Research

Serious injuries in the mining industry: preparing the emergency response

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Abstract

Introduction

Paramedics are employed by Australian and international mining and petroleum organisations to provide emergency medical response, injury prevention, health promotion, chronic disease management, medical referral, primary healthcare and repatriation co-ordination for miners in exploration, construction and production. These are challenging roles given the often isolated, potentially hazardous and clinically unpredictable nature of the sites where these paramedics work. The purpose of this article is to review injuries that occurred in the mining industry with a view to sharing this information with paramedics who work within the mining sector.

Methods

Data was collected under legislative authority by the Western Australian Department of Mines, Industry Regulation and Safety (DMIRS). Data efficacy was optimised via strong legislative support whereby all organisations involved in mining activities are legally compelled to report to the DMIRS all accidents involving injury.

Results

A total of 837 injuries were reported during the 6-month period between 1 July and 31 December 2013. These comprised 658 serious injuries, including three fatalities, and 179 minor injuries. Sprains and strains were the most common injury comprising 69% of injuries followed by fractures 10%, lacerations 6%, crushing injuries 5%, bruises and contusions 4%, and dislocations and displacements 2%. Foreign bodies, punctures, bites, amputations, chemical effects, thermal burns, flash and arc burns and loss of consciousness each recorded less than 1% of the injuries.

Conclusion

Findings presented in this article can be used by paramedics working in the mining sector across Australia and worldwide. Paramedic awareness of the nature and cause of injury is useful for optimally preparing paramedics to perform appropriate diagnosis and treatment and to minimise patient mortality and morbidity.

Keywords:

paramedic; injuries; mining

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Introduction

Paramedics are employed by Australian and international mining and petroleum organisations to provide emergency medical response, primary healthcare and promotion, medical referrals, chronic disease management, injury prevention and repatriation coordination to miners working in exploration, construction and production (1). These are challenging roles given the often isolated, potentially hazardous and clinically unpredictable nature of the sites where these paramedics and the workforces they support work (2-4). Mining has been highlighted as particularly dangerous by Acker et al (1) who point to analyses by SafeWork Australia showing the number of mining fatalities within Australia to be 3.84 per 100,000 employees in 2011-2012, thereby exceeding the national fatality rate by 70% (5). Ehsani et al (6) also report fatalities within the mining sector to be among the highest within Australian workforce sectors.

Fortunately in many countries, including Australia, optimising health and safety within the mining sector is a focus of those involved in the industry (7). See, for example, government bodies such as the Department of Mines and Petroleum (8-10) and SafeWork Australia (5,11). Whereas isolation can be mitigated to some extent through telemedicine, i.e. remote diagnosis via telecommunications technology (12-14), the workforce on isolated mine sites face very real challenges due to an absence of the same level of medical care available in metropolitan centres (15). For example, surgical expertise is almost non-existent outside the capital of Perth with only 14 surgeons operating in the 74 non-metropolitan hospitals within the 2.5 million square kilometres of Western Australia (16). All major acute tertiary hospitals serving the state are located in the capital and transfer to the capital is required for all major trauma patients given the limited access to specialist expertise in rural WA. Indeed, a person suffering a major injury in rural or remote Australia is twice more likely to die than if the injury is sustained in a metropolitan setting (17). In rural and remote WA mortality from traumatic injury is up to four times higher than mortality rates in Perth, the only location in WA with a level 1 trauma centre (16).

Australia covers an area of 7.69 million square kilometres (2.97 million square miles) most classified as rural, remote or very remote by the Australian Institute of Health and Welfare (18). Within this vast area there are 420 mine sites with 187 of these in WA (19). In addition there are 75 mineral processing plants in Australia with 23 of these in WA (20). Mining activities are broad ranging and include those above and below ground. In addition, mining activities cover the spectrum of minerals including iron ore, gold, silver, nickel, coal and mineral sands.

Given the paramedics who work on the exploration, construction and production plants are primarily responsible for dealing with the trauma that occurs in and around these plants

it is worthwhile to review the accidents and the subsequent traumatic injuries that occur. Paramedics who work in these environments and the organisations that support them will have an optimal understanding of the types of inquiries that occur and the frequency with which they occur. The purpose of this article is to review 837 injuries that have occurred in the large mining industry within WA with a view to optimising the preparation of paramedics who work within the mining sector.

Methodology

Data collection

Data was collected under legislative authority by the Western Australian Department of Mines, Industry Regulation and Safety (DMIRS). Most relevant to the research reported in this article are the Mines Safety and Inspections Act 1994 (21) and the Mines Safety and Inspection Regulations 1995 (22). Under this legislation, all mining industry activities within WA are legally compelled to report to the WA Department of Mines and Petroleum all accidents involving injury and all 'near misses' (unplanned incidents that may not necessarily result in injury). This legislative requirement yields a comprehensive dataset and strong support for the efficacy of the data within the dataset.

Types of injuries

Four types of injuries were considered: serious injuries, minor injuries, lost time injuries and restricted work injuries. A serious injury is legislatively defined by the Mines Safety and Inspections Act as an injury that 'results in the injured person being disabled from following his or her ordinary occupation for a period of 2 weeks or more; or involves unconsciousness arising from inhalation of fumes or poisonous gases or asphyxiation due to lack of oxygen or displacement of oxygen by an inert gas; or results from an accident, including fuming, arising out of the use of explosives' (21). Serious injury data include fatalities. A minor injury is a legally reportable injury of lesser severity than a major injury. Lost time work injuries are those resulting in the injured person being absent from work for a minimum of a full shift or full day. Restricted work injuries are injuries that prevent the injured person from performing their usual work related tasks but are not classified as lost time injuries.

Notifiable incidents

The DMIRS also collects information about unplanned incidents that may result in injury. These data include a large proportion of 'near misses'. The DMIRS collects data on the following notifiable incidents with the aim of reducing or eliminating injury (10):

1. Extensive subsidence or major collapse of ground
2. Outbreak of fire
3. Breakage of equipment that has the purpose of raising or lowering workers
4. Inrush of water into mining operations

5. Presence of harmful or asphyxiant gas or unintentional ignition of dust below ground
6. Unintended or untimely delay or acceleration of explosive detonation
7. The bursting or explosion of pressure vessels, air receivers or boilers
8. Burns, electrical shock and hazardous electrical activity
9. Poisoning or exposure to toxic fumes or gas
10. Loss of control of heavy earth moving equipment.

Sample and sample size

Data collected by the DMIRS from 2002 to 2013 shows that the number of employees within the WA mining industry increased from 40,000 to 100,000 over this period (10). Research reported in this article focusses on the 6-month period between 1 July and 31 December 2013.

Results

Overview

A total of 837 injuries and 1036 near misses were reported during the study period. These comprised 658 serious injuries including three fatalities and 179 minor injuries. The spread of these injuries across mining related activity is reported in Table 1. Operations activities were responsible for the majority of injuries (54%) including operations in open pit, quarries and below ground. This was followed by maintenance activities (28%) including workshops and fixed plant areas, support activities (6%), construction (4%) and exploration (4%). Seven-eighths (88%) of serious injuries occurred on the surface and only one-eighth (12%) occurred underground.

Table 1. The number of serious and minor injuries by operational activity

Operational activity	Serious injuries (%)	Minor injuries (%)	Total injuries (%)
Construction	27+1 fatality (4)	13 (7)	40+1 fatality (5)
Mining operations	355+2 fatalities (54)	88 (49)	443+2 fatalities (53)
Mining maintenance	187 (28)	50 (28)	237 (28)
Mining exploration	29 (4)	10 (6)	39 (5)
Mining support	42 (6)	14 (8)	56 (7)
Exploration operations	14 (2)	3 (2)	17 (2)
Exploration maintenance	1 (0)	0 (0)	1 (0)
Exploration support	0 (0)	1 (1)	1 (0)
Total	655+3 fatalities (79)	179 (21)	834 (+3 fatalities) (100)

Note. Column percentages that do not add to 100 result from rounding to the nearest whole number.

Patient age

The age of those workers who received a serious injury is reported in Table 2 by 5-year age groups. Lower numbers in the 18-22 years and more than 58 years age groups are likely due to the lower number of workers in these age groups.

Table 2. The number of serious injuries by 5-year age group (*age groups with greater likelihood of comorbidities), N=658

Age (years)	Serious injuries (%)	Age (years)	Serious injuries (%)
18–22	32 (5)	43–47	83 (13)
23–27	73 (11)	48–52*	99 (15)
28–32	103 (16)	53–57*	63 (10)
33–37	78 (12)	58–62*	24 (4)
38–42	91 (14)	63–67*	12 (2)

Note. Column percentages that do not add to 100 result from rounding to the nearest whole number.

Nature of injury

The nature of the serious injuries is reported in Table 3. Sprains and strains were by far the most common injury comprising 69% of injuries followed by fractures 10%, lacerations 6%, crushing injuries 5%, bruises and contusions 4%, and dislocations and displacements 2%. Foreign bodies, punctures, bites, amputations, chemical effects, thermal burns, flash and arc burns and loss of consciousness each recorded less than 1% of injuries.

Table 3. The number of serious injuries by the nature of injury

Nature of injury	Serious injuries (%)	Nature of injury	Serious injuries (%)
Sprains and strains	451 (69)	Amputations	6 (1)
Fractures	68 (10)	Chemical effects	5 (1)
Lacerations	37 (6)	Thermal burns	5 (1)
Crushing	34 (5)	Flash/arc burns	1 (0)
Bruises/contusions	23 (4)	Loss of consciousness	1 (0)
Dislocations/displacements	15 (2)	Multiple injuries	1 (0)
Foreign bodies, punctures, bites	8 (1)	Unspecified injuries	2 (0)

Note. Column percentages that do not add to 100 result from rounding to the nearest whole number. N=657, as one injury report was excluded from the analysis because it was missing information on the nature of the injury.

Cause of injury

The cause of serious injuries is reported in Table 4. This provides a greater understanding of the events surrounding the occurrence of injuries and provides additional insight into the nature of the injuries. Overexertion was the most common

cause accounting for a third of injuries (37%). Approximately 10% of injuries were caused by either stepping and miss-stepping; being struck by objects; caught between moving machinery and objects; and trips and falls. Vehicle related, recurrent, and combined falls from heights and vehicles each accounted for less than 7% of injuries.

Table 4. The number of serious injuries by the cause of injury

Cause of injury	Serious injuries (%)	Cause of injury	Serious injuries (%)
Overexertion	240 (37)	Recurrence	37 (6)
Stepping/ miss-stepping	76 (12)	Bodily contact	30 (5)
Struck by object	71 (11)	Fall from height	12 (2)
Caught between	63 (10)	Fall from vehicle	12 (2)
Trip and fall	61 (9)	Other	9 (1)
Vehicle related	46 (7)	-	-

Note. Column percentages that do not add to 100 result from rounding to the nearest whole number. N=657, as one injury report was excluded from the analysis because it was missing information on the cause of injury.

Discussion

Serious injuries were apparent in all phases of mining from exploration through to construction and production operations. This has implications for the perception the WA 'mining boom' has ended simply because the construction phase of many mining projects has come to end. Importantly, the production and maintenance phases of mining operations include a large proportion of patients with injuries and these phases will continue for decades after the recent construction boom has finished. Of particular note is that almost half (54%) of serious injuries occurred in the post-construction mining operations phase and a further 28% of serious injuries occurred during mining maintenance. Whereas the incidence of serious injury above ground to below ground occurred at a ratio of 7:1 this is likely to be a consequence of the greater number of above ground mining activities compared to below ground activities. This should not be interpreted as above ground activities being more dangerous than below ground activities.

That 31% of patients were 48 to 67 years of age has important implications for the medical care provided to these patients. With increasing age comes a concomitant increased probability of patients suffering comorbidities and a potentially decreased survivability to massive shock (23). The treating paramedic will need to consider this during comprehensive diagnosis and treatment. The fitness of mining employees cannot

be guaranteed by mining companies and it is commonly misperceived that physically demanding work such as mining will assist employees in maintaining mobility and strength (24). Consequently, older employees with reduced mobility and strength may be exposed to overexertion injuries (24). The physically demanding nature of mining is unlikely to sufficiently increase aerobic capacity and it is likely paramedics will encounter scenarios where an injured mine worker will be suffering from potential cardiac and/or respiratory complications or conditions such as diabetes. It is recommended that the wise paramedic will be prepared for these eventualities.

The most commonly recorded injuries were strains and sprains (69%), followed at a distance by fractures (10%). This supports the finding of a recent systematic review by Nowrouzi-Kia et al (25) who found strains and sprains to be the most commonly reported injury across nine studies across numerous countries. Musculoskeletal injuries such as these tend to be caused by lifting and employee mobilisation, e.g. walking around site, stepping down from ladders and tripping over self or objects. This fits with the most commonly reported cause of injury, overexertion, which was found to be the cause of more than a third of injuries (37%). Generally, overexertion is often associated with 'lifting, carrying, pushing, pulling and moving objects or strenuous and repetitive work or awkward or sustained postures' (10). In the mining context, the use of non-powered hand tools, handling material and loading and unloading materials, working in awkward spaces, getting on and off equipment, vibration exposure and maintenance activities have been found as common causes of overexertion injuries (26). This differs from overexertion injuries found by paramedics in other work settings such as the military where overexertion commonly results from marching, hiking, team sports or running (27). A prepared paramedic will be aware of the types of injuries they are likely to encounter to ensure they are optimally equipped for appropriate diagnosis and treatment of patients.

In addition to providing medical diagnosis and treatment the role of paramedics on a mines site may also involve health promotion and injury prevention. This awareness should assist paramedics in educating mines workers about injury prevention and first aid treatment. Additionally, a paramedic may have the opportunity to promote better health and fitness strategies, such as stretching to reduce musculoskeletal injuries, as well as to be aware of potential mental health issues amongst mine workers. The 'near misses' reported in the study may also provide direction to the type of injury prevention education provided by the paramedic to miners. Within the aviation industry near misses have been regarded as valuable sources of data for minimising and, in some cases, eliminating injuries (28,29).

Future direction

Analysing the rate of injury was beyond the scope of this study however we recommend predictive analyses be conducted

in future to identify relationships such as age and type of injury. Moreover, we recommend future studies analyse the breakdown of near misses to identify the most commonly reported incidents to assist paramedics in targeting injury prevention education.

Conclusion

It is argued that given the breadth of mining activities and injuries sustained within WA the findings presented in this article can be applied to paramedics working in the mining sector across Australia and worldwide. An awareness of the type of patients and the nature and cause of injuries is very helpful for assisting paramedics prepare physically and intellectually to enable appropriate diagnosis and treatment. It also provides direction for targeted health promotion that paramedics may seek to engage to reduce injuries.

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Conflict of interest

The authors declare no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

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