REPORT

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An Analysis of Chainsaw Lacerations to the Leg in the New Zealand Logging Industry-1983 to 1996

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Abstract

Logging is recognised as an occupation associated with a high risk of chainsaw injury to the leg. The frequency, injury mechanism, severity of injury and location of chainsaw lacerations to the legs of forest workers was investigated between 1983 to 1996 using data obtained from the Forest Industry Accident Reporting Scheme (ARS). During the period of study, lacerations to the leg have been reduced from nearly 30% of all reported lost time injuries in 1983, to 4% in 1996. The most common mechanisms of injury were cutting an unprotected part of the leg (17%), and cutting through the cut-resistant legwear (16%). Chainsaw injuries to the leg were most severe when no cut-resistant legwear was worn (average 22 days lost). The least severe injuries resulted from cutting through the protective legwear (average 3 days lost). This shows that even if protective legwear does not always completely prevent an injury, in all cases the injury will be much less severe than if no protection was worn.

Introduction

There has been an extensive amount of literature published on the fact that the New Zealand logging industry has high injury and fatality rates (e.g. Cryer and Fleming, 1987; Gibson, 1994; Kawachi et al., 1994; Kawachi et al., 1995; Marshall et al., 1994). However, other than Sullman et al. (1996), very little work has been published describing how specific types of injuries have changed over time, the cause of the injury and the impact of various interventions. This type of research is essential if the

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forest industry is to better understand the reasons for its high injury rate and develop effective methods of eliminating or reducing the problem. With this in mind, an analysis of data on chainsaw lacerations to the leg reported between 1983 and 1996 was undertaken to highlight trends, and provide information on the mechanisms of injury. Knowledge of the mechanisms of injury will provide valuable information on; where to target research, the adequacy of standards, the effectiveness of current legwear designs, and how to further reduce the number and percentage of chainsaw cuts to the leg.

Using data between 1975 and 1988, Kawachi et al. (1994) found loggers were at a high risk of work-related injury. They also found that contact with a chainsaw accounted for 39% of all deaths, hospitalisations and lost time accidents. Kawachi et al. (1995) found that the leg was the second most common site of injury (26%), followed by the hand (27%). They also noted a decline in the incidence of leg injuries between 1979 and 1988, which they stated provided some evidence for the effectiveness of protective legwear. Since this time there has been a large number of changes to the forest industry, including: changes to worker compensation; increasing mechanisation; and the introduction of the Health and Safety in Employment Act (1992) with its increased emphasis on safety, the provision of adequate protective equipment, and training.

Only one previous research project has specifically looked at chainsaw lacerations to the legs of New Zealand loggers (Gaskin, 1986). This research found that the number and proportion of chainsaw cuts to the leg declined considerably between 1983 and 1986 (Gaskin, 1986). An analysis of the severity of injury also noted that the average number of days lost declined from 12.6 days in 1985 to 8.4 days in 1986. Unfortunately, it was not possible to extend the trend back to 1983, as the number of days lost was not recorded by the ARS until the beginning of 1984. Therefore, the reduction in average lost time may have been a random fluctuation and not the downward trend Gaskin attributed it to. Unfortunately, partly due to an absence of data, Gaskin's research could not go any further than showing a four year decline in the number of chainsaw cuts to the leg, and a two year decline in the average severity of injury. Given the significant changes in the forest industry, the dated nature of previous research, and the absence of data on the mechanisms of injury, this report was produced.

Method

The cases in the present study include all lost time injuries involving laceration to the leg, during the period 1983-1996. A lost time injury is defined as an injury which causes a worker to miss the next scheduled full day's work. The data were obtained from the Liro administered Forest Industry Accident Reporting Scheme. The data were selected and extracted from the ARS using the sort function of Microsoft Excel. The data were sorted according to the injury types "laceration" and "amputation", the part of body injured "upper leg", "lower leg" and "knee", and the severity category "lost time".

For each lost time injury extracted, the free text description of the accident was examined. So far as the data permitted, detailed information on the circumstances surrounding each injury was collected and analysed. The lost time injuries involving a chainsaw or other object were readily identified through the mentioning of "chainsaw" or other object, such as "stick", "branch", "machine" or "axe" in the free text description. The mechanism of injury was also assessed using the free text description. In some cases, the mechanism of injury was not readily identifiable. These cases were classified as "unknown".

For calculating injury rates, the denominator data were obtained from the Department of Labour's Quarterly Employment Survey, as published by the New Zealand Forest Owners' Association and the Ministry of Forestry (New Zealand Forest Owners' Association and the Ministry of Forestry, 1997).

Results

Lacerations to the Leg - General

Between 1983 and 1996 there were 355 lacerations to the leg reported to the ARS. These consisted of 305 lacerations caused by contact with a chainsaw and 50 where the laceration was caused by contact with another object, such as a stick, axe, branch, or machinery. Given that in the period 1983-1996 there were approximately 37,230 person years, the estimated injury rates for this period were calculated to be; 9.5/1,000 (meaning 9.5 lost time injuries for every 1,000 workers) for all lacerations to the leg, 8.2/1,000 for chainsaw lacerations and 1.3/1,000 for lacerations caused by contact with an object other than a chainsaw.

Figure 1 shows, by year, the number of lacerations to the leg according to the instrument of injury (chainsaw or other). This graphically illustrates, that in the period shown, chainsaw lacerations to the leg accounted for the majority of all lacerations to the leg. However, the gap between chainsaw and other has decreased dramatically. The narrowing of the gap has been due to a decrease in the number of chainsaw lacerations, while the number of reported lacerations to the leg that were not the result of a chainsaw has remained relatively constant.

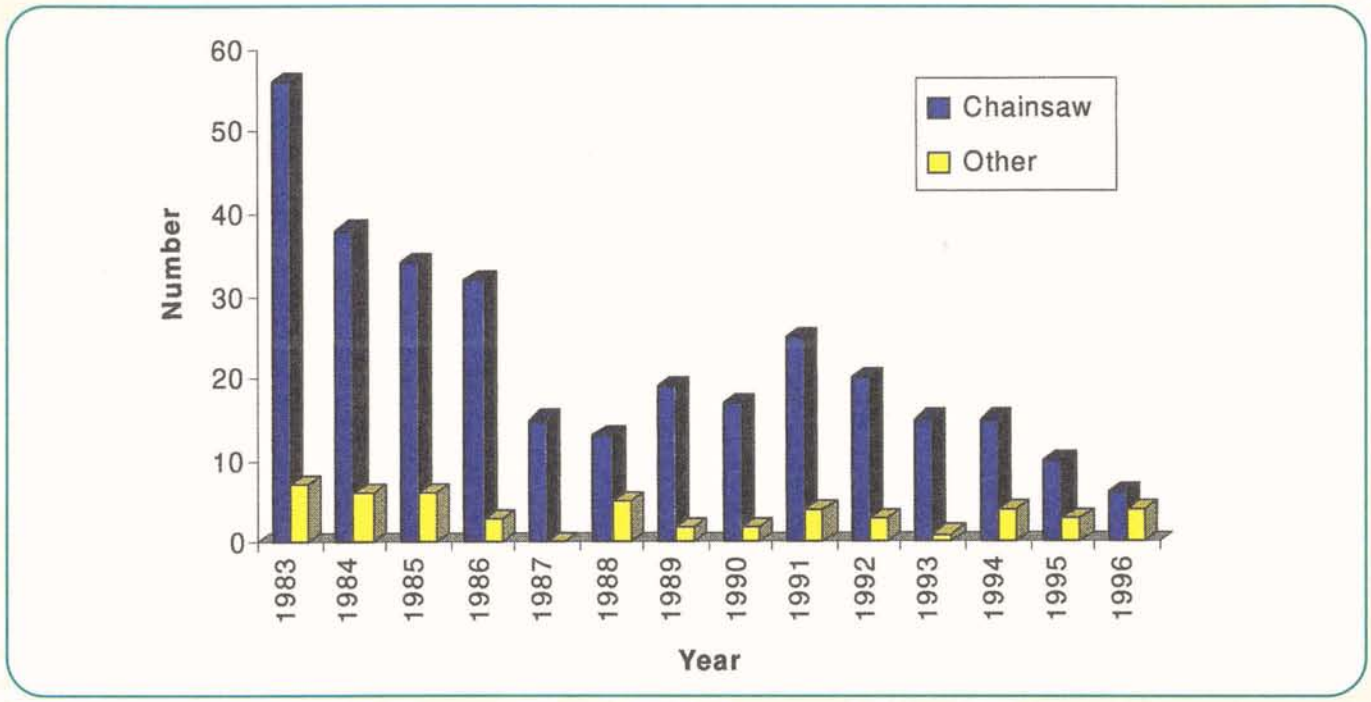

Figure 1 - Lacerations to the leg

Chainsaw lacerations to the Leg

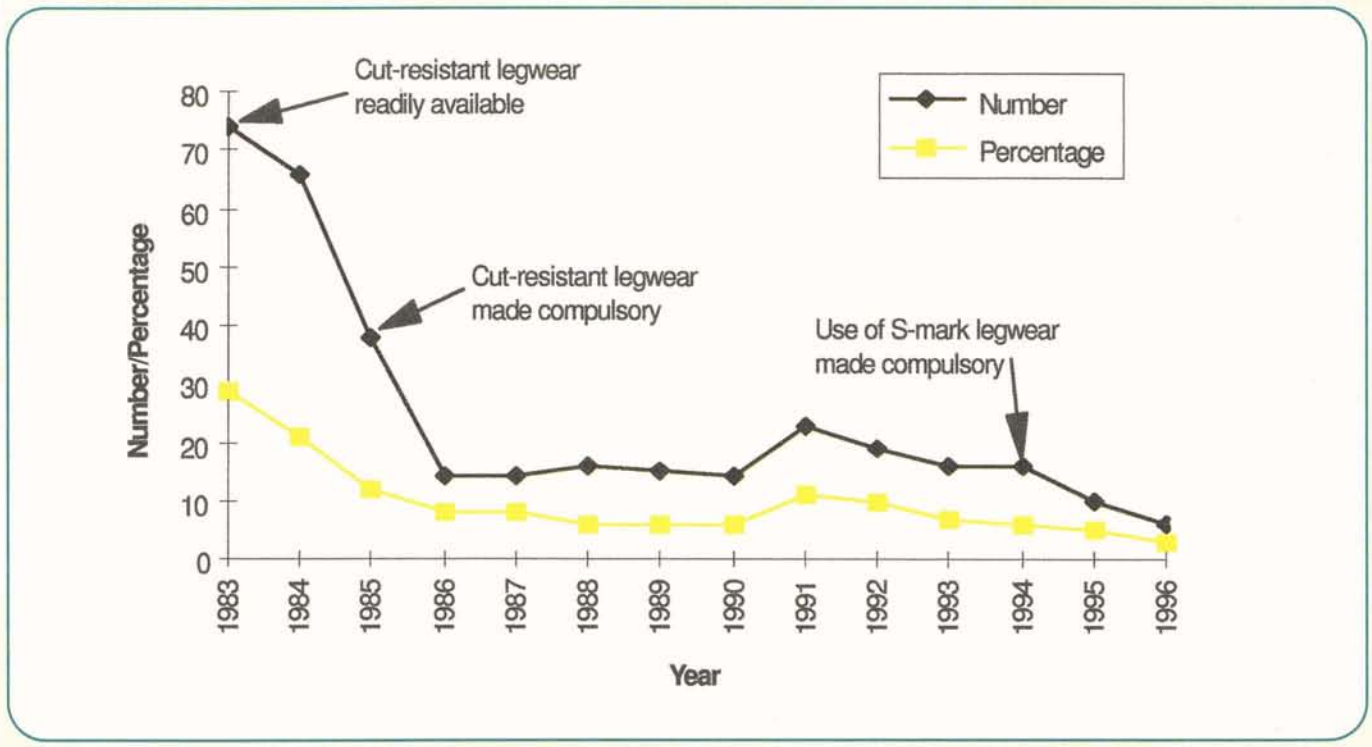

Figure 2 - Chainsaw cuts to the leg - 1983 to 1996

Figure 2 illustrates the percentage and number of all lost time accidents that were chainsaw cuts to the leg. This shows an initial dramatic decline from 1983 to 1986, with chainsaw cuts to the leg declining from 29% of all reported accidents, to 8%.

Figure 2 shows that after cut-resistant legwear was introduced in 1983, the number and percentage of reported lacerations to the leg fell. This trend continued for one year after protective legwear was made compulsory, falling to 8% of all reported injuries in 1986. From 1986 until 1994, chainsaw lacerations to the leg fluctuated between 5-11% of all reported lost time injuries. However, in 1994 the use of protective legwear with the S-mark (evidence that the legwear is certified to have passed the New Zealand Standard NZS 5840:1988) was made compulsory in the New Zealand logging industry. This resulted in a further small decrease in the number and percentage of chainsaw lacerations to the leg.

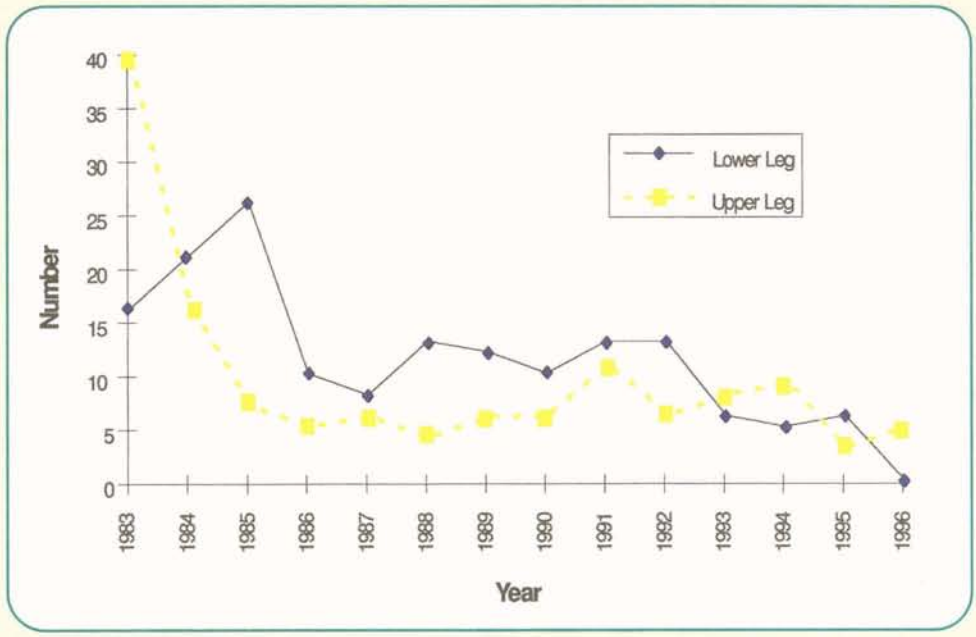

Figure 3 - Number of chainsaw lacerations to the upper and lower leg

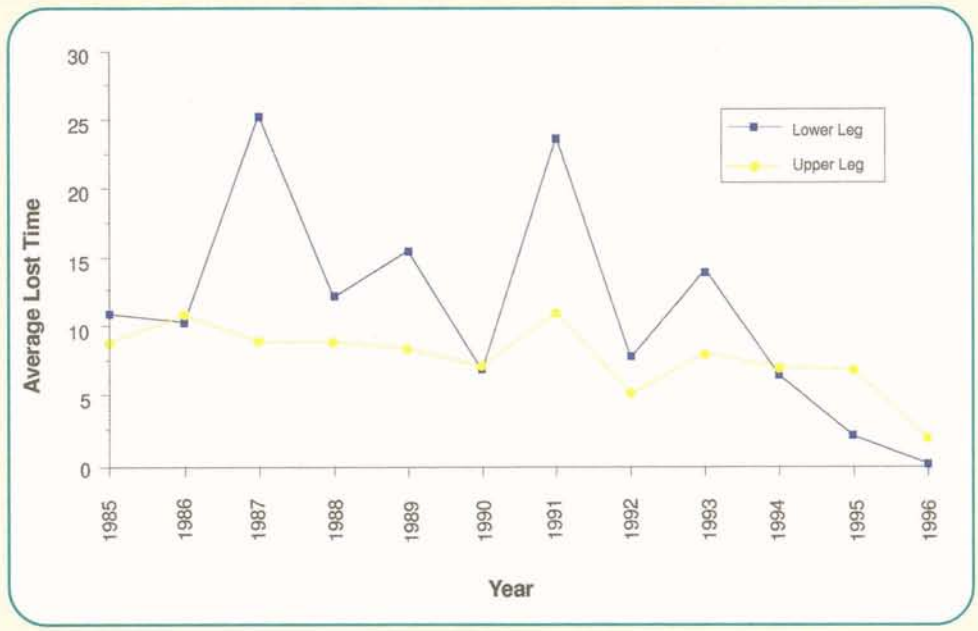

Figure 4 - Average lost time by part of the

Figure 3 shows the number of chainsaw lacerations and their location on the leg. During the period shown, chainsaw lacerations to the lower leg have declined to the point that in 1996 there were none reported. The number of chainsaw lacerations to the upper leg shows an initial dramatic decline to 1985. Since this time, the number of lacerations to the upper leg has remained relatively static.

Figure 4 shows the average lost time for lacerations to the upper and lower leg. This figure clearly shows an overall decline in the severity of chainsaw lacerations to the upper leg. Ignoring the "noise", the average severity of chainsaw lacerations to the lower leg also shows a downward trend.

Figure 5 shows the mechanism of injury for each two year period, as a percentage. The cases where the mechanism was unknown were included in the calculation of the percentage, but were not presented in the graph to enable a clear view of the known mechanisms of injury. One clear change has been an increase in the percentage of reported chainsaw cuts to the leg, where the mechanism of injury was able to be identified (Figure 5). In the 1983-84 period, it was possible to identify the mechanism of injury in a very small number of cases. In the last two periods, the mechanism of injury was able to be determined in the vast majority of cases.

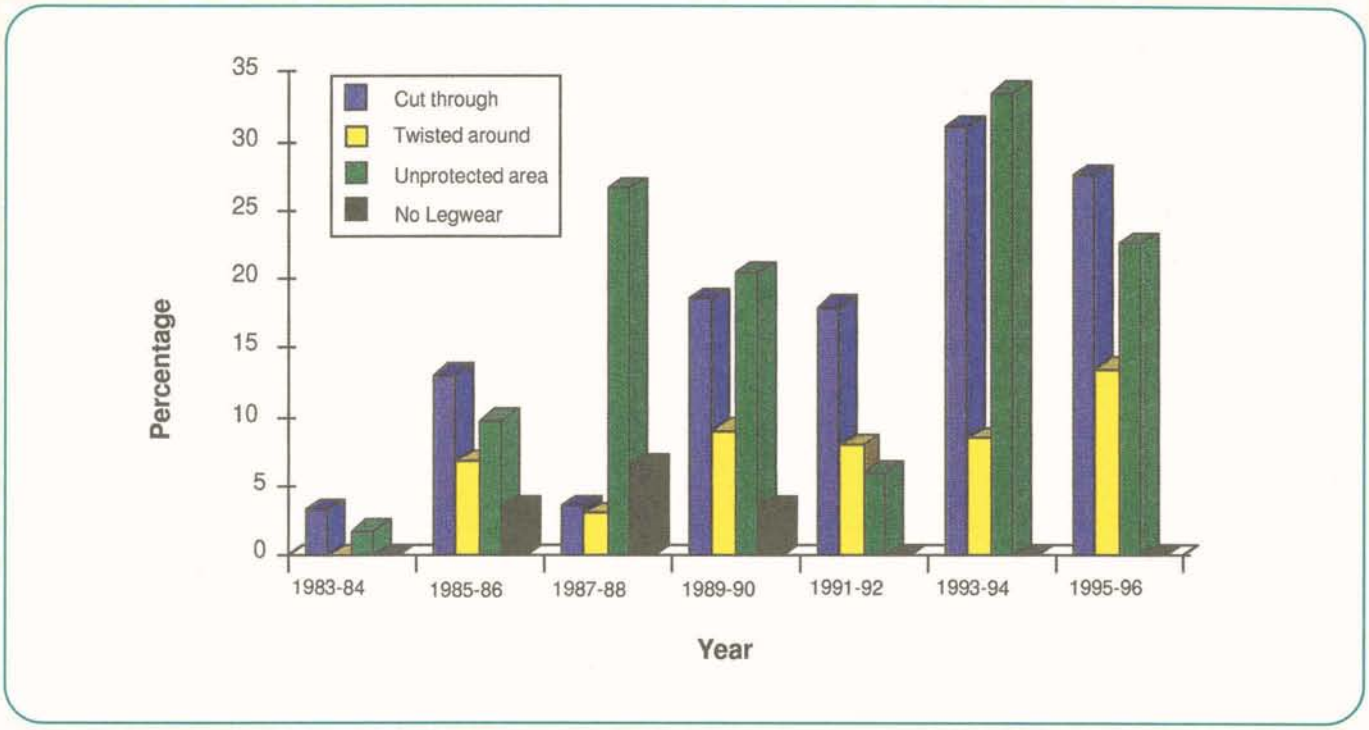

Figure 5 - Mechanism of injury

Overall, from 1983-1996 the most common mechanism of injury has been cutting an unprotected area of the leg, which on average accounted for 17% of all chainsaw lacerations to the leg. This was followed closely by cutting through the protective legwear, which overall accounted for 16% of all chainsaw lacerations to the leg. The third most common (7%) mechanism of injury was the chainsaw twisting the legwear around to expose a previously protected part of the leg, which was then cut. Chainsaw lacerations to an unprotected leg were reported up until 1990. This was despite the fact that the use of protective legwear was made compulsory for every New Zealand logging worker in 1985. However, since this time period no further injuries have been reported where the injured worker was not wearing protective legwear.

Figure 6 shows the average time lost for each injury mechanism, from 1985 to 1996. This clearly shows that chainsaw cuts to the leg were the most severe when no cut-resistant legwear was worn (average 22 days lost). The second largest amount of lost time occurred when the mechanism of injury was unknown (average 10 days lost). The third highest amount of lost time occurred when there was a chainsaw cut to an unprotected area of the leg (average 8 days lost). The second lowest average lost time (average 6 days lost) was caused by the chainsaw twisting the legwear to expose a previously protected area of the leg. The lowest amount of lost time was where the chainsaw cut through the protective materials (average 3 days lost).

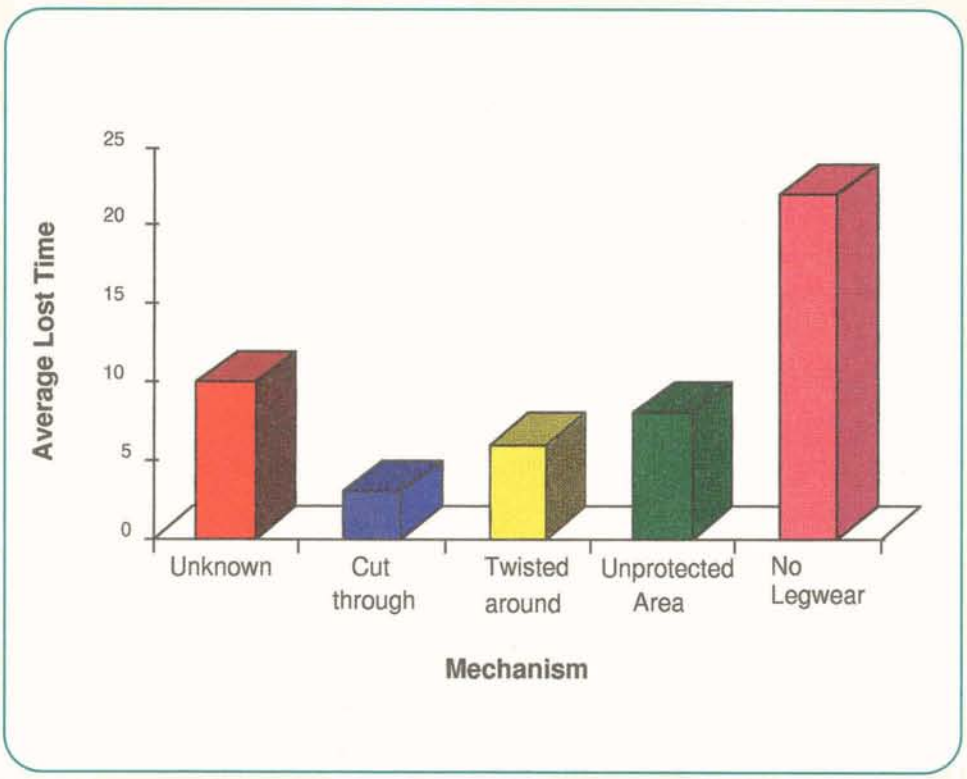

Figure 6 - Average lost time for each mechanism of injury

Discussion

During the period 1983-1996 the majority of lacerations to the leg were caused by contact with a chainsaw (Figure 1). However, this gap had narrowed significantly in the most recent data, due to a large reduction in the number of chainsaw lacerations to the leg. The principal cause of this downward trend in chainsaw injuries to the leg was thought to be the use of cut-resistant legwear (Gaskin, 1986). This downward trend was also noted by Kawachi et al. (1994), between 1979 and 1988, which they also took to provide evidence for the effectiveness of protective legwear. Figure 2 provides further evidence of the effectiveness of protective legwear.

However, the compulsory use of protective legwear did not completely eliminate chainsaw lacerations to the leg. One reason for this is that, in New Zealand cut-resistant legwear is designed to prevent an injury when the chainsaw is producing a chain speed of 20 metres a second (m/sec). Most chainsaws currently being used in the New Zealand logging industry can exceed this speed. There is protective legwear available in Scandinavia that can provide protection from a chainsaw with a chain speed of 28 m/sec. However, the thermal properties of the garment would place an unacceptably high amount of heat stress upon the wearer in New Zealand's sub-tropical climate. Since thermal comfort has been identified as the most important factor affecting wearer acceptance of protective clothing (Batel and Hinz, 1988), it is extremely unlikely that loggers would accept protective legwear that produced a higher level of thermal discomfort than those they are already wearing. In other words, a compromise has been made between the needs of the worker to be protected from the chainsaw, and the needs of the worker to be protected from heat stress.

Another potential reason for the failure to eliminate all chainsaw lacerations to the leg, is the possible deterioration in the protective qualities of the legwear over time (Gaskin and Parker, 1993). However, Gaskin and Parker (1993) had no evidence upon which to base this hypothesis, apart from their common sense opinion that the legwear must deteriorate over time. Recent Liro research has found that within six months' full time use by loggers, the legwear no longer provided the level of protection required by the New Zealand Standard (NZS 5840:1988) (Sullman, 1996b). More recent research has found that one factor responsible for the legwear's deterioration was spilling oil on the legwear (Sullman, 1997). These results were particularly concerning, as chainsaw operators frequently spill oil on their legwear and often wear the legwear for well over a year before replacement.

The number of chainsaw cuts to the lower leg has been substantially reduced, to the point that in 1996 there were none reported (Figure 3). This is in contrast to the pattern shown for the upper leg. The number of reported chainsaw cuts to the upper leg showed an initial decline to 1986, but since this time have remained relatively static. One possible reason for this could be the fact that the upper leg is exposed to more oil than the lower leg. However, it is possible that the absence of reported injuries to the lower leg was due to a random fluctuation. Therefore, the analysis of this data needs to be continued to discover what happens to the number of chainsaw cuts to the lower leg.

The average lost time for chainsaw lacerations to the leg has decreased between 1985 to 1996 (Figure 4). This supports Gaskin's (1986) data, in that it shows a downward trend in the severity, although in this case the trend is over 11 years, not two.

There are several possible explanations for the downward trend in injury severity. Firstly, during the period of study, there have been improvements to the chainsaw's chain brake. Secondly, there has been an improvement in the quality of the cut-resistant legwear, culminating in the 1994 requirement that all cut-resistant legwear, used in the New Zealand logging industry, be "S-mark" certified. This ensures that the legwear is of the functional quality required by the New Zealand Standard (NZS 5840:1988). Prior to 1994, there were no guarantees that the protective legwear was of the required quality. The third possible factor contributing to the decrease in injury severity is the fact that from 1990 onwards, there were no further cases where the injured worker was not wearing cut-resistant legwear. These injuries were by far the most severe (Figure 6) and would have increased the average lost time from 1985 to 1990. The elimination of these types of injuries would have decreased the average lost time for the following years, thereby contributing to a decrease in the severity.

Injuries were the most severe (the largest amount of time lost) when no cut-resistant legwear was worn (Figure 6). The cases classified as unknown were the second highest. This is not surprising, as this category may contain cases from the other four mechanisms of injury. One surprise was that cutting an unprotected area of the leg resulted in a significantly lower amount of lost time than when no cut-resistant legwear was worn. There could be several possible explanations for this. Firstly, there is the fact that the back of the leg is the only unprotected

part of the leg and a chainsaw cut to the back of the leg may cut into skin, muscles and some tendons before reaching the bone. However, if the chainsaw operator was not wearing cut-resistant legwear and cut into the front part of the lower leg, the chainsaw will cut through a small layer of skin, muscles and tendons before reaching the bone. A cut to the bone would result in a more severe injury than a cut to the back part of the leg. The second possible explanation is due to the improvement of the chain brakes. All cases where the injured worker was not wearing any cut-resistant legwear were pre-1990, whereas the cuts to an unprotected area of the leg would be both before and after this date. Since 1990 there have been some improvements in the speed at which chain brakes are activated. Consequently, there will be some reduction in the severity of the injury. A third possible explanation is that when cutting into an unprotected part of the leg, the chainsaw may have encountered part of the cut-resistant legwear covering the rest of the leg. It is possible that a combination of these factors may have contributed to the difference in severity between no legwear and cutting an unprotected part of the leg.

As expected, injuries caused by the legwear twisting around to expose a previously protected area of the leg, were less severe than cutting an unprotected part of the leg. Twisting the legwear around would absorb some of the cutting chain's energy, that would otherwise be used to cut into the leg. Cutting through the protective legwear was the least severe mechanism of injury, as expected. This is because the legwear slows the chain speed significantly, thereby reducing the severity of the injury. Overall, this shows that cut-resistant legwear may not always prevent injury, but in all cases will reduce the severity of the injury. The only possible exception to this is cutting an unprotected area of the leg.

The use of data from two separate sources could have resulted in an under-estimation of the injury rates. One problem highlighted by Kawachi et al. (1994) is that the ARS may not cover all loggers working in New Zealand. The ARS is provided with data from the forest companies, so injuries to those not working for a forest company are unlikely to be included in the ARS. However, the data from the Department of Labour survey includes all loggers, regardless of whether they work for a forest company or not. There is also the possibility that some of those classified, in the Department of Labour survey, as loggers were not really loggers. Both of these problems mean that the rates calculated here should be considered to be underestimates of the true injury incidence rates.

Other factors influencing the reduction in the number of chainsaw cuts to the leg include an improvement in the chainsaw chainbrakes to help reduce the chance and severity of cuts caused by chainsaw kickback. There has also been an increase in the mechanisation of logging work, although this would not be expected to have changed the proportions, only the raw number. There has also been an increase in the industry's awareness of the vulnerability of the leg to chainsaw cuts, and increased knowledge that the legwear is not cut-proof. This has been achieved through presentations to employers throughout the country, the publication of research results in forest company newsletters, industry magazines, industry newsletters and Liro reports. Another factor which may have contributed to the reduction in the number and percentage of chainsaw cuts to the leg is an increase in the quality and quantity of the training of logging workers. The large percentage of cases where the mechanism of injury was unknown highlights the need to improve accident/injury reporting procedures. Although an improvement over the period is illustrated by the increase in the cases where the mechanism of injury was able to be identified (Figure 3), further improvements to accident/injury reporting procedures should be made.

Conclusions

Lacerations to the leg caused by contact with the chainsaw have been greatly reduced over the duration of the study, probably due mainly to the use of protective legwear. Lacerations to the leg caused by contact with an object other than the chainsaw have remained relatively static. Chainsaw cuts to the lower leg have been reduced over the period of study, to the point where there were none reported in 1996. Chainsaw cuts to the upper leg decreased from 1983 to 1985, but since this time the number has remained relatively static. The mean severity of injuries has been reduced over the study period. The two most common mechanisms of injury were cutting an unprotected part of the leg and cutting through the protective legwear. The severity of injuries when the worker was not wearing protective legwear were by far the most severe. The least severe were those when the chainsaw cut through the protective legwear. A further area in need of investigation is why chainsaw cuts to the upper leg have not declined as much as those to the lower leg, and how to resolve this problem.

Recommendations

Design changes to legwear need to be investigated to avoid/reduce:

- loggers cutting themselves in an unprotected area
- the protective legwear twisting upon contact with the chainsaw
- the number of those injured by cutting through the protective legwear
- the number of chainsaw cuts to the upper leg.

Further research is also needed to discover the specific location of cuts, the condition of the legwear when the worker was injured, the brand and type of legwear the injured workers were wearing, whether the upper or lower legs are more prone to twisting and the exact reason why injuries to the upper leg have not declined.

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