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Estimating the true number of work-related fatalities due to injury: The traumatic injury fatalities dataset

Sophie I. Lindquist¹, Alison J. Yardley¹, Fleur E. Champion de Crespigny¹

Abstract
The Work-related Traumatic Injury Fatalities (TIF) dataset provides the best estimate of the number of work-related fatalities that occur due to injury in Australia each year. Safe Work Australia compiles this dataset annually, with its statistics used to inform a number of reports regarding work health and safety within Australian workplaces including the Australian Work Health and Safety Strategy, 2012-2022. The TIF dataset is compiled from three sources of work-related fatality data; the National Coronial Information System (NCIS), the National Dataset for Compensation-based Statistics (NDS) and the Notifiable Fatalities Collection (NFC), which enables coverage of the entire Australian workforce. The contribution that each data source makes to the overall estimate of traumatic work-related fatalities is different, with almost all work-related fatalities identified in the NCIS and around half in the NDS and the NFC. However, notwithstanding some limitations, the TIF dataset provides the best estimate of work-related fatalities in Australia, provides a resource for researchers and enables the Australian Government and State and Territory regulators to make informed policy decisions to help to make Australian workplaces safer.

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Introduction
An accurate count of work-related fatalities is important in the development of effective preventive action by regulators and employers. This paper describes the utility of the Work-related Traumatic Injury Fatalities (TIF) dataset in providing an estimate of the total number of work-related fatalities due to injury in Australia. It describes the data sources used and explains the methodology used to compile this dataset.

The information in the TIF is compiled from a number of sources: workers’ compensation data, notified fatalities, coronial information and the media. By combining available sources of work-related fatality data, the TIF database provides Australia’s best estimate of work-related fatalities.

The database also contains information on bystanders killed as a result of another person’s work activity. However, these data are believed to be understated due to the difficulties in identifying these occurrences.

Annual reports from this database have been published by Safe Work Australia since 2003. Data from the TIF database are also featured in the Comparative Performance Monitoring Report (e.g. SWA, 2012 a), industry fact sheets and other thematic publications that are available on the Safe Work Australia website.

Establishment of the TIF has revealed the inadequacy of only using workers’ compensation data as a measure of work-related deaths. As a result the TIF will be used to measure performance relative to the fatalities target in the Australian Work Health and Safety Strategy 2012-2022 (the Australian Strategy) (SWA, 2012 b).

The Australian Strategy provides a framework to drive improvements in work health and safety in Australia and promotes a collaborative approach between the Commonwealth, state and territory governments, industry and unions and other organisations (SWA, 2012 b). The Australian Strategy fatalities target has been set as a reduction in the number of worker fatalities due to injury of at least 20% by 2022.

Data sources
The TIF dataset is compiled from the data sources listed below. The combination of these datasets enables the TIF collection to hold information covering the entire Australian workforce.

The National Dataset for Compensation-based Statistics (NDS)
There are 10 workers’ compensation jurisdictions in Australia that report to Safe Work Australia: each of the eight states and territories, the Commonwealth (Comcare) and Seacare. The NDS is a standard set of data items, concepts and definitions for inclusion in the respective workers’ compensation systems that enables national comparisons of data. These data are provided to Safe Work Australia to create the NDS database which is currently the most comprehensive source of compensation-related work health and safety data in Australia.

The NDS is updated annually following provision of the latest available information from the jurisdictions. Information from jurisdictions also includes revised data for previous years.

The NDS does not provide good coverage of fatalities in industries where a
significant proportion of workers are self-employed, it does not include defence force workers or bystanders and is incomplete if there are no dependants to lodge a claim. Employees who die overseas are included in the NDS but are excluded from the TIF scope as they occurred outside of the Australian work health and safety environment. In addition, the date of death is not available for all fatalities although jurisdictions are progressively introducing this data item. The names of the deceased and narratives are not provided in the NDS.

Notifiable Fatalities Collection (NFC)
Under work health and safety legislation around Australia, a death occurring at a workplace must be notified to the relevant authority. The Australian Safety and Compensation Council established a project to collect these data nationally from 1 July 2003 (ASCC, 2006). The scope of the NFC is all workers (employees and self-employed) who suffered a fatal injury at work and bystanders who died as a result of work activity. There are 13 work health and safety jurisdictions in Australia that report to Safe Work Australia: each of the eight states and territories; the Commonwealth (Comcare); the mining sectors in New South Wales, Queensland and Western Australia; and the National Offshore Petroleum Safety and Environmental Management Authority. Due to the different work health and safety legislation across Australia this collection did not collect comparable data from all jurisdictions until December 2011.

From 1 January 2012 more comprehensive reporting of fatalities has occurred with work-related fatalities previously not notifiable under state and territory work health and safety legislation now falling within the scope of the Work Health and Safety Act and reportable to Safe Work Australia. The main outcome of this change is that deaths from vehicle incidents on public roads that involved a working vehicle are now included in the NFC.

The NFC captures fatalities of employees, self-employed, contract workers, defence workers and bystanders. There is an assessment of work-relatedness by trained work health and safety officers, and a brief narrative account of the circumstances of the fatality is provided. However, only limited information is available at the time of notification and the NFC tends to capture work-related fatalities only when they occur shortly after the injury. Information on age is often inaccurate and there is limited though improving coverage of transport-related fatalities because these deaths are notified to and investigated by the police, road traffic authority or, in the case of plane crashes and marine fatalities, by Commonwealth agencies.

National Coronial Information System (NCIS)
The NCIS was officially launched in July 2000 and is a national internet-based data storage and retrieval system for all fatalities referred to an Australian coroner. It includes all deaths reported to an Australian coroner regardless of compensation status or work arrangements and it contains the most comprehensive information on the circumstances of the incident. It uses standard industry and occupation classifications.

Coroner’s findings, police reports and autopsy reports may be available to assist with identifying the circumstances of the incident. The NCIS contains a work-relatedness data item although this does not capture all cases considered work-related under the TIF. Work-related fatalities are not always identified and coded and industry information is more closely linked to the workplace than the employer. It is difficult to identify bystander fatalities, and crucial data items, including name, date of birth and date of death, as well as documentation, may be missing in records for open cases and even some closed cases. Also, it can be many years before the case is coded and closed and not all cases will have police and other files loaded.

Access to NCIS is via an application process with ethics approval required to access cases.

Other sources of information
Accident investigation reports from the Australian Transport Safety Bureau relating to plane crashes, train crashes and maritime incidents are used to supplement information found in each of the datasets. The media is searched on a daily basis for work-related fatalities. The media is a valuable source of information on road fatalities and aids in the identification of incidents that involved a working vehicle. Where a media report of a fatality is found, a search is conducted in the NCIS to determine if the case meets the requirements of the TIF. Where there is insufficient information the case is referred back to the WHS authority for confirmation. Cases are only included in the TIF if sufficient information is available to determine work-relatedness.

Methods
Definition of work-related fatalities and scope of the dataset
The TIF includes all persons who died from injuries incurred while working or in the case of bystanders, from injuries incurred due to someone else’s work activity. The definition of working includes unpaid volunteers and family workers, persons undertaking work experience and defence force personnel killed within Australian territories or territorial waters. This definition includes people travelling for work but does not include those commuting to or from work.

A workplace can include a public road or a private residence where work activity is being undertaken.

Injury is defined as a condition coded to ‘External Causes of morbidity and mortality’ and ‘Injury, poisoning and certain other consequences of external causes’ in the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM, 2006).

Specific inclusions
Bystander deaths
Bystanders are persons such as visitors to a workplace, or persons (including children) who received fatal injuries as a result of someone else’s work activity or work factors (including work factors that persist outside working hours). Included are bystanders who received fatal injuries away from a recognisable workplace,
such as those connected with the travel of a vehicle being used for work (for example, a truck, trades vehicle or police vehicle), where identified in the data.

Under this definition an ‘at fault’ rule is applied. Information from a variety of sources including police reports is used to determine whether or not the bystander’s action directly contributed to their death. If the bystanders’ actions directly contributed to their death then the death is considered to be a ‘bystander fault’ death and is not included in the database. The most common example of this is when a non-working person drives their vehicle into the path of a truck and is killed.

Deaths resulting from criminal activity
Fatality cases that occurred as a result of work-related criminal activity are included within the scope of this dataset. Work-related criminal activity includes instances where a worker is killed due to the criminal actions of others. Instances where a person is killed whilst undertaking criminal activity are not, however, included in the dataset.

Exclusions
Deaths due to natural causes
Natural causes include heart attacks, strokes and where death is a natural progression from a disease. In the NCIS a death is classed as Natural Causes when the person did not die from external causes. An external cause death is defined as any death that resulted directly or indirectly from environmental events or circumstances that caused injury, poisoning and other adverse effects (WHO, 1992).

Deaths due to complications of surgical and medical care
The case definition for work-related fatalities excludes deaths due to complications of surgical and medical care, also termed adverse events or deaths from iatrogenic injury. These cases involve unintended and preventable harm resulting from health care rather than from the underlying condition of the person. Although the death of patients who die as a result of medical negligence or malpractice are in principle Bystander fatalities, deaths arising from such iatrogenic injuries are specifically excluded from this database.

Suicide
The scope of the TIF database excludes deaths that are the result of suicide. Assessing the extent of any connection between work and a decision to take one’s own life is extraordinarily difficult, even when detailed information is available. This makes it unlikely that a clear cut assessment of work-relatedness can be made in many suicide cases.

Suicides are included within the scope of the NDS whenever assessed as work-related by the workers’ compensation authority, and these can be identified by reference to the workers’ compensation authority’s assessment of intent as recorded in the ‘Mechanism’ data item. In the TIF dataset however, all suicide cases are removed from the set of NDS records by reference to the ‘Mechanism’ data item and removed from the set of NCIS records by reference to the coroner’s assessment of intent recorded in the ‘Intent’ data item. Suicides are excluded from the scope of work-related deaths recorded in the NFC.

Deaths of persons undertaking criminal activity
Persons fatally injured while undertaking criminal activities, such as gaining illegal entry into a building or work site or crashing a car while evading a police pursuit are excluded from this collection.

Commuting deaths
Deaths from injury sustained when commuting to or from work, irrespective of whether or not the worker was covered by workers’ compensation, were originally included in the TIF dataset. However, due to the difficulties associated with identifying these fatalities and the resulting lack of confidence in the number of commuting deaths within the TIF dataset a decision was made by Safe Work Australia to no longer include these fatalities in the TIF dataset.

Identifying cases
The methodology for estimating the number of persons who died in Australia from work-related injuries is based on the construction of lists of in-scope deaths during a reference year —one each from the NDS, NFC and NCIS. The data on each list are restructured to enable comparison across the lists obtained from each data source. Details of the deaths on each of the lists are then compared in order to identify and remove duplicate records and a count of the remaining unique cases is obtained. The data items that are extracted from each data source are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Data items extracted from each data source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data items</strong></td>
</tr>
<tr>
<td>Identification number</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Date of incident</td>
</tr>
<tr>
<td>Date of death</td>
</tr>
<tr>
<td>Date of notification</td>
</tr>
<tr>
<td>Occupation</td>
</tr>
<tr>
<td>Industry of employer</td>
</tr>
<tr>
<td>Jurisdiction</td>
</tr>
<tr>
<td>Agency</td>
</tr>
<tr>
<td>Mechanism</td>
</tr>
<tr>
<td>Breakdown agency</td>
</tr>
<tr>
<td>Narrative of incident</td>
</tr>
<tr>
<td>Cause of death</td>
</tr>
<tr>
<td>Activity</td>
</tr>
</tbody>
</table>

1Identification numbers are unique to each dataset

NDS
From the NDS work-related injury deaths are obtained by excluding non-fatals, journey cases and deaths that were the result of work-related disease by means of filtering the full data set across the data items ‘Fatal’ (=1), ‘Duty Status’ (not equal to 4 or 5) and ‘Nature’ (=0). Suicides are then excluded by reference to the Mechanism of incidence data item (=85). Where the date of death is not included the date of occurrence is used to determine if the case is in scope for the relevant reference period.

NFC
The full NFC dataset is used based on the case definition as outlined below. The NFC dataset includes a short text description of each case and is used as an
aid in identifying matching cases across the datasets.

**NCIS**
TIF compilers have the highest level of access to NCIS so identifying information on both open and closed cases can be viewed. Safe Work Australia undertakes an extraction using the *Query design* feature of the NCIS which enables details of all deaths notified to an Australian coroner in the reference period to be extracted. For each reference year the query process generates a file with around 19,000 unique cases. Of these, around 7,000 are injury-related and about 300 work-related. A range of sort codes are used to identify the work-related injury fatalities.

**Data matching**

*Identification of matching cases*
Details of the deaths on each of the lists are compared in order to identify and eliminate duplicates and triplicates in the data. In order to simplify this process, the lists are combined into a single Microsoft Excel worksheet. Matching is achieved by sorting this file by date variables and reviewing groups of records that had the same or similar values and were therefore adjacent, or nearby, in the sorted file. Pairs or triplets that look plausible on the basis of dates are scrutinised, using other data items to confirm or refute the match. The other data items used most often are occupation, nature, agency and mechanism of injury, age, sex, jurisdiction and industry.

The NCIS is further investigated to find matches for cases that are identified in the NDS or NFC but do not have a match in the extracted NCIS file. Many of these tend to involve vehicle incidents on public roads that are not easy to identify as work-related in NCIS based on the coding.

**Results**

*Dataset contribution*
Figure 1 shows that the proportion of cases each dataset contributed to the total number of work-related fatalities incurred by workers in each year has remained relatively stable over the time series, with a slight increase for the NFC and slight decrease for the NDS in 2010–11. Nearly all worker fatalities have been found in the NCIS with around half identified in the NDS and NFC, though the contribution of the NFC will increase from 2012 due to the expanded coverage of this collection.

**FIGURE 1:**
Worker work-related fatalities – dataset contribution, 2003-04 to 2010-11

<table>
<thead>
<tr>
<th>Year</th>
<th>NCIS</th>
<th>NDS</th>
<th>NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>100%</td>
<td>52%</td>
<td>45%</td>
</tr>
<tr>
<td>2004-05</td>
<td>99%</td>
<td>59%</td>
<td>49%</td>
</tr>
<tr>
<td>2005-06</td>
<td>99%</td>
<td>65%</td>
<td>48%</td>
</tr>
<tr>
<td>2006-07</td>
<td>98%</td>
<td>65%</td>
<td>48%</td>
</tr>
<tr>
<td>2007-08</td>
<td>97%</td>
<td>65%</td>
<td>51%</td>
</tr>
<tr>
<td>2008-09</td>
<td>96%</td>
<td>62%</td>
<td>47%</td>
</tr>
<tr>
<td>2009-10</td>
<td>100%</td>
<td>64%</td>
<td>51%</td>
</tr>
<tr>
<td>2010-11</td>
<td>99%</td>
<td>55%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Of the 220 worker fatalities in 2010–11, around one-third (70 fatalities – 32%) were identified in all three datasets. All of the NFC cases were identified in either the NDS or NCIS while 48 (22%) were found only in the NCIS. There were also three that could only be found in the NDS. There have been a few NDS cases in each year the TIF collection has been operational that could not be found in NCIS. It is likely that incorrect data, particularly dates of birth and death, has meant a match could not be made. It is possible that the NCIS match may actually be in the TIF and therefore there is a duplicate. It is also possible that the death occurred overseas and is therefore not in NCIS. It is hoped that the postcode of workplace field will be coded on all NDS cases in the near future to assist with matching. There are also incidents where the worker dies from underlying health issues following a serious workplace injury. The Coroner is only notified of a fatality where the death is unexpected.

**Coverage of worker fatalities by industry and dataset**
The coverage of each dataset by industry varies due to data capture limitations. As workers’ compensation only covers employees, the NDS cannot be expected to capture all fatalities in industries where there are higher proportions of self-employed workers. As can be seen in Table 2, while 89% of Australian workers are covered by workers’ compensation, only 58% of those in the Agriculture, forestry & fishing industry, 74% of those in the Construction industry, 78% of those in the Other services industry and 79% of those in Administrative & support services industry are employees. Due to the relatively high representations of self-employed workers in these industries, workers’ compensation data are not likely to be an accurate representation of the fatalities occurring in these industries.

(Continued on next page)
There were however 11 industries where 90% or more of workers were employees. The NDS should be a reliable source of information on work-related fatalities for industries where employees comprise the majority, particularly in the Mining, Public administration & safety and Electricity, gas, water & waste services industries (99% and 97% employees, respectively). The TIF data shows that this is not always the case. Table 3 shows that the NDS captured only half of all worker injury fatalities in 2010–11 (SWA, 2012 c) with only 43% captured for the Mining industry where 99% of workers are employees. This may be linked to the difficulty in accurately identifying the Industry of employer in the NCIS with labour hire workers possibly being coded to their industry of workplace rather than industry of employer. This may explain the better than expected proportion for the NDS for Administrative & support services.

**TABLE 2:**
The proportion of employed and self-employed workers by industry, Australia, 2011–12

<table>
<thead>
<tr>
<th>Industry</th>
<th>Employees</th>
<th>Self-employed*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry &amp; fishing</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Construction</td>
<td>74%</td>
<td>26%</td>
</tr>
<tr>
<td>Other services</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>Administrative &amp; support services</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Arts &amp; recreation services</td>
<td>84%</td>
<td>16%</td>
</tr>
<tr>
<td>Professional, scientific &amp; technical services</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>Transport, postal &amp; warehousing</td>
<td>87%</td>
<td>13%</td>
</tr>
<tr>
<td>Rental, hiring &amp; real estate services</td>
<td>89%</td>
<td>11%</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Retail trade</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Accommodation &amp; food services</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Information media &amp; telecommunications</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Health care &amp; social assistance</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Education &amp; training</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>Financial &amp; insurance services</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>Electricity, gas, water &amp; waste services</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Mining</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>Public administration &amp; safety</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89%</strong></td>
<td><strong>11%</strong></td>
</tr>
</tbody>
</table>

* Includes employers, own account workers and contributing family workers.

Source: ABS 6291.0.55.001 Labour Force, Australia, Detailed - Electronic Delivery, Quarterly.

**TABLE 3:**
Proportion of worker fatalities by dataset by industry of employer, 2010–11

<table>
<thead>
<tr>
<th>Industry of employer</th>
<th>NCIS</th>
<th>NDS</th>
<th>NFC</th>
<th>Number of fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry &amp; fishing</td>
<td>100%</td>
<td>27%</td>
<td>50%</td>
<td>62</td>
</tr>
<tr>
<td>Transport, postal &amp; warehousing</td>
<td>98%</td>
<td>48%</td>
<td>38%</td>
<td>42</td>
</tr>
<tr>
<td>Construction</td>
<td>100%</td>
<td>59%</td>
<td>77%</td>
<td>39</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>100%</td>
<td>70%</td>
<td>90%</td>
<td>20</td>
</tr>
<tr>
<td>Administrative &amp; support services</td>
<td>100%</td>
<td>91%</td>
<td>55%</td>
<td>11</td>
</tr>
<tr>
<td>Arts &amp; recreation services</td>
<td>100%</td>
<td>25%</td>
<td>38%</td>
<td>8</td>
</tr>
<tr>
<td>Public administration &amp; safety</td>
<td>100%</td>
<td>88%</td>
<td>38%</td>
<td>8</td>
</tr>
<tr>
<td>Mining</td>
<td>100%</td>
<td>43%</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>100%</td>
<td>100%</td>
<td>50%</td>
<td>6</td>
</tr>
<tr>
<td>Retail trade</td>
<td>100%</td>
<td>75%</td>
<td>25%</td>
<td>4</td>
</tr>
<tr>
<td>Accommodation &amp; food services</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Health care &amp; social assistance</td>
<td>100%</td>
<td>100%</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Information media &amp; telecommunications</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Other services</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>2</td>
</tr>
<tr>
<td>Professional, scientific &amp; technical services</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Education &amp; training</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Electricity, gas, water &amp; waste services</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Rental, hiring &amp; real estate services</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Financial &amp; insurance services</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99%</strong></td>
<td><strong>50%</strong></td>
<td><strong>57%</strong></td>
<td><strong>220</strong></td>
</tr>
</tbody>
</table>

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Coverage of bystander fatalities by industry and dataset

Figure 2 shows that the proportion of cases each dataset contributed to the total number of work-related bystander fatalities has varied over the years. While the NDS does not usually capture bystanders, the cases identified were all commuters who were compensated but were killed by another working vehicle. There were an unusually high number of these in 2004–05. The number of bystanders identified in the NFC has experienced fluctuations over the past few years, with the highest proportion of 34% identified in 2010–11. The contribution of the NFC is expected to increase from 2012 due to the expanded coverage of this collection.

FIGURE 2: Bystander work-related fatalities – dataset contribution, 2003–04 to 2010–11

Of the 47 bystander fatalities identified in 2010–11 no one case was identified across all three datasets. The NCIS identified 29 bystander fatalities (62%), the NFC 16 (34%) and only 2 were found in the NDS. All bystander cases identified in the NFC were matched to cases in the NCIS.

Extra coding undertaken in TIF

Over the years additional fields have been added to the TIF dataset in order to provide further insight into the circumstances surrounding traumatic injury fatalities. These include: whether the fatality occurred on a public road; whether a vehicle was involved; whether a truck was involved; the type of vehicle operated by the victim involved in the incident; whether a counterpart vehicle was involved in the incident; and whether the incident occurred on a working primary production property.

These extra data items have informed the project that one-third of workers killed were involved in a vehicle incident on a public road, a further one-third in a vehicle incident at a worksite away from a public road and the final one-third did not involve a vehicle.

Discussion

The TIF dataset provides the best estimate of all work-related traumatic injury fatalities that occur in Australia. While the NCIS has the best coverage of fatalities, the other datasets are required to identify those that are work-related.

The importance of the data collected and held within the TIF database is evidenced by the growth in the number of publications and policy decisions incorporating the TIF data. This is particularly true for the Australian Strategy where the TIF data have been used to inform the fatality target, enabling this target to move from employees as was measured in the previous strategy to all Australian workers. Recent publications incorporating work-related fatalities extracted from the TIF dataset include: Work-related Traumatic Injury Fatalities, 2010–11 (SWA, 2012 c), Work-related Injuries Experienced by Young Workers in Australia, 2009–10 (SWA, 2013 a) and Work-related Injuries and Fatalities on Australian Farms (SWA, 2013 b).

Strengths

Dynamic dataset

As additional information is added to open cases in NCIS the information in the TIF is updated so numbers for previous years may change. Furthermore, cases that may have previously been identified as within the scope of the TIF may be removed following investigation by the Coroner. This means the TIF dataset is constantly changing, with the representativeness and completeness of the dataset being improved with each update.

Coverage

The main benefit of the TIF dataset is that coverage extends to all workers in Australia, rather than just employees as is the case with the NDS, or only fatalities that are notified under previous and the now harmonised work health and safety laws as is the case for the NFC. As a result, it can be assumed that all industry sectors are well-represented by the TIF data, particularly industries with high proportions of self-employed workers, such as the Agriculture, forestry & fishing and Construction industries.

The coverage of the TIF dataset enables regulators to make informed and targeted decisions regarding work health and safety policy as well as design interventions to reduce the prevalence of work-related fatality in Australian workplaces. This evidenced-based approach to policy formation in Government using quality data is widely considered best practice.

Limitations

Timeliness

Information on work-related fatalities identified through the NFC is usually available three to four months after the death while workers’ compensation data are not provided to Safe Work Australia until at least eight months after the end of each financial year. The TIF dataset cannot be finalised until all data are compared with NCIS. This results in a lag of around one year from date of death to date of publication. While this lag is not ideal, given the process involved in identifying and matching TIF records as well as the time lags of the NDS and NFC data, the TIF dataset provides detailed information regarding all work-related fatalities in Australia within a timeframe similar to the publication of workers’ compensation data by Safe Work Australia.
Personal Judgement of Cases

The manual nature of the process used to create the TIF dataset and the lack of adequate details surrounding the incident in some cases means that coders are required to use their own judgement and make decisions regarding work-relatedness and whether there is a match between cases. This potentially introduces error. While this is a concern, because the TIF database is dynamic any errors in judgement are likely to be identified during routine updating. Notwithstanding this, confidence in the TIF dataset could be improved through the use of an objective computer-based decision making system.

Bystanders

The number of bystanders who die as a result of someone else’s work activity is likely to be underestimated in the TIF dataset owing to difficulties associated with their identification. The media and the NCIS are the best sources for identifying bystanders, however those who die on the roads as a result of a worker’s activity (i.e. crash involving a working vehicle) can be very hard to identify given the information provided. Due to the political and economic issues associated with changing workers’ compensation legislation to cover bystander fatalities, it is unlikely that the estimate of bystanders in the TIF dataset will improve.

International comparison

The extent of the Australian workforce coverage and the range of incidents included in the TIF make it one of the best work-related injury fatality databases in the world. Its data compilation follows a similar approach to the USA’s Census of Fatal Occupational Injuries with the exception that the TIF specifically excludes suicides. However, comparison of the TIF dataset with other similar international data collections is challenging owing to differences in reporting schemes, definitions of work-relatedness and health systems between countries. In addition, not all data collected are necessarily reported in a work health and safety context e.g. work-related public road fatalities or air incidents in some countries including Great Britain (HSE, 2013). Other countries are restricted to notification (e.g. Denmark or Norway) or compensation data (e.g. Finland and Switzerland) or do not publish fatalities for the whole workforce (NOHSC, 2004).

Conclusion

The TIF dataset provides the best estimate of work-related fatalities in Australia due to the incorporation of three individual fatality datasets and with reference to the media. The information available in the TIF dataset enables the Australian Government to make informed policy decisions, which help to make Australian workplaces safer. The information contained in the TIF dataset is also of great use to researchers and State and Territory regulators. The development and maintenance of this dataset is another step in the right direction in ensuring that Australian workers’ return home from work safely, every day.

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References


RISKGATE analysis of slips, trips and falls at NSW surface and underground coal mines

Danellie Lynas¹, Robin Burgess-Limerick¹, Philipp Kirsch¹

Abstract

Slips, trips and falls are a common cause of occupational injury within Australian coal mines, accounting for approximately 22% of injury compensation claims. Injury severity ranges from medical expenses only, through to significant Lost Time Injuries. Fatalities are rare, but are also potential outcome of slips, trips and falls.

RISKGATE is an on-line knowledge management system which assists the coal mining industry to capture and recover knowledge related to safety and health risks. Knowledge regarding initiating events, causes and control measures has been gathered through action research workshops with industry experts and uploaded in the online database for delivery in the form of Bow-Tie analyses across a range of topic areas.

Injury narratives reported by all surface and underground coal mines in NSW over a 5 year period (10,252 narratives) were examined to identify those which involved slips, trips, or falls (1,994 narratives). These narratives were subsequently categorized according to the initiating events and causes identified in the RISKGATE Slip/Trip/Falls topic area to gain a better understanding of the circumstances surrounding and factors involved in slips, trips and falls in surface and underground coal mines.

Slips, trips and falls injuries were found to occur disproportionately in underground coal mines compared to surface mines, and most occur through slipping or tripping while moving on surfaces, platforms, ramps or stairs. The most common causal factors associated with the loss of balance on surfaces, platforms or stairs was the undertaking of operational tasks. Individual factors were rarely identified as causal factors for any of the initiating events.

Slips, trips and falls are prevalent in other high-risk industries, and the RISKGATE body of knowledge could be adapted to assist risk management practices in domains outside coal mining, such as construction, transportation and energy generation.

CITE THIS ARTICLE AS:

KEY WORDS:
Slips, trips and falls; mining; RISKGATE

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Introduction
Slips, Trips and Falls
Coal mines are relatively high risk workplaces. Slips, trips and falls are a common unwanted event leading to injury (Burgess-Limerick & Steiner 2006; 2007; Maiti, Chatterjee & Bangdiwalla 2004; Donoghue 2004; Layne and Pollack 2004; McPhee 2004). A number of factors place miners at risk of slips, trips and falls, including the dynamic and unpredictable nature of the mining environment and weather conditions. Deficiencies in the design of mobile and fixed plant also contribute to the risks of slips, trips and falls within both surface and underground coal mines.

The National Institute for Occupational Safety and Health (NIOSH 2008) reported that 25% of nonfatal lost-time injuries in mining from 2002-2006 were attributed to slip or fall. Falls from equipment accounted for 2.7% of all mining related injuries in the USA in 2007 (Mine Safety & Health Administration 2007). Schutte & Shaba (2003) investigated slipping and falling accidents and materials handling in the South African mining industry between the period 1999 to 2002, concluding the causes of slipping and falling to be multi-factorial and a complex interaction between workplace factors, work organisational factors and personal factors related to the individual involved in the accident. Falls associated with mobile plant access/egress have been identified as a common injury mechanism (Bloswick & Chaffin 1990; Patenaude, Marchand, Samperi & Belanger 2001; Shepard, Kahler & Cross 2006) as has the use of ladders (Partridge, Virk & Antosia 1998).

A report on Occupational Health and Safety Priorities for the Australian Coal Industry (Culvenor, Knowles & Cowley 2000) highlighted slips, trips and falls as comprising 22% of injuries in both underground and surface mining. In open cut mining, injuries were predominantly associated with mobile plant (52%) including dump trucks; dozers; and front-end loaders. Floor surfaces, and steps and stairs (11% combined) were also commonly involved in open cut mine injuries. Underground accidents were found to be more diverse and involved a wide range of mobile/semi-mobile plant and the work environment itself. The report found powered plant was often associated with underground accidents (17%) and included: conveyors; transporters; roof-bolters; chocks; and loaders, and other plant such as the trailing cable (3%) and ventilation equipment (2%).

RISKGATE
RISKGATE (riskgate.org) is an on-line knowledge management system developed with funding from the Australian Coal Association Research Program. RISKGATE is being used by the coal mining industry to progressively capture knowledge regarding the management of safety and health risk and to make this information available to Australian coal mining companies in an accessible format.
to inform subsequent risk management activities. RISKGATE has been built on a foundation of industry expert knowledge gathered through topic specific action research workshops (Kirsch, Goater, Harris, Sprott & Joy 2012, Kirsch, Harris & Sprott, 2013, Kirsch, Harris, Cliff & Sprott, 2013, Worden, Sprott & Whittaker 2013). The system uses an intuitive online interface to deliver practical Bow-Tie analysis based checklists to assist the Australian coal mining industry in managing key hazards. Topics which have been completed to date include: fires (Harris, Kirsch, Sprott, Spinks, Goater & Cliff 2012), underground strata control (Kirsch, Harris, Cliff, Hebblewhite, Sprott, Shi, Ranjan, Sharma, Biswas & Sharma, 2013), open cut ground control, collisions, tyres, isolation, explosions (Kirsch et al., 2013c), explosives (Harris, Sprott, Torrance, Shi, Ranjan, Sharma, Biswas, Sharma & Kirsch, 2013), manual tasks, and slips trips & falls.

The RISKGATE slips, trips and falls topic considers hazards associated with slipping or tripping at ground level or falls from one level to another. It includes stairs, ladders, or platforms including temporary structures (e.g. scaffolding, and covers both mobile equipment (particularly access and egress) and fixed plant (including coal preparation plants), and includes consideration of construction, operation and maintenance tasks as well as pedestrian movement around sites. The scope of this RISKGATE topic extends across all life of mine stages from exploration through to decommissioning, and considers activities performed during both surface and underground extraction of coal, as well as exploration, the transport of coal to, and processing in, coal handling and preparation plants.

RISKGATE employs Bow Tie Analysis as a framework for capturing knowledge (Chevreau et al. 2006, De Dianous & Fievez 2006, Duijim 2009). At the centre of each bow tie is an initiating event. The range of potential causes is listed for each initiating event, as are the potential consequences. For each cause, the potential control measures are identified (preventive controls), and measures which can be taken to reduce the severity of the consequences of each initiating event are identified (mitigating controls).

**RISKGATE divides the Slip, Trip & Fall topic into three initiating events:**

**Initiating event 1** – Loss of balance through either slipping or tripping while moving on surfaces, platforms, ramps or stairs. Causes identified for this initiating event included: Mine design; Slips/trips/ falls risks inherent to mine operation and maintenance tasks; Equipment, procedural or environmental changes; Environmental conditions; Failure of infrastructure; and Personnel behaviour and routine violations.

**Initiating event 2** – Loss of balance during access to/from mobile plant. Causes identified for this initiating event included: Design and selection of access systems; Equipment access/ egress designs that do not control slips/ trips/falls risks during maintenance and inspection; Environmental factors; Task design; Equipment, procedural or environmental changes; Mechanical failure of equipment; and Personnel behaviour and routine violations.

**Initiating event 3** – Fall from mobile, temporary or fixed plant, infrastructure or environment. Causes identified for this initiating event included: Mine or facility design; Falls from heights risks inherent to mine operation and maintenance tasks; Construction/rebuild / shut-down / demolition activities; Equipment, procedural or working environmental changes create falls from heights risks; Failure of infrastructure; Personnel behaviour and routine violations; and Individual characteristics.

In each case, the consequences identified are injury, permanent disability or fatality.

At June 30, 2012 there were 61 coal mines in NSW (31 surface mines and 30 underground mines) employing 25,000 workers. All injuries in NSW coal mines must be notified to CMI a subsidiary of Coal Services Pty Ltd, and each notification includes a short narrative description of the event leading to the injury. While the detail and quality of the descriptions varies, these narratives have potential to provide valuable information regarding the causes of injuries sustained in coal mines.

**Method**

Information regarding injuries reported to CMI by the population of all NSW surface and underground coal mines was obtained for the five years to June 30, 2011 (N=10,252). An initial review was undertaken by the researchers to determine whether each injury was associated with a slip, trip or fall. This examination identified 1,994 narratives describing an injury arising as a consequence of a slip, trip or fall. Each of these narratives was then examined to determine which of the three initiating events described within the RISKGATE Slip, Trip and Fall topic best corresponded to the injury described by the narrative.

Each narrative was then examined to determine whether it could be categorised as being related to one of the causes identified within each RISKGATE initiating event. Sufficient detail was provided to allocate 1,851 narratives (93%) to a causal category. The coding strategy employed here differs from the grounded theory strategy employed previously (Burgess-Limerick, 2011) in that the categories were based on expert opinion gathered during RISKGATE workshops. Additional information available for each case included: injury date; mine type (surface or underground); and whether the injury was associated with lost time. Frequency rates were estimated based on the average employment numbers for each sector across the five year period (Surface mines = 8,929; Underground mines = 8,256). Data describing the total hours worked were not readily available.

The RISKGATE process uses a semi-structured action research workshop cycle based around bow-tie analysis as described in Kirsch et al. 2012, Kirsch et al. 2013ab and Worden et al. 2013. With respect to the RISKGATE Slips, Trips, Falls topic, 39 different industry experts (mean experience: 10.5 years, range 1-22 years) participated in nine total days of workshops.
between June and October 2012 to build the body of knowledge. Industry experts were nominated by Australian coal mining companies that participate in the Australian Coal Association Research Program (ACARP)(Robertson 2010); and included health and safety, ergonomics, fitness for work, risk management and operations practitioners.

Results & Discussion

Table 1 and 2 provide the numbers of lost time, and non-lost time injuries allocated to the initiating events for surface and underground mines respectively, and the allocations to RISKGATE causes. All injury narratives which contained sufficient detail were allocated to an existing RISKGATE cause.

Despite employing roughly equal numbers of miners, a greater number of slip trip fall injuries were reported by underground mines (1,570) than by surface mines (424). The estimated annual frequency rate for slip, trip and fall injuries at underground mines was 0.038 injuries per person year, four times higher than the estimated annual frequency rate for surface mines (0.0095 injuries per person year). Averaged across mine type, initiating event 1 (loss of balance through either slipping or tripping while moving on surfaces, platforms, ramps or stairs) occurred more frequently (72% of injuries reported) than initiating event 2 (loss of balance during access or egress to/from mobile plant; 24%) or initiating event 3 (fall from mobile, temporary or fixed plant, infrastructure or environment, 4%).

Differences in these proportions existed between surface and underground mines however: Initiating event 1 represented a greater proportion of injuries occurring in underground mines (77%) and only 51% of injuries occurring at surface mines; while initiating event 2 represented a high proportion of injuries at surface mines (44%) than at underground mines (19%).

Averaged across mine type, the ratio of LTI to non-LTI injury was relatively constant across the initiating events (33% of injuries allocated to initiating event 1 were associated with lost time; 35% of injuries allocated to initiating event 2 were associated with lost time; and 38% of injuries allocated to initiating event 3 were associated with lost time). Again, differences were seen between mine methods however, for surface mines, 188 of the 424 slip trip fall injuries reported were associated with lost time (44%). For underground mines, 490 of the 1,570 slip trip fall injuries reported were associated with lost time (31%).

A large number (834) of non-lost time injuries at underground mines are characterised by rough, muddy, roadways (frequently covered with water) which may well be a common cause of relatively minor injuries, and this may account for the difference in the ratio of LTI to non-LTI injury rates noted between site types.

Initiating Event 1 – Loss of balance through either slipping or tripping while moving on surfaces platforms, ramps or stairs

Initiating Event 2 – Loss of balance during access or egress to mobile plant

Initiating Event 3 – Fall from mobile, temporary or fixed plant, infrastructure or environment

Table 1:

Lost time and non-lost time injuries by initiating event and RISKGATE causes for Slip Trip Fall injuries reported by NSW surface coal mines for the 5 years to June 30, 2011. N=424.

<table>
<thead>
<tr>
<th>RISKGATE Cause</th>
<th>LTI</th>
<th>No LTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile equipment design</td>
<td>25</td>
<td>39</td>
</tr>
<tr>
<td>Environment</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>Operational tasks</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Individual factors</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Unable to determine</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>120</td>
</tr>
</tbody>
</table>

Table 2:

Lost time and non-lost time injuries by initiating event and RISKGATE causes for Slip Trip Fall injuries reported by NSW underground coal mines for the 5 years to June 30, 2011 (N= 1570)

<table>
<thead>
<tr>
<th>RISKGATE Cause</th>
<th>LTI</th>
<th>No LTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile equipment design</td>
<td>25</td>
<td>42</td>
</tr>
<tr>
<td>Environment</td>
<td>45</td>
<td>109</td>
</tr>
<tr>
<td>Operational tasks</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Individual factors</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unable to determine</td>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>Total</td>
<td>380</td>
<td>834</td>
</tr>
</tbody>
</table>

Averaged across mine type, the number of injuries allocated to initiating event 3 were associated with lost time). Again, differences were seen between mine methods however, for surface mines, 188 of the 424 slip trip fall injuries reported were associated with lost time (44%). For underground mines, 490 of the 1,570 slip trip fall injuries reported were associated with lost time (31%).

Using the causal factors identified by the Australian coal industry participants (described above) in the RISKGATE action research workshops as categories, the greatest proportion of injuries resulted from slips, trips and falls.
mine operations and maintenance tasks (72% of all open-cut injuries and 94% of all underground injuries associated with this initiating event); followed by the design of the work environment (18% of all open-cut injuries; 3% of all underground injuries). Human/individual factors could be attributed to only 5 (0.5%) of all injury narratives analysed during this period. Overall, 44 narratives were not coded to a RISKGATE causal category due to narratives being of insufficient detail to allow coding.

Examples of injury narratives include the following:

“Whilst assessing a competition he was walking through a swilly when he turned to answer someone asking a question, his leg became stuck in the mud causing him to twist his leg straining his left knee”.

“While pulling a hose from under the coal the hose came loose causing him to fall on the ground and injury his right hand side ribs”.

The design of the work environment contributed to comparable injury numbers across both open-cut and underground environments, however when expressed as a percentage, a greater percentage of open cut injuries are related to work environment design compared to underground mining injuries. Causal factors included uneven ground, lighting issues/shadowing, and water lying on the ground.

Both underground and surface mining operations occur in harsh and hazardous environments that present a number of slip, trip and fall hazards and is perhaps not surprising that performing operational tasks was coded as a contributing cause in the majority of injuries associated with this initiating event, and there may be little which can practically be done to reduce exposure to these tasks. Injuries resulted from a range of mechanisms including stepping in holes; onto broken rocks, uneven surfaces or pieces of equipment; and stepping or climbing onto or off equipment (both maintenance and operational roles). Environmental factors also contributed to injury causes. Underground travel ways are often poorly lit and filled with water containing dips, cluttered with debris and in some instances shafts are sloping tunnels containing rail tracks or other haulage equipment. Additionally, open cut sites are exposed to the full range of climatic conditions as well as many of the above factors. Mining equipment, machinery and plant structures introduce additional hazards.

Human/individual factors received very little attention in the injury narratives across all three initiating events. Personal protective equipment (PPE) was mentioned in two narratives, and individual behaviour was mentioned in one narrative relating to this event.

Initiating Event 2 – Loss of balance during access or egress to/from mobile plant.

Using the RISKGATE developed causal factors as indicators of injury mechanism, for both surface and underground mining environments, the greatest proportion of injuries resulted from design of the environment around the mobile equipment (40% of all open-cut injuries and 58% of all underground injuries related to this initiating event). This was followed by design of mobile equipment (34% of open-cut injuries; 24% of underground injuries). Access/egress to mobile equipment including the surrounding environment was the third causal factor (8% of all open-cut injuries; 3% of underground injuries). Human/individual factors could be attributed to 8 (2%) of all injury narratives analysed during this period. Overall, 69 narratives provided insufficient detail to allow coding to a RISKGATE causal category.

Examples of injury narratives were as follows:

“When getting off forklift he put his right foot on the ground and twisted the top part of his body to get off then felt the inner part of his right knee click and a sharp pain go up his leg causing a strain”.

“Whilst he was stepping out of snyb his left foot rolled on the uneven ground”.

Causal factors linked to injury from this event in both underground and surface mining include insufficient lighting, shadowing, uneven ground and water on the ground, access systems and egress systems (including ladders, steps, handholds) and associated structural integrity. This is particularly apparent in the underground data, where 174 injuries (of 299) were attributed to the surrounding environment. This finding suggests that increased attention to maintaining roadways may be justified.

Injuries resulting from the design of mobile equipment are comparable across both LTI and non-LTI and between open-cut and underground mining. This may largely be due to poor design of the equipment, or inappropriate retrofitting to meet the needs of both the environment and the task for which the equipment is required. An additional factor to consider may be maintenance of the equipment. Equipment is typically not designed well for maintenance causing mine-workers to use various equipment structures in unintended ways (Moore, Porter & Dempsey 2009).

Extensive research has been undertaken regarding access and egress via ladder and stair systems (Bloswick & Chaffin 1990; Patenaude, Marchand, Samperi & Belanger 2001; Shepard, Kahler & Cross 2006) and using ladders for the purpose of completing an occupational task (Partridge et al, 1998). While much of this research has focused on physical changes to ladder position, some of the research is applicable to situations where an individual would be exiting or entering equipment on a routine basis (Moore et al, 2009). Moore et al (2009) report that the activity the miner was involved in at the time of the incident was critical, with egress accounting for almost 75% of injuries. Interestingly Moore noted a “handful of injuries” occurred as the operator jumped out of/ off a vehicle. Only two of the narratives reviewed for this study indicated this same mechanism of injury.

Initiating Event 3 – Fall from mobile, temporary or fixed plant, infrastructure or environment.

Falls occurred relatively infrequently compared to the preceding initiating events. Using the RISKGATE developed causal
factors as indicators of injury mechanism, for both surface and underground mining environments the greatest proportion of injuries resulted from mine operations (52% of open-cut injuries and 84% of underground injuries associated with this initiating event) followed by design of the work environment (42% of open-cut injuries; 9% of underground injuries). Human/individual factors accounted for 5 (4%) of all injury narratives analysed during this period. All narratives could be coded to a RISKGATE causal category.

Examples of injury narratives were as follows:

“He was lifting an extendable platform when it gave way and he and the platform fell. He landed on the rib protection tower and then fell further to the ground fracturing a rib on his right side”.

“There filling up the header tank on the continuous miner he slipped and fell on the boom plate straining his right elbow”.

Moore et al (2009) investigated falls from equipment injuries in U.S. mining equipment between 2006 and 2007. Their findings differ to the findings of this study, suggesting that the majority of injuries (63%) occurred at surface mines, with underground mining accounting for 12% of injuries. However they did identify four types of equipment, each accounting for at least 5% of injuries: dozers, large trucks, wheel loaders and conveyors/belts, with injuries frequently occurring during maintenance tasks. A Mine Safety & Health Administration investigation undertaken in 2007 reported that 2.7%, or nearly 400 of all mining related injuries resulted from falls from equipment (Mine Safety and Health Administration 2007). Moore comments that factors associated with these falls are largely unknown and cannot be completely accounted for in design of equipment, development of work practices or in training programs for mine workers. This research provides an opportunity for equipment designers, ergonomists and health and safety professionals to understand where to focus interventions that best address these uncertainties.

Conclusion

Slips, trips and falls remain a significant source of injury in coal mines, accounting for about 20% of all injuries. Such injuries disproportionately occur in underground coal mines, and are most likely to occur as an outcome of an initiating event which may be described as losing balance through slipping or tripping while moving on surfaces, platforms, ramps or stairs. Injuries associated with a loss of balance during access to mobile plant are also prevalent in both surface and underground coal mines, however falls were reported relatively infrequently.

The most common causal factors associated with the loss of balance on surface, platforms or stairs were the undertaking of operational tasks, followed by the design of the work environment. The most common causes associated with loss of balance during access to mobile equipment were the condition of the environment around the equipment and the design of the equipment access systems. Individual factors were rarely identified as causal factors for any of the initiating events.

Injury prevention is unlikely to be successful unless the complexity of the incident is understood and the interplay between environmental, organisational and behavioural factors is addressed. This requires a broad framework for analysing injury data and subsequently informing the development of both cost effective intervention strategies and relevant research strategies. The RISKGATE initiating events and causes provided a useful framework for considering the injury narratives describing slip trip fall injuries reported to CMI by NSW coal mines. This framework can be applied to a standardized analysis of injury or incident data from other mining jurisdictions, thereby facilitating direct comparison of outcomes across diverse mining jurisdictions.

Improving the descriptions of injuries would allow more rigorous interrogation of valuable data bases such as that currently maintained by NSW Coal Services and used in this study. Mapping the information gathered from the injury narratives over the RISKGATE framework of identified initiating events and causal factors provides a robust perspective for understanding the issues contributing to slips, tips and falls in coal mines.

Finally, slips, trips and falls are prevalent in other high-risk industries (e.g. construction: Lipscomb et al, 2004, 2006). The RISKGATE body of knowledge could be adapted to assist and improve risk management interventions in domains outside coal mining, such as construction, transportation and energy generation (Kirsch et al, 2013a).
References


Officers’ due diligence: Is work health and safety an accounting problem?
Sharron O’Neill¹, Karen Wolfe²

Abstract
The work health and safety (WHS) legislation recently enacted in many Australian States and Territories places specific due diligence obligations on an organisation’s officers – including accounting and finance officers. Questioning whether these obligations are justified, this paper critically examines the capacity of accountants and accounting to influence work-related injury and illness outcomes across an organisation. Detailed third-party analyses of two fatal WHS disasters are reviewed and factors that may be directly or indirectly traced to accounting practices are identified and explored. The findings suggest various accounting practices, including the resource allocation and performance management decisions of accountants, financial controllers, chief financial officers, chief executive officers and directors, can contribute significantly to an increasing risk of WHS failure. Consequently, the imposition of WHS due diligence obligations on those with oversight of the accounting function appears justified. A framework for corporate (WHS) risk management is developed that illustrates the conceptual bridge between the accounting, governance and WHS literature and highlights the important role of corporate governance in WHS risk management. The paper calls for a change in thinking from ‘resourcing health and safety’ to ‘resourcing safe and healthy work’ and offers a number of recommendations for integrating WHS considerations into traditional accounting and governance practices.

CITE THIS ARTICLE AS:

KEY WORDS:
Governance, work health & safety, risk management, due diligence, integrated thinking

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Introduction
Senior accounting and finance professionals play a critical role in controlling an organisation’s performance. Where their role meets the definition of an ‘officer’ under the Corporations Act (2001), WHS legislation imposes specific due diligence accountabilities relating to the governance of work health and safety (WHS) performance. Although prosecutions of these accounting officers over work-related fatalities are relatively infrequent, they remain a source of frustration for those who perceive a distinct lack of influence over the safety of individual workers at the ‘coal face’ (see for example Kumar V Ritchie).

In Australia, the introduction of a positive duty of care requirement for officers in the recent Work Health and Safety Act”¹ (hereafter, the WHS Act) has been cited as a “significant improvement on the liability position for individual directors” (Gray and Kellock 2010: p1) and “one of the most important reforms” in the new legislation (Sherriff and Tooma 2010: 32). Rather than automatically deeming the (poorly defined) ‘persons in control’ as liable for a firm’s failure to ensure WHS, the new provisions impose a specific duty of care on officers and clearly articulate minimum due diligence requirements for compliance.

These apply to all officers, including those in the accounting discipline.

However, the questions remain: is it appropriate for accounting officers to be subject to this duty of care and associated legal liability? Are accounting officers genuinely in a position of influence with respect to the health and safety of workers? Anecdotally, claims of cost-cutting are occasionally cited as contributing factors in WHS disasters (see for example reflections on the Piper Alpha disaster (Berger 2009) and Bhopal chemical disaster (Dutta 2002)) and cases of individual workplace fatalities such as Cooper et al. 2011; Ede 2008). Despite this, there is little evidence of research that has empirically or theoretically explained the hypothesised relationship between WHS failure and the financial resourcing and other routine activities of senior accounting professionals.

This paper seeks to explore whether holding accounting officers legally accountable for WHS risk management is justified and appropriate. It critically examines the capacity of accounting professionals to influence WHS outcomes (performance) and outlines the case by which accounting executives may be identified as ‘officers’. Two case studies are examined to illustrate how accounting can support or inhibit WHS, and conceptual framework for WHS governance is offered.

Officer’s duty of care
Senior executives who meet the Australian Corporations Act 2001 definition of an ‘officer’ by virtue of their individual role and accountabilities are subject to the specific duty of care (to exercise due diligence) provisions in the WHS Act. In Australia slightly different legal requirements exist for officers at this stage of WHS legislative harmonisation process². Those operating in New South

¹ Australia, a federation of six States and two Territories, is in the process of harmonising their respective occupational health and safety legislation. As at 1 January, 2014, only two jurisdictions (Victoria and Western Australia) are yet to enact the model Work Health and Safety Act (2010).
² See note 1 above.
Wales, Queensland, the Northern Territory and the Australian Capital Territory organisations have been subject to the new duty of care requirement since 1st January 2012. The WHS Acts in Tasmania and South Australia came into force on 1st January 2013. In contrast, Victoria and Western Australia have not sought to adopt the ‘harmonised’ legislation. However their existing legislation already imposes WHS accountability on ‘persons in control’ of a workplace, that is, persons who have, “to any extent”, the management or control of a workplace (see s26(1), Occupational Health and Safety Act (Vic) 2004 and s22(1), Occupational Safety and Health Act (WA) 1984). Together, this demonstrates the applicability of WHS due diligence considerations to officers in all Australian organisations.

The new WHS Act imposes specific obligations on a ‘person conducting a business or undertaking’ (a PCBU) and on the ‘officers’ of that PCBU. These duties cannot be delegated and financial and custodial penalties for failure to comply are significant and coverage by directors’ and officers’ insurance is not legally enforceable (Tooma 2012). The PCBU is essentially the entity that controls the workplace. Included as PCBUs are some individuals (such as sole traders and partners conducting a business in partnership), organisations (including volunteer organisations) and legal ‘persons’ (e.g. companies). A primary duty of each PCBU is to ensure, so far as reasonably practicable, the health and safety of workers. This includes workers directly engaged by the PCBU as well as those whose work activities are influenced or directed by the PCBU (WHS Act 2010, s19).

The duty of care required of an officer of a PCBU is that the officer “must exercise due diligence to ensure the PCBU complies with its duties or obligations” (Corporations Act 2001, s27(1), emphasis added). The minimum due diligence requirements outlined in section 27(5) of the WHS Act provide important guidance about the actions officers need to undertake to ensure compliance. These include taking reasonable steps to,

(a) acquire and keep up-to-date knowledge of work health and safety matters; and
(b) gain an understanding of the nature of the operations of the business or undertaking of the PCBU and generally of the hazards and risks associated with those operations; and
(c) ensure that the PCBU has available for use, and uses, appropriate resources and processes to eliminate or minimise risks to health and safety from work carried out as part of the conduct of the business or undertaking; and
(d) ensure that the PCBU has appropriate processes for receiving and considering information regarding incidents, hazards and risks and responding in a timely way to that information; and
(e) ensure that the PCBU has, and implements, processes for complying with any duty or obligation of the person conducting the business or undertaking under this Act; and
(f) verify the provision and use of the resources and processes referred to in paragraphs (c) to (e).

(Source: Model Work Health and Safety Act 2010, s27(5))

Notably, the potential relevance of both financial and non-financial accounting practices to WHS is demonstrated by inclusion of references to activities such as resourcing, performance reporting and analysis and verification (see above, sections 27(5) c, d and f respectively). The accountability of those officers with oversight of the accounting function may be justified to the extent there is some capacity on the part of accountants to control or influence WHS.

The “controllability principle” is a fundamental concept in management accounting practice. It recognises that decreased motivation, perceived injustice, increased role stress and dysfunctional behaviour may occur when managers are held accountable for factors and results beyond their control (Burkert, Fischer and Schaffer 2011) and argues that a manager should be held accountable only for those items or performance s/he is able to control (Burkert et al. 2001; Otley 1990). The principle operates as a “cornerstone in the design of responsibility accounting systems” (Ferrara 1967; Solomons 1965), although evidence suggests companies do not apply it in its strictest sense but their hold managers “accountable for performance factors that they cannot totally control but that they can at least influence” (Giraud, Langevin and Mendoza 2008: 34, see also Dearden 1987; Merchant 1989). While accounting performs a critical role in both informing and enacting the strategic and financial decisions of senior management, their capacity for accounting officers to influence on, let alone control of, WHS remains unclear.

The contribution of accounting to WHS

practices, including cost control and performance measurement, suggesting further consideration of the influence of accounting on WHS may be warranted.


On the 25th September, 1998 a leak from a steel cylinder resulted in a catastrophic fire and explosion that killed two men, injured eight others and cut Melbourne’s gas supply for two weeks. The company’s investigation is purported to have concluded that the on-duty control room operators and supervisors made a number of crucial and inexcusable errors. However, the Royal Commission took the view that “neither this man nor any of the others present on the day was at fault, for none of them understood the significance of the mysterious events they were witnessing. The fault was Esso’s. The company had “failed to take measures which were plainly practicable”, measures which it “could and should” have taken.” (Hopkins 2000 p1). Hopkins (2000) demonstrates how operator error should be the beginning not the end, of the analysis and suggests,

Asking why errors were made is far more useful than asking who is to blame. Asking why leads invariably to more fundamental cultural and organisational causes. Inquiries must get to this level if they are to be of any value in preventing recurrences. Moreover, once it is understood that there are reasons why people behave as they do, blame becomes far less appropriate (Hopkins 2005, p27).

Hopkins’ (2000) identified many contributing factors. Importantly, resource allocation decisions were identified as a key driver of many organisational-level contributing factors. For example, cost reductions reportedly led to a maintenance backlog, inadequate training and understaffing. The latter was implicated in poor engineering design, inadequate operational supervision and the indefinite postponement of the gas plant’s crucial hazard identification and operability audit (HAZOP). Furthermore, Hopkins observes cost control concerns “had been effectively communicated to the workforce” to such an extent that an operator reported to the Royal Commission inquiry,

I would go so far as to say I faced a dilemma on the day, standing 20 metres from the explosion and the fire, as to whether or not I should activate the ESD 1 (Emergency Shutdown 1), because I was, for some strange reason, worried about the possible impact on production (Hopkins 2000 p146).

Furthermore, Hopkins’ (2000) suggests the firm’s incident reporting, performance auditing and performance management systems had “systematically ignored previous upsets which might have provided warnings of disaster” (p79) and instead focused (almost entirely) around an inappropriate KPI (lost time injuries\(^5\)) that “distracted attention from the risk of a major incident” (p76). Hopkins notes,

Safety was measured in terms of lost time injuries and Esso’s safety efforts were therefore focused on minimising the number of minor injuries... Such a strategy ignored completely the special role of management in controlling major hazards...

The focus on lost time injuries impeded the recognition of hazards implicit in unrepai red equipment, thereby distorting Esso’s maintenance program (Hopkins 2000 p79).

Dekker (2011) suggests that within a complex system, reliance on a single performance measure can serve to limit (or to amplify) the local knowledge available for others to see and thus “direct and constrain what other people in the complex system will see as sensible, rational or even possible” (p14). For Esso, it appears that over time the absence of lost time injury came to be (incorrectly) interpreted within the organisation as ‘safety’ even though latent hazards and their warning signs had routinely been present. This illustrates what Dekker (2011) calls a ‘drift to failure’; the gradual, incremental decline into disaster driven by factors that serve to ‘normalise deviations’ (Turner 1978) and by doing so obscure ever increasing levels of risk.

Hopkins (2000) observes that companies should actively seek out and apply the valuable lessons to be learned from the mistakes of others. Among the ‘lessons from Longford’ are cautionary tales for those with responsibility for cost control and the oversight of budgeting and financial resource allocation processes (such as capital expenditure, equipment maintenance, training and human resourcing). Critically, the findings also present lessons for those charged with the design and implementation of performance management systems by demonstrating the importance of understanding what KPIs actually capture. Without this knowledge, valid interpretation of performance information may be compromised and the ability to pre-empt and assess potentially significant dysfunctional consequences impaired.

Case B: The Glenbrook Train Crash - Glenbrook, New South Wales.

On 2nd December 1999 a commuter train carrying passengers from the Blue Mountains to Sydney stopped at a red light at Glenbrook Station. The driver had already been told that the light was probably defective and that it had gone to red as a failsafe mechanism, so he radioed the signaller and asked for permission to proceed. Minutes earlier another train, the Indian Pacific, had been authorised to pass the same signal however, it had stopped just over a kilometre ahead at a second red light. The signaller did not know that the Indian Pacific had stopped for a second time, because the driver had been unable to make contact due to difficulties with a trackside phone, Thus the signaller authorised the movement of the commuter train. Upon rounding a bend the driver saw the interstate train in his way. He applied the emergency brakes.

\(^5\) Despite becoming a “cornerstone” of WHS reporting, LTI data are a poor measure of safety (i.e. freedom from risk of injury) because they 1) are incapable of measuring latent hazards that have yet to translate to injury, and 2) only capture that subset of injuries outcomes and are therefore an incomplete measure of injury.
and ran back through the carriage warning people of the impending crash. The driver survived but seven passengers died. (Hopkins 2005: 25).

Hopkins (2005) reports that the rail track owner “argued that the driver of the commuter train was solely to blame, because he was driving too fast”, while conversely, counsel acting for the lives lost in the accident “argued the signaler and a train controller had shown ‘reckless indifference’ to their jobs” (p27). By again asking why errors were made, rather than focusing on issues of blame, Hopkins identified a multitude of factors as contributing to the incident. Hopkins adopts an organisational culture perspective in his analysis, and identifies that “the question of why the driver did not proceed with ‘extreme caution’ is no more or less important that the question of why the Indian Pacific was delayed” (p78).

Hopkins’ (2005) concluded that four cultural drivers contributed to the disaster. First, a culture of rules, portrayed in the creation of seemingly endless volumes of detailed safety rules and amendments that workers failed to fully understand or comply with. Second, a culture of silos, where individuals for various reasons possessed limited awareness of how their tasks, responsibilities and problems connected with and contributed to broader organisational processes and risks. Third, a culture of on time-running in which “production” goals were perceived not only as paramount, but non-negotiable. Finally, a subsequent culture of risk-blindness, as inadequate training, bureaucratic rule-reliance and inadequate support for individuals seeking to report and act on safety issues left many workers increasingly disempowered and ever less risk aware.

Two types of accounting practices appear to have been implicated in these cultural contexts, and ultimately in the WHS risk that led to disaster. First is the performance management system that motivated the institutionalised pursuit of on-time-running (OTR). The Commissioner conducting the Inquiry concluded, in part, that the emphasis on OTR performance targets had compromised safety. OTR “had become so entrenched in the attitudes of railway operational personnel that they could no longer objectively assess anomalous situations” and consequently, the indoctrination of OTR performance goals had led to “an attitude that could not be varied under any circumstances – trains had to run on time despite the circumstances” (p51). Other instances of safety having been “sacrificed to punctuality” came to light in the inquiry’s proceedings (p57). These included the modification of speed triggers on safety mechanisms so that trains could move more quickly through intermediate stops, and reports of pressure on drivers to operate trains that were known to be defective.

The latter alludes to the second way in which financial decision-making appeared to be implicated in safety failure; inadequate investment in infrastructure and routine maintenance. The lack of capital expenditure on communications technology was a particular case in point. First, the signal box which covered the Glenbrook area did not have the commonly available electronic ‘train indicator board’ to indicate the exact position of trains in the area. Second, no fewer than five different systems were used for communication between drivers, controllers and signalers, some of which were so antiquated that the Commissioner conducting the enquiry stated,

*Perhaps he could send up a smoke signal. Really, in the 21st century, a technology that was early 20th century is still being used to communicate. I find that very difficult to understand (cited in Hopkins 2005 p64).*

The combination of “archaic phone technology” (p77) and “non-functioning radios” with evidence of “defective brakes” (p35) and “defective signals” (p58) suggest a cost-culture of systemic under-investment in the purchase and routine maintenance of critical infrastructure that undermined the organisation’s many WHS risk management efforts. In summing up his analysis of the Glenbrook crash, Hopkins (2005) offers the following lesson,

*This analysis of the New South Wales railways has revealed a complex and multifaceted relationship between organisational culture and safety. ...improving safety is not simply a matter of grafting a culture of safety onto an existing organisational culture. The point is that the existing organisational culture, whatever it is, has implications for safety, and these need to be understood. Some aspects of an existing culture may need to be modified before significant safety improvements are possible (p78).*

**Discussion: Accounting for WHS Governance**

This review illustrates how financial resource allocation and performance management decisions can inadvertently contribute to latent hazards that precipitate WHS failure and loss of life. It demonstrates the clear potential for inadequate or misdirected financial resources to undermine an organisation’s capacity to operate safely. It further suggests that, like technical factors and environmental constraints, management decisions may also “create error-enforcing and violation-promoting conditions” that shape and provoke unsafe behaviours (Reason 1995: 1714, Borys 2000).

Traditional technical and behavioural WHS controls, although important, appear insufficient to ensure WHS. Effective governance is a necessary third component of WHS risk management as illustrated in Figure 1.

Importantly, due diligence requirements of officers in the WHS Acts have helped articulate and clarify critical concepts of WHS governance. They seek to help stem the fundamentally preventable tide of WHS failures - be they explosions in high hazard facilities, collapses in underground mines, road crashes and vehicle roll-overs in transport, falls from height on construction projects, stress-related disorders among office workers, or amputated or crushed limbs in machines and conveyor belts; incidents repeated time and again amid claims of a “depressing sameness” in their causes (Hopkins 2008 p4). Moreover, the causes...
are not unique to the Australian experience. Accident investigations around the world repeatedly point to issues of goal conflict, inadequate investment in risk-awareness, training, staffing, plant and equipment maintenance, capital expenditure on risk-controls and inappropriate choices in performance measures and systems (see for example Berger 2007; 2009; Hopkins 2008; Reason 1995, 2008).

It is a tragic but widely understood irony that the financial costs associated with WHS failure tend to far outweigh the savings realised through under-investment in WHS risk management. So what is preventing organisations, and their officers, from learning the vital lessons embedded in the tragedies of others? This review suggests perhaps the most important lessons for accounting practice relate less to recognising the need for WHS risk management and more to understanding how resource allocation processes can engage most effectively in supporting operational-level risk management.

Both organisations in the case studies examined in this paper had already dedicated significant financial resources to WHS, both had well-established WHS risk and WHS performance management programs in place and Esso had even won an industry award for its safety record the year prior to the Longford disaster. However, these efforts appear to have been undermined by a failure to sufficiently integrate WHS considerations into routine business decision-making at the corporate level. As Hopkins (2005) observes, efforts to ‘graft’ WHS objectives on to existing financial objectives are prone to creating serious goal conflict that can threaten the ultimate success of WHS investment and programs.

Officers must therefore appreciate and address the interconnectedness of financial and WHS goals. For many decision-makers, there will require a fundamental but critical change in thinking from ‘resourcing work health & safety’ to ‘resourcing safe & healthy work’.

The concept of resourcing safe & healthy work draws on potentially disconcerting new territory for accountants (Meyer and Land 2006: xv) in that it may appear counterintuitive from the primarily financial, ‘relevant cost’ perspective of traditional accounting education in a discipline which has tended to ignore externalities, disregard those costs incapable of reliable measurement, and remain largely disengaged from the way in which accounting decisions may impact the lived WHS experience across an organisation.

Implications for accounting practice
At a practical level, the accounting strategies and process for ‘resourcing safe & healthy work’ contrast starkly with those for allocating resources to conceptually separate activities of 1) work, or productive activity and 2) WHS risk management. The latter is often enacted by grafting WHS-related line items on to budgets and management reports and implementing WHS systems that essentially function as an organisational ‘silo’. In contrast, resourcing safe & healthy work requires ‘integrated thinking’; the deliberately considered integration of production and safety goals, facilitated by attention to holistic assessments of work that can inform both performance appraisal and financial (including human resource) allocation decisions (Tooma 2012). Notably, the due diligence provisions contained in the WHS Act(s) promotes an integrated approach to officers’ decision-making and oversight. They encourage all officers to engage in WHS risk assessments, processes often demanded only of employees at much lower levels in an organisation’s structure (Hopkins 2008). This does not mean CFOs, for example, need to be specialists in WHS risk assessment; but to be aware how their actions impact operational decisions and WHS outcomes. Integrated thinking requires much closer engagement with WHS professionals and novel approaches to gathering, evaluating and applying information about the potential WHS impact of accounting choices and activities. These insights are particularly important to inform decisions relating to activities such as organisational change, budgeting and capital expenditure as illustrated below.

Organisational change: Many strategies for making workplaces more competitive and productive (such as: downsizing; restructuring; and increasing work hours, work intensification (workload) and work pace (throughput)) have simultaneously been associated with significant adverse impact on WHS risk and WHS failure
Due consideration must be given to safe (and healthy) staffing levels for both operational and supervisory positions in planning and implementing organisational change. Safe staffing levels provide capacity to: accommodate typical patterns of planned and unplanned leave; ensure reasonable workloads; and allow employees to participate in support, training, and supervisory activities. In particular, individuals receiving on-the-job training must be supported by appropriate safeguards, supervision and guidance.

Safe staffing practices acknowledge that while unwanted circumstances may be unplanned and even unexpected they are not unforeseeable, and contingency planning is needed to ensure the safe work practices of workers are not compromised. Furthermore, efforts to align individuals and the desired safe work culture may present particular challenges for organisational control systems in circumstances such as mergers and takeovers or where tasks are outsourced or new employees recruited, due to the potential for entrenched differences in the WHS knowledge, values and culture between the new and pre-existing employees. (Jones 1985, Rooney and Cuganesan 2009).

**Budget allocations:** Both case studies (above) also reinforce the need for routine maintenance to essential property, plant and equipment as crucial for a firm’s success. However recent public sector research reveals that decision-makers perceive “maintenance could be deferred up to 5 years” and that accountants were less likely than engineers to perceive maintenance as having been “deferred” (Walker and Jones 2012: 399). A failure to see routine maintenance as a top priority explains why the physical condition of infrastructure assets has been successfully used as a proxy for predicting financial distress (Jones and Walker 2007).

The social importance of adequate investment in asset maintenance is underscored by cases such as the explosions at BP’s Texas City (2005) and DeepWater Horizon (2010) sites and the deadly methyl isocyanate gas leak at Union Carbide’s (1984) site in Bhopal. Deterioration of key infrastructure not only affects the “quality of service delivery” but may pose a “risk of critical failure” (Jones, Hensher, Rose and Walker 2012: 465) with potentially “catastrophic social and financial consequences” (Walker and Jones 2012: 411).

Integrated thinking may drive a much broader interpretation of ‘critical failure’; one which sees any serious but preventable injury as a critical failure to ensure safe and healthy work. Since poorly maintained equipment is implicated as a contributing factor in hundreds of workplace fatalities and serious injuries each year. It could be argued that inadequate maintenance constitutes a failure to exercise due diligence in ensuring WHS to the extent reasonably practicable.

**Capital expenditure appraisal:** Continued pressure for corporate sustainability is focusing managerial attention on a broad range of whole-of-life considerations in the assessment of capital expenditure alternatives. Deegan’s (2008) examination of capital investment in power poles provides a useful illustration. He shows incomplete analysis and “inappropriate capital investment decisions” can arise from failure to consider various life cycle costs including: installation, maintenance, disposal and contingent costs, such as those relating to potential breeches of legislation or regulations; costs relating to reputation and image; and various externalities currently imposed on society (Deegan 2008).

Injury prevention through safe design seeks to eliminate WHS failures through addressing risks at design and purchasing stages. Examples include procurement programs which target purchases with safety features over cheaper alternatives (e.g. see Kovalchik, Matetic, Smith and Bealko 2008). Potential cost savings include reductions in after-market safety modifications and personal protective equipment, and the elimination of a range of workers’ compensation and other WHS failure costs.

Together this review demonstrates the potential for integrating WHS considerations into purchasing, resource allocation and performance management decisions; focusing decision-making on safe and healthy work (as opposed to seeing ‘work’ and ‘health and safety’ as two discrete organisational objectives). As a result, the WHS goal no longer stands in direct competition for resources with other organisational goals such as production but becomes an essential component of the production goal itself. This holistic approach to WHS governance better positions WHS risk within the organisational risk management framework.

**5. Conclusion**

The duty of care and due diligence obligations imposed on all officers of an organisation by Australian WHS legislation renders many senior accounting professionals individually responsible, and legally accountable, for WHS governance. Findings presented in this paper suggest the WHS Act’s due diligence requirements offer two important contributions to the accounting discipline. First, they acknowledge the potentially significant, albeit often indirect, influence of accountants on the day-to-day reality of WHS. Second, and more importantly, they target the specific accounting practices that have indirectly but repeatedly contributed to the occurrence and reoccurrence of work-related fatality, injury and illness; actively undermining other WHS risk management efforts. The imposition of a legal duty of care on those accounting officers charged with oversight of resource allocation performance management functions therefore appears justified.

The move to articulate officers’ WHS due diligence duties within legislation suggests the WHS consequences of corporate level decisions were previously either poorly understood, or poorly addressed, at an executive level. This paper illustrates the tangible and potentially significant

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7 Some tasks require more than one person for safety reasons. For example, in October 2012, a 21 year old youth working alone on a construction site in Canberra’s CBD fell more than 6 metres down a ventilation shaft onto concrete receiving serious spinal and respiratory injuries, including a broken back, broken ribs, punctured lung, loss of consciousness and slight bleeding on the brain. The young man lay alone in the dark for over two hours until found (see Towell 2012).
implications that routine decisions of chief financial officers, financial controllers, senior accountants, directors and small business owners have for the WHS risk to which other individuals are ultimately subjected. Consequently, an appreciation of the need to ensure safe and healthy work has never been more important for those charged with organisational governance.

Overall, the officers’ due diligence requirements contained in the WHS Act (2010) not only appear appropriate but offer important guidance for senior executives; both in terms of interpreting their legal duty of care obligations (where applicable) and developing a holistic framework for risk management and decision-making that has the potential to reduce WHS costs and actually save lives.

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References


Fatigue: A case study of sleep obtained versus sleep opportunity in mining

Liam Wilson

Abstract

Shift rosters should be designed to give individuals the opportunity to obtain adequate sleep and thereby operate at an effective level. Once the roster is designed and validated against a scientific bio-mathematical model, the actual sleep that workers are obtaining needs to be quantified and verified to confirm that it is providing sufficient supporting sleep.

This paper outlines the sleep opportunity versus sleep obtained for shift work operators in a mining environment. It also analyses whether there were differences in the individuals’ sleep patterns and individual effectiveness. Twelve operators voluntarily wore actigraphs for a month covering a number of shift roster cycles to determine their individual sleep/wake patterns. Each individual was given a comprehensive individual report and feedback on their statistics, positive behaviours and areas for improvement in their sleep hygiene. It also identified any abnormal sleep patterns for further investigation.

The roster analysis utilising FAST® showed that the roster was designed to provide an opportunity for eight hours of good sleep. On average the operators recorded 7:17hrs sleep/day (SD = 0:42min), however five out of the 12 operators recorded less than the recommended minimum average of 7hrs/day.

Actigraphs are one tool that can be used as a part of a holistic fatigue management system to determine individual sleep/wake patterns and provide a potential opportunity for improvement in individual sleep hygiene and increased individual effectiveness.

Introduction

“Fatigue can be defined as a state of impairment that can include physical and/or mental elements, associated with lower alertness and reduced performance” (Industry and Investment, 2009). There are a number of contributing factors to fatigue but they usually relate to lack of sleep quantity or quality, extending the time someone is awake or other work related or individual factors (Department of Employment, Economic Development and Innovation, 2010). Signs include tiredness even after sleep, psychological disturbances, loss of energy, and inability to concentrate. Levels of work related fatigue are similar for different individuals performing the same task. Fatigue can lead to incidents as workers are not alert and are less able to respond to changing circumstances (Industry and Investment NSW, 2009).

Humans were not designed for night work. Due to our circadian rhythms, we have a natural tendency to feel sleepy at night and alert during the daytime. Circadian rhythms never fully adapt to the night shift because of sunlight’s effect on the biological clock and people return to a daytime sleep schedule on their days off. Due to this process, people may not get adequate sleep to prevent fatigue (Moore-Ede, 2011).

A shift roster analysis can be used to ensure that the roster allows adequate sleep opportunity for workers to obtain a minimum of 7 hours sleep per day (Archinoetics, 2006). Such an analysis was undertaken at an operating surface mine in Australia. The mine has a village on site 1km from the operation with accommodation providing a good sleep environment (e.g. ensuite, split air conditioning, heavy curtains/blackout) (Archinoetics, 2006). The operators reside at the village during their shift roster and are bussed in and out of the operation at the start and end of the roster. The obtained sleep was compared to the roster modelled-sleep opportunity and recommended sleep guidelines to determine if the sleep obtained was different to the modelled opportunity of 8hrs or the minimum recommended sleep guideline of 7hrs.

This paper is based only on recorded wake/sleep patterns. It does not take into account controls that are implemented at the operation to manage operational hazards and increased accident risk of the shift roster.

Methodology

Twelve (12) actigraphs were worn by volunteers to measure individual wake time/sleep time patterns (obtained sleep) and potential fatigue levels over a 28 day period. The period covered 4 panels (crews) and a number of cycles of the forward rotating three days on, one day off, three nights on, five days off (3,1,3,5) 12.5hr shift roster. The study was conducted during November and December 2011. The sleep opportunity for the roster was modelled using the FAST® software programme (Archinoetics, 2006). The roster was designed by the mine operation in consultation with workers to provide an opportunity for eight hours of good sleep. Good Sleep environment is defined as 2 interruptions per hour providing 50 minutes per hour of effective sleep. An interruption is not necessarily a full awakening, but may be a change in sleep conditions.

CITE THIS ARTICLE AS

KEY WORDS:
Actigraph, shift work, sleep opportunity, circadian rhythm, obtained sleep, sleep debt, wake time, sleep time, effectiveness, accident

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quality caused by outside interference. Figure 1 shows an example roster modelled using the FAST® programme. The model has been scientifically validated (Office of Research and Development, 2006).

The actigraphs used to measure awake/sleep time were Texas eZ430 Chronos (Texas Instruments, 2010). The actigraph also operates as a normal digital watch, having functions including time, date and stopwatch. The actigraph measures activity through sensors by movement of the watch on the wearer’s wrist. The sensors have the capability to measure activity, temperature and altitude. The actigraph has a limited memory capacity and therefore more frequent measurement intervals, saving intervals and recording of activity limits the duration that data can be recorded and stored. For this study the temperature and altitude settings were not used as not being the focus of the study and to increase the amount of data that could be collected. The actigraph may be set to start on a nominated date and time. For this study the start and finish date and time was set for each participant. The actigraphs were set to local time, to record a measurement interval of five (5) seconds and a saving interval of 240 seconds. Individuals who volunteered to wear the actigraph wore the actigraphs for 28 days. The individuals were given the watch at the start of shift on the first day of a shift cycle. A total of 318 sleep times were used for the analysis. Where sections of data were invalid, these were removed from the calculations.

The actigraphs use the software program FRMSWatch® to set and download data (Fachhochschule Schmalkalden 2011). The data is analysed using the software program FRMSAnalyse® (Fachhochschule Schmalkalden 2011).

Figure 2 shows an example print out of a break down into seven days for a wearer’s activity in absolute format. The absolute format analysis provides the total wake time and sleep time in the 24hr period, midnight to midnight. Absolute data was used for the analysis.

The data was analysed using Minitab® statistical analysis software programme (Minitab, 2012). The key Statistics provided in each individual report were: range of sleep per day; average sleep per day; longest single sleep; shortest/longest overnight/day sleep; range of awake per day; average awake per day; longest single awake period.

Each individual was given a report and feedback on positive behaviours and areas where sleep hygiene could be improved to increase effectiveness. Effectiveness is measured as the level of mental capability (speed of cognitive performance) as a percent of the best normal performance of a fully rested person. If abnormal sleep patterns were identified, further investigation was recommended. Individual sleep patterns have been compared to determine if significantly different.

**Results**

The results are summarised in Table 1 (following pages) and statistically in Figures 3-5.
### TABLE 1:
Sleep Statistics Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Range (Hrs)</th>
<th>Study Result (Hours)</th>
<th>Standard Deviation</th>
<th>Outside Normal Range</th>
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<tr>
<td>Range of Sleep per day (hrs/day)</td>
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<td>0 – 18:12</td>
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<td>Y</td>
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<td>Average sleep per day (hrs/day)</td>
<td>7-9</td>
<td>7:17</td>
<td>1:49 (all data) 0:42 (individual ave)</td>
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<tr>
<td>Longest single sleep (hrs)</td>
<td>7-9</td>
<td>20:28</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Shortest single sleep (hrs)</td>
<td>7-9</td>
<td>2:26</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Range of Awake per day (hrs/day)</td>
<td>15</td>
<td>5:48 – 24</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Average awake per day (hrs/day)</td>
<td>15 - 17</td>
<td>16:42</td>
<td>0:42</td>
<td>N</td>
</tr>
<tr>
<td>Longest single awake period</td>
<td>15 - 17</td>
<td>46:44</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Range for single nap*</td>
<td></td>
<td>1:08-3:08</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Not main sleep for day/night

### FIGURE 3:
I-MR Chart of Hours Sleep

![I-MR Chart of Hours Sleep](image)

### FIGURE 4:
Hours of Sleep Statistical Analysis

![Hours of Sleep Statistical Analysis](image)

**Anderson-Darling Normality Test**
- A-Squared: 2.61
- P-Value: 0.005

<table>
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<tr>
<td>StDev</td>
<td>0.10357</td>
</tr>
<tr>
<td>Variance</td>
<td>0.01073</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.24562</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.32434</td>
</tr>
<tr>
<td>N</td>
<td>318</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00000</td>
</tr>
<tr>
<td>1st Quartile</td>
<td>0.24722</td>
</tr>
<tr>
<td>Median</td>
<td>0.29722</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>0.36667</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.75833</td>
</tr>
</tbody>
</table>

**95% Confidence Interval for Mean**
- Lower: 0.29186
- Upper: 0.31471

**95% Confidence Interval for Median**
- Lower: 0.28889
- Upper: 0.31111

**95% Confidence Interval for StDev**
- Lower: 0.09610
- Upper: 0.11232
The sample size was 318. The average (mean) sleep/day for the study period (318 samples) was 7:17 hours/day with a standard deviation of 1:49 hrs as shown in Figure 4. Ten (10) samples (hours sleep/day) exceeded the Upper Control Limit (UCL = 13:44 hrs) or Lower Control Limit (LCL = 00:48 hrs). Five exceeded the UCL and five the LCL (zero [0] hours sleep in a 24hr period) as shown in Figure 3. The Lower Confidence Limit of the mean for all data was 7:00 hrs and the Upper Confidence Limit of the mean for all data was 7:34 hrs as shown in Figure 4. The sleep patterns of the individuals were significantly different as shown in Figure 5.

Individual 6 is significantly different to 3, 5, 7, 11 and 12. Individual 10 is significantly different to 7, 11 and 12.

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There was a standard deviation of 0:42 hrs on the 12 participants’ average (mean) sleep/day. The average hours of sleep/participant/day ranged from 6:23 to 8:39 hrs. Five (5) of the 12 participants averaged less than the recommended minimum of 7hrs sleep/day.

The shortest overnight/day sleep time 2:26 (hrs) was recorded for an individual after being up for a period of 22:30 hrs. The range for the group was 2:26 hrs to 6:00 hrs. The longest sleep time was 20:28 (hrs). The range was 9:12 hrs to 20:28 hrs.

The shortest day of wake time was 5:48 (hrs). The longest period of wake time 46:44 (hrs) was recorded from 3:36am on Friday 25/11/2011 to 2:40 am on Sunday 27/11/2011. This person was awake from 3:36am on their last day shift until 2:40am into their 2nd R&R shift, 31:34hrs after finishing the shift. The individual was operating at 34% effectiveness at 2:30am on Sunday 27/11/2011.

Studies have shown that after 17hrs without sleep a person’s reaction time is equivalent to a blood alcohol level of 0.05%, after 21hrs 0.08% and after 24hrs 0.1%. Table 2 summarises the reaction time equivalent Blood Alcohol Content (BAC) and effectiveness for the longest wake time. At 0.1%, the risk of a crash is seven times greater than driving with a BAC of zero (Dawson and Reid, 1997).

Table 3 (following page) outlines the effectiveness comparison for sleep opportunity versus sleep obtained.

The modelled sleep opportunity for the 3135 roster predicts a work average increased accident risk of 11% and the wake average increased accident risk of 10% based on effectiveness prior to implemented controls.

**Discussion**

The average (mean) sleep/day for the study period was 7:17 hrs/day with a standard deviation of 0:42 hrs. The average hours of sleep/day ranged from 6:23 to 8:39 hrs. There was a significant difference in the sleep/day between participants. Although the average was greater than 7hr sleep/day, five (5) of the 12 participants averaged less than the recommended minimum of 7hrs sleep/day (National Sleep Foundation, 2011).

**TABLE 2:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Reaction time Equivalent BAC %</th>
<th>Effectiveness %</th>
</tr>
</thead>
<tbody>
<tr>
<td>25/11/2011</td>
<td>8:36pm</td>
<td>0.05</td>
<td>77.5</td>
</tr>
<tr>
<td>26/11/2011</td>
<td>00:36am</td>
<td>0.08</td>
<td>70</td>
</tr>
<tr>
<td>25-26/11/2011</td>
<td>8:36pm – 00:36am</td>
<td>0.05-0.08</td>
<td>77.5 – 70</td>
</tr>
<tr>
<td>26/11/2011 – 27/11/2011</td>
<td>03:36am – 2:40am 27/11</td>
<td>&gt;0.1</td>
<td>70-34</td>
</tr>
</tbody>
</table>
TABLE 3:
Effectiveness comparison of Sleep Opportunity versus Obtained Sleep

<table>
<thead>
<tr>
<th></th>
<th>Modelled 3,1,3,5 Roster</th>
<th>Longest awake period, first 10 days</th>
<th>Longest awake period</th>
<th>Shortest Average hrs sleep/day</th>
<th>Longest Average hrs sleep/day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Work</td>
<td>Wake</td>
<td>Work</td>
<td>Wake</td>
<td>Work</td>
</tr>
<tr>
<td>Average Increased Accident Risk (%)</td>
<td></td>
<td>11</td>
<td>13</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Average Roster effectiveness %</td>
<td></td>
<td>83</td>
<td>77</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Average Work effectiveness %</td>
<td></td>
<td>81</td>
<td>76</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>90% effectiveness</td>
<td></td>
<td>72</td>
<td>74</td>
<td>80</td>
<td>77</td>
</tr>
<tr>
<td>80% effectiveness</td>
<td></td>
<td>40</td>
<td>22</td>
<td>48</td>
<td>69</td>
</tr>
<tr>
<td>77.5 % effectiveness</td>
<td></td>
<td>37</td>
<td>20</td>
<td>46</td>
<td>67</td>
</tr>
<tr>
<td>70% effectiveness</td>
<td></td>
<td>24</td>
<td>13</td>
<td>40</td>
<td>61</td>
</tr>
<tr>
<td>60% effectiveness</td>
<td></td>
<td>2</td>
<td>1</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>50% effectiveness</td>
<td></td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>40% effectiveness</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

The individual with the longest single awake period had an average increased accident risk at work of 19%, however their average sleep (6:43hrs) was longer than the shortest average sleep per day (6:23hrs). This individual had a higher increased accident risk (19% versus 16%) as a result of the amount of time they spent below each individual percentage effectiveness level i.e. below 90, 80, 70% etc. The individual recovered some of the sleep debt incurred during the single awake period (44:46hrs) over the study period. In analysing the individual actigraph data it is important to look at all parameters to determine outcomes.

The individual with the shortest average sleep per day (6:23hrs) resulted in an average increased accident risk of 16% (work and wake) compared to the individual with the longest average sleep per day (8:39hrs) with an average increased accident risk of 6.8% (Work). All other individuals were within the range of 7-19% compared to the modelled sleep opportunity with an average of 11% (Work).

Although education and awareness around fatigue and its management is provided, a number of individuals are not managing their sleep habits, decreasing their effectiveness and increasing the risk of incident occurring at and away from work.

The results show that the roster provides adequate sleep opportunity to get the minimum obtained sleep and that some participants did get this or an even greater amount (Office of Research and Development, 2006).

Conclusion
This study has shown that modelling is a useful tool to design an effective shift roster, however once implemented it is important to measure the actual effectiveness of the roster as there can be a significant difference between both individual sleep patterns and the actual sleep obtained versus the opportunity. The use of actigraphs can be a very effective tool for one on one awareness and education of individuals on their current sleep habits and where improvements can be made to increase effectiveness.

The results of the study show the importance of a robust and effective Fatigue Management System (Sufficient staffing levels, sufficient sleep opportunity, sufficient obtained sleep, controlled workplace environment, alertness, behaviour and incident investigation & prevention) to ensure all risks are identified and managed effectively through a shared responsibility approach, between employers and employees.

This paper was first presented to the 30th AIOH annual conference Adelaide 1-5 December 2012

References
Archinoetics 2006 Sleep, Activity, Fatigue and Task Effectiveness/Fatigue Avoidance Scheduling Tool, computer software, Honolulu
Circadian Technologies Inc., 2010 Fatigue Risk Management System, Stoneham MA USA
Fachhochschule Schmalkalden 2012 FRMSSanalyse, version 11, computer software, Schmalkalden, Germany
Fachhochschule Schmalkalden 2011 FRMSWatch, version 4, computer software, Schmalkalden, Germany
Industry and Investment NSW (2009), Fatigue Management Plan, A practical guide to developing and implementing a fatigue management plan for the NSW mining and extractives industry, NSW
Minitab, Minitab 16, computer software, State College PA USA