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Changes in logging injury rates associated with use of feller-bunchers in West Virginia

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Abstract

Problem: It is well documented that logging is one of the most dangerous occupations and industries in which to work, and trees fellers are at greatest risk of injury. The objective of this study was to determine whether West Virginia (WV) logging companies experienced a reduction in injuries after beginning to use feller-bunchers (tree cutting machines, which replace some of the work done with a chainsaw) during harvesting operations. *Methods*: WV workers compensation claims and employment data from 1995 to 2000 were used to calculate injury rates. Injury trends in the rest of the WV logging industry, not using feller-bunchers, were also assessed. *Results*: For 11 companies, the pre-feller-buncher injury claims rate was 19.4 per 100 workers and the post-feller-buncher rate was 5.2 per 100 workers. This was a significant difference, with an adjusted rate ratio of 2.8 (95% CI: 1.8–4.5) of pre to post claims. Struck by injuries also showed significant decline, with the pre-feller-buncher injury rate being 3.8 (95% CI: 1.8–8.2) times as great as post-feller-buncher rate. During the time of the study, the injury rate rose in the rest of the WV logging industry. The average cost of a workers compensation claim in the WV logging industry during the time of the study was approximately $10,400. *Impact on industry*: As mechanization of logging tasks becomes more widespread, the WV logging industry as a whole may see substantial injury declines and a reduction in the total cost of injury claims. Struck by injuries, the most common and potentially fatal of logging injury types, appear to be particularly affected. However, logging operations in areas of very steep terrain where it is not possible to use these machines may need to rely on strategies other than feller-bunchers to reduce injuries.

Keywords: Logging; Mechanization; Feller-buncher; Occupational injuries; Workers' compensation

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1. Introduction

With an estimated lifetime fatality risk of 62.7 per 1,000 full-time workers, it is well documented that logging is one of the most hazardous occupations (Fosbroke, Kisner, & Myers, 1997; Leigh, 1987; Marshall et al., 1994; Myers, Kisner, & Fobroke, 1998). However, despite acknowledgment of the dangers of logging, fatality rates remain high (Bailer, Stayner, Stout, Reed, & Gilbert, 1998; Myers & Fosbroke, 1994; Sygnatur, 1998). In studies that have examined fatal injuries in loggers, falling trees/snags/branches account for the greatest percentage of injuries, ranging from 34% to 86% of total injuries (Paulozzi, 1987; Rodriguez-Acosta, & Loomis, 1997; Salisbury, Brubaker, Hertzman, & Loeb, 1991; West, Shkrum, & Young, 1996). "Struck by" injuries have also been reported as the most common nonfatal logging injuries. The U.S. Department of Labor (2001) shows "struck by object" injuries to account for 36% of injuries involving days away from work from 1994 to 1999. In a study of severely injured loggers (Holman, Olszewski, & Maier, 1987), 67% of the injuries were due to being struck by a falling or rolling log.

Because so many loggers are injured by falling objects, it has been suggested that greater levels of mechanized harvesting could result in lower injury rates (Axelsson, 1998; Holman et al., 1987; Husberg, Conway, Moore, & Johnson, 1998; Myers & Fosbroke, 1994). Tree fellers have the most dangerous job in the logging industry (Occupational Safety and Health Administration [OSHA], 2000). Presumably, if machinery is used to harvest trees, the person operating the equipment will be protected by the cab of the machine, thus reducing the number of injuries caused by a falling object.

A feller-buncher is likely to have the strongest impact on injuries because it is used to cut down trees. OSHA describes a feller-buncher as a mobile machine with an operator enclosure and an articulating extensible arm onto which a felling head (either a disc saw or chain saw) is attached. The operator moves the machine into position in front of a tree, grapples the tree with the felling head, cuts it from the stump, and then lowers the tree into a horizontal position onto a pile or bunch of trees on the ground, hence the term feller-buncher.

Conversely, it is also possible that using mechanized harvesting equipment could cause an increase in machinery-related injuries. Workers in the agriculture/forestry/fishing industry were found to have high rates of machinery-related occupational fatalities (Pratt, Kisner, & Helmkamp, 1996). Machinery-related incidents (such as struck-by moving equipment and rollovers) were found to account for 14–19% of fatal injuries in certain logging injury studies (Myers & Fosbroke, 1994; Paulozzi, 1987; Rodriguez-Acosta & Loomis, 1997; Salisbury et al., 1991), and less than 10% of nonfatal injuries requiring days away from work (U.S. Department of Labor, 2001). Although the percentage of injuries caused by machinery is considerably lower than the percentage of injuries caused by falling objects, machinery-related incidents still represent an important source of injury for loggers. The objective of this study is to determine whether West Virginia (WV) logging companies experience a reduction in injuries after beginning to use feller-bunchers during harvesting operations.

2. Methods

Logging companies in the state of West Virginia that own and use feller-bunchers during harvesting were identified by timber-buying companies and nonprofit research and extension agencies in the state. Procurement foresters from two major timber-buying companies in the state provided a list of logging companies that they knew used feller-bunchers in their operations. Researchers from the Appalachian Hardwood Center at West Virginia University also provided names of companies. The Appalachian Hardwood Center was established in 1987 by the West Virginia Legislature, in part to provide the wood products industry with technical, research, and training support. The West Virginia Forestry Association, a nonprofit organization dealing with issues related to forest resources, also provided names of companies. These contacts indicated that use of feller-bunchers was generally new to the state, so there would not be a large number of companies using them yet.

Workers' compensation injury (including illness) claims records for the entire logging industry, including the companies with feller-bunchers, were requested from the West Virginia Bureau of Employment Programs, Workers' Compensation Division. West Virginia is one of a few states that has a state-mandated workers' compensation insurance system (Islam, Velilla, Doyle, & Ducatman, 2001). Because most West Virginia logging companies are small and have few employees, they are not required to keep OSHA 200 injury logs. Thus, workers' compensation claims data were the only readily available source of injury data for the logging industry. Claims from the time period 1995–2000 were used.

Denominator information in the form of employment data were requested from the WV Bureau of Employment Programs, Unemployment Compensation Division. With few exceptions, state law requires companies to report monthly number of employees to the Unemployment Compensation division. To match the time period of injury claims, employment data were examined for 1995–2000.

Of the identified companies that used a feller-buncher, companies not found in the employment data files were excluded. Companies that were based out of state were also excluded. These companies were only recently required to have West Virginia workers' compensation coverage, so no historical data were available for these companies.

In order to calculate injury claims rates for each company before and after starting to use a feller-buncher, it was necessary to know the date each company began using their equipment. Eligible companies were contacted by mail and were asked to send back a form indicating the date (day, month, year) they first began using a feller-buncher during harvesting operations. The mailing process was modeled after the techniques suggested by Dillman (1978) for mail and phone surveys. The letter to the logging companies included an explanation of the goals of the research.

2.1. Data analysis

Injury rates were calculated with number of workers' compensation injury claims in the numerator and number of reported employees in the denominator, extrapolated to 100 workers per year. The date provided by each logging company noting when they first

started using a feller-buncher during harvesting operations was used to divide injury and employment data into pre- and post-time periods. Poisson regression, using SAS software (SAS, 1993), was used to calculate rate ratios from the before and after time periods, and to assess statistical significance.

Generalized estimating equations (GEE) were used to account for within-company correlation in pre- and post-rates (Liang & Zeger, 1986; SAS, 1996). Companies identified as using feller-bunchers were analyzed separately and compared to the rest of the WV logging industry in both their pre- and post-time periods. It was assumed that once the feller-buncher companies were analyzed separately, the rest of the industry would represent companies not using feller-bunchers.

3. Results

Contacts from the two timber buying companies, the Appalachian Hardwood Center at West Virginia University and the West Virginia Forestry Association, provided a total of 28 logging companies. Of these 28, three were based out of state, and had no employment data. Of the 25 left, 20 companies provided information on their feller-buncher start date, one declined to participate, and four did not respond. Two of the four nonrespondents were missing from the employment files. Of the 20 companies that provided a feller-buncher date, four were missing from the employment files. This left 16 companies that both had usable data with which to calculate rates, and provided date of feller-buncher use. Not all of these companies had data available prior to the time they started using a feller-buncher. Either due to missing data, or due to being new, five companies had post-feller-buncher data only. Eleven companies had data pre- and post-feller-buncher use.

On average, each of the 11 companies had 2.4 years of injury and employment data pre-feller-buncher, and 2.2 years post-feller-buncher. The companies began using their machines at varied points in time; two companies started using their machines in 1996, three in 1997, four in 1999, and two in 2000. The average number of employees reported per month prior to feller-buncher use was 5.2; the average number of employees reported per month after feller-buncher use was 6.5. The pre-feller-buncher injury claims rate for the 11 companies was 19.4 per 100 worker years (Table 1). The post-feller-buncher rate for the same companies was 5.2 per 100 worker years. Using Poisson regression, there was a

Table 1
Changes in injury claims rates before and after feller-buncher use in 11 West Virginia logging companies

	Pre-feller-buncher injury rate	Post-feller-buncher injury rate	Unadjusted rate ratio	Adjusted rate ratio[a]	95% CI
Total injury claims	19.4 per 100 workers	5.2 per 100 workers	3.8	2.8	1.8–4.5
Struck-by injury claims	10.1 per 100 workers	1.9 per 100 workers	5.3	3.8	1.8–8.2

Average amount of available data was 2.4 years pre-feller-buncher and 2.2 years post-feller-buncher. Ratio is expressed as pre-rate divided by post-rate.

[a] Rate ratio and confidence interval were calculated using GEE-adjusted Poisson regression to adjust for within-company correlation between pre- and post-measurements.

significant difference between the pre- and post-time periods, with injury rate being 3.8 (95% CI: 1.7–8.3) times higher before feller-buncher use than after. After using GEE to account for within-company correlation, the adjusted rate ratio was 2.8 (95% CI: 1.8–4.5) between pre- and post-rates.

Of all injury types, 'struck-by' injuries comprised the greatest proportion of injuries in both the pre- (51%) and post- (38%) feller-buncher time periods, but the rate of 'struck-by' injuries showed a significant decline from the pre- to post-period (Table 1). The pre-rate was 10.1 per 100 workers and the post-rate was 1.9 per 100 workers. The pre-rate was 5.3 (95% CI: 1.5–18.0) times greater than the post-rate. After adjusting for within-company correlation, the rate ratio was 3.8 (95% CI: 1.8–8.2). Only one injury in the feller-buncher group was coded as having machinery being the source of injury, and it involved a skidder. Although the workers' compensation database captures fatal injuries, there were no fatalities recorded for any of the feller-buncher companies during the time period of this study.

Feller-buncher companies were removed from the injury and employment datasets for the entire WV logging industry. One other company (not a feller-buncher company) in 2000 was removed because it appeared not to be a logging company. An average overall non-feller-buncher rate was then calculated from the 1995–2000 data. The injury claims rate for non-feller-buncher companies was 16.6 claims per 100 workers. The pre- and post-feller-buncher time periods for the 11 companies were compared against this industry average. There was no significant difference between the pre-feller-buncher rate of feller-buncher companies and the average non-feller-buncher company claim rate (Table 2). The average non-feller-buncher company claim rate for 1995–2000 was significantly greater than the post-feller-buncher injury claims rate of feller-buncher companies. Non-feller-buncher companies reported an average of three employees per year, based on 1995–2000 data.

The injury claims trend for the entire WV logging industry (with the feller-buncher companies removed) was calculated for 1995–2000. During this time, there were approximately 430 companies with employment data each year. Yearly injury rates are shown in Fig. 1. Poisson regression revealed a significant increase in the injury claims rate over this time period (slope estimate = 0.0338, $P = 0.0325$).

To put this information in terms of cost of injuries, during the time covered by this study, the average cost of an injury claim in the WV logging industry was $10,400. The rest of the industry (not using feller-bunchers) had an average yearly rate of 16.6 claims per 100 workers.

Table 2
Comparison of the pre- and post-feller-buncher injury claims rates of companies with feller-bunchers to the rest of the West Virginia logging industry's (non-feller-buncher companies) average rate based on 1995–2000 data

	Feller-buncher companies	WV logging industry	Rate ratio	95% CI
Pre-feller-buncher time period	19.4 per 100 workers	16.6 per 100 workers	0.9	0.6–1.3
Post-feller-buncher time period	5.2 per 100 workers		3.2	1.6–6.4

Ratio is expressed as the rest of the industry rate divided by feller-buncher company rate.

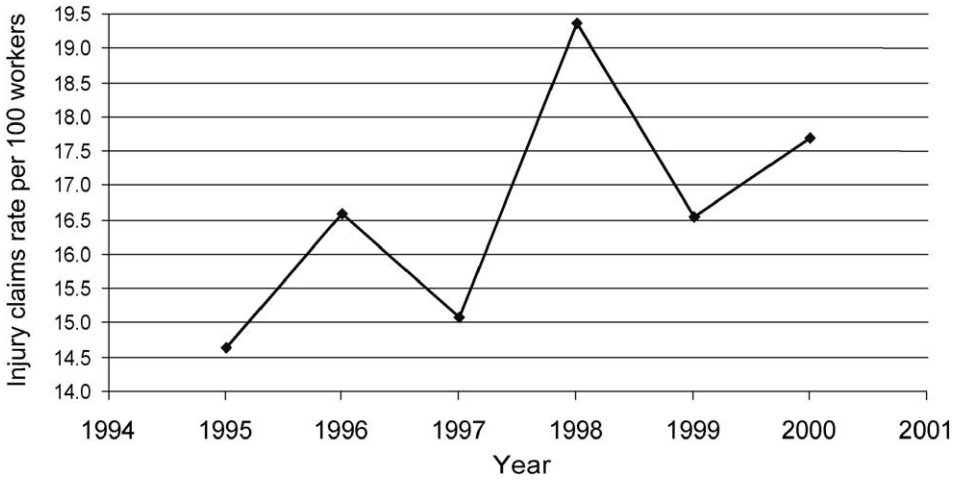

Fig. 1. Injury claims rate for the rest of the West Virginia logging industry (non-feller-buncher users), 1995–2000.

If they went down to the post-feller-buncher rate of 5.2 per 100, that would be an injury reduction of 11.4 per 100, or $118,560 per 100. The WV logging industry reported approximately 1,500 employees each year from 1995 to 2000. Extrapolated to this number, the reduction in cost could potentially be near $1.8 million.

4. Discussion

The results of this study provide evidence that companies using a feller-buncher during harvesting operations experience a decline in workers' compensation injury claims. Three lines of evidence were used to reach this conclusion. First, a pre- and post-analysis was done that showed a significant decline in injury rates after feller-buncher start date. These companies began using their feller-bunchers at different points in time, thus staggering the pre-post data across a range of time periods. Second, these companies were compared to the rest of the West Virginia logging industry; their rates were found to be similar to the industry average before they started using a feller-buncher, but significantly lower than the industry average after they started using a feller-buncher. Third, there was no general decline in injury claims rates in the WV logging industry as a whole from 1995 to 2000; rather there was a slight increase in injuries over this time period.

In their analysis of logging-related fatalities, Myers and Fosbroke (1994) found higher rates in the eastern portion of the United States, including West Virginia, and suggested this may be due in part to forest type (primarily hardwood tree species) and low levels of mechanization in harvesting. Other papers describing logging injuries have hypothesized that increased mechanization should reduce numbers of injuries (Axelsson & Ponten, 1990; Holman et al., 1987; Husberg et al., 1998; International Labour Organisation, 1981;

Nordansjo, 1988; Slappendel, Laird, Kawachi, Marshall, & Cryer, 1993), but did not address the issue quantitatively.

Two studies have looked quantitatively at the relationship between mechanization and injuries in the logging industry (Laflamme & Cloutier, 1988; Shaffer & Milburn, 1999). Both of these studies took the approach of comparing conventional or partially mechanized logging operations to fully mechanized logging operations during the same time period. Laflamme and Cloutier (1988) examined the relationship between the mechanization of delimbing and debranching activities in two logging companies. They found that sites logged with conventional logging methods have almost three times the injury rate as sites logged with mechanized methods; however, they do not specifically mention mode of felling or feller-bunchers. They also found that injuries in mechanized sites were more likely to occur to skidder operators, and during maintenance and repair activities, and that in conventionally logged sites, injuries were more likely to occur to fellers.

Shaffer and Milburn (1999) compared workers compensation injury claims between partially mechanized and fully mechanized (feller-buncher/grapple skidder) logging operations. They found that fully mechanized operations had a lower proportion of injuries due to manual chainsaw delimbing, and a higher proportion of injuries due to equipment maintenance and repair. There was no statistical difference in the proportion of manual chain saw felling injuries between the two types of logging operations. Similar to the current study, they found that the proportion of 'struck by' injuries was lower in more mechanized operations, but that 'struck by' injuries were still the most predominant injury type. However, without denominator data, it cannot be determined whether injury rates were lower in fully mechanized companies.

Although several lines of reasoning were used to reach the conclusions in the current study, this study is not without its limitations. These include the fact that a complete list of companies using feller-bunchers in the state did not exist. Therefore, the opinions of experts were solicited. These entities were dispersed geographically throughout the state and work closely with the WV logging community.

Because the use of feller-bunchers is still relatively uncommon in the West Virginia, these results are based on a small number of companies. More solid results could be obtained by continuing to add new companies to the analysis, as feller-buncher use becomes more widespread in the state of West Virginia. Similar data from other states could also be added and analyzed.

The study does not include data on other potential confounding factors such as changes in other pieces of equipment (e.g., cable vs. grapple skidders) or training programs. However, West Virginia's Certified Logger Program was initiated in 1992, before the 1995 start date of this study (Egan, Hassler, & Grushecky, 1997). All logging operations are required to have one Certified Logger on site for at least part of the day, thus presumably affecting all companies, regardless of feller-buncher use, equally. The injury rates described in this study are subject to the biases associated with the use of any workers' compensation injury data. For example, if companies under-report number of employees, but report whatever injuries may occur in their actual workforce, then this may make rates appear higher. However, there is no evidence to suggest that these biases would have changed over the time period of this study. Most logging companies, particularly in the east, are relatively small, and are not required to keep OSHA 200 injury logs. Because of a

lack of structured injury records, it is difficult to track nonfatal injuries in this industry. Despite the limitations of workers' compensation claims data, they are the only data source through which company-specific injuries in this population can be monitored.

5. Conclusions

In conclusion, the results of this study provide evidence that West Virginia logging companies experienced a decline in workers compensation injury claims rates after beginning to use a feller-buncher during harvesting operations. 'Struck by' injuries were the most common injury type, and the rate of this type of injury showed a significant decline after feller-buncher use. Greater use of machinery to perform dangerous logging tasks (such as chainsaw felling) may reduce workers' exposure to injury risk. One might expect that increased mechanization could lead to a reduction in the number of employees, but this did not appear to be the case. Companies that started using a feller-buncher reported a small increase in the number of employees. As mechanization of logging tasks becomes more widespread, the industry as a whole may see substantial injury declines, and potentially a substantial reduction in yearly total workers compensation claims costs.

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