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EMERGING TRENDS IN INJURIES IN THE UNDERGROUND COAL SECTOR: AN ANALYSIS OF QUEENSLAND DATA FROM 2006-2017

Nikky LaBranche¹

ABSTRACT: This paper analyses the Queensland Mines Inspectorate's (QMI) Lost Time Injury (LTI) historical data set for underground coalmines. LTI data is reported to the QMI by mine operators on Form 5A. Data discussed includes: injury, body location, worksite location, occurrence class, mechanism of injury, and major equipment involved. Results are presented along with a discussion of contributing factors. Currently published analysis of these injuries only includes the number of injuries of each type. This analysis expands that information to include the severity of the injury (number of days lost and/or days on alternative duties) and the average days away for each type of incident. This analysis also includes cross-references of different data types such as injury types by body location. The analysis includes severity measures for different types of injuries related to the factors collected and drills down deeper into the data than is currently available in existing reports. The value in LTI data comes from analysing the types of incidents occurring and using that information to implement controls that prevents recurrence. This information can inform the Coal Mine Worker (CMW) of additional risks they may not have been aware of, previously the mining companies where controls have failed and the inspectorate where systemic issues are arising.

INTRODUCTION

This paper analyses the LTIs reported to the QMI for underground coalmines over the past 11 years. An LTI is described as any injury which requires a worker to either miss one or more days of work, or to not be able to perform the normal duties of their job, referred to as alternative duties. This paper looks at those incidents occurring between 1 July 2006 and 30 June 2017, covering Australian financial years FY07 to FY17 (Department of Natural Resources and Mines (DNRM) 2017a and 2017b). There were 954 LTIs reported over this period with an average of 52 days away. There were 28,162 days lost and 21,830 days on alternative duties, totaling 49,992 days away. The term 'days away' refers to the combination of days lost and days on alternative duties, and is used in the averages. It was identified that there were 53 lost time injuries recorded with zero days lost time or an alternative duties. This makes the numbers previously listed an underestimation of the true number of days away.

While mines and mining companies collect their own data, it is also important for this data to be collected centrally and analysed in aggregate. While one mine might have only one reported incident involving a certain piece of equipment other mines might also be experiencing the same issues in isolation. Having this analysis identifies areas of concern, which in turn identifies areas where further controls are needed. For example, the mining contractor Redpath Australia Pty Limited identified a number of LTIs due to catching hands in equipment doors and implemented the SAFE STOP Anti Door Jam Unit that recently won the Innovation Award at the Queensland Mining Industry Health and Safety conference in 2017 (Graeme, 2017). This is an example of using LTI data to identify and implement an engineering control that eliminates the opportunity for injuries of this nature to occur in the future. LTI data is most appropriately used for acute and traumatic injuries, but does not capture occupational health harms and long term exposures adequately.

METHOD

The data for this project was provided by the Queensland Department of Natural Resources and Mines DNRM from the information collected on Form 5A. Form 5A collects a range of data including time and date, a written description of the incident, shift roster patterns, and demographics of the injured party. This data is entered at the mine site by the mining

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company. Each person entering the data for the incident is asked, as part of the submission, to code fields for the injury type, body location, worksite location, occurrence class, mechanism of injury and major equipment involved.

In order to ensure a more consistent comparison for this paper, the incident descriptions and associated coding were reviewed by the author. When it was clear that a different category in the field was a more suitable descriptor, the incident was recoded. If there was insufficient clarity in the description to identify a coding, the original data entered in the database was maintained. New categories in fields were added as appropriate when a number of similar incidents showed up, for instance categories for drilling/bolting activities and installing vent control devices were added under occurrence class. This paper analyses the number of injuries and the average and total days away for each category and presents a graph of the summarised categories for total days away.

ANALYSIS

Upon review, inconsistencies have been noticed in how different individuals code the same incident. This was especially evident when it was found that several incidents had been entered in the database more than once, and were coded differently. There were 24 repeats identified. The department is currently undertaking a project on LTI and HPI data collection to add clarity to the data and available options within the fields. Better coding options will allow for more accurate representations of the nature and mechanism of injuries occurring which will in turn allow for better identification of injury prevention controls.

This analysis includes an examination of injury severity as well as a count of injuries. Simply having the count of incidents does not provide an accurate quantification of the safety and health impact to workers and the industry. The average and total number of days away for each field are also considered as part of this analysis. Broadbent (2017) discusses this point in the following terms, "Guess what LTIFR strategically measures. The "small stuff". It does not discriminate between the infected finger and the amputated wrist. If you have six infected fingers and one amputated wrist you quite realistically will get a worse LTIFR result in the workplace with the infected fingers. People want to know about the amputated wrists."

BODY LOCATION

Of the 954 injuries, the most frequent contributor to body location is *hand/finger/thumb* with 195 injuries accounting for 20% of the injuries sustained. *Knees* and *back - upper/lower* each accounted for 14% of the injuries with knees slightly more frequent than backs at 137 versus 135 injuries. By contrast, knees were the third most frequently injured location in the underground metalliferous sector data behind backs and hands (LaBranche, 2017). There were 90 *shoulder* injuries accounting for 9% of the injuries. The 53 *foot/toe* injuries accounted for 6% overall. *Ankle* and *neck* injuries each accounted for 5% at 48 and 44 injuries respectively. *Lower leg* accounted for 35 injuries (4%) while the *abdomen/pelvic region* injuries accounted for 3% of the injuries. The top three categories, hands, knees and backs account for 49% of the injuries and the top five make up 64% of the injuries.

Hand/finger/thumb injuries with the largest number of incidents also accounted for the greatest number of days away 7970 (16%) consisting of 3553 days lost and 4417 days on alternative duties. *Knee* injuries accounted for the greatest number of days lost, 3937 and the second largest number of days away, 7474 (15%) with 3537 days on alternative duties. *Shoulder* accounted for 7471 days away, only three less than knees. While shoulders were only 9% of the injuries, they account for 15% of the days away. *Back – upper/lower* at 14% of the injuries, only accounted for 11% of the days away at 5613, consisting of 3353 days lost and 2260 days on alternative duties. *Foot/toe* injuries accounted for 1603 days lost and 968 days away (5%). *Lower leg* injuries accounted for 1504 days lost and 845 days on alternative duties while *wrist* injuries accounted for 1023 days lost and 1046 days on alternative duties (4%).

There was one *neck and trunk* injury where a CMW was struck in the back of the head and right shoulder by a rock while loading chock legs on the Armoured Flexible Conveyor (AFC)

chain which accounted for 321 days, the highest average in the body location field. There were four pelvis injuries that averaged 200 days away. There was one injury to each of the *upper and lower limbs*, where a CMW strained his upper arm and thigh trying to brace himself for a fall, which accounted for 159 days away. There were eight upper arm injuries averaging 127 days away and 22 wrist injuries averaging 94 days away. The 195 *hand/finger/thumb* injuries average 41 days away while the *knee* injuries average 55 days away. The *back – upper/lower* injuries average 42 days away while *shoulder* injuries are almost double that at 83 days away per injury.

A summary of days away by body location is presented in Figure 1. Many of the categories were combined for ease of viewing in the figure and combined category titles are capitalised. The figure shows that over the 11 year period Back injuries have had the largest increase in number of days away, even while having the largest decrease in the number of injuries. Over the last five years (FY13-17) there were 3504 days away from Back injuries as compared to the previous five years (FY08-12) with 1551 days away. The number of days away due to Arm injuries has also increased over time.

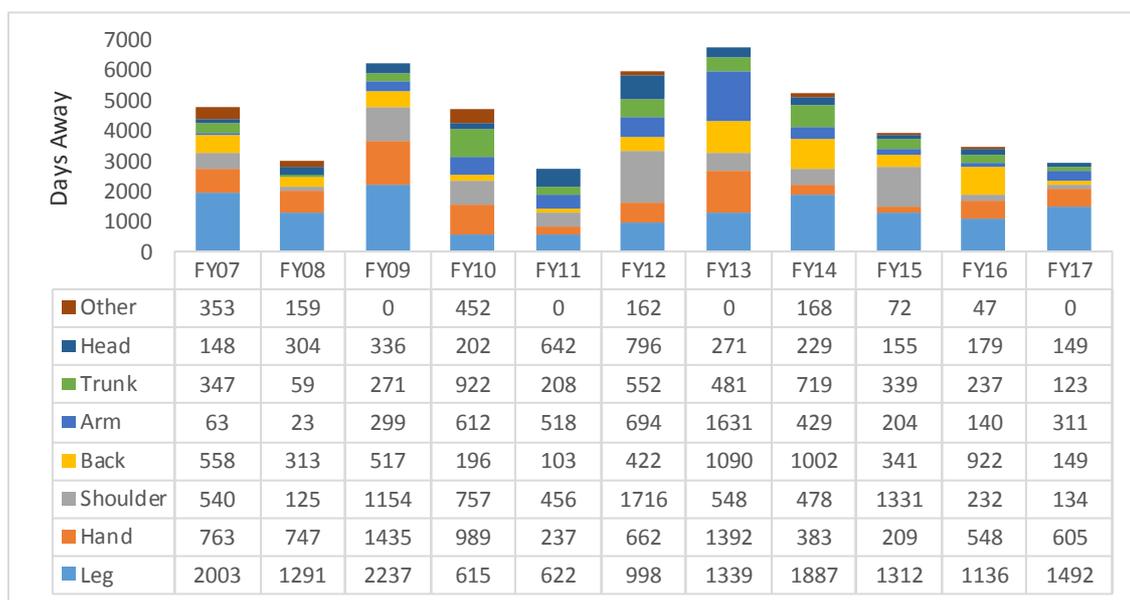


Figure 1: Days away by body location group

INJURY TYPE

The type of injury was analysed for each LTI. Categories were added for *Bite- animal or insect, displacement of disc, infection, loss of consciousness, splinter, repetitive strain injury* and *whiplash*. Some categories were renamed to better facilitate their use, for instance *ischaemic heart disease* was never used in the data set, so it was relabelled as *heart attack*, the one instance in the data set having been submitted as *other disease*. There were 127 *other and unspecified injuries* and 15 *other disease* injuries that were reclassified appropriately.

For LTIs by type of injury, *sprain/strain* was the largest contributor with 445 injuries accounting for 47% of the total injuries. The next largest category was *fracture (not of the vertebral column)* with 160 injuries (17%), followed by *contusion with intact skin surface/crush* with 131 injuries (14%). There were 67 *open wound* injuries (7%) and 24 *traumatic amputation* injuries (3%). There were 18 *dislocation* injuries accounting for 2% of the injuries.

The most significant contributor to the total number of days away was *sprain/strain* injuries with 12,137 day lost and 11,585 days on alternative duties (47%). *Fracture (not of the vertebral column)* account for the second highest number, with 6511 days lost and 3865 days on alternative duties (21%). These were followed by *contusion with intact skin surface/crush* at 3002 days lost and 1814 days on alternative duties (10%) and *open wound* injuries at 1828

days lost and 1990 days on alternative duties (8%). *Traumatic amputations* accounted for 519 days lost and 673 days on alternative duties (2%) while *dislocations* accounted for 889 days lost and 632 days on alternative duties (3%).

There were seven *fractures of the vertebral column* averaging 107 days away ranging from a reported three days away to 292 days away. There were five *poisoning/toxic effect* injuries averaging 98 days, three of these being a single day, with the largest amount of time off being 450 days for the Lectra Clean (1-Bromopropane electric motor and equipment cleaner) chemical exposure, which resulted in Simtars research to recreate the potential exposures (Djukic 2017). The 18 *dislocations* averaged 85 days away, while the 11 *mental disorders* averaged 68 days away. *Fracture (not of the vertebral column)* injuries averaged 65 days away while *sprain/strain* injuries averaged 53 days away.

Figure 2 shows the days away for the top six injury types by financial year. The injury types are too dissimilar to meaningfully combine, so this figure shows only the top contributors and does not account for all the days away for the time period. *Fracture (not of the vertebral column)* and *Contusion with intact skin surface/crush* have both had an increase in the number of incidents and the total days away for those incidents over the 11 year period. *Sprain/strain* has had the most dramatic decrease in the number of incident and number of days away.

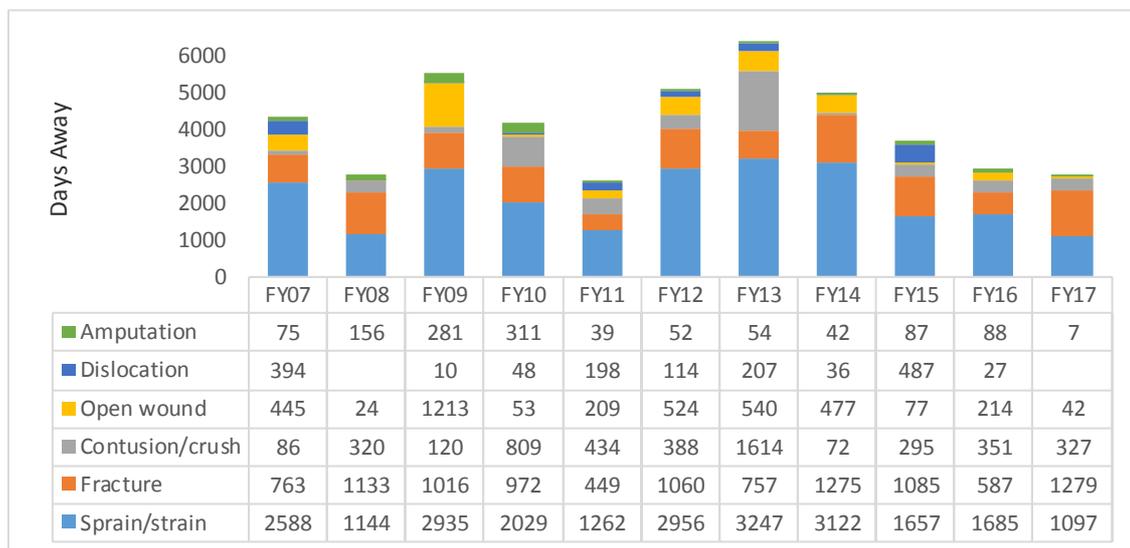


Figure 2: Days away by injury type

OCCURRENCE CLASS

The LTIs were analysed by occurrence class. Several new categories were added as necessary to provide better data clarity based on the types of incident in the dataset. Categories were added for *drilling/bolting* and *installing vent control devices*. A category for *no specific incident* was added to cater for the repetitive motion injuries that occur over long periods of time. A category for equipment *ingress/egress* was added for incident involving getting on and off equipment. This includes vehicles like LHDs and personnel transporters. The injuries while getting on/off the longwall beam stage loader (BSL) and district control breaker (DCB) are included as discrete pieces of equipment in equipment *ingress/egress*, but slip/trips falls on the longwall face itself are categorised as *other equipment access e.g. moving about*. A category for *proximity to operating equipment* was added to cover instances where the CMW was operating the equipment as intended or near the equipment during operation, for instance a rock striking a CMW while operating the shearer or standing near a bolter when struck. The *working on equipment* category was used for repair and maintenance activities. A category for *transporting with lifting aids* was added, this includes cranes, jacks and chainblock.

The largest category in occurrence class was *moving on foot* with 159 injuries (17%). There were 122 injuries (13%) *working on equipment*. *Transporting manually i.e. carrying, dragging*

and *drilling/bolting* each had 106 injuries (11%). There were 84 *other manual handling* injuries (9%) and 57 equipment *ingress/egress* injuries (6%). There were 53 injuries (6%) related to *proximity to operating equipment*. There were 51 injuries (5%) *travelling in equipment/vehicle*, 24 of which were LHDs. *Operation of non powered hand tools* accounted for 37 injuries (4%). *Others loading/unloading from vehicles* each had 28 associated injuries (3%).

The largest number of injuries (159), moving on foot also account for the most days away with 5013 days lost and 4038 days on alternative duties (18%). *Transporting manually i.e. carrying, dragging* was the next most significant contributor to days away with 2669 days lost and 3005 days on alternative duties totaling 5674 days away (11%). *Working on equipment* injuries accounted for more days lost (3765) than *transporting manually i.e. carrying, dragging*, but significantly less days on alternative duties (1778), totaling 5543 days away (11%). *Drilling/bolting* accounts for 2113 days lost and 2116 days on alternative duties (9%). *Other manual handling* accounts for 2069 days lost and 1875 days on alternative duties (8%), while *travelling in equipment/vehicle* accounts for 2294 days lost and 1174 days on alternative duties (7%). *Proximity to operating equipment* accounts for 2332 days lost and 1059 days on alternative duties (7%).

There was one occurrence of *ascending – ground/floor not involved* that had the highest average number of days away at 95 days where a CMW was climbing up onto a chock using the inter-chock hoses as a step. The next highest average was 84 days away for the 26 *other equipment access e.g. moving about* injuries. The 37 instances of *operation of non powered hand tools* averaged 75 days away while the five *welding* related injuries averaged 72 days away. Incidents related to *traveling in equipment/vehicle* averaged 68 days away. The 159 *moving on foot* injuries averaged 57 days away while the 122 *working on equipment* injuries averaged 45 days away. There was an average of 54 days away for the 106 *transporting manually i.e. carrying, dragging* injuries. For the 106 *drilling/bolting* related injuries there was an average of 40 days away. The 84 *other manual handling* injuries averaged 47 days away while the 57 *equipment ingress/egress* injuries averaged 48 days away.

A summary of the types of occurrence classes that contributed to days away is shown in Figure 3. Many occurrence classes have been combined to make the categories easier to view. The number of drilling and bolting related injuries have increased over the time period, while there was also a slight increase in equipment access. The number of Travelling in equipment related injuries has remained steady over time. The largest decrease over time has been to manual handling injuries, followed by Operating tools/equipment and Moving on foot with other being the smallest decrease.

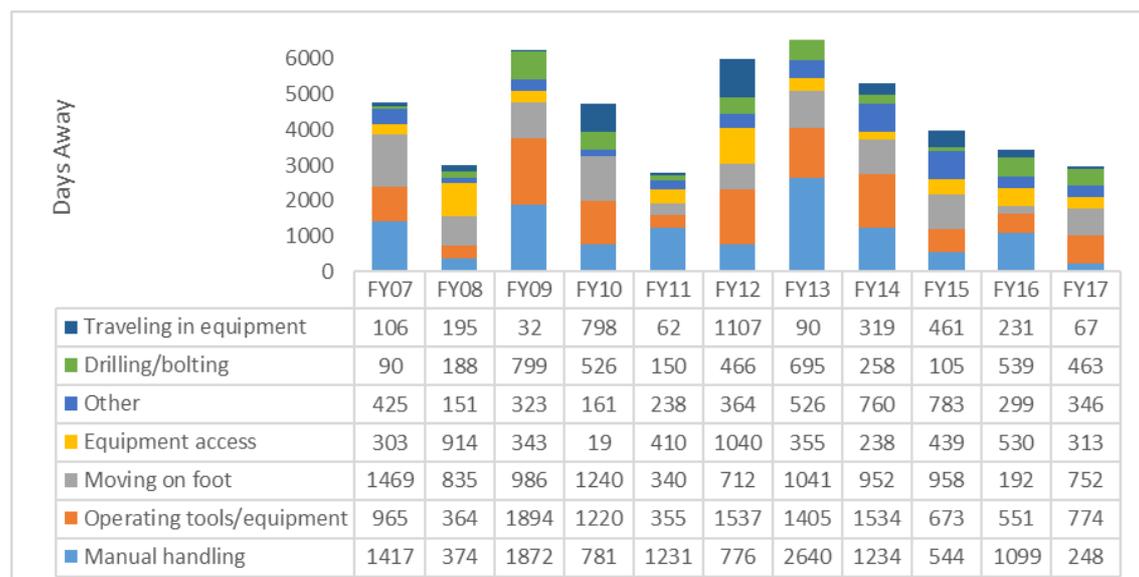


Figure 3: Days away by occurrence class group

MECHANISM OF INJURY

The LTIs were also analysed by mechanism of injury. When recoding the data, any incident of a rock hitting a person was categorised as fall/slide/cave-in of material, and taken out of being hit by falling object if previously categorised that way, raising the number of incidents from 20 to 72. New categories were added for *equipment ingress/egress* as a more specific type of slip/trip/fall, for *infection* and for *no specific incident* for long term injuries. There were 43 of the 44 injuries originally submitted at unspecified mechanism of injury and 25 of the 26 submitted as other and multiple mechanisms of injury that were able to be assigned to the appropriate category.

Fall/slip/trip on the same level accounts for 150 injuries (16%) while *muscular stress - lift/lower/carry object* accounted for 134 injuries (14%). There were 104 instances of being *trapped between stationary and moving object* (11%), while there were 80 instances of *being hit by a moving object* (8%). *Fall/slide/cave-in of material-underground* is now at 72 injuries (8%) while there were 61 instances of *being hit by a falling object* (6%).

Fall/slip/trip on the same level was the largest contributor to days away with 4510 days lost and 8545 days on alternative duties (17%). *Muscular stress - lift/lower/carry object* accounted for 3583 days lost and 3454 days on alternative duties (14%). Being *trapped between stationary and moving objects* resulted in 2874 days lost and 2312 days on alternative duties (10%), while *being hit by a moving object* accounted for 2952 days lost and 2616 days on alternative duties (11%). All types of *Fall/slip/trips* accounted for 22% of days away while all *Muscular stress* related injuries accounts for 25% of the LTIs. Being *Struck by/striking/trapped by object* was the largest contributor with 32% of the days away.

The two *vehicle collision* incidents averaged 113 days away, one being 223 days away for a shoulder injury. The five *exposure to mental stress factors* injuries averaged 99 days away while the 10 *single contact with chemical/substance* averaged 81 days away. *Other variations in pressure* averaged 72 days away while *being hit by moving object* averaged 70 days away. *Fall/slip/trip on the same level* averaged 57 days away while *muscular stress- lift/lower/carry object* averaged 53 days away.

The frequently occurring mechanisms of injury were rolled up into their larger themes to analyse how the mechanisms have changed over time, shown in Figure 4. Over the decade there has been an increase in the number of and days away from injuries caused by Material Movement and Muscular Stress. Due to miscoding this has gone largely undetected in the data set with only 20 injuries being originally coded as *fall/slide/cave-in of material - underground* and 71 being identified upon review of the data. While the number of Equipment Motion and Access injuries has slightly decreased there has been a slight increase in the days away. The reverse has happened for *Struck by/striking/trapped by object*, where the number of injuries has increase, but the days away has decreased over time. *Fall/slip/trip* and *Other* have decreased both in number and days away.

WORKSITE LOCATION

A significant amount of recoding was done to the worksite locations. This included 70 of the 122 *other underground location*, 17 of the 18 *unknown underground location* and 47 of the 62 *coalface – working unspecified* being recoded to a more appropriate descriptor. Instead of using *coalface 1st working* and *coal face – 2nd working*, which submitters found confusing, the categories for development were split into *coal face – CM (continuous miner)*, *CM Section* (outbye face to feeder breaker), *CM flitting* and *CM – second working* (floor brushing, pulling pillars, etc.). There were also categories created for *coalface – place change mining* and *coalface – place change bolting*. The reclassification increased the number of *coalface – longwall* injuries from 88 to 182 (19%) averaging 55 days away with a total of 5,745 days lost and 4,232 days on alternative duties (20%). *Coal face – CM* accounts for 159 injuries averaging 54 days away and including 4698 days lost and 3905 days on alternative duties (17%).

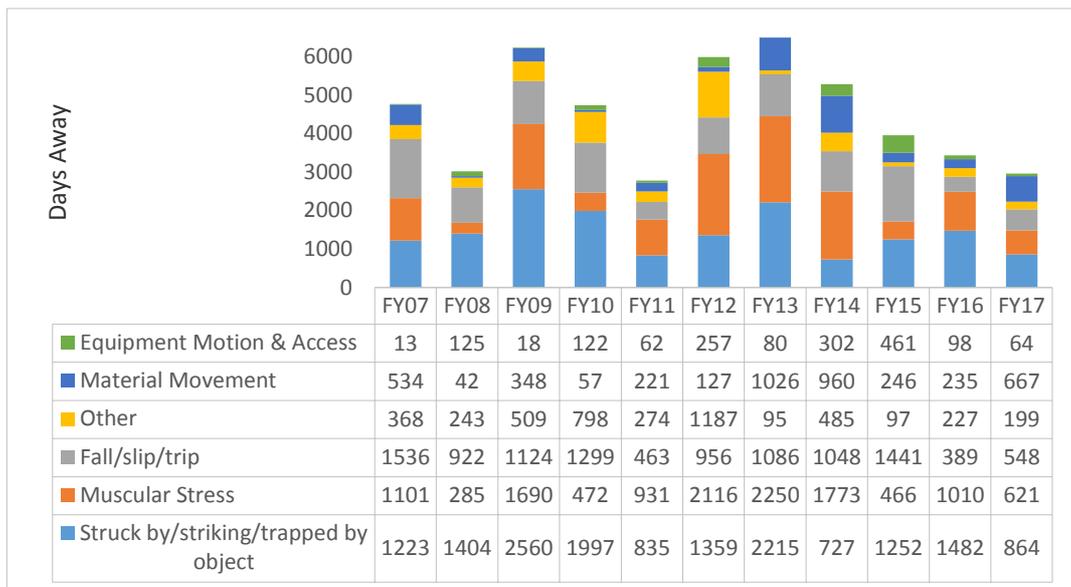


Figure 4: Days away by mechanism of injury

MAJOR EQUIPMENT INVOLVED

There were a great number of inconsistencies in the major equipment involved category, which required a significant amount of rework during recoding. Performing maintenance activities and instances where more than one piece of equipment is involved are particularly prone to errors based on the way the system is set up. For instance, when lifting double acting (DA) cylinders from the front AFC with a chainblock there was some confusion as to whether *longwall chock*, *non-powered lifting equipment. e.g. jack, chain block* or *other non-powered equipment/object* would be the appropriate category. These were all recoded to reflect the action being taken that contributed to the injury, so in this case the *non-powered lifting equipment. e.g. jack, chain block* was coded. For future data collection by the Department, the author recommends that any injuries sustained while working on equipment have the ability to code data on both the tool and the piece of equipment being worked on.

CM bolting accounted for 63 injuries (7%) and averaged 36 days away with 1140 days lost and 1118 days on alternative duties (5%). *Rock drill/roof bolter/borer – portable* accounted for 43 injuries, averaged 50 days away and accounted for 1140 days lost and 1031 days on alternative duties. When combined with *drilling rig* (10) and *roof support (not L wall chock)* (6), the number of injuries for Drilling/bolting jumps to 122, the largest of any type of equipment. If you cross reference this combined bolting group with the mechanism of injury an overwhelming 82 of these are related to being Stuck by/striking/trapped by object, while 15 are related to Material movement, 14 to Muscular stress and 11 to Fall/slip/trip. Other than the 82 Stuck by/striking/trapped by object, 55 are *hand/finger/thumb injuries* and 12 are *foot/toe*. This suggests that there is room for reviewing these instances where the same injuries are repeatedly occurring the same way for ways to improve the system.

There were 91 injuries (10%) with *no equipment involved* (176 before recoding), many being slips/trips/falls, which averaged 39 days away and accounted for 2037 days lost and 1489 days on alternative duties. None also includes the 10 *no specific incident* injuries. Separate categories for *cable, pipe* and *hose* were combined into *cable/pipe/hose – not pressurised* with 62 entries (6%) as these most frequently represented the same type of manual handling injury as opposed to *pressurised pipe/hose/gas cylinder*. with 27 injuries which together make *Cable/pipe/hose*. *Cable/pipe/hose – not pressurised* averaged 58 days away and accounted for 1140 days lost and 1118 days on alternative duties (5%). Many of these involved muscular stress while lifting/carrying or a slip/trip/fall. Longwall includes the *longwall chock* which accounted for 59 injuries combined with *longwall armored face conveyor* (6), *longwall shearer* (28), *longwall – BSL* (8), *longwall – DCB* (3) and *longwall - other equipment* (16) totaling 120 injuries, only slightly behind drilling/bolting. Longwall chock averaged 51 days

away and accounted for 1689 days lost and 1929 days on alternative duties (6%). Most of these involved slip/trip/falls or being hit by falling rock.

Conveyor consists of *belt conveyor* (12 injuries) and *conveyor structure* was added as a category to capture the 47 injuries related to pulling structure and changing rollers. CM/shuttle car includes the 39 *CM*, 18 *CM cable*, 14 *shuttle car – underground*, 7 *feeder breaker (coal)* and 2 *trailing cable to machine (shuttle car)* injuries.

Figure 5 shows that over the period Drilling/bolting injuries had the largest increase in the number of injuries over time and a slight increase in the number of days away. Longwall related injuries had a slight increase in the number of injuries and the largest increase in the number of days away. CM/shuttle car related injuries had the largest decrease in the number of incidents and in the total days away.

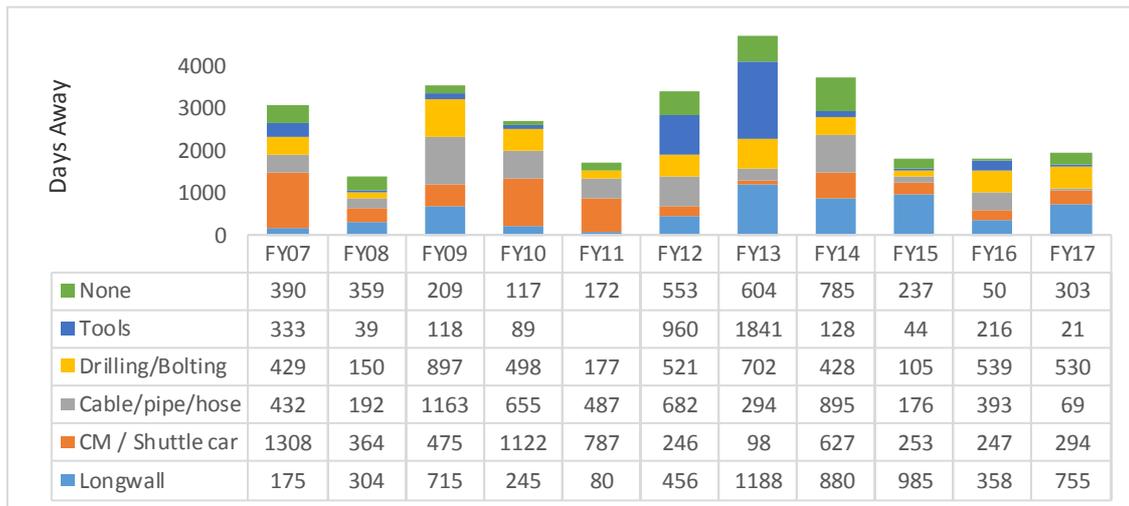


Figure 5: Days away by equipment involved group

CONCLUSIONS

For the 954 injuries occurring between 1 July 2006 and 30 June 2017 in underground coalmines there were 28,162 days lost and 21,830 days on alternative duties, totaling 49,992 days away. Overall these incidents averaged 52 days away. The overall LTI frequency rate has plateaued since FY12 while the contractor LTIFR has increased in the past 2 years. The days away per million man-hours has decreased over the period.

The recoding and analysis performed so far has served to appropriately categorise the data to identify the trends and area of interest. There is still a significant amount of work that can be done in further investigation of the injuries in this data set to put together prevention strategies to guard against future injuries of the same nature in the industry. The project the Department has undertaken to revamp the Form 5A seeks to rectify some of the current mistakes made in coding and improve information collation for analysis. For example one common mistake found in coding was rock fall injuries being codes as *being hit by falling object* instead of the *fall/slide/cave-in of material – underground*. As a result this has emerged as a much larger risk than previously thought with the number of incidents identified rising from 20 to 72.

Hands are the most likely body location to be injured and care should be taken in these areas to minimise future injuries, especially around drilling and bolting activities. Of the 122 drilling/bolting accidents 58 were hand injuries and the number of traumatic amputations related to these have increased in recent years. The number of fractures has increased with record highs in FY17 of 26 fractures and 12 of those being hands, the next highest annual total being FY14 with 20 and a tie for 9 hand fractures in FY08 and FY12. The most likely injury mechanism for drilling/bolting is *being trapped between stationary and moving object* (37) followed by *being hit by falling object* (21) which is usually the drill steel or bolt falling on

them. There were also 16 *fall/slide/cave-in of material – underground* incidents associated with drilling/bolting. There is a rising trend in the number of fractures sustained that should be investigated further.

Knees are the second most likely body location to be injured, accounting for 14% of the injuries as opposed to 8% of the underground metalliferous sector injuries. Of the 137 *knee* injuries Fall/slips/trips account of 74 of them with 49 due to muscular stress. The most common occurrence class is moving on foot with 168 injuries, 67 of those being *knee* injuries.

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