision test accepted by the licensing authority and health professional.

Recommendations

Presuming that the standard vision test as applied by the licensing authorities is fair to all drivers, in terms of minimizing the risk of collision and considering that vision is integral in the drivers information-decision-action sequence, it must be considered that if a truck drivers vision is compromised, the risk of collision increases. Therefore, the licensing authority and health professionals have a duty to ensure these standards of vision testing are consistent with real-world driving and reflect environmental conditions that are commonly experienced by truck drivers, as these tests will be able to demonstrate if the driver has adequate vision, and have the ability to identify if the truck driver is prone to other medical conditions.

Truck drivers require stereoscopic or binocular vision to accurately interpret objects across the entire horizontal visual spectrum (Read 2015), and normal binocular vision allows a driver to target and track objects in a truck drivers peripheries (Changizi & Shimojo 1988). Therefore it must be considered that all truck drivers should be able to form a three-dimensional environment; suggesting that the considerations given for acquired monocular vision (Coday et al. 2002) should be removed, since the truck driver would only be able to assume that the information is accurate, the truck is travelling in a straight line and the behavior of all other road users and vehicle is meeting with the expectations of the truck driver.

To accurately measure a truck drivers entire field of vision, a visual field test is appropriate (Johnson & Keltner 1983) and is a reliable indicator for conditions related to glaucoma, or to determine the presence of other ocular diseases (Hood et al. 2014). Such visual field test will be able to determine if blind spots or scotomas and other visual field defects are present, which can be an early sign of eye and brain disorders, causing loss of peripheral vision and other visual field abnormalities. The size and shape of a scotoma will enable the health professional to identify visual field defects and diseases of the retina, optic neuropathy, brain tumors and stroke (Marmor, Chien & Johnson 2013; Grillo et al. 2016).

Truck drivers must also understand the vast array of colours found in the road traffic network and interpret these correctly in terms of the location; even though, no standardized test platform has been adopted (Austroads 2014) from the myriad available (Whillans 1983) to ensure a driver has adequate colour vision. Even though Austroads (2006) excised the recommendation that drivers with an increased number of collisions at stop lights should be referred for a red hue assessment, due to improvements in road engineering, Owsley and McGwin (2010) suggests that colour deficient drivers, are unlikely to recognise and respond to all of the overlapping colours that make up road signage and traffic signals. All of this means that if truck drivers experience difficulties in distinguishing colour, they are likely to present with poor visual acuity, as well as have increased sensitivity to light or photophobia.

Since drivers may commonly experience visual disruption as a direct result of direct sunlight or head-lamp luminescence, truck drivers require heightened scotopic vision (Blanco 2002) to see effectively in extreme low light conditions. For this reason, Pelli and Robson (1988) recommend heavy vehicle drivers working in situations of low light, fog or glare, when the contrast between objects; such as pedestrians and other dark objects in poorly lit environments is reduced, undertake contrast sensitivity testing after extended periods of exposure (Atkin et al. 1984). While this test differs from common visual acuity testing in a routine eye exam, contrast sensitivity could indicate a range of health conditions or be able to determine if the driver is likely to experience permanent reductions in visual acuity (Woods & Owens 2005).

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Development of an analytical grid to compare policy aspects of OHS qualification frameworks

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ABSTRACT

Whilst there is a recognized need from OHS professional bodies, there has been little examination into how governmental policies regulate qualification levels for Employer appointed Safety professionals. With the use of an analytical grid, this exploratory project looks at five countries and discusses the impact of highlighted policy challenges. Whilst it is acknowledged that research on a larger scale needs to be completed, the exploratory project results suggest further use of the analytical grid is used in future studies.

Keywords

OHS. Qualification. Training. Safety

Introduction

Countries have a long history of regulating the various aspects of occupational health and safety (OHS), and have over the years adopted several International Labour Standards [ILS] in this area (www.ilo.org/normes). There are ILS covering the overall organisation of OHS, some for sectors of economic activity (construction, mining and agriculture), and other for specific OHS risks (e.g. occupational cancer, benzene). These ILS are complemented by Codes of Practices but none of them specifically addresses the qualification requirements of OHS practitioners in order to ensure that they are properly equipped to assume their roles, functions and responsibilities. Hence the qualification requirements of OHS practitioners are left to countries and/or jurisdictions within these countries to decide upon.

The purpose of this exploratory project is to look at how selected country legislation currently regulates the qualifications of OHS practitioners. It aims to develop and test a preliminary analytical grid to facilitate the identification of key policy aspects and compare national regulation. Whilst there is the recognized need by the professional member organizations to standardize qualifications, there is limited research into the determinants and impact of governmental policy on the adoption and implementation of such standards.

The term OHS covers a broad spectrum of professionals and practitioners, but this report is focused on those professionals who are Employer appointed specifically in regards to Safety within the workplace.

Method

This exploratory project aims to develop and provisionally test an analytical grid covering key policy aspects of occupational health and safety [OHS] professionals' qualification frameworks in support of the International Labour Organisation [ILO] initial monitoring of country experiences.

Specific Objectives

- Develop an analytical grid presenting key policy aspects related to the regulation of OHS practitioners' qualifications, specifically in regards to those concerned with the Safety aspect of OHS
- Highlight similarities, differences and apparent challenges in regulating the qualifications of OSH practitioners between some governmental jurisdictions of Australia, Canada, United Kingdom and the United States.
- Discuss possible implications of policy aspects of relevance

<u>Research</u>

Research was conducted into the afore mentioned countries OHS legislation through direct access to government sources as well as the use of the ILO Global Database on Occupational Safety and Health Legislation [LEGOSH]. Research focused on legislative definitions that related to an Employer appointed Safety professional as well as policies and regulations which may impact the training and qualifications of said person. An additional academic literature review was conducted using the Science Direct database using the key words "OHS qualification" AND "education". This initial search produced 3,713 results and after further refinement in the search parameters for those articles in Safety Science, the final result was 35. Four articles were then cited within this report, with a further four gained through citations from reviewed articles.

Information was also gathered from the following OHS professional organizations to ascertain current frameworks and OHS qualification definitions.

- Institute of Occupational Safety and Health [IOSH]
- International Network of Safety and Health Practitioner Organizations [INSHPO]
- European Network of Safety and Health Professional Organizations [ENSHPO]
- Safety Institute of Australia [SIA]
- Board of Certified Safety Professionals [BCSP]
- Board of Canadian Registered Safety Professionals [BCRSP]

- National Institute of Occupational Safety and Health [CDC/NIOSH]

Analytical Grid
A preliminary grid containing the key OHS policy aspects which impact definitions and qualifications in regards to OHS Safety professionals was developed and country data incorporated. Further analysis of content was conducted to identify any similarities and/or discrepancies between country specific regulatory frame work.

Upon the development of the analytical grid and analysis of the information gathered, reference to relevant policy challenges relating to qualifications were identified within the selected country regulatory texts. Apart from Federal legislation, one state or province from Australia, United States of America and Canada were also examined. Based on the analysis, the relevance of use of an analytical grid to compare OHS qualifications related policy items is discussed.

Results
Since the establishment of the United Kingdom's Occupational Health and Safety Act in 1788, the definition of roles within OHS has been under constant scrutiny. The need to delineate between various professional groups within OHS was highlighted by Booth, Hale, and Dawson (1991) as well as the importance to look beyond individual country definitions and to establish an international aspect for OHS professional registration. This idea has grown further in recognition with OHS professional organizations seeking to establish their own definitions of OHS qualifications and is rapidly organizing into national and cross-national associations to promote and protect their professional interests. Networks such as INSHPO are actively engaged in establishing a framework clarifying the roles, functions and tasks for OHS professionals including competencies required of professionals (Pryor, Hale, & Hudson, 2015).

Some OHS definitions stated in peer reviewed literature and generally acknowledged terminology within the OHS community are;
Certification of Training
"used to indicate that the level and content of training is approved by law, a government agency, a professional body or other third party certification agency." A. Hale (1995) p. 177]

Professionals in a generalized capacity as
"people who work in a specified discipline or field as a life time career (or at least a significant part of their career), who have a deeper knowledge of that discipline of field (and, by implication, a much shallower knowledge of what lies outside of it) than others." A. R. Hale (1995), p. 235]

Safety practitioners, as "the people within a company who are regularly and directly involved in the health and safety matters of the organization" Brun and Loiselle (2002), p. 526]

Competency, as "the consistent application of knowledge and skills to the standard of performance required in the workplace." Naidu, Stanwick, Fraser, (2013), p.36]

Capability, as "the applied theoretical knowledge that underpins practice in the occupations and professions and also the industry specific knowledge and skills that transcend particular workplaces and the tactic knowledge of the workplace." Wheelahan and Moodie (2000, p. 22]

Further motivating the need for clarification, are workers' rights to having a workplace managed safely and for managers to be aware of the level of expertise they can expect from an OHS practitioner with a defined qualification. It has also been recognized within both Australia and Europe (Arezes & Swuste, 2012; Pryor, 2016; Wybo & Van Wassenhove, 2016) that there is an increasing requirement for OHS practitioners to have a higher level of education than previously required by employers due an expanding role driven by societal and legislative requirements.

The USA (Federal), Australia (Federal), Western Australia and Ontario each specify authorities who are responsible for devising and approving OHS education and training programs. The relevant Acts and Regulations though do not specify how the authorized bodies are meant to conduct this. In fact, Ontario Occupational Health and Safety Act 1990 states that the Chief Prevention Officer 'may' establish and approve training programs. This does not state specifically that it is something they 'must' do. It does also not give any indication of where the information on the requirements for OHS educational needs come from.

The United States Federal Occupational Health and Safety Act of 1970 has methodology in place which actively assesses current education provision against requirements by employers going forward. The policy gives both State and Federal governances a clear set of obligations for the provision of sufficient number of qualified OSH personnel but it doesn't indicate the level of education qualified personnel are expected to have at the end of the education program.

Australian Work Health and Safety Regulations 2011 (Cwlth), places responsibility on the Regulator but doesn't give further details about how the regulator goes about ensuring the level of education and training is sufficient. Occupational Safety and Health Act 1984 (WA) directs the Commission to take direction from the National Occupational Health and Safety Commission Act 1985 (Cwlth) in regards to establishing training courses, though this Act is no longer in force in Australia.

Some organisations have taken the steps towards establishing guidelines for the implementation of OHS professional certification, one being the Australian OHS Body of

Knowledge, which was developed after reviews were undertaken of the OHS legislation and education within Australia (Health and Safety Professionals Alliance [HaSPA], 2012). Further support towards legislation is the National Institute of Occupational Safety and Health [NIOSH] report written in 2011 which examined the supply and demand of OHS professionals as well as the competencies and qualifications required by Employers going forward. There was projected to be an insufficient supply of suitably qualified professionals to meet future demands during the following 5-year period, with the report indicating areas where improvements in training and funding for training programs need to be given (McAdams, Kerwin, Olivo, & Goksel, 2011).

Extracts from the policy analytical grid were.

Quality Control; Who devises and approves the training and education programs for OHS

USA - Federal	**Australia - Federal**	**Western Australia**	**Canada – Ontario**
Occupational Health and Safety Act (1970, s. 2.8) states the purpose of the Act is to ensure the number and competency of OHS personnel increases through the implementation of training programs.	Australia Work Health and Safety Regulations (Cwlth) (2011, p. 8, div. 1, s. 152) states one of the roles of the Regulator in relation to work health and safety is to promote and support education and training.	Occupational Safety and Health Act (WA) (1984, s. 14) seeks to promote education and training in OHS by having requirements established in regards to the formulation and accreditation of training courses for OHS.	Occupational Health and Safety Act R.S.O. 1990, CHAPTER O.1 states the Chief Prevention Officer may establish standards for training programs, approve training programs and set standards for training providers.

Type of qualification (Generic vs Specific)

Australia - Federal	**Western Australia**	**Canada - Federal**
Australia Work Health and Safety Regulations (2011, Ch. 1, Part 1.1, s. 5) is specific to working with asbestos. Specific qualifications are stated as well as requisite experience period.	OSH Act (1984 s. 14A) states in relation to the Mining Industry Advisory Committee. The committee is to set and maintain appropriate standards for OHS including education, training and training courses.	Canada OHS Regulations SOR/86-304 PART II Permanent Structures DIVISION III HVAC specifies employers are required to ensure qualified persons are employed, trained and instructed in all aspects of HVAC systems.

Australian Work Health and Safety Regulations 2011 and the Occupational Health and Safety Act 1984 for Western Australia each have legislation which are sector and risk specific. Federally, specific qualifications are required for working with asbestos and in Western Australia, the Mining Industry Advisory Committee has authority to provide advice on education and training for those working within the Mining Sector.

Canada's Federal Occupational Health and Safety Regulations SOR/86-304, states qualified people should be employed for specific system operation and maintenance but isn't specific as to required qualifications, unlike Australia in regards to asbestos. Any other mention by countries keeps qualifications generic in nature, with no specific requirements mentioned for working in areas of higher risk.

Co-operation with other authorities i.e. Health/Education

USA - Federal	**Western Australia**
Occupational Health and Safety Act (1970, s. 21.a) states consultation is required with other Federal departments and agencies in order to provide education programs which will ensure an adequate supply of qualified practitioners.	Occupational Safety and Health Act (1984, s. 14.1) states the need for cooperation between the Commission and educational authorities to devise and approve courses for OHS.

The Occupational Health and Safety Act 1984 of WA specify one of the functions of the Commission is to work in conjunction with educational authorities to produce relevant courses for OHS. Occupational Health and Safety Act of 1970 (USA), states the Secretary of Health and Human Services, should consult with other appropriate Federal departments and agencies prior to committing to grants and contracts in relation to education and training. Due to the Federal directive within the USA, it would be assumed that all States would be actively involved in providing suitable education and training for OHS Safety Professionals. The Australian Work Health and Safety Regulations 2011, does not give the same directive from a Federal level, so it may be that only Western Australia has legislation directing the liaison between Government departments.

<u>Certification: How are qualifications/training regulated or certified?</u>

USA – New York State	Canada - Ontario
Workers' Compensation Reform Law (2007, s.59-1.12) states that any consultants contracted by employers to perform workplace safety and loss prevention consultations must be certified by the Department of Labor of the State of New York. Eligibility for certification requires specific qualifications, educational degree and documented workplace experience.	Occupational Health and Safety Act (c. 11, s. 3 - 1/06/201), the Chief Prevention Officer may establish training and other requirements for committee members to become a 'certified member'

Ontario's Occupational Health and Safety Act uses the term 'certified member' in relation to committee members. There was no information found stating who a 'certified member' was, what qualifications were required, whether formal or informal.

<u>Burden of responsibility to ensure qualified persons employed</u>

UK - Federal	Australia - Federal	Canada - Federal	Canada - Ontario
The Management of Health and Safety at Work Regulations (1999, s.5.1) states the employer has responsibility for appointing competent people to assist him in complying with OHS requirements. It also states basic requirements for people to be regarded as competent.	Australian Work Health and Safety Regulations (2011, div. 4, s. 27.5.a) places the onus on officers to ensure they have up to date knowledge on all matters relating to OHS.	Canada Occupational Health and Safety Regulations SOR/86-304 states employers are responsible for ensuring qualified people are retained for operation and maintenance of specific operating systems.	Occupational Health and Safety Act R.S.O. 1990, CHAPTER O.1 gives directions to employers that when appointing a supervisor, a competent person must be employed.

Additionally, several Countries seem to place the responsibility back on the Employer to ensure they recruit OHS practitioners who have the correct qualifications. The UK Health and Safety Act 1974 and The Management of Health and Safety at Work Regulations 1999 requires Employers to hire competent people but no specifics are mentioned as to the level of training required. Occupational Health and Safety Regulations SOR/86-304 (Canada) also puts the onus back on Employers to engage suitably qualified individuals for specified systems, though again there is no specifics relating to qualification requirements. Ontario Occupational Health and Safety Act R.S.O. 1990 states the need for employing competent people for supervisory positions. Ontario classifies this as someone who is qualified because of knowledge, training and experience to organize the work and its performance. The Australian Work Health and Safety Regulations 2011 puts the responsibility of ensuring up to date knowledge of OHS requirements and continuing professional development on the individual/officer. It does not mention any responsibility on Employers to ensure suitably qualified people are employed.

<u>Definitions as a key policy challenge</u>

Comparison between acknowledged terminology within the OHS community and the generalized acceptance of terms stated within countries laws and regulations showed a lack of available information. The terms 'competence, professional, training and qualification' were accepted at some level by either Australia (Federal), Western Australia, Canada (Federal) and Ontario. All definitions given in reviewed legislation were comparable to each other. All countries researched acknowledged and defined employee/worker and employer.

Discussion

The methodology basis for this report was to review a reasonable part of the abundant and diversified academic literature in relation to the topic, OHS related websites and Government OHS Acts and Regulations in regards to education and qualifications for an employer appointed qualified OHS safety practitioner. When accessing information, it was found that not all was easily accessible, especially in regards to OHS regulations and terminology. Due to this it is acknowledged that the information provided in the analytical grid may not be complete.

As previously mentioned various national and international OHS professional organizations have developed their own framework regarding educational and experience requirements for certification. All certification appears to be on a voluntary basis and is seen by the professional bodies as a way to ensure high levels are achieved within the OHS profession. With the exception of New York, USA no other countries, states or provinces researched have integrated OHS professional organizations into their OHS Acts and Regulations. Another point raised is why is there no obvious cohesion between OHS professional bodies who have defined certification and qualification levels and government legislation. As a majority of the OHS professional bodies have already established or are in the process of establishing qualification frameworks, further research should be conducted to ascertain whether they are able to take on the role of self-regulation.

The burden of responsibility is predominantly placed on Employers to ensure they employ 'competent' and 'qualified' people to assist them with OHS in the workplace. Apart from several sector and risk specific requirements, the majority of OHS legislation from countries have no set regulations on what competencies/qualifications these people should have to fill the role of a Safety professional. Also, important to highlight is the lack of easily accessible information for Employers in regards to the different levels of qualifications, which means they may not have a full understanding of the specific requirements for employing suitably qualified people for their workplace. Further impacting this, Employers may have their own judgement on what is considered sufficient in regards to requirements on knowledge, training and experience for employing Safety professionals.

Legislation in regards to training programs for OHS professional also differs between countries. Government authorities are responsible for the instigation and on-going development of training programs but only the USA through the NIOSH funded research were found to be actively assessing projected needs by Employers for Safety professionals against those estimated numbers proposed to be in the workforce. There is also lack of information within legislation that governs the level of qualifications OHS professionals are expected to have upon completion of the training programs, regardless of education level. If Countries are able to establish given standards on graduating from a designated level course, then this will ease the burden on Employers by given explicit details on what they should expect.

Review of the researched countries terminology used in policies and legislation showed the disjointed way in which OHS industry recognized terms were used by some legislation but could not be found in other country legislation. It is acknowledged by the author that whilst every effort was made to access all Government information, sector specific terminology was difficult to find. Also of importance to compare is any differentiation between terminologies used by different OHS professional organizations.

This initial research raises the questions of who ultimately holds the burden of establishing and maintaining education and qualification levels for OHS and why are some countries and jurisdictions able to produce policies and regulations which assist in OHS qualifications, whilst others are not? Also needing further discussion is, if a formalized qualification framework was achieved throughout, how would this impact on lower socioeconomic countries and would effective regulation of the framework be able to be conducted. The countries covered in this exploratory research are all among the most developed economically, and disparity is apparent even at that level.

Many of the points raised in the report are interrelated and taking a step back and looking at what the primary needs are for OHS qualification frameworks to become legalized in paramount. The issue is one of complexity and there is not going to be one easy solution to bring this to fruition as highlighted by the amount of additional questions raised in the report.

Conclusion

It is important to note that the scope of this report is limited due to the small amount of countries examined. Further study and analysis of other Governments including the European Union OHS directives needs to be conducted to be able to gain a broader picture as to the key policy aspects relating to OHS Safety professional qualifications. Not all additional questions raised in this paper, can answered with the use of an analytical grid. For legislation purposes, it provides a comparatively easy way, once data is collated, to review the information. Furthermore, accessibility to all available OHS information is important to be able to gain an accurate indicator of challenges. Whilst this report purely looks at OHS Safety professionals within a small research group, there are many other roles within OHS which also require examination in regards to how countries OHS legislative policy may affect their education and qualification requirements.

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QUAD BIKE SAFETY: A REVIEW OF ASSOCIATED SAFETY HAZARDS

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ABSTRACT

Quad bikes have over time become a common feature throughout the Australian agricultural sector. Tragically however, over the last decade there have been at least 160 fatal incidents in Australia associated with the use of quad bikes. This article reviews contemporary research, regulator guidance and related literature to examine the hazards associated with the operation of such mobile plant and to further investigate potential mitigation strategies to reduce this notable industry issue.

Key words: Quad bikes, all-terrain vehicles (ATV), safety hazards, risk management, agricultural safety.

Introduction

The Australian agricultural sector faces a myriad of risks within a contemporary business context. One such risk, which is often underestimated by a significant number of industry stakeholders, is occupational health and safety. There is little disagreement that farming is dangerous and research from the Department of Environment and Primary Industries (n.d.) suggests that within Victoria, those with operational roles in farming are at greater risk of fatal and serious injuries than those working elsewhere, with approximately 30% of Victorian occupational fatalities occurring in farming. This is a trend that is not dissimilar nationwide, particularly given the proportionally small size of the workforce.

Whilst there are a variety of workplace hazards that impact on any farming operation, the use of quad bikes is one hazard that stands out clearly over the rest. In the period ranging from 2001 to 2012, over 160 deaths occurred on farms in Australia directly involving the use of quad bikes. Such significant incidents have positioned quad bikes as the leading cause of accidental deaths on farms (Franklin, Knight, & Lower, 2014).

With respect to this specific type of mobile plant, of the 15 fatalities occurring Australia wide in 2014, 60% of these were classified as being the result of a rollover. In 2013, 21 fatalities occurred with over 42% again being attributed to a rollover, as were over 47% of the 19 fatalities recorded in 2012. This is a trend that has been ongoing for more than a decade (Safe Work Australia, 2015).

So what exactly are the hazards and their associated impacts as they relate to this piece of mobile plant and further, what mitigation strategies and robust controls are required to significantly halt the unacceptable loss of life associated with this plant? This review is aimed at examining and reviewing contemporary research, regulator guidance and related literature to answer these questions, whilst considering such mobile plant not only in Australian operations but also within an international context.

Hazard Identification

There are obviously a myriad of health and safety hazards associated with the use of any type of mobile plant and quad bikes are no exception. The Victorian WorkCover Authority (2011) examined risk factors, vehicle selection and safe work practices as they relate to quad bikes, within the context of operational farm users. This was completed in order to provide guidance material to quad bike operators as well as farmers and other interested parties, who utilize such mobile plant in their workplaces. From this examination they explain that there are a wide range of hazards associated with this type of mobile plant, ranging from vehicle ejection, crush injuries, collision, as well as plant rollover.

Of note throughout the literature is the specific reference to and sections relating to quad bike rollovers. Deeper examination of the literature describes factors such as slope traversing, high speed operation, overloading and the carriage of unstable loads as being significant factors placing such mobile plant operators at a high risk of rollovers and associated hazards. (Victorian WorkCover Authority, 2011).

Further weight is added to this identification of hazards through Franklin, Knight and Tower's (2014) consultative development of a policy statement relating to quad bike safety in the Mount Isa area. This policy statement was developed consultatively with subject matter experts, at a themed conference on the matter. In the course of this policy development Franklin, et al. (2014), examined statistical data relating to quad bike fatalities and injuries, identifying crush injuries, plant collision and again rollovers as critical hazards associated with quad bike operation. Specifically factors influencing these hazards included speed, alcohol and drug use, load management, supervision, safety equipment, as well as training and competence.

As a significant national safety issue in the sector, the Australian Centre for Agricultural Health & Safety (2011) produced the *Safety of Quad Bikes and Side-by-Side Vehicles on Australian Farms* management guide for the agriculture sector. Within this guide the authors identify crush related injuries, plant rollovers, as well as collision and ejection from the mobile plant as critical hazard associated with farm quad bike use. The authors further identify that the majority of non-fatal incidents involving quad bikes resulted in significant blunt force trauma injuries.

Understandably, given the high frequency of crush and rollover occurrences associated with this plant, Lower and Trotter (2014) conducted research specifically relating to the use of crush protection devices as they relate to quad bikes used on dairy farms. This study focused on the rollover hazard, with the authors having identified that 46% of the 127 Australian quad bike related fatalities between 2001 and 2010 were related to rollover events. The authors further demonstrated the significance of the roll over hazard internationally, identifying that over 70% of the over 11,000 fatalities occurring in the United States of America relating to quad bikes since early 1980's were attributed to plant rollovers.

Such findings introduce an international context to the issue. Milosavljevic, et al. (2011) conducted research into the effect of the vibration hazard on operators of quad bikes in the agricultural sector. Through the monitoring of rural workers in New Zealand, the authors determined that whilst there was a range of variable such as age, work practices and physical characteristics that contributed to the impact of the vibration hazard in this mobile plant. Overall quad bike operators are exposed to mechanical shock and vibration at high levels, thus increasing their risk of sustaining musculoskeletal injuries.

In the United Kingdom, the Health and Safety Executive (2014) prepared guidance material relating to the agricultural and forestry sectors use of quad bikes from an occupational health and safety perspective, further building an international context on this issue. As the national regulator for the jurisdiction, within their assessment of quad bike safety the Health and Safety Executive clearly asserts that pedestrian vehicles and interactions, plant rollovers and crush injuries are significant hazards operators are faced with. The impacts of which, are notable blunt trauma injuries, as well as significant spinal and head injuries. Such findings , as well as those across Australia, the United States of America and New Zealand, clearly demonstrate the wide reaching impact of this hazard, demonstrating the need for effective safety management of quad bike safety hazards and associated risks.

Hazard Mitigation & Control Strategies

Having identified a variety of high risk hazards associated with the use of quad bikes, it is critical that a robust risk management methodology is applied to mitigate and control the associated risks. The Victorian WorkCover Authority (2009), having conducted their own risk assessments into this hazard, provide guidance on developing controls after giving due consideration to a four main categories of risk factors. These include equipment and attachments, operator characteristics, operator behaviours and the operating environment.

Of specific note to the most frequent and serious hazards being plant rollover and serious crush type injuries, the factors of load carriage and restraint, speed, environmental conditions and operator competence should be addressed. It was recommended more specifically that operators ensure the correct selection of “fit-for-purpose” mobile plant, implement appropriate load restraint strategies, while implementing appropriate maintenance and inspection regimes (Victorian WorkCover Authority, 2009). It was further outlined that effective risk assessment processes as well as a robust farm safety management system, would be of great value in creating sustainable solutions for this plant, as well as other workplace hazards.

Similarly, Franklin, et al. (2014) through the consultative forums in Mount Isa explored a variety of risk mitigation strategies that could be investigated further and implemented in the region. Some such risk mitigation strategies again included selecting “fit for purpose” plant, the installation of crush protection devices, including roll over protection systems and wearing approved helmets.

As seen throughout the literature, as well as the research of Franklin, et al. (2014) rollover protection systems and crush protection devices are a high order control that can be implemented with relatively positive success. Literature from Lower & Trotter (2014), examines specifically the adoption of quad bike crush protection devices on dairy farms, with overall general success from study participants, albeit with some critical barriers to implementation being identified. Such control measures however have been significant not only in terms of their effectiveness as an engineering control, but also from an awareness raising and educational standpoint.

Aside from crush and rollover type hazards, the research of Milosavljevic, et al. (2011) in New Zealand identified whole of body vibration and mechanical shock as being a notable hazard faced by operators of quad bikes. In terms of control strategies the author’s outlined a variety of mitigation strategies relating to the hazards, particularly focused on the selection of “fit for purpose” plant, the use of appropriate rear suspension systems and associated hardware, as well as more specific interventions to influence operator behaviors around the type of terrain conditions in which they operate the mobile plant.

The *Safety of Quad Bikes and Side-by-Side Vehicles on Australian Farms* (2011) management guide, like the related literature provides a range of control strategies relevant to quad bike operations in the sector. Further to this, the guide also provides a basic however robust set of risk management principles to guide interested parties with the development and implementation of risk management and hazard control strategies. Similarly to related literature recommended hazard control relating to quad bike use include correct mobile plant selection, implementation of crush and rollover protection devices, load carriage and restraint processes, maintenance and inspection regimes, training and competency programs, as well as supervision (Australian Centre for Agricultural Health & Safety, 2011). The authors further identified controls relating to the identification of “no go” areas, where terrain is not suitable for quad bike operation, again highlighting the common point that quad bikes, contrary to popular and even some industry participant’s beliefs, are in fact not all terrain vehicles.

Finally whilst quad bike hazards are a major issue in Australia, they are also commonplace internationally. Likewise the United Kingdom regulator provides guidance on control measures related to such mobile plant hazards. Again these are reasonably similar to the various Australian regulators’ guidance, being around measures to ensure relevant training, effective route planning, management of plant stability, safe work practices, as well as crush and rollover protection hardware and related controls.

Conclusion

From the reviewed literature it can clearly be seen that the most critical risks associated with quad bike operations arise from the hazards of rollover, crush, collision and whole of body vibration. Such hazards play a significant role in the devastating and disproportionate burden that such mobile plant places on the farming and agricultural sector.

Unfortunately Safe Work Australia (2014) demonstrates the ongoing and current nature of this significant hazard advising that two quad bike related fatalities had already occurred in the first three weeks of January in 2015, exemplifying the need for such hazards that are already well known, to be effectively controlled and those involved in the industry to be made aware of the severity of the impact that relates to theses.

Contemporary literature on this matter outlines a variety of specific robust and effective control measures that can be implemented in an attempt to curb the high number of fatal and serious incidents that occur from the use of this type of mobile plant both in Australia and internationally (Comcare, 2013). Further, strong safety management systems are required to outline the steps to be taken to approach the management of such hazards and their associated risks in a coordinated and sustainable manner. It can be seen however that what is also required within the industry is a strong cultural change towards risk management and occupational health and safety as a whole, but also specifically towards the operation of quad bikes and related mobile plant both occupationally and recreationally, for the benefit of the sector and all operators themselves.

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The Benefits of Incident / Accident Investigation

By Dr. Donald E. Rhodes, Ph.D., M.H.S. (1943–2014)

ABSTRACT

This article provides a good guide for people new to workplace accident investigations to use when there is a need to investigate an accident to identify the cause, contributing factors and make recommendations to prevent accidents with the same, or similar causes for occurring in the workplace. It begins by identifying the benefits of investigating accidents, determining what accidents should be investigated, who should conduct the investigation, when the investigation should be conducted, where to investigate and what to investigate. The article concludes with how to make recommendations for corrective actions to prevent the contributory factors that lead to the unsafe conditions and unsafe act. A valuable part of this article is the Supervisor's accident investigation report template that includes common accident causes and suggested corrective measures.

Key words: Accident investigation. Accident prevention.

Introduction

Maximizing production is of prime concern in most business operations. Production levels depend on the efficiency of operations. Operational efficiency and production can suffer unless all factors affecting production are tightly controlled to prevent operational errors. In industrial operations, the operational errors that cause production problems are usually the same errors responsible for injuries. An accident can be defined as "an unplanned happening of events that may or may not result in personal injury, property damage, or both". In this sense, an operational error can be viewed as an accident if it causes damage or production delay, whether or not injuries result. In any case, interference with the smooth flow of production can be expected. Accident investigations should be a vital part of any safety program. A thorough accident investigation is a necessary tool for the prevention of recurring accidents.

It is important to remember that an accident investigation is not a trial to find fault or someone to blame. The purpose is to find accident causes so similar accidents can be prevented, either by physical or mechanical improvement, or employee training and motivation. For an accident investigation program to be successful, all accidents resulting in an injury requiring medical attention or significant property damage should be investigated. In addition, all "close calls," (i.e., incidents that could have resulted in a serious injury or significant property damage) should be investigated.

What are some benefits of accident investigation?

Discover the causes of production interruptions and indicate the corrective action to be taken. Prevent accident recurrence. Eliminate the distress and suffering caused by injury. Eliminate economic losses resulting from damaged tools, machines and materials. Create an awareness of problem areas. Discover how methods and procedures can be improved. Identify areas in the current safety program that can be strengthened. Identify topics that should be included in training programs. Identify additional items to be included in future safety surveys. Relate accident costs to costs of production.

What accidents should be investigated?

This is a frequent question. Should all accidents be investigated or just those that result in serious injuries?

As an employer, managers and supervisors of all levels should be interested in any incident that causes an interruption in production. The time spent investigating an accident will vary according to: How serious it was in terms of production loss, injury, potential for future recurrence, or more serious injuries; and their complexity and extent of its causes. A minor injury accident may warrant an in-depth investigation because initial information may indicate a serious, potential hazard exists. In other words, all accidents should be investigated to some extent. The more complicated the causes and the more serious the results, the more detailed the investigation should be. In the end, it is a management decision that must be made as to what accidents will be investigated. The broader the definition management selects for "accident" and "incident", the better the chances are that the causes will be identified and the corrective action taken before a serious loss occurs.

Who should conduct the investigation?
Usually, the first line supervisor should investigate. The supervisor:
Knows the most about the employees, and the situation.
Has a personal interest in identifying accident causes (views accidents as affecting "MY" workers, equipment, materials, and operation).
Is able to take immediate action to prevent an accident from recurring.
Can communicate more effectively with the employees.

In addition, there are some direct benefits if the supervisor does the investigation as his or her involvement demonstrates concern for employees. Effective investigation reveals a supervisor's ability and capabilities to superiors. Sound investigation and corrective measures make employees feel their supervisor is in control. They will tend to take pride in working for someone who can do the job. Furthermore, it is the responsibility of the first line supervisor to ensure the existence of safe operating methods and work conditions. He or she is in constant contact with employees and should be fully aware of their attitudes, problems, and all aspects of their job performance.

When should an investigation be conducted?
While it seems obvious that accidents should be investigated immediately, often considerable time elapses before a thorough investigation is carried out. Accidents should be investigated immediately because:
Facts are fresh in the minds of witnesses and those involved in the accident.
Witnesses have not had a chance to talk and influence each other's thinking.
All physical conditions remain the same.
People are still available.
Quick response will show the employee management's concern for reporting, investigating and taking corrective action.

A report should be prepared describing the investigation in detail. All possible questions regarding the accident should be answered, and the corrective actions to prevent a recurrence listed. The following questions should be helpful in completing the report:

Who was involved? Accidents usually affect more than just the injured person, and very often, more than just the injured person contributed to the cause. Who, therefore, should go beyond who was injured and who was present? Who supervised the injured employee? Who failed to report the unsafe condition?

All of those people involved are important to the underlying cause of the accident. Get the names of everyone involved.

Where did the accident occur? Again, we must look beyond the obvious answer to this question. The name of the department is not enough. A detailed description of the accident site should be included. Also, determine if the people involved were where they were supposed to be. Was the equipment in its proper location?

What happened? This question can be further broken down to uncover the following facts:
What was being done? (The answer to this question describes an action or procedure.)
What things were involved? (A description of the tool(s) or equipment involved answers this question.)
What was the result? (This is answered by a description of the actual injury, including the nature of injury and the part of the body injured.) If a near miss, list possible results.

When? The answer to this question requires more than just the date. The time of day, the day of the week, and the time during the shift are also very important.

How did the accident occur? In order to determine or recommend what corrective action should be initiated, it must be determined exactly why the accident occurred.

The following are examples of questions that may be used to get accurate answers as to why the accident happened:
Why was the injured person inattentive?
Why was he/she poorly trained?
Why did someone fail to report an unsafe

condition or procedure?
Why did what happened produce an accident?
Why did the event result in anything other than an ordinary, everyday occurrence?

These questions, and others you may think of, will help you determine if and why an unsafe act occurred.

Where to investigate
All investigations should be made where the accident occurred. At the scene of the accident are the tools, materials, machines, employees, and circumstances that give direct evidence of, or clues to underlying causes. Investigations preferably should not be carried out in the hospital or medical clinic, in the supervisor's office, or in any place other than the scene of the accident.

What to investigate
There are a number of weaknesses in accident investigations. One primary weakness is that too often the investigator looks only at the obvious conditions and facts; often, many related causative factors go unnoticed. A thorough accident investigation involves exploring:
Unsafe practices-departure from an accepted, normal or correct procedure.
Unsafe conditions-physical defect, errors in design of equipment, tools or workstations, faulty planning, or omission of recognizing safety requirements.

Environmental factors-this may be better interpreted as ergonomic elements, that is, the relationship of employee and his workplace environment. Examples of areas to be considered in the investigation would include noise that can dull a person's senses so he is not alert to sound which could cause or warn of impending danger. Placement of controls of equipment and how they are identified could be included as well as ineffective lighting. If the accident occurs out of doors, report the weather conditions at time of accident. Indoor temperatures and the length of the shift can also be considered.
Accident agency or source of the accident-tool, material or equipment involved in order to pinpoint the corrective action.
The type of accident-manner in which the person was injured (such as by falling, by being struck by an object, or by getting caught in or between moving equipment).
Part of body affected-identify part(s) of body that incurred injury.
The personal factor-reason for the person's unsafe action or practice (such as lack of knowledge of a safe practice, disregard of instructions, physical handicap, or emotional upset).
Ergonomic factors-technique, posture or motions used, frequency of the task (per minute or per hour), weights handled and distances objects are moved (lifted from/to, distances objects pushed/pulled).

Recommended corrective action
After evaluating the facts of an accident, you will most likely find that the accident was caused by a combination of unsafe acts and/or unsafe conditions. Recommendations to prevent a recurrence should be directed toward correcting all contributing factors leading to an unsafe condition and/or unsafe act. Once you have developed recommendations designed to correct all contributing factors, your report should be submitted to top management. After the report has been submitted, it is very important to follow up with those people involved to be sure that recommended changes have taken place.

Summary
Remember, all accidents should be investigated as soon as possible. All people involved should be interviewed to determine exactly how the accident occurred. Once all the facts have been put together, a report should be submitted to top management. The report should answer the questions who, where, what, when, how, and why.


Dr. Donald E. Rhodes, Ph.D., M.H.S., WSO-CSE, CEO / Senior Managing Consultant, Behavior Safety Associates, Lakewood, California, USA. (1943–2014).

The following is an accident investigation form that has been found useful to use by the author.

<table>
<tr><td colspan="3">SUPERVISOR'S ACCIDENT INVESTIGATION REPORT</td></tr>
<tr><td colspan="2">NOTE TO SUPERVISOR:</td><td>REMEMBER AN ACCIDENT INVESTIGATION IS NOT DESIGNED TO FIND FAULT OR BLAME. IT IS AN ANALYSIS TO DETERMINE CAUSES THAT CAN BE CONTROLLED OR ELIMINATED.</td></tr>
<tr><td>Date:</td><td>Time:</td><td>Employee Involved:</td></tr>
<tr><td colspan="2">Position:</td><td>Date Employed:</td></tr>
<tr><td colspan="2">Supervisor:</td><td>Department:</td></tr>
<tr><td colspan="3">How Long Was Employee Performing This Operation?</td></tr>
<tr><td colspan="3">Was The Employee Instructed?</td></tr>
<tr><td colspan="3">Did The Accident Result In An Injury?</td></tr>
<tr><td colspan="3">Nature And Extent Of Injury?</td></tr>
<tr><td colspan="3">WHEN COMPLETING THE INVESTIGATION, TRY TO ANSWER THESE QUESTIONS:</td></tr>
<tr><td colspan="2">How Did The Accident Occur?
Where Did It Happen?
What Materials, Machines, Equipment or Conditions Were Involved?
Who Was Injured?
When Did It Happen?</td><td>Date Injury Reported:
Was First Aid Given?
If So, When And By Whom?
How Did Accident Occur?
Cause of Accident:
Recommendations To Prevent A Recurrence:
What Action Has Been Taken?
Signed:
Dept: Date:</td></tr>
<tr><td colspan="3">MAKE RECOMMENDATIONS!
NO INVESTIGATION IS COMPLETE UNLESS CORRECTIVE ACTION IS SUGGESTED.</td></tr>
<tr><td colspan="3">FOLLOW-UP
DETERMINE WHAT ACTION IS BEING TAKEN ON YOUR RECOMMENDATIONS.</td></tr>
<tr><td colspan="2">SAFETY COMMITTEE COMMENTS</td><td>EXECUTIVE</td></tr>
<tr><td colspan="2">Recommendations:
Signed:
Date:</td><td>Special Orders:
Signed:
Date:</td></tr>
</table>

CAUSES	DEFINITION OF CAUSE	SUGGESTED CORRECTIVE MEASURES
<u>ENVIRONMENTAL</u> UNSAFE PROCEDURE	HAZARDOUS PROCESS: MANAGEMENT FAILED TO MAKE ADEQUATE PLANS FOR SAFETY	JOB ANALYSIS FORMULATION OF SAFE PROCEDURE
DEFECTIVE EQUIPMENT THROUGH USE	MACHINES OR EQUIPMENT THAT HAVE BECOME ROUGH, SLIPPERY, SHARP EDGED, WORN, CRACKED, BROKEN OR OTHERWISE DEFECTIVE THROUGH USE OR ABUSE.	INSPECTION PROPER MAINTENANCE
IMPROPERLY GUARDED EQUIPMENT	MACHINES OR EQUIPMENT THAT ARE UNGUARDED OR INADEQUATELY GUARDED.	INSPECTION CHECKING PLANS, BLUEPRINTS, PURCHASE ORDERS, CONTRACTS AND MATERIALS FOR SAFETY. INCLUDE GUARDS IN ORIGINAL DESIGN, ORDER AND CONTRACT. PROVIDE GUARDS FOR EXISTING HAZARDS.
DEFECTIVE EQUIPMENT THROUGH DESIGN	FAILURE TO PROVIDE FOR SAFETY IN THE DESIGN, CONSTRUCTION AND INSTALLATION OF BUILDINGS, MACHINERY AND EQUIPMENT. TOO LARGE, TOO SMALL, NOT STRONG ENOUGH.	SOURCE OF SUPPLY MUST BE RELIABLE. CHECKING PLANS, BLUEPRINTS, PURCHASE ORDERS, CONTRACTS AND MATERIALS FOR SAFETY. CORRECTION OF DEFECTS.
UNSAFE DRESS OR APPAREL	MANAGEMENT'S FAILURE TO PROVIDE OR SPECIFY THE USE OF GOGGLES, RESPIRATORS, SAFETY SHOES, HARD HATS AND OTHER ARTICLES OF SAFE DRESS OR APPAREL.	PROVIDE SAFE DRESS OR APPAREL OR PERSONAL PROTECTIVE EQUIPMENT IF MANAGEMENT COULD REASONABLY BE EXPECTED TO PROVIDE IT. SPECIFY THE USE OR NON-USE OF CERTAIN DRESS OR APPAREL OR PROTECTIVE EQUIPMENT ON CERTAIN JOBS.
UNSAFE HOUSEKEEPING FACILITIES	NO SUITABLE LAYOUT OR EQUIPMENT NECESSARY FOR GOOD HOUSEKEEPING - SHELVES, BOXES, BINS, AISLE MARKERS, ETC.	PROVIDE SUITABLE LAYOUT AND EQUIPMENT NECESSARY FOR GOOD HOUSEKEEPING.
IMPROPER VENTILATION	POORLY VENTILATED OR NOT VENTILATED AT ALL.	IMPROVE THE VENTILATION.
IMPROPER ILLUMINATION	POORLY ILLUMINATED OR NO ILLUMINATION AT ALL.	IMPROVE THE ILLUMINATION.
<u>BEHAVIORISTIC</u> LACK OF KNOWLEDGE OR SKILL	UNAWARE OF SAFE PRACTICE; UNPRACTICED; UNSKILLED; NOT PROPERLY INSTRUCTED OR TRAINED.	JOB TRAINING
IMPROPER ATTITUDE	WORKER WAS PROPERLY TRAINED AND INSTRUCTED, BUT HE FAILED TO FOLLOW INSTRUCTIONS BECAUSE HE WAS WILLFUL, RECKLESS, ABSENTMINDED, EXCITABLE, OR ANGRY.	SUPERVISION DISCIPLINE PERSONNEL WORK
BODILY DEFECTS	WORKER HAS POOR EYESIGHT, DEFECTIVE HEARING, HEART TROUBLE, HERNIA, ETC.	PRE-PLACEMENT PHYSICAL EXAMINATIONS PERIODIC PHYSICAL EXAMINATIONS PROPER PLACEMENT OF WORKERS IDENTIFICATION OF WORKERS WITH TEMPORARY BODILY DEFECTS

Learning from past mistakes in the Australian mining industry to make a safer future.

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ABSTRACT

The aim of this study was to evaluate whether the Australian mining industry has failed to learn from past mistakes with regards to the prevention of certain types of workplace injuries. This research was conducted through a review of published literature. Research results identified that the number of serious and disabling injuries in the Australian mining industry between 2009 and 2013 had increased substantially with the mining industry in Western Australia having 1 in 144 miners and the Queensland mining industry having 1 in 219 miners permanently disabled as a result of injuries that they sustained in their workplace. The reasons why these particular types of injuries continued to have this ongoing impact were explored and were attributed to several interacting mining industry misconceptions, namely those regarding Heinrich's and Bird's Incident Triangles, focussing on unsafe acts & human error models and overlooking key aspects of Heinrich & Weaver's Domino Theories. As an outcome of the findings of this research a Triage Preventative Focus Model was developed for use by the mining industry to assist with the prevention of workplace injuries. Other recommendations included the need to analyse injury trends and sort by Category 1,2,3 type injuries; to develop safety interventions specific to the relative direct costs and downtime in lost days of each injury Category; to dedicate adequate time, energy and safety resources in proportion to each injury Category; to utilise a quality incident investigation methodology for the analysis all workplace injuries (ICAM); to focus incident investigations on identifying organisational and management system failures; to devise corrective and preventative actions with a focus on organisational and management system failures; to develop management commitment and engage all staff in improving organisational safety culture and effective safety and health systems of employee and work management. Areas for future field based research were identified.

Key words: Injury prevention. Mining industry. Workplace safety and health.

Introduction

Australia has profited greatly from mining, however the number of lives lost to the industry over the years have been both staggering and tragic. In Queensland alone, more than 1,500 people have lost their lives in disasters in both coal and metalliferous mines since European settlers began mining in Queensland in the early 19th century (QLD Department of Natural Resources & Mines, 2014).

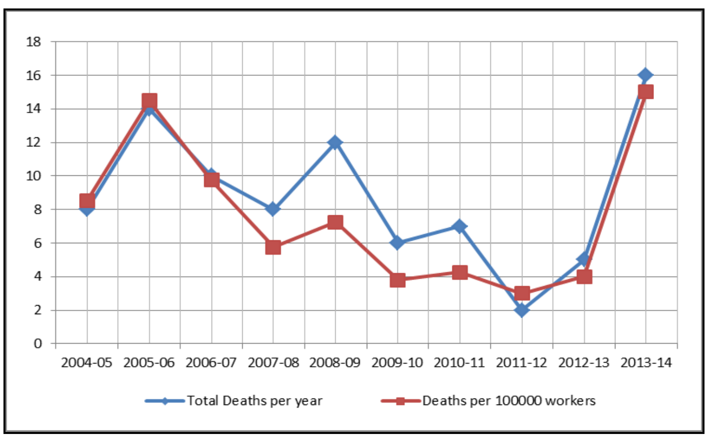


Figure 1: Mining related deaths per financial year vs deaths per 100,000 workers (Adapted from Hagemann, 2014 & SafeWork Australia, 2014).

Relative to the number of workers in the mining industry, this figure equates to a frequency rate of approximately 15 deaths per 100,000 workers (Hagemann, 2014 & SafeWork Australia, 2014). This is the highest total number of mining fatalities and the highest industry fatality rate seen since 2005-06 when 14 lives were lost and the industry experienced a fatality rate of 14.5 deaths per 100,000 workers (Hagemann, 2014 & SafeWork Australia, 2014). However, the likelihood of mine workers experiencing a permanently disabling injury is far greater.

Between 2009 and 2013, a total of 2,471 mine workers (from a work force of 90,000) sustained non-fatal permanently disabling injuries in Western Australia (WA) and another 1,262 workers (from a work force of 55,000) were permanently disabled as a result of workplace injuries in Queensland (QLD) mines during the same period (WorkCover WA, 2013 & Queensland Resources Council, 2013). Based on this data and relative State workforce sizes, the likelihood of experiencing a permanently disabling injury in either State during this period was a staggering 1 in 144 workers in WA and 1 in 219 workers in QLD. This spike in fatalities, coupled with high prevalence of permanent disabling injuries sustained within the mining sector over the past decade poses the question of whether the Australian Mining Industry has failed to learn from past mistakes when it comes to the prevention of workplace injuries. This key question forms the basis of the research aims and objectives.

Research Aim and Objectives

The aim of this study was to evaluate whether the Australian mining industry had failed to learn from past mistakes with regards to the prevention of certain types of workplace injuries.

The objectives of the research were to:

- Review current literature to determine the types of injuries with the greatest overall impact on the mining industry in terms of direct costs and production downtime from lost man hours.
- Explore the reasons why these types of injuries have continued to have a sustained prominent impact on the mining industry.
- Draw conclusions as to whether the mining industry has failed to learn to prevent these types of injuries based on what and why the industry had failed to learn
- Develop recommendations that can be used by the mining industry to prevent these types of injuries.

Research Method

The primary focus of this literature review was to identify if there was a failure to learn with regards to the prevention of workplace injuries in the Australian mining industry. Scientific databases including ProQuest and Science Direct (Elsevier) were utilised to locate recent relevant journal articles for inclusion in this study. Searches within these databases utilised the below key terms as the search criteria and returned the following results:

- 'failure to learn' – returned 1,316,440 search results in ProQuest and 143,797 in Science Direct
- 'failure to learn AND prevention of workplace injuries' – returned 24,545 search results in ProQuest and 1,418 in Science Direct
- 'failure to learn AND prevention of workplace injuries AND Australian mining industry' – returned 1,490 search results in ProQuest and 62 in Science Direct

Science Direct was found to be the most useful scientific database returning the most relevant search results specific to the search topic. ProQuest returned a much higher overall number of search results, however the returned search information was not as relevant and specific to the search topic as the articles sourced by Science Direct. The majority of journal articles returned by both databases were published between 2000 and 2009. Some of the reviewed publications were published by the same collaboration of authors, although a different first author was used. For publications that had similar information only the most recent publication was used. The Curtin University library database was also utilised to identify additional book publications on the different predictive models and theories regarding workplace incidents and injuries. Of the filtered search results a total of 44 relevant journal articles and 14 book publications most applicable to the topic were used for this research.

Results

Categories of injuries

To answer the research aim and objectives the issue of the notion of personal injury was first simplified and categorised into the subsets of Category 1, 2 and 3 injuries as shown in figure 2.

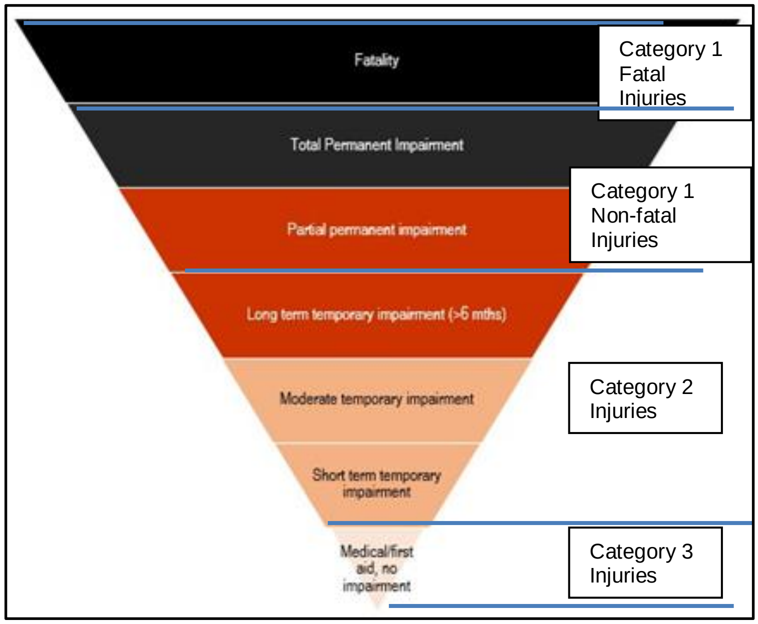


Figure 2: Categorisation of Work Related Personal Injury Types (Adapted from O'Neill, Martinov-Bennie, & Cheung 2013)

Category 1 injuries comprise those of a permanent life changing nature that can be either fatal injuries (inclusive of single or multiple fatalities) or non-fatal permanent disabling (PD) injuries (including but not limited to paralysis, amputation, disfigurement and psychological damage). Non-fatal PD injuries carry with them long term implications whereby in serious cases a worker either cannot return to work in any capacity or in less serious cases the worker is only able to return to work in a limited or permanently altered capacity.

Category 2 injuries are those of a temporary reversible nature and may include but are not limited to such injuries as sprains, strains, fractures, deep cuts and abrasions. In the case of Category 2 injuries, a person is fully able to recover from and return to full normal work duties after a designated period of time through means of appropriate treatment and a tailored graduated return to work program. The mining industry commonly associates Category 2 type injuries with Lost Time Injuries (LTI) or Restricted Work Injuries (RWI).

Category 3 injuries are those of a minor and superficial nature that may include superficial bruising, minor cuts and abrasions. Category 3 injuries are adequately treated with minor first aid or medical treatment and these types of injury are commonly referred to by the mining industry as Medical Treatment Injuries (MTI) or First Aid Injuries (FAI). The following table shows the impact of the three above-mentioned categories of injury in Australia?

Table 1: Percentage Distribution of Total Cost of Personal Injury to Australian Industry by financial year (Adapted from WHSIC, 1995; NOHSC, 2004; ASCC, 2009; O'Neill et al., 2013; & World Bank Group 2014).

Year	1992-93	2000-01	2005-06	2008-09
Cost of Category 1 Fatal Injuries as a percentage of Total Injury Cost	1.5%	3.5%	3.3%	5.3%
Cost of Category 1 Non-Fatal Injuries as a percentage of Total Injury Cost	80.5%	88.5%	88.0%	85.2%
Cost of Category 2 Temporary Reversible Injuries as a Percentage of Total Injury Cost	18.0%	8.0%	8.7%	9.5%
Total Cost of Category 1 & 2 Injuries to Australia (AU$Billion)	$20	$34.3	$57.5	$60.6
Australia GDP* Value (AU$Billion)	$463.5	$739.3	$872.5	$1,275.2

*Note: Gross Domestic Product (GDP) measures the national income and output for a given country's economy. The gross domestic product (GDP) is equal to the total expenditures for all final goods and services produced within a country in a stipulated period of time.

The combined total cost of all Category 1 and 2 injuries to Australian workplaces over the past two decades has increased from AU$20Billion per year in 1992-93 up to a staggering AU$60.6Billion per year in 2008-09 (WHSIC, 1995, & O'Neill *et al.*, 2013). This equated to approximately 4.3% of Australia's AU$463.5Billion Gross Domestic Product (GDP) in 1992-93 and 4.8% of Australia's AU$1.275Trillion GDP in 2008-09 (WHSIC, 1995, O'Neill *et al.*, 2013, & World Bank Group, 2014).

What the mining industry has failed to learn is the magnitude, specific nature and pattern of the Category 1 non-fatal PD injury issue in Australia. There is a need for further detailed studies to more adequately address these failed industry learnings and help prevent these types of injuries going forward. In identifying what it is that the mining industry has failed to learn with regards to Category 1 non-fatal PD injuries, the other key question to be addressed is *why* it is that the mining industry has failed to make these learnings?

<u>Factors influencing why the Australian mining industry has failed to learn</u>

There are several interacting factors that potentially influence why it is that the mining industry has failed to learn from Category 1 non-fatal PD injuries over the years. The first of these involve the Heinrich Loss Control Triangle, originally developed in 1959.

Heinrich's Model

In Heinrich's original 1959 study of approximately 75,000 workplace injury insurance claims he analysed a total of 330 workplace accidents of a similar cause and nature and revealed a unique inherit pattern to these incidents (Heinrich, 1959). Heinrich demonstrated that for every 330 incidents of a similar cause, 1 incident (0.3%) would result in a major injury, 29 incidents (8.8%) would result in minor injuries and the remaining 300 incidents (90.9%) would result in no visible injury or damage (near misses). The resulting pattern of incident distribution (300-29-1) was used to create Heinrich's Triangle as shown in figure 3 below (Heinrich, 1959).

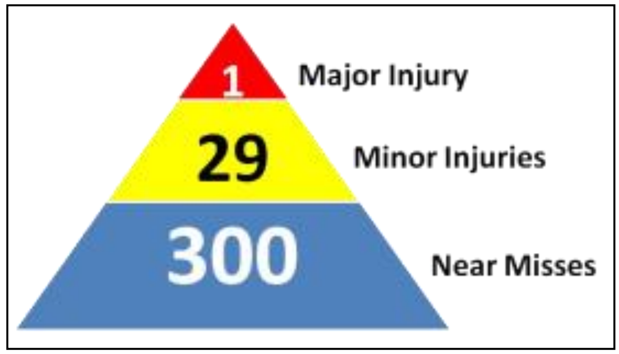


Figure 3: Heinrich's Accident Ratio Triangle (Adapted from Heinrich, 1959).

Bird's Model

Ten years later Frank E. Bird reproduced a more widely recognised version of this accident ratio model in 1969, with the development of what is now known as Bird's Triangle shown in figure 4 (also known as Bird's Accident Ratio Triangle, the Safety Triangle or the Accident Pyramid) (Bird, 1992).

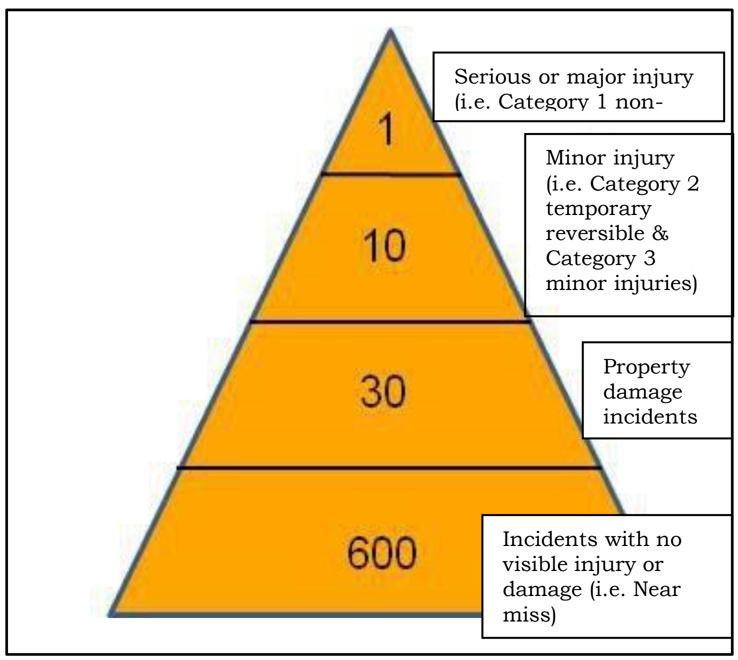


Figure 4: Bird's Accident Ratio Triangle (Adapted from Bird, 1992).

In the development of this model, Bird undertook a far more comprehensive study of workplace accidents and injuries, analysing approximately 1.75 million workplace accident reports in the process (Bird, 1992). In comparison to the 300:29:1 ratio put forward by Heinrich, Bird proposed a ratio of 600-30-10-1 (Bird, 1992). For example, for every 641 workplace incidents, 600 of these incidents will be near miss with no visible property damage or injury, 30 will be property damage incidents, 10 incidents will result in minor injury and 1 incident will result in a serious or major injury (Bird, 1992). Bird hypothesised that, given the distribution of incidents in the 600-30-10-1 ratio, it would make more sense for organisations to dedicate the majority of their time, effort and resources to the prevention of near miss and property damage type incidents that accounted for the majority of all workplace incidents, rather than wasting time and effort on trying to prevent the relatively few serious incidents or major injuries (Bird, 1992).

Bird's incident triangle encompasses two well recognised safety performance measures that are widely used throughout the mining industry to this day, namely near misses and *lagging* safety indicators (property damage, minor and major injuries) (Petersen, 1989). Historically the mining industry has focused heavily on the status of near misses and lag indicators to gauge site safety performance and provide a means of identifying and prioritising the critical areas to allocate resources to and concentrate preventative efforts on (SafeWork Australia, 1994).

Misconceptions regarding Bird's Incident Triangle

Over the years a number of industry misconceptions have formed regarding the application of Bird's incident triangle. For example, managing and concentrating preventative efforts on near miss incidents at the base of Bird's triangle will also address and help prevent the serious / major injuries as the top of the triangle (Petersen, 1996). Secondly, measuring safety performance based on minor (Category 3) injuries at the lower quadrant of the incident triangle will gauge the overall effectiveness of implemented injury prevention controls (McDonald, 1994). So how does the mining industry Category 1, 2 and 3 injury data analysed compare with these industry misconceptions?

A recent study by O'Neill *et al.* (2013) examined the Category 1 non-fatal PD injury issue in closer detail. The findings of this study are presented in the following figures 5 and 6 that depict the total numbers of workers affected by Category 1, 2 and 3 injuries from an injury compensation perspective (O'Neill *et al.*, 2013). With reference to figure 5 it is clear that Category 2 temporary reversible injuries affect the greatest number of people overall (285,600 in 2008-09). However, the study by O'Neill *et al.* (2013) also illustrates a very different trend in terms the number of weeks lost to each Category of injury, and the significantly high number of compensated weeks lost to Category 1 non-fatal PD injuries (5,434,920 weeks lost) as shown in figure 6.

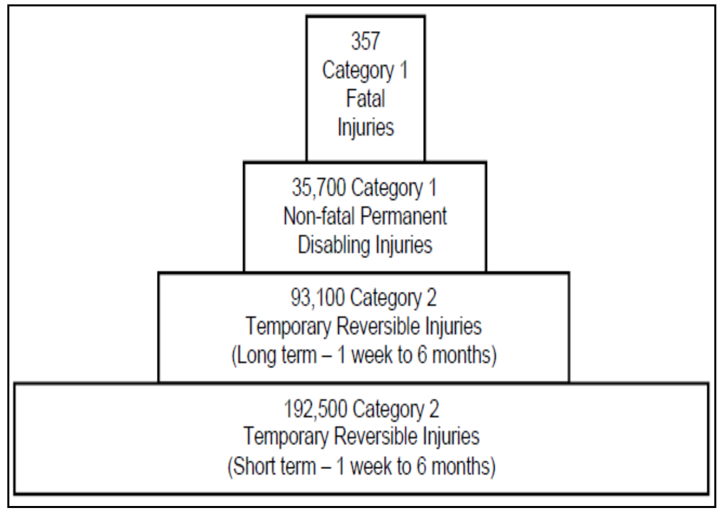


Figure 5: Total Number of Compensated Category 1 & 2 Injuries for all Australian Industries - 2008-09 (Adapted from O'Neill et al., 2013).

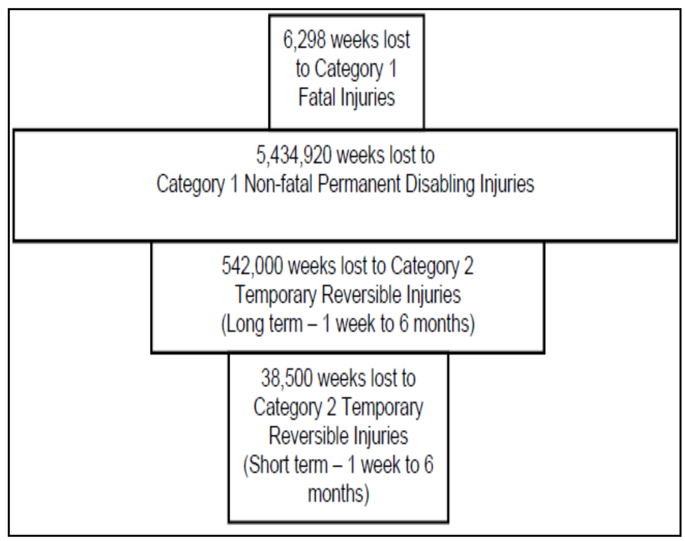


Figure 6: Total Compensated Weeks Lost to Category 1 & 2 Injuries for all Australian Industries - 2008-09 (Adapted from O'Neill et al., 2013).

The evidence examined so far demonstrates that over the past decade both the total numbers and relative cost of Category 1 non-fatal PD type injuries to Australian industry have increased dramatically and that the likelihood of an Australian worker experiencing this type of injury remains relatively unchanged despite the advances in and more stringent application of workplace health and safety management principles (Bottomley, 2000). Furthermore, Category 1 non-fatal PD injuries are rarely the focus of Australian organisations as these organisations tend to focus more on the analysis, reporting and prevention of Category 2 and 3 type injuries (Comcare, 2004). These initial observations suggest that current industry approaches to the prevention of Category 1 non-fatal PD injuries are less than adequate.

Based on the evidence it would be logical to assume that Australian organisations should focus the majority of their preventative health and safety efforts (i.e. 80% or more) in terms of time, resources, workplace inspections, workplace interactions, health and safety management system content and safety leadership behaviours to the prevention of Category 1 type injuries, inclusive of single fatalities, multiple fatalities and non-fatal PD injuries (SafeWork Australia, 2012) as the pattern of compensated injury distribution does not necessarily conform to the Bird triangle model, i.e. the pattern for the total number of compensated Category 1 and 2 injuries shown in figure 5 does not match up with the pattern for total compensated weeks lost to these types of injury as shown in figure 6. The patterns of each type of injury (Category 1 and 2) are clearly not uniform with one another hence the frequency of one type of injury cannot be used as a reliable method to predict the frequency of another. Any intervention targeted at preventing Category 2 or 3 type injuries at the lower levels of the incident triangle will not necessarily prevent or reduce the frequency of Category 1 type injuries.

An example of this would be a low-level safety intervention specifically targeting the prevention of hand injuries, which are a common minor (Category 3) injury in the mining industry (Blewett, 1994). In this scenario, commonly implemented controls might include enforcement of a gloves policy whereby mine workers must wear gloves at all times in all areas where they would be required to wear their hardhats (Blewett, 1994). The safety intervention may also include educating mineworkers to keep their eyes on hands when performing tasks and to remove gloves whenever working around rotating parts (Blewett, 1994). However focusing the majority of safety energy and resources on the prevention of minor hand injuries will not necessarily also address the prevention of injuries at higher levels of the triangle (i.e. Category 1 type fatal and non-fatal PD injuries) and doing so may result in the prevention of these more critical types of injuries being overlooked (Glendon, 2009). Low level interventions can therefore not be assumed to have any impact on injury types at other levels of the incident triangle and thus the prevention of higher level injuries must be dedicated sufficient effort and resources independently of any lower level interventions.

Based on these observations and the injury data provided it is clear that Bird's incident ratio triangle is more a descriptive than inferential statistic (SafeWork Australia, 2013). The reduction in frequency of Category 3 type injuries as a result of a tailored safety intervention would only be applicable to and representative of this Category of injury and could not be generalised to the prevention of or predicted change in frequency of any other Category of injury. The results from implementation of the above example intervention targeting Category 3 type injuries at the base of the incident triangle, could not be used to infer what results might be observed at the upper levels of the incident triangle. These misconceptions regarding the application of Bird's incident triangle are no doubt part of the reason why the mining industry has failed to learn, particularly in the case of Category 1 non-fatal PD injuries. However, in comparison to the consistently high proportion of Category 1 non-fatal PD injuries relative to the other types of injury, a clear progressive downtrend in industry fatalities can be observed over the past two decades as shown in figure 7.

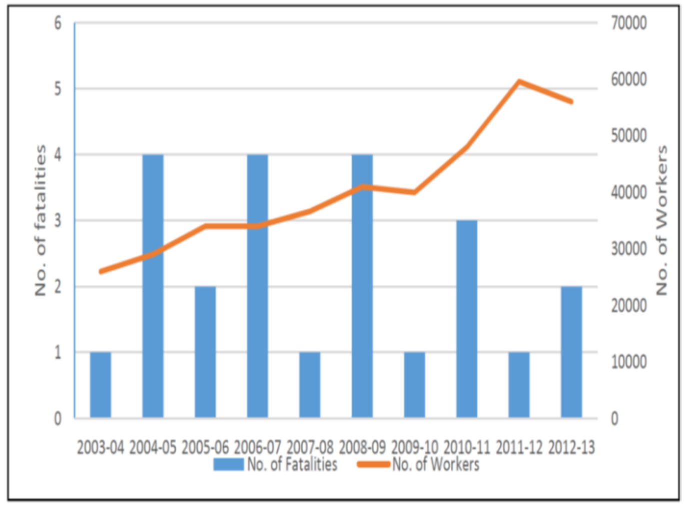


Figure 7: Fatalities versus Total Employment Numbers in Queensland Mining, 2003-13 (Adapted from Queensland Department of Natural Resources and Mines, 2013)

This suggests the mining industries failure to learn is more applicable to the high occurrence of Category 1 non-fatal PD injuries than that of Category 1 fatal injuries. There are however, other interacting factors contributing to the mining industries failure to learn, including the notion that the majority of incidents occur as a result of human error (ASCC, 2005).

<u>Misconceptions regarding Unsafe Acts & Human Error Models</u>

A popular misconception that the modern day mining industry has embraced as fact is the theory that unsafe acts and human error accounts for approximately 90% of all workplace incidents (McDonald, 2006). This theory infers that the majority of incidents can be solely attributed to the unsafe acts of a single person as the root cause (McDonald, 2006). This notion of human error incident causation originated from Heinrich's early studies where he proposed that 88% of all workplace incidents were caused by the unsafe acts of people (Heinrich, 1959). Hence the emergence of the 88:12 incident ratio model that suggested 88% of all incidents were caused by workers unsafe acts and human error, 10% could be attributed to inherit unsafe physical mechanical or conditions and the remaining 2% were unavoidable as shown in figure 8.

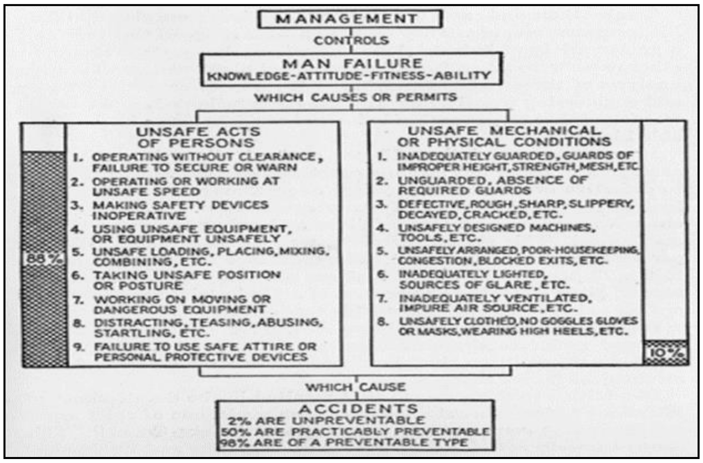


Figure 8: Heinrich’s Human Error Incident Causation Model (Heinrich, 1959, p.252).

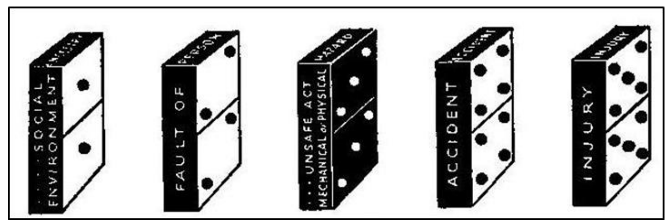
Many revised adaptions of this human error incident causation ratio have been published over the years, all of which tend to hover around the 85-90% human error figure (Hopkins, 1994). Bird’s incident triangle and the progressive evolution and popularity of the various human error incident causation models throughout the mining industry have paved the way for the modern day incident investigation process (Work Health & Safety Industry Commission, 1995). However, many incident investigations unfortunately have the tendency to focus heavily on the actions of the individual involved in an incident and devise the majority of corrective actions based on this selective focus (Frederick & Lessin, 2000). For example, an incident investigation finding based on an individual’s unsafe behaviour might be ‘operator failed to give way at intersection.’ A resultant behaviour orientated system related finding identifying the organisational failures that led to the individual making this mistake might be ‘site wide culture of rolling through stop signs’ (Petersen, 1989). By focusing on the individuals unsafe behaviour as the root cause the resultant actions might include behavioural based actions such as “coaching of operator on mine traffic rules”, “site disciplinary process to be followed with operator”, and “reinforcement of mine traffic rules to crews at pre-start meetings” (Petersen, 1989).

Individual perception of the term ‘unsafe’ will vary widely from person to person. What one individual considers to be unsafe will not necessarily be shared by another (Collins, 2013). Use of such terminology creates bias and convolution in an investigation process that is based on linking key investigation findings back to the “unsafe” acts of an individual (Gilovich, Griffin, & Kahneman, 2002). In order to consider the term “unsafe” to be an appropriate measure within an investigation process, the term itself must be must be valid, reliable and relevant, that is: it measures what it purports to measure (valid); the measure is closely connected or appropriate to the matter in hand to allow for informed decision making (relevant); and the measure is complete, free from omission, bias, error and produces similar results under consistent conditions (reliable) (Straus & Haynes, 2009).

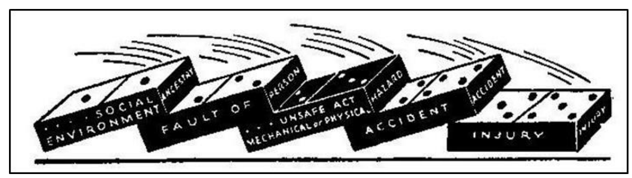
Hence, an incident investigation measure based on individual perception of the term ‘unsafe’ is not a valid, reliable and relevant measure (Gilovich *et al.,* 2002). The mining industries preoccupation and focus on unsafe acts as part of the incident investigation process is yet another reason as to why the industry has failed to learn from past mistakes.

Heinrich & Weaver’s Domino Theories

Incorporation of Heinrich’s human error incident causation ratio, along with the concepts of unsafe acts and conditions were also depicted in Heinrich’s domino theory (refer figure 9) and Weaver’s revised domino theory (refer figure 10) (Heinrich, Petersen and Roos, 1980).



a) The five domino factors in the accident sequence



b) Injury is caused by the action of the preceding factors (dominos)

Figure 9: Heinrich’s Domino Theory (Heinrich, 1959, p.327-328).

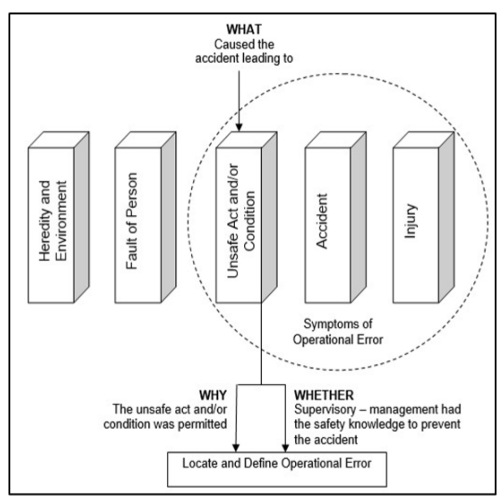


Figure 10: Weaver’s Revised Domino Theory (Heinrich, Petersen & Roos, 1980, p.29).

With reference to figures 9 and 10, a key point to note in these models is that an injury is caused by action of all preceding factors. A person is not injured solely as a result of their unsafe acts, it is the result of the preceding organisational and management system failures that allowed the right conditions leading up to the point of incident.

A major issue with the modern day mining industry is that these preceding organisational and management system failures have a tendency to be overlooked with incident investigations primarily focusing on the unsafe acts of individuals as the root cause of injury (Cedergren, 2013). The injured person was simply the last link in the chain of events allowing the incident to occur hence the worker is blamed for the incident. Overlooking other key aspects of the domino theory during the incident investigation process is another reason why the industry has failed to learn.

Reason's Swiss Cheese Model

Heinrich and Weaver's Domino theories later gave rise to Reason's Swiss cheese model of human error causation (1990) as shown in figure 11. This model again reinforces the organisational and management system failures preceding the unsafe acts of people as the last point in the chain of events allowing an incident to occur (Reason, 1990).

Figure 11: Reason's Swiss Cheese Model (MacLeod, 2010, p.1 adapted from Reason, 1990).

Refocussing Incident Investigation Outcomes for Prevention of Workplace Injuries

As shown in figure 12, the root causes of most category 1 and 2 incidents can be traced back to organisational and management system failures over which the worker had no control (Hale & Hovden, 1998). From figure 12 it can be seen that unsafe acts are situated at the causal level of an investigation, but not at the root cause level. A quality incident investigation methodology must be utilised to analyse the incident in enough depth to identify the actual root causes that allowed the incident to occur in terms of the organisational and management system failures.

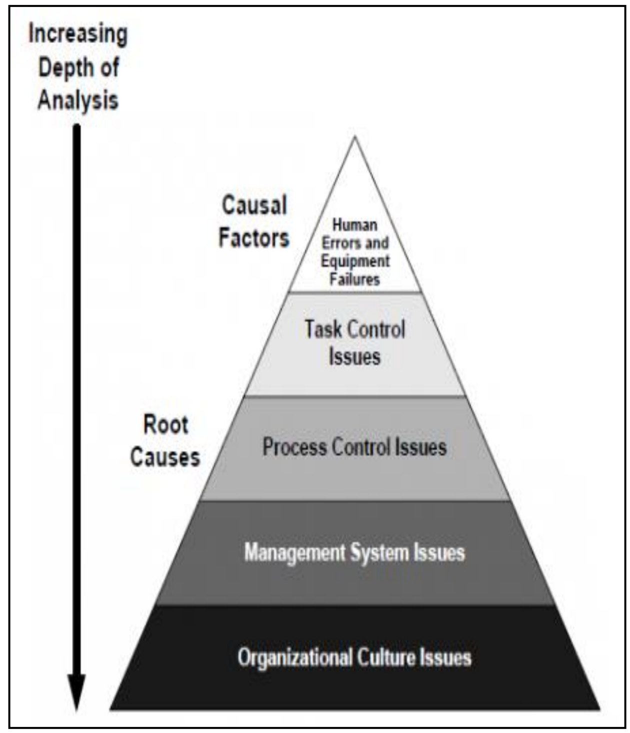


Figure 12: Incident Investigation Levels of Analysis Model (Hale & Hovden, 1998, p.131).

Hence it is critical for modern day mining operations to ensure a quality incident investigation methodology is utilised to ensure sufficient depth of investigation to identify inherit organisational and management system failures as root causes, rather than human error. An example of one such investigation methodology that focusses on organisational and management system failures rather than the unsafe acts of an individual is the Incident Cause Analysis Method (ICAM) as shown in figure 13.

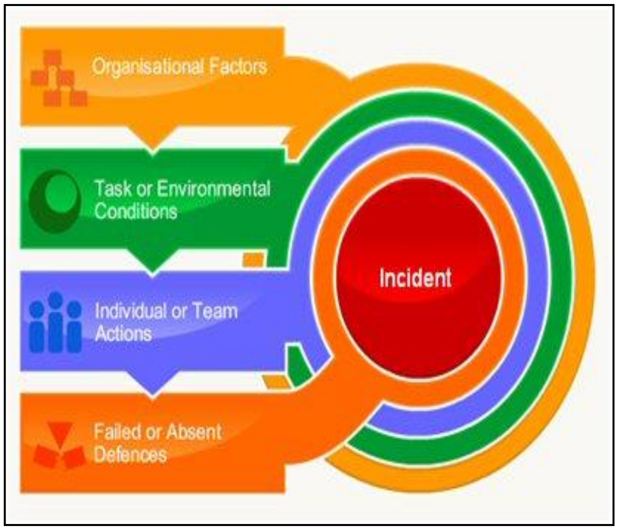


Figure 13: ICAM Incident Investigation Model (University of Queensland, 2014, p.1).

Establishing a Positive Safety Culture for the Prevention of Workplace Injuries

Lastly, the use of lagging (reactive) indicators such as refocussing incident investigations to identify inherit organisational and management system failures as root causes are useful in preventing future injuries from the learnings of past incidents. However, reactive incident prevention models are not appropriate for the prevention of higher level incidents such as fatalities, explosions, or other major catastrophic events which may not have necessarily occurred in the past (Drupsteen & Hasle, 2014).

With regards to these types of higher level incidents, leading safety indicators must also be adopted to prevent these types major incidents and injuries altogether through developing and increasing the maturity of organisational safety culture (Step Change in Safety, 2003). Doing so will allow for proactive management of the three lower organisational, management and process factors identified in figure 12 and hence prevent higher level incidents without having to learn from past events (Step Change in Safety, 2003).

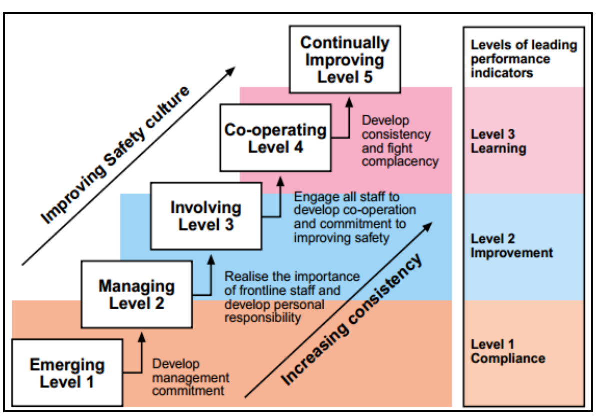


Figure 14: Safety Culture Maturity Model (Step Changes in Safety, 2003, p.6).

The safety culture maturity model shown in figure 14 depicts the relationship between the five levels of organisational safety culture maturity and the three levels of leading performance indicators, namely level 1 (compliance culture), level 2 (improvement culture), and level 3 (learning culture) (Chiri, 2014). Within this model, an organisation will progress through increasing levels of safety culture maturity in a continuous improvement process. The issues most important for improving safety performance and the specific actions that will assist an organisation in progressing to the next level of maturity are different for each level of maturity (Chiri, 2014). Application of this model allows each of the five levels of safety culture maturity to be matched against the three levels of leading performance indicators (Chiri, 2014). The use of leading indicators allows the lessons learnt about the root causes of serious and disabling injuries to have risk control measures implemented, workplace safety compliance and learning continually improved and measured through the use of leading indicators to assist with preventing work related accidents reoccurring.

Conclusions and recommendations

As a result of this review of published literature to meet the research aim and objectives the following conclusions and recommendations are made.

Conclusions

The aim of this study was to evaluate whether the Australian mining industry had failed to learn from past mistakes in the prevention of certain types of workplace injuries. This was achieved through identifying which specific types of workplace injuries have consistently had the greatest overall impact on the mining industry and exploring the reasons why these particular types of injuries continue to have this ongoing impact. This study has demonstrated that Category 1 non-fatal permanent disabling type injuries consistently account for more than 80% of all Australian work related injury costs. This trend has remained consistent for the past twenty years. This type of injury also accounts for the greatest number of compensated weeks lost from work of all categories of injury in Australia. In 2008-09 the number of compensated weeks lost to Cat 1 PD injuries was nearly ten times greater than the number of weeks lost to Cat 2 temporary reversible type injuries. For this reason, what the mining industry has failed to learn is how to prevent this type of injury from occurring, hence meeting both the overall aim and objective 1 of the study which was to 'review current literature to determine the types of injuries with the greatest overall impact on the mining industry in terms of direct costs and production downtime from lost man hours.'

Research objective 2 was to 'explore the reasons why these types of injuries have continued to have a sustained prominent impact on the mining industry.' Objective 3 was to 'draw conclusions as to whether the mining industry has failed to learn to prevent these types of injuries based on what and why the industry had failed to learn.' Conclusions based on the achievement of objective 3 are that the reasons why these types of injuries have continued to have a sustained prominent impact on the mining industry were due to several interacting mining industry misconceptions; namely those regarding Heinrich's and Bird's Incident Triangles, as prevention actions commonly focused on unsafe acts & human error models and overlooked key aspects of Heinrich & Weaver's Domino Theories. From the findings of achieving both objectives 2 and 3 it is clear that the mining industry has failed to learn how to prevent Category 1 permanently disabling injuries. Achievement of objectives 1 and 3 have identified and provided justification as to what, and the reasons why, the industry has failed to learn.

Study objective 4 was to 'develop recommendations that can be used by the mining industry to prevent these types of injuries.' Following are the recommendations developed to achieve this objective.

Recommendations

Based on the research findings, there are a number of recommendations put forward by this study as part of achieving the 4th research objective that should be adopted by the mining industry to prevent workplace injuries. These are:

1. Analyse injury trends and sort by whether they are Category 1, 2, or 3 type injuries.
2. Develop safety interventions specific to the relative direct costs and lost days in downtime of each injury Category.
3. Dedicate adequate time, energy and safety resources in proportion to each injury Category.
4. Utilise a quality incident investigation methodology for all workplace injuries (ICAM).
5. Focus incident investigations on identifying organisational and management system failures.
6. Devise corrective and preventative actions from incident investigations with a focus on organisational and management system failures.
7. Develop management commitment to improve organisational and management system safety culture.
8. Engage all staff to develop interdependent cooperation and commitment to improving organisational and management system safety culture.
9. Develop consistency and fight complacency to continually improve organisational and management system safety culture.
10. Implement the Triage Preventative Focus Model (as shown in figure 15) for the Prevention of Workplace Injuries (including Category 1 non-fatal permanent disabling injuries).

Explanation of the Triage Preventative Focus Model

Based on the research findings the Triage Preventative Focus Model was developed for use by the Australian mining industry with the intent of preventing workplace injuries. See Appendix one for the Triage Preventative Focus Model diagram. The model comprises of three distinct areas of preventative focus that are each complementary of one another. Each focus area must be simultaneously addressed by organisations within the mining sector in order to assist them with the prevention of workplace injuries. The three distinct preventative focus areas comprise of:

- Lagging Proactive Preventative Focus
- Lagging Reactive Preventative Focus
- Leading Indicator Preventative Focus

Lagging Proactive Preventative Focus, the first component of the Triage Preventative Focus Model, has been developed for organisations within the mining sector to address the identified industry misconceptions regarding Heinrich's and Bird's Incident Triangles, and the industries tendency to focus on unsafe acts & human error models. It encompasses three main steps. The first of which is for an organisation to proactively analyse current lagging injury trends and to sort them by injury Category, i.e. whether they are Category 1, 2, or 3 type injuries. The next step is for the organisation to develop safety interventions that are specific to the relative direct costs and downtime (days lost to injury) of each injury Category analysed in the previous step. The final step involves the organisation dedicating adequate time, energy and safety resources in proportion to each analysed injury Category and in doing so prevent workplace injuries.

The second component of the Triage Preventative Focus Model is *Lagging Reactive Preventative Focus* which addresses the identified issue of the mining industry overlooking key aspects of Heinrich and Weaver's Domino Theories and incorporates the research findings regarding refocussing of incident investigation outcomes for the prevention of workplace injuries. The first step in the three step Lagging Reactive Preventative Focus process involves organisations utilising a quality incident investigation methodology for the reactive investigation all workplace injuries (i.e. ICAM methodology). The next step is ensuring the key focus of the incident investigation is the identification of organisational and management system failures. The final step in this process is devising corrective and preventative actions that focus on organisational and management system failures as an outcome of the incident investigation, the implementation of which will impact positively on the prevention of workplace injuries in the mining sector.

The final component of the Triage Preventative Focus Model, *Leading Indicator Preventative Focus,* is derived from the findings of Chiri (2014) and involves organisations within the mining sector establishing a positive safety culture for the prevention of workplace injuries. The first step in this process is for an organisation to develop management commitment to improve its overall organisational and management system safety culture. Next is for the organisation to engage all staff to develop interdependent cooperation and commitment to improving the organisational and management system safety culture. The final step in this process is for the organisation to develop consistency and fight complacency to continually improve its organisational and management system safety culture. Following this process will result in an improvement in organisational safety culture and hence prevent workplace injuries that occur as a result of poor safety culture. Based on the findings and recommendations of this research, it is anticipated that implementation of this model by organisations in the mining sector will assist them in the prevention of workplace injuries.

Based on the identified limitations of this study a number of future studies are recommended to further industry knowledge in the prevention of workplace injuries. These comprise of:

- Studies on the workplace injury statistics of other countries and/or industries to compliment the review of current literature based on the Australian mining industry.
- Obtain post 2009 NSW injury data to allow for full comparison to other Australian States for years of 2009-2013 and beyond.
- Obtain Compensated weeks lost data specific to the Australian mining industry.
- Obtain injury data for analysis of Category 3 type injuries in Australia.
- Research the patterns of causes of Category 1 non-fatal PD injuries in the mining industry.
- Field based studies to compliment the review of published literature on the topic.
- Field based testing of the proposed model (Figure 15) to confirm its effectiveness and usability.

The findings of this research, including the Triage Preventative Focus Model developed to investigate and prevent workplace injuries, have international application as they can be used in all industries and countries throughout the world through the promotion and guidance of the United Nations Economic and Social Council to improve workplace safety and prevent work related ill health.

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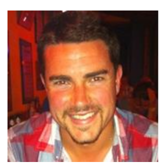

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Appendix 1

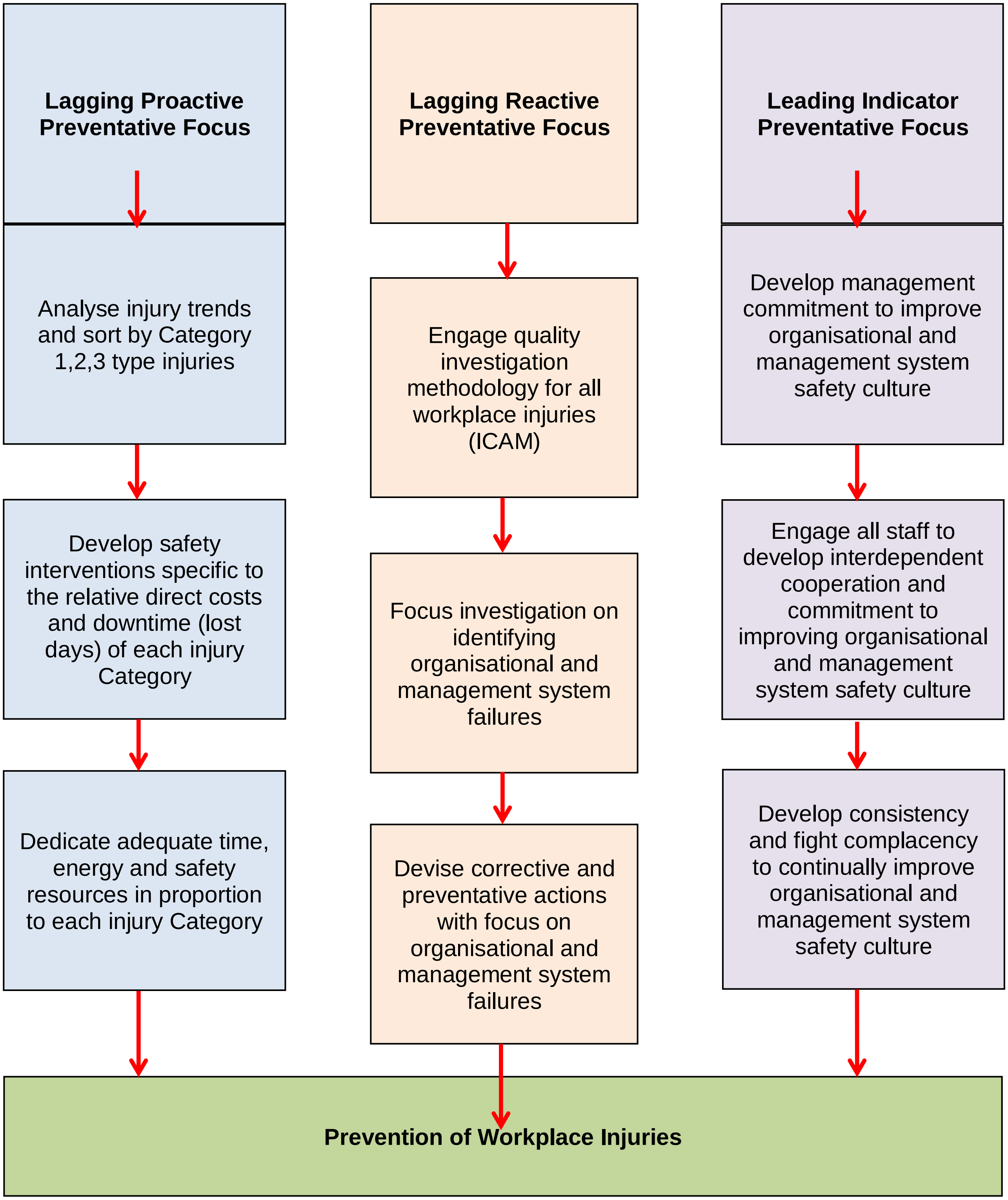

Figure 15: Triage Preventative Focus Model

World Safety Organization

Code of Ethics

Members of the WSO,
by virtue of their acceptance of membership
into the WSO,
are bound to the following Code of Ethics
regarding their activities
associated with the WSO:

Members must be responsible for
ethical and professional conduct in relationships
with clients, employers, associates, and the public.

Members must be responsible for professional competence
in performance of all their professional activities.

Members must be responsible
for the protection of professional interest,
reputation, and good name of any deserving WSO member
or member of other professional organization
involved in safety or associate disciplines.

Members must be dedicated to professional development
of new members in the safety profession
and associated disciplines.

Members must be responsible
for their complete sincerity in professional service
to the world.

Members must be responsible for continuing improvement
and development of professional competencies
in safety and associated disciplines.

Members must be responsible
for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

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