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Analysis of forestry work accidents in five Australian forest companies for the period 2004 to 2014

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ABSTRACT: There is little knowledge available regarding Australian forestry work safety and accident rates. Machine operators and forestry workers are vital parts of the forestry sector and their health and well-being can greatly impact on their work quality and efficiency. To increase our knowledge of forest workers' safety this project aimed to analyse the frequency, type and root causes of work accidents which occurred within different forestry activities of five industry partners of Australian Forest Operations Research Alliance over the period from 2004 to 2014. A questionnaire was designed and distributed to the partners to collect the safety incident reports. Total number of work accidents was 470 for a period of 11 years (a rate of 43 accidents per year). Considering the estimated yearly production rates of the industry partners that participated in this project, the accident severity rate was 14.40 accidents per million m^3 of harvested wood. The majority of accidents occurred in harvesting operations (37%) and forest management (30.2%). Based on the results 8.1% of the accidents occurred during firefighting and 24.3% of work accidents occurred in other forestry activities. Main root causes of accidents for different types of activities were personal errors such as lack of personal protective equipment, operator error, poor body position and poor techniques applied. Work safety training could be delivered to forestry personnel to minimise accidents caused by personal errors. Back and shoulder (as upper parts of the body) received most injuries. To avoid/reduce muscular damage (such as strain and sprain) the workers should be provided with proper ergonomic training.

Keywords: operations; safety; accident rate; root cause; injury; protective equipment

Research projects carried out by Cooperative Research Centre for Forestry and Australian Forest Operations Research Alliance (AFORA) have investigated economic and environmental impacts of forest operations. These projects have mostly helped the industry improve machine productivity, reduce costs of harvesting operations, reduce the potential environmental impacts and improve yield and stand productivity (Acuna et al. 2012; Ghaffariyan et al. 2012, 2015; Ghaffariyan, Brown 2013; Ghaffariyan 2015). Machine operators and forestry workers are a vital part of the forestry sector and their health and well-being can greatly impact on their work quality and efficiency. Work accidents may also impact on the labour cost due to the required absence time for medical recovery (Klen 1989). Potočnik et al. (2009) studied the accidents of the forest harvesting operations in Slovenia for the period 1990 to 2005 and reported that 685 accidents occurred in felling operations while skidding operations had the lowest share of accidents (29% of the accidents). Other researchers also indicated that tree felling and wood extraction cause a larger number of accidents than loading or transportation (Evanson et al. 2001; Parker et al. 2002; Nikooya et al. 2012). Peters (1991) mentioned that felling trees with a chain saw caused more injuries than any other forestry tool/equipment. However, there is little knowledge available regarding Australian forestry work safety and accident rates. To increase our knowledge on forest workers' safety this project aimed to analyse the frequency, type and root causes of work accidents which occurred within different forestry activities of five industry partners of AFORA over the period from 2004 to 2014.

METHODS

Five industry partners participated in this project. A questionnaire was designed and distributed to the partners to collect the safety incident reports from 2004 to 2014 (this period was selected to match most of the provided information of each partner). The information was classified (Tsioras et al. 2011) and put in an Excel-based data base including: date of accident, time of accident, type of forestry activity, operation, harvesting system, harvesting machine/forestry tool, age of worker, root cause, category of accident, type of injury, injured parts, side of body, type of first aid provided, number of days off work, cost paid for medical insurance/treatments and employment type.

Root causes were classified into personal errors [fatigue, lack of personal protective equipment (PPE)], operator error, poor body position, poor technique applied and poor judgment), environment (such as poor maintained equipment and excessive heat) and system (such as lack of safety training, pre-existing injuries). Parts of the body were classed into upper body (including hands/fingers), lower body and head/neck. Injury types were classified as skin damage (including cut, abrasion, scratch, rash and laceration), contusion (bruise/struck, fracture, dislocation, struck and broken bone), muscular damage (strain, sprain and soft tissue), and others (object in eye, bitten by insect/snake, blood nose, infection and dehydration).

The total harvesting volume per each company was collected for the study period. The accident severity rate was calculated using Eq. 1:

$$\text{Severity rate} = \frac{\text{total number of work accidents over study period}}{\text{total harvesting volume over study period (millions m}^3\text{)}} \quad (1)$$

RESULTS AND DISCUSSION

Overall outcomes

Total number of work accidents was 470 for a period of 11 years (a rate of 43 accidents per year). Considering the estimated yearly production rates of the industry partners that participated in this project, the accident severity rate was 14.40 accidents per million m^3 of harvested wood. Frequency and percentage of the work accidents for each forestry activity are presented in Table 1.

The majority of accidents occurred in operations (37%) and forest management (30.2%). Operations included harvesting, transport and roading. Forest management included activities such as silviculture, planting, nursery, planning, assessment, establishment and fertilisation. Based on the results 8.1% of the accidents occurred during firefighting. The distribution of work accidents over the study period (2004–2014) is shown in Fig. 1a. A large number of accidents occurred in 2012 (16%) and 2013 (14%) while the lowest percentage was in 2007 and 2008 (about 3%). Fig. 1b presents the distribution of accidents for different months. The worst months for accidents were January and February (> 10%), while the lowest accident rates occurred in December and September (Fig. 1b). This might be due to warmer weather conditions of summer and longer work hours in this period of time (Parker et al. 2002; Bell, Helmkamp 2003).

Table 1. Frequency and percentage of accidents for different activities

Activity	Frequency	Percentage
Forest management	142	30.2
Operations	176	37.4
Firefighting	38	8.1
Others	114	24.3
Total	470	100

There is a suggestion that workers aged between 50 to 59 years may have had a higher accident rate while workers older than 65 years had the lowest share of the accidents. However, 51% of the incident reports [shown as n/r (not reported) in Fig. 1c] had no records of worker age, which makes it difficult to get an accurate estimate of age distribution and proportion of accidents. Although Nikooya et al. (2012) reported in their case study that workers with age between 30 to 40 years had higher work accident rates than other ages.

Results of detailed analysis on work accidents for each component of the forestry activities are presented below.

Harvesting accidents

There were 101 harvesting accidents, which corresponds to an average severity rate of 2.85 accidents per million m^3 of harvested wood in this case study. The harvesting methods were mostly cut-to-length (using harvester and forwarder) and whole tree (using feller-buncher and skidder) in this case study, however it was not possible to calculate the accident rates for each harvesting method or machine due to the lack of recorded information in the incident

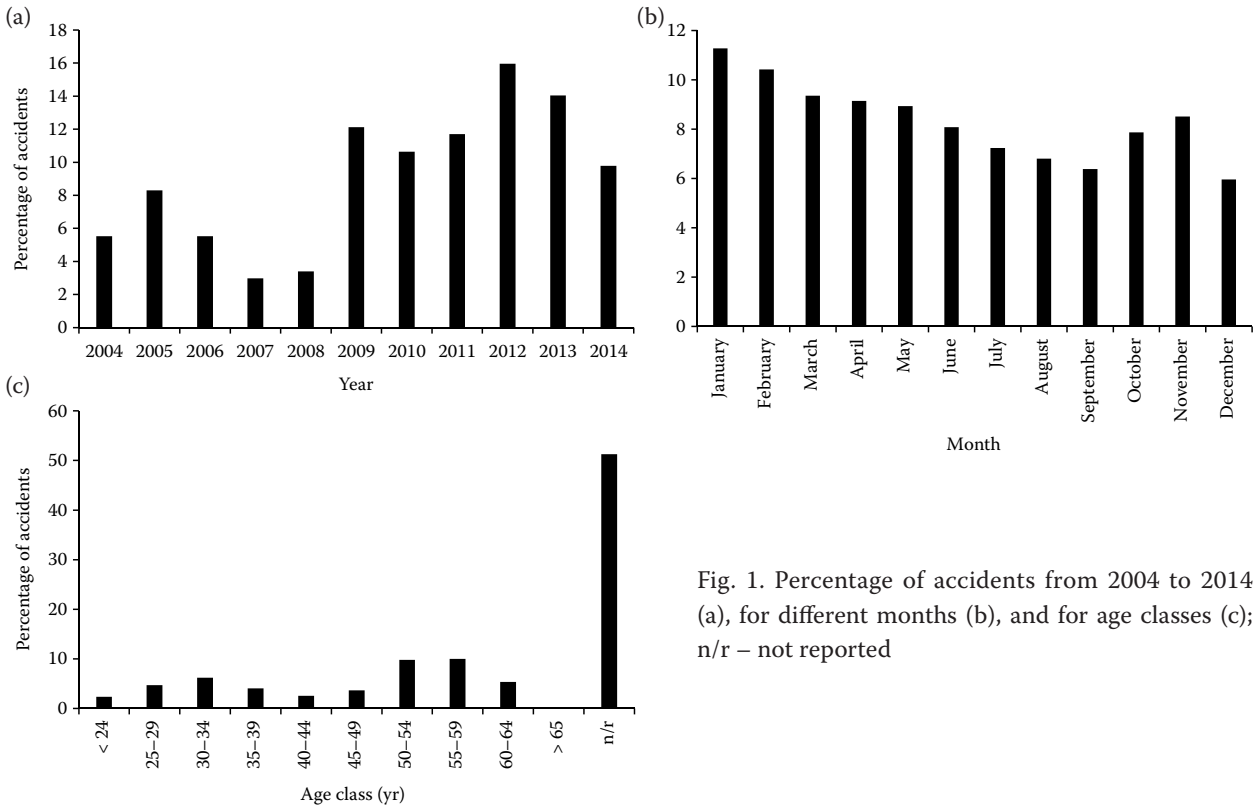

Fig. 1. Percentage of accidents from 2004 to 2014 (a), for different months (b), and for age classes (c); n/r – not reported

reports. The rate is lower than the accident rate of 6.03 accidents per million m^3 for harvesting using harvester and forwarder and it is also lower that the severity rate of 12.00 accidents per million m^3 for harvesting using skidders in Austria (Jänlich 2009; Kühmaier 2011). The accident rate of 2.85 per million m^3 in this study is also lower than the maximum rate of 9.52 accidents per million m^3 and is higher than the minimum rate of 0.03 accidents per million m^3 in some European countries reported by Klun and Medved (2007). Khodaei et al. (2013) calculated the severity rate for a forest harvesting company in Northern Iran. They reported a variation of severity rate from 10.96 to 19.72 accidents per million m^3, which is higher than the rate in this case study in Australia. The difference might be due to different level of safety standards, workers' experience and level of mechanization.

Most of accidents (72.3%) were caused by personal error (such as lack of PPE, error of operators or poor body position) and 5.9% were due to system/management issues (such as lack of safety training) (Fig. 2a). Categories of accidents included first aid (26.7%), injury (21.8%), lost time (24.8%), medical treatment (25.7%) and n/r (1.0%). Most workers were employees (workers employed by the company) (48.5%) while 39.6% were contractors and 11.9% was not recorded. Major types of injury were skin damage (such as bitten by insect or cut) and muscle damage (such as sprain and strain) (Fig. 2b). The main injured part was upper body with 39.6% of total injuries (Fig. 2c). Main injury points included eye (12.9%), leg (12.9%), back (8.9%), ankle (6.9%) and knee (5.9%) while the remaining injuries (52.5%) were on other points of the body. In a similar study in Slovenia, Potočnik et al. (2009) reported that most of the injuries in harvesting operations (60% of injuries) were caused by a direct contact of tree parts with stones, rocks and surface which resulted in 20 days lost time. It should be mentioned that the lost time due to injuries had not been recorded in the incident reports of this current study. Additionally Potočnik et al. (2009) stated that most frequent injury types were stroke (56%), open sore (19%) and sprain with muscle strain (11%). In an Austrian case study on work accidents of the cable yarding operation, 63.2% of harvesting accidents were caused by broken spar and anchor trees, bouncing cables and falling objects. Hands and feet were the most frequent injury areas (64% of injuries) while head and neck accounted for 15.2% of injuries. The most frequent injury types were contusions (37.8%), fractured bones (12.8%), strain/sprain (11.6%) and punctures/lacerations (10.45%). Eye injuries took 3 days of lost time to recover while other injuries required 20 days of lost time (Tsioras et al. 2011). In Queensland (Australia) the average days lost per injury were 25.9 for 2012–2013 and 21.0 for 2013–2014 according to the statistics reported by DAF (2015).

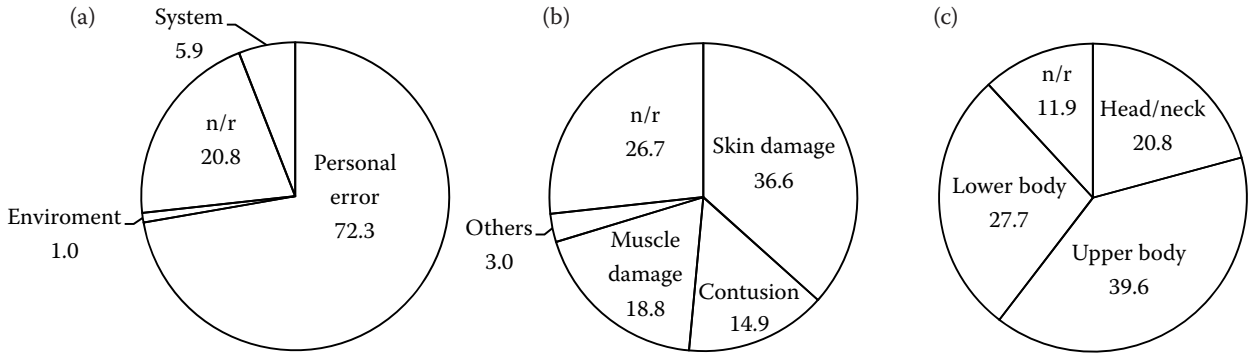

Fig. 2. Percentage of root cause (a), injury types (b), and injured parts (c) for harvesting accidents; n/r – not reported

Transportation accidents

There were 61 transportation accidents in the data base, which corresponds to 13% of total forestry accidents. Case studies carried out in the USA reported that transportation accounted for 22–24% of total harvesting accidents (Shaffer, Milburn 1999; Roberts et al. 2005; Bolding et al. 2009). It is difficult to compare the rates due to a different base of calculations as in this current study all forestry activities were taken into account but in those American case studies harvesting accidents were used. Personal errors (Fig. 3a) were the main root cause of accidents (such as operator error, poor body position, poor technique applied and lack of PPE). Excessive speed (as personal error) caused 4.9% of the accidents. Roberts et al. (2005) reported that the majority of the injuries (49% of transport injuries) occurred during driving trucks in a case study conducted in the southern USA. Other injuries occurred during other elements of transportation such as binding, trimming load, maintenance and mounting/dismounting. However, the current case study used the incident reports where work injuries were recorded only for trucks (transportation) but not identified for each element of transportation. The accidents were categorised as lost time (45.9%), medical treatment (31.2%), first aid (13.1%) and injury (9.8%). Employment type of operators included contractor (78.7%), employee (4.9%) while 16.4% were not recorded.

Major injury types were muscle damage (32.8% of accidents) (such as strain and sprain) and skin damage (such as cuts which accounted for 11.5% of records) (Fig. 3b). Upper body and lower body were the main areas of injury with 39.3 and 26.2% of total accidents, respectively. Head/neck accounted for 19.7% of injuries (Fig. 3c). Drilling down to specific body parts, ankle injuries were the most prevalent for transportation (11.5% of injuries) while injuries to other parts of the body such as back (9.8%), shoulder (9.8%), knee (6.6%) and fingers (6.6%) were also very frequent compared to other parts of the body.

Silviculture accidents

Of the 83 accidents occurring in silvicultural practices (17.6% of total accidents), the root cause of most injuries was not recorded on the incident forms (54.2%). However, personal errors (such as poor judgment, operator error, poor technique ap-

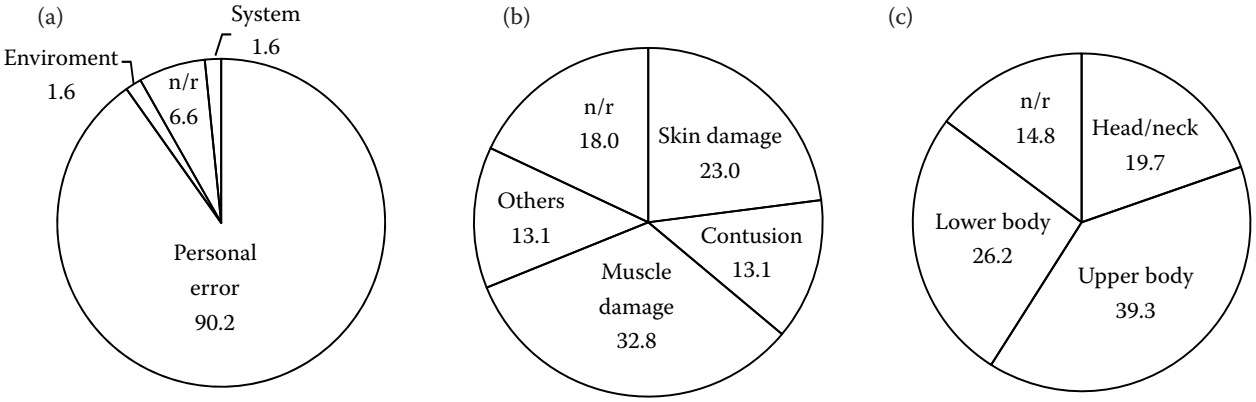

Fig. 3. Percentage of root cause (a), injury types (b), and injured parts (c) for transport accidents; n/r – not reported

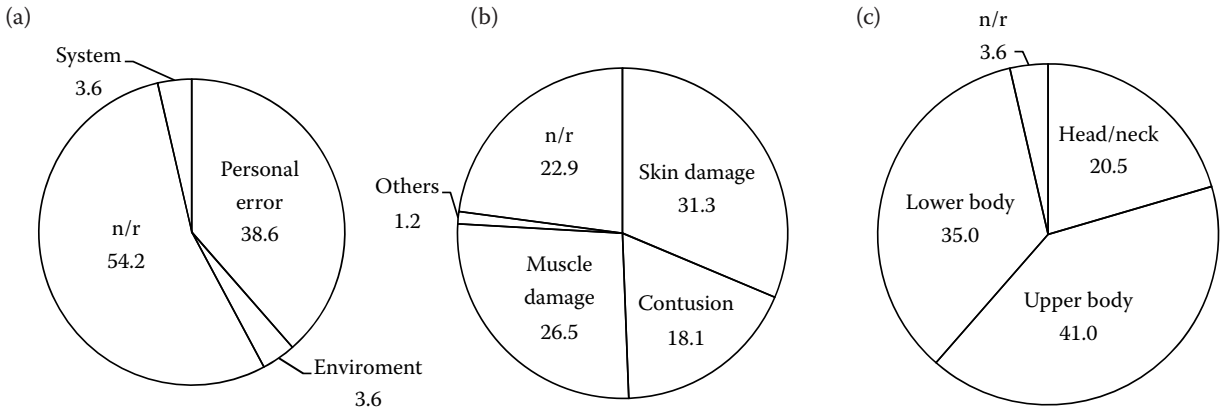

Fig. 4. Percentage of root cause (a), injury types (b), and injured parts (c) for silviculture accidents; n/r – not reported

plied and lack of PPE) were the major cause of accidents (Fig. 4a). The main category of accidents was injury accounting for 38.6%, while the share of first aid, medical treatment and n/r accounted for 31.3, 20.5 and 9.6%, respectively. The majority of workers were employees (80.7%) while 19.3% were contractors.

Major types of injury that occurred were skin damage (31.3%, such as cuts) and muscle damage (26.5%, such as sprain and strain). Contusion resulted from 18.1% of accidents, in which hit (9.6%) was the most frequent. Based on the results 22.9% of accidents had no injury type reported (Fig. 4b). The upper body was injured more than other parts (Fig. 4c). Back injuries resulted from 14.5% of all silvicultural accidents while foot (12%), knee (9.6%), eye (7.2%), shoulder (6%) and ankle (6%) were also frequently injured in silviculture operations.

In this case study 17.6% of accidents occurred within silvicultural practices. This rate is higher than a rate of 2.7% accidents for a study carried out by Skogforsk in three forest companies in Northern Sweden as reported by Axelsson (1998). Detailed studies on root causes and injury types of silvicultural practices were not available to compare the results with.

Planting accidents

There were 48 cases of planting accidents (85.4% of these workers were employees and 14.6% were contractors). While most root causes were not recorded in the incident reports (68.8%), the most frequent accidents were due to personal errors (including operator error, poor body position and lack of PPE) (Fig. 5a). Planting accidents were categorised as injury (64.6%), lost time (16.7%), first aid (10.4%) and medical treatment (8.3%). Fig. 5b illustrates that the majority of planting injuries included muscle damage (e.g. strain) and skin damage (e.g. cut) while the largest share of reported accidents (37.5%) had no record of injury type. Upper body injuries accounted for 62.4% of planting accidents (Fig. 5c). Shoulder (20.8%), finger (10.4%), knee (10.4%) and back (8.3%) were also prevalent injuries in planting operations.

According to the Work Safe British Columbia (2006), 58% of injuries occurred on the upper parts of body (such as wrists, back or shoulders) and the share of knee injuries was 5% for tree planters. The share of injuries in the upper parts of body for the Canadian study is consistent with results shown in Fig. 5c, where 62.4% of accidents occurred in the upper parts of body.

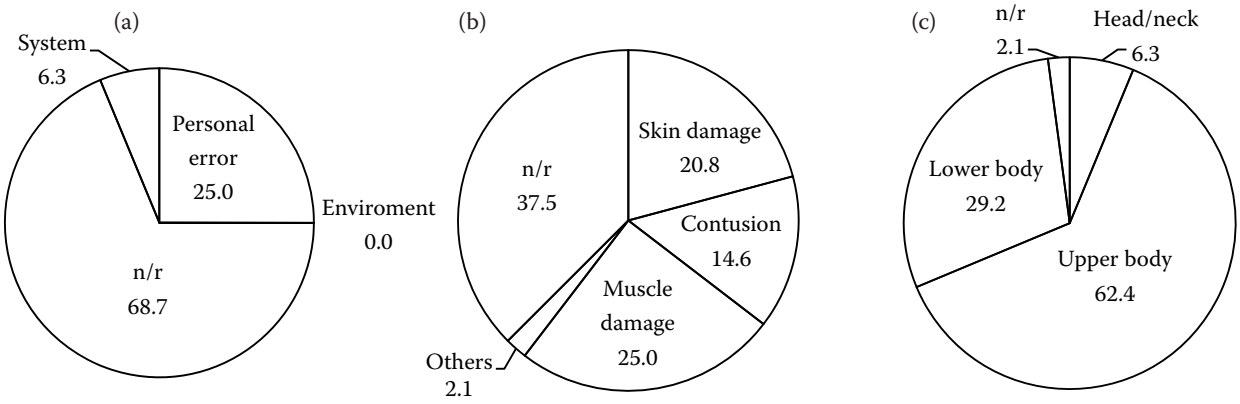

Fig. 5. Percentage of root cause (a), injury types (b), and injured parts (c) for planting accidents; n/r – not reported

Firefighting accidents

There were 38 accidents for firefighting in the data base (92.1% of workers were employees while 7.9% were contractors). More than 76.4% of the accident reports had no record of root causes, however personal errors (such as operator error, poor technique applied) and environment (such as heat and excessive smoke) during firefighting were the most frequent recorded root causes of accidents (Fig. 6a). The accident categories included injury (52.6%), medical treatment (26.3%), first aid (15.8%) and lost time (5.3%). Skin damage (42.1%) and muscle damage (15.8%) were the most frequent types of injuries (Fig. 6b). Britton (2010) analysed the risk factors for injury among federal wildland firefighters in the USA. She reported that 29.4% of injury types were sprains/strains, which is more than in this case study (15.8% for muscular damage). Injuries including burns, heat-related ones, contusions and wounds accounted for 27.9% of injuries in Britton's study, which is less than the skin damage percentage (42.1%) in this forestry firefighting case study. Most frequently injured were upper body [such as back (15.8%) and hand (13.2%)] and lower body [such as knee (13.2%) and foot (10.5%)] (Fig. 6c). Britton (2010) indicated that in her study the share of injuries for lower and upper body parts was 35.0 and 25.0%, respectively. The share of injuries for the upper part of body was higher than for the lower part of body in the current study unlike the wildfire case study by Britton (2010). The share of head/neck injuries accounted for 9.3% in Britton's study while this share was 18.4% for our case study (Fig. 6c).

Accidents of other forestry activities

Within other forestry activities including assessment, establishment etc. 114 work accidents occurred in the period 2004 to 2014. Employment statistics indicated that 76.3% of workers were employees, while 23.0% were contractors and 0.7% was not recorded. The root cause of a large proportion (53.2%) of accidents was not documented. However, according to Fig. 7a, personal errors (such as operator error, lack of PPE and poor judgment) were the most frequent root causes. The accidents were categorised as injury (43.9%), medical treatment (23.0%), first aid (22.3%), lost time (9.4%) and n/r (1.4%). Skin and muscular damage was the most frequent injury types (Fig. 7b). 65.5% of injuries occurred on the upper part of body (Fig. 7c). Mostly injured were fingers (11.5%), back (9.4%), leg (9.4%), hand (8.6%), shoulder (7.9%) and knee (7.2%).

CONCLUSIONS

Important information omitted from incident reporting prevented to do a more in-depth analysis of the time of accident occurrence, working machines, side of body injured, number of days off work, medical cost associated with accidents and near miss incidents. The incident reporting system should be improved to capture details of working accidents for the purposes of better work safety management. Near miss safety cases should also be considered in the incident reports.

The trend of the accident distribution over the study period (Fig. 1a) might be influenced by the fact that after 2008 there have been more accidents in the data base. This might be due to reporting more accidents by one of the larger companies participating in this study due to extended forestry activities.

Main root causes of accidents for different types of activities were personal errors such as lack of PPE, operator error, poor body position and poor techniques applied. Work safety training could be delivered to

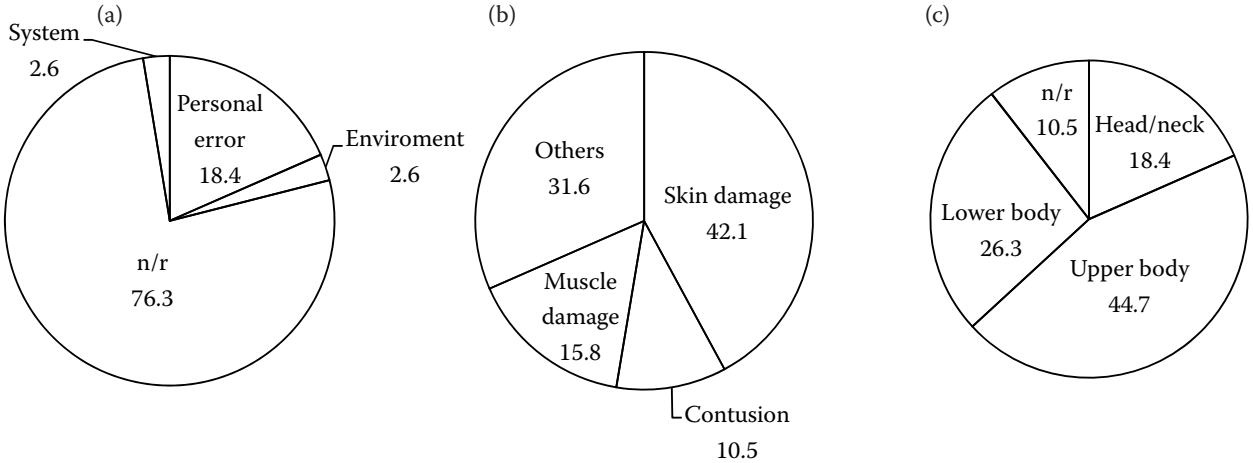

Fig. 6. Percentage of root cause (a), injury types (b), and injured parts (c) for firefighting accidents; n/r – not reported

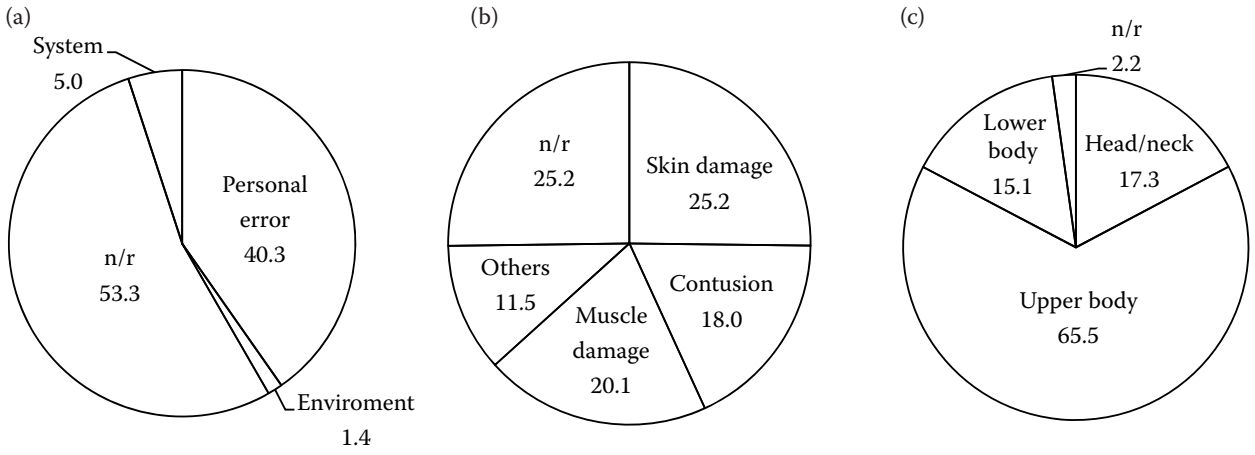

Fig. 7. Percentage of root cause (a), injury types (b), and injured parts (c) for other forestry accidents; n/r – not reported

forestry personnel to minimise accidents caused by personal errors (Wilhelmson et al. 2005).

Back and shoulders (as upper parts of the body) received the most injuries. To avoid/reduce muscular damage (such as strain and sprain) the workers should be provided with proper ergonomic training. Some of the skin injuries (such as cuts and abrasions) to legs/foot/ankle/knee could be reduced by using protective clothing and correct safety boots (Milburn 1998). Eye injuries could be reduced by using safety helmets equipped with eye protection guard (also with hearing protection to reduce exposure to noises e.g. in the case of chain saw operations). The study results provide valuable scientific information on the type and cause of forestry work accidents in Australia as there has been not much information available in the past. The study results can also help forest managers improve the design of their current work accident reporting system due to the limitations described in this article. The provided information on root causes, accident types and injured body parts can assist forest managers and operations contactors to improve the health and safety of the forestry workers in future activities.

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