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RESEARCH ARTICLE

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Factors associated with injury among Maine logging workers

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Abstract

Introduction: Despite dramatic improvements in safety, logging remains one of the most dangerous industries in the United States. The purpose of this study was to explore longitudinal injury trends among Maine logging workers.

Methods: Loggers participated in seven quarterly surveys, over the course of 18 months. Categorical and free text data related to traumatic and acute injury, musculoskeletal disorders (MSD), and chronic pain were exported from REDCap into SAS 9.4, Excel, and NVivo, for quantitative and qualitative analysis, respectively. Time to injury was modeled using two different approaches: (1) time to the occurrence of first injury modeled by proportional hazard regression and (2) an intensity model for injury frequency. Two research team members also analyzed qualitative data using a content analysis approach.

Results: During the study, 204 injuries were reported. Of the 154 participants, 93 (60.4%) reported musculoskeletal pain on at least one survey. The majority of injuries were traumatic, including fractures, sprains, and strains. Lack of health insurance was found to be related to increased risk of first injury [HR = 1.41, 95% CI = 0.97–2.04, $p = 0.069$]. Variables found to be related to injury intensity at the univariate level were: (1) a lack of health insurance [HR = 1.51, 95% CI = 1.04–2.20, $p = 0.030$], (2) age [HR for 10-year age increase;= 1.12, 95% CI = 0.99–1.27, $p = 0.082$], and (3) years employed in logging industry [HR for 10-year increase = 1.12, 95% CI = 0.99–1.26, $p = 0.052$]. Seeking medical attention for injury was not a priority for this cohort, and narratives revealed a trend for self-assessment. A variety of barriers, including finances, prevented loggers from seeking medical attention.

Discussion: We found that loggers still experience serious, and sometimes disabling, injuries associated with their work. It was unsurprising that many injuries were due to slips, trips, and falls, along with contact with logging equipment and trees/logs. The narratives revealed various obstacles preventing loggers from achieving optimal health. Examples included geographic distance from healthcare, lack of time to access care, and entrenched values that prioritized independence and traditional masculinity. Financial considerations were also consistently cited as a primary barrier to adequate care.

Institution where work was performed: Northeast Center for Occupational Health and Safety (NEC), Bassett Medical Center.

Conclusion: There is a continued need to emphasize occupational health and safety in the logging industry. Implementation of relevant safety programs is key, but it is likely that the benefits of these will not be fully realized until a cultural shift takes place within this industry.

KEYWORDS

health, logging, longitudinal cohort, Maine, safety

1 | INTRODUCTION

Despite dramatic improvements in safety, logging remains one of the most dangerous industries in the United States. In 2021, logging had the highest fatality rate of any civilian occupation with 82.2 deaths per 100,000 full time equivalent (FTE) workers, nearly 23 times the national average.[1] The logging work environment and risk profile is not consistent around the United States. The process of felling trees, and removing them from the forest, can range from manual or conventional logging using chainsaws, skidders and even horses, to mechanized operations using highly computerized heavy equipment that can fell, buck and limb a tree within a matter of seconds. Further, risk profiles may be influenced by factors such as terrain, weather, and economics.

A variety of logger health and safety studies have been performed to date, both in the United States and abroad. It is well understood that many factors contribute to frequency of injuries among the traditional logging population, including harsh weather conditions, rugged terrain, the operation of dangerous tools, and long hours performing physically demanding labor.[2] In recent decades, as the industry has become more mechanized and technologically advanced, new problems have arisen. One study, conducted in the southern US, looked at the incidence of self-reported pain and diagnosed musculoskeletal disorders (MSDs) among logging machine operators. Within this sample, 10.5% reported an MSD diagnosis, 74.3% reported at least mild back pain, and 71.7% reported at least mild neck pain over the past year.[3] Another study of work-related MSDs among logging machine operators in the Arkansas, Louisiana, and Texas (Ark-La-Tex) region involved a self-administered 93-item questionnaire with six different sections: (1) demographics, (2) lifestyle and medical background, (3) work experience, (4) job training, (5) occupational heat-related stress, and (6) occupational injuries and musculoskeletal symptoms. This research found that the most problematic factors for the lower back were performing a repetitive task, working very fast for short periods, and awkward bending and twisting. Further, awkward and cramped conditions were noted as an adverse exposure for lower extremities as well.[4]

Studies worldwide have examined the health consequences that arise from spending excessive sedentary periods inside a cramped logging equipment cab.[5,6] A Slovakian study focused on work-related factors straining the cardiovascular system found that operators' height, machine types, parts of the shifts, equivalent noise, lighting, and whole-body vibrations explained about 72% of the elevated heart rate variability.[7] Another study conducted in Italy looked specifically at the effect of hand-arm vibration on musculoskeletal disorders in forestry workers. They found a significantly higher prevalence of persistent upper limb pain, muscle-tendon syndromes, and carpal tunnel syndrome among the test logger group as opposed to the controls (who weren't exposed to vibration).[8] The consensus is that while increased mechanization in forestry has decreased certain occupational hazards, it has also led to a rise in chronic, long-term health problems.

As the logging industry becomes increasingly mechanized, and therefore more sedentary in nature, studies focused on comparable industries are useful in our examination of logger health, as well. One nation-wide survey from 2014 collected data from 1670 long-haul truck drivers throughout the US, and found that obesity and current smoking status were twice as prevalent in this population as compared to the 2010 US adult working population.[9] Further, 61% reported having at least two of the following risk factors: hypertension, obesity, smoking, high cholesterol, no physical activity, and six or fewer hours of sleep per 24-h period.[9] Chronic health problems were also observed in a sample of Canadian truck drivers, with obesity, back pain, and cardiovascular disease (CVD) risk all being widespread concerns.[10] Research has shown that among heavy equipment operators in construction, unhealthy behaviors such as smoking, drinking, poor nutrition, and lack of physical activity are prevalent.[11] The inherent nature of these sedentary jobs coupled with poor health behaviors put these worker populations at high risk for many diseases, including heart disease and cancer.[11]

Longitudinal studies are particularly useful for gathering robust data on a cohort, as they allow for analysis and understanding of change over time. For example, Vedaa et al.[12] demonstrated a relationship between quick returns of less than 11 h off between working shifts and occupational accidents among Norwegian nurses. Over a 2-year follow-up period, the researchers identified a consistent pattern of association between the numbers of quick returns and a corresponding change in the risk of occupational accidents.[12] In another study, researchers were able to demonstrate a relationship between Indoor Environmental Quality (IEQ) and work performance.[13] The researchers surveyed employees over a period of 8 months and were able to demonstrate a cumulative negative relationship between the number of IEQ and an employee's productivity and morale.[13]

The overall purpose of our study was to gather information on a cohort of workers in the logging industry, with particular interest in understanding the factors contributing to logger health and safety over time. To do this, we explored longitudinal injury trends among Maine loggers. Information related to the development of the cohort and their health status have been reported elsewhere.[14,15] The logging industry is a crucial component of the Maine economy, and understanding these data are critical to implementing targeted health and safety interventions in the future.

2 | METHODS

The development of the logger cohort has been explained in detail in a previous publication.[14] Once the cohort was assembled through enrollment in an initial survey, loggers participated in six subsequent quarterly surveys over the course of 18 months. At enrollment, loggers could choose their preferred method of contact: postal mail, email, telephone call, or text link. They were also invited to participate in a one-time, in-person health assessment. Results from the health assessment substudy have also been previously reported.[15]

The survey modules can be seen in Table 1. Surveys were (1) mailed out every 3 months in paper format, (2) shared electronically using a REDCap[16,17] link via email or text message, or (3) collected through a phone call with the participant. Recipients had 6 weeks to respond. If a participant did not return the survey within that period, a second survey was sent. If a respondent failed to return two quarterly surveys in a row, they were deemed lost to follow up (e.g., missing data greater than 6 months). Participants received a $25 gift card for each survey completed.

2.1 | Data management and cleaning

Paper surveys were reviewed for completeness before data entry. Data collected through electronic means were saved directly into the database and telephone data were entered into the REDCap database during the conversation with the participant. Regardless of the type of data collection, the information gathered was identical. Data were cleaned before analysis. REDCap was also used to maintain statistics on response rates throughout the longitudinal study.

Categorical and free text data related to traumatic and acute injury, musculoskeletal disorders (MSD), and chronic pain were exported from REDCap[16,17] into Excel (Microsoft Corporation). Traumatic and acute injuries were coded using the Occupational Injury and Illness Classification System (OIICS) into the categories of Nature, Type of Event, Source of Injury, and Body Part. In addition to OIICS, MSD and chronic pain were further coded into dichotomous acute (<6 months) and chronic (≥6 months) pain. This process was completed by two coders working independently. Following coding completion, discrepancies were reconciled between both coders. When agreement between coders could not be reached, cases were referred to the Principal Investigator for final assignment.

2.2 | Definitions

This study focused on injuries reported throughout the reporting period. Injuries were classified for the purposes of these analyses into (1) less severe—not requiring professional medical attention or returning straight to work after medical attention (e.g., receiving stitches for a laceration and returning immediately to work) and (2) more severe—requiring medical attention and requiring one or more days of lost work time.

2.3 | Quantitative analysis

Data were exported into SAS 9.4 (SAS Institute, Inc). Binary data such as company type (conventional vs. mechanized logging),

TABLE 1 Survey modules.

	Survey						
Modules	1	2	3	4	5	6	7
Work history	X						
Work role	X	X	X	X	X	X	
Company information	X	X	X	X	X	X	
PPE and workplace safety	X	X	X	X	X	X	
Demographics	X	X	X	X	X	X	
Health questions	X	X	X	X	X	X	X
Health insurance	X	X	X	X	X	X	X
Workers' compensation	X	X	X	X	X	X	X
Important health and safety issues (free text)						X	
Foot protection						X	
Sun protection						X	
Tick exposure						X	
Skin cancer						X	
Dental						X	
Work satisfaction (free text)							X
Logging information access							X
Marital status							X
Dependents							X
Education							X
Public health (browntailed moth exposure)							X
Public health (community opioid misuse)							X
Financial well-being							X
Personal health (SF36)							X
Social support							X

were reported as proportions and standard error. Continuous data, such as years in logging, were reported as mean and standard deviation.

In all time to event analyses, follow up time at risk was taken to begin 12 months before the first survey, as the first survey asked subjects to report injuries sustained over the previous year. This convention of 12 months prior combined with six subsequent quarterly surveys resulted in a maximum possible follow-up time of 30 months. The primary analysis considered follow-up time across contiguous survey responses. A sensitivity analysis was employed to test the effect of missing data. In this analysis a subject with two consecutive missed surveys (Table 2, subject B) was right censored at the time of the last completed survey. Subjects with a single missed survey (Table 2, subjects A, D, and E) were right censored at the time of the following survey or contiguous surveys completed.

Time to injury was modeled using two difference approaches. In the first, time to the occurrence of first injury was modeled by proportional hazard regression. Initially separate univariate models tested the relationship of age, years of logging experience, type of logging (mechanized vs. conventional) company size (sole operators, 2 to 10 employees, or more than 10 employees), having an annual medical checkup, or type of medical insurance (none, employer provided, government, or self-purchased). Variables found to be significant in these univariate models were combined into a single model to identify independent predictors of time to injury.

In the second approach, an intensity model was employed to test the relationship of this covariate set to injury frequency. In this approach, each subject had as many risk episodes as the total number of injuries sustained plus one row for right censoring of the last risk episode. The Andersen-Gill model was employed, which included a random effect for the subject. The Andersen-Gill model is in the family of intensity models. Each row of the data matrix is an episode of risk, rather than necessarily a unique subject. The resulting nonindependence of rows is modeled by including a random effect for the subject and using the sandwich estimator for the variance-covariance estimator.[18] These two models were used for each of two outcomes: (1) time to any injury and (2) time to more severe injury.

2.4 | Qualitative analysis

Injury reports were exported from REDCap and imported into NVivo 12 (QSR), a qualitative analysis software. Two research team members analyzed these data using a content analysis approach. This involved reading the verbatim descriptions of injuries reported by the loggers, both to understand the overall injury event, but also to deduce underlying themes related to loggers' perspective on injury. Nodes were created both inductively and deductively, and a third qualitative researcher reviewed these data to evaluate and add to the NVivo analysis, as well. Nodes were created based on text queries and word frequencies. NVivo tools including word clouds and hierarchy charts helped to visualize patterns and prioritize responses.

3 | RESULTS

3.1 | Survey response rates

Table 3 shows the response rates to each quarterly survey. Out of 1811 initial surveys, there were 325 subjects with usable data. Response rates showed a decline after each survey. By survey 7, 18 months from the initial survey, there were responses from 43.4% of the original responding cohort. Throughout the survey series, 204 injuries were reported, with over 80% of these noted in the first survey (Table 3). Further, nearly 15% of loggers reported more than one injury in the initial survey. Initial coder agreement to the second level (2 digit) of OIICS was as follows: type of event (59%), source of injury (68%), nature of injury (50%), and body part (75%). Coder resolution meetings with the Principal Investigator resulted in all injuries being coded and team congruence on decision-making.

3.2 | Quantitative results

3.2.1 | Pain

Of the 154 participants, 93 (60.4%) reported musculoskeletal pain on at least one of the surveys, 33.4% reported chronic pain (pain

TABLE 2 Time to injury event.

Example participants	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7
A	Y	Y	Y		Y		Y
B	Y	Y	Y			Y	Y
C	Y	Y	Y	Y	Y		
D	Y	Y		Y	Y		
E	Y	Y		Y			
Table key =	Continuous surveys		skipped or non-continuous surveys		Right censored		

TABLE 3 Response rates and reported injuries across surveys.

	Survey 1		Survey 2		Survey 3		Survey 4		Survey 5		Survey 6		Survey 7	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Number of surveys distributed	1811	100.0	314	100.0	305	100.0	301	100.0	300	100.0	287	100.0	275	100.0
Excluded/missing	1486	82.1	98	31.2	114	37.4	120	39.9	131	43.7	133	46.3	134	48.7
Respondents (% of initial respondents)	325	100.0	216	66.5	191	58.8	181	55.7	169	52.0	154	47.4	141	43.4
Injured subjects	117	36.0	10	4.6	6	3.1	7	3.9	4	2.4	5	3.2	5	3.5
Noninjured subjects	208	64.0	206	95.4	185	96.9	174	96.1	165	97.6	149	96.8	136	96.5
Number of injury events	165	50.8	11	5.1	6	3.1	7	3.9	4	2.4	6	3.9	5	3.5
Participants with more than one injury	48	14.8	1	0.5	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0

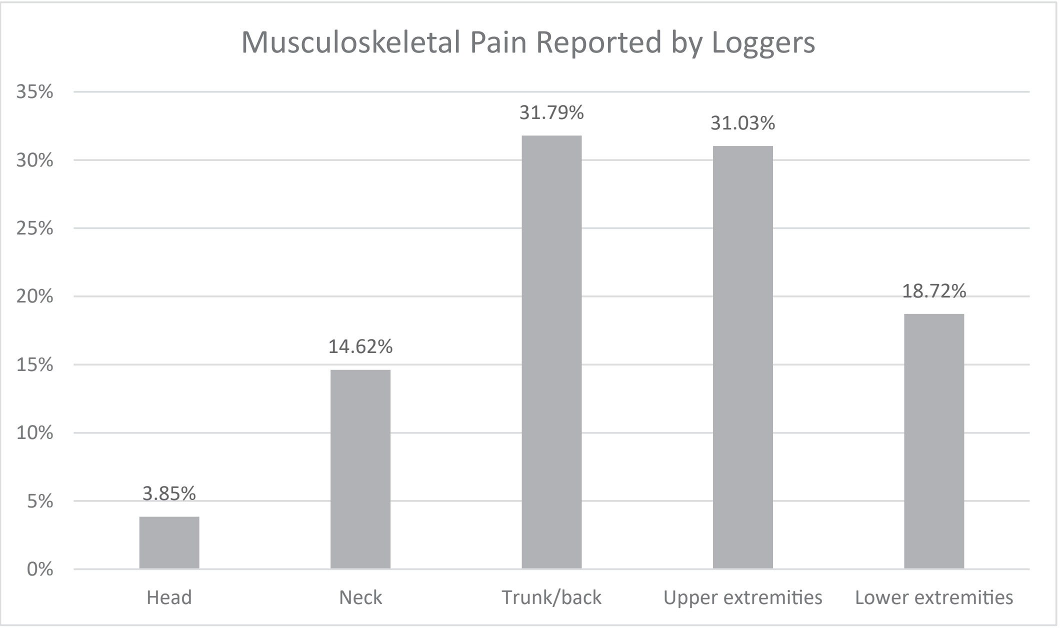

FIGURE 1 Reported musculoskeletal pain by area of body.

reported on three or more surveys), with an additional 26.6% reporting acute pain at one or two points during the study period. There were 284 individual reports of pain, with 137 reports (48.2%) noting pain in more than one part of the body. The areas loggers reported pain can be seen in Figure 1.

3.2.2 | Reported injuries

Reported injuries ranged from minor wounds that required first aid with no lost work time to traumatic injuries requiring hospitalization and resulting in substantial lost work time. Table 4 shows logger injuries classified by the four categories of the Occupational Injury and Illness Classification (OIICS) System: (1) nature of injury, (2) body part, (3) source of injury, and (4) type of event. The information provided by the subjects made it possible to assign the nature of the injury in all but 10.3% of the cases. The majority of cases were traumatic injuries, with fractures, sprains, and strains making up nearly one quarter (24.1%) of all cases. The source of the injury could be assigned in nearly half (49.0%) of cases.

3.2.3 | Injury modeling

Results from injury modeling can be seen in Tables 5 and 6.

Time to first injury
The only variable found to be related to time to first injury at the univariate level was lack of health insurance [HR = 1.41, 95% CI = 0.97–2.04, $p = 0.07$]. Multivariable modeling was not performed.

Time to first severe injury
No significant predictors were identified in either the univariate model for this outcome. Multivariable modeling was not performed.

TABLE 4 OIICS classification of logger injury.

	OIICS #	Description	N	%
Nature of injury	10	Traumatic injuries and disorders, unspecified	101	49.5
	111	Fractures	24	11.8
	123	Sprains, strains, tears	25	12.3
	1972	Soreness, pain, hurt	28	13.7
	9999	Nonclassifiable	21	10.3
	Other[a]	Other	5	2.5
Body part	10, 20	Head or neck	26	12.8
	30	Trunk	30	14.7
	40	Upper extremities, unspecified	26	12.7
	44	Hand(s)	24	11.8
	50	Lower extremities, unspecified	18	8.8
	51	Leg(s)	26	12.7
	80	Multiple body parts	7	3.4
	9999	Nonclassifiable	47	23.0
Source of injury	323	Logging and wood processing machinery	21	10.3
	40	Parts and materials	7	3.4
	50	Persons, plants, animals, and minerals, unspecified	5	2.5
	587	Trees, logs, limbs	34	16.7
	70	Tools, instruments, and equipment	17	8.3
	90	Other sources	20	9.9
	9999	Nonclassifiable	100	49.0
Type of event	40	Fall, slip, trip	47	23.0
	60	Contact with objects and equipment	61	29.9
	70	Overexertion and bodily reaction	14	6.9
	9999	Nonclassifiable	79	38.7
	Other[a]	Other	3	1.5

Note: Each row of the table is mutually exclusive.

[a]*n* of less than five collapsed into “other” category.

Andersen Gill intensity model for any injury

Variables found to be related to injury intensity at the univariate level were: (1) a lack of health insurance (using employer provided insurance as the reference group) [HR = 1.51, 95% CI = 1.04–2.20, *p* = 0.03], (2) age [HR for 10-year age increase = 1.12, 95% CI = 0.99–1.27, *p* = 0.08], (3) company size [6 to 10 employees—HR = 0.58, 95% CI = 0.32–1.05, *p* = 0.07, and 26 to 50 employees—HR 0.55, 95% CI = 0.32–0.95, *p* = 0.03] and (4) years employed in logging industry [HR for 10-year increase = 1.12, 95% CI = 0.99–1.26, *p* = 0.05]. Variables related to injury intensity at the multivariable level were: (1) a lack of health insurance [HR = 1.63, 95% CI = 1.12–2.37, *p* = 0.01], (2) age [HR for 10-year age increase = 1.14, 95% CI = 1.00–1.30, *p* = 0.05] and years employed in logging [HR = 1.01, 95% CI = 1.00–1.02, *p* = 0.04].

Andersen Gill intensity model for severe injury

Variables related to injury intensity at the univariate level were: (1) age [HR for 10-year age increase = 1.16, 95% CI = 1.02–1.33, *p* = 0.03] and (2) years employed in logging industry [HR for 10-year increase = 1.14, 95% CI = 1.00–1.30, *p* = 0.05]. There were no independently significant variables in the multivariable model.

3.3 | Qualitative results

Analysis of survey responses revealed several major themes related to loggers' perspectives on injury, what it means to be a logger, and medical seeking behaviors. In general, seeking medical attention for injury was not a priority for this cohort. The narratives revealed a

TABLE 5 Results of univariate injury modeling.

Variable	Description	Hazard ratio Time to first injury (any)	*p* Value	Hazard ratio Time to first severe injury	*p* Value
Work role	Work role	1.16	0.54	1.08	0.73
Company size	1 (sole operator)	1.06	0.82	1.26	0.46
	2 to 5	Reference		Reference	
	6 to 10	0.62	0.12	0.92	0.82
	11 to 25	1.05	0.87	1.33	0.40
	26 to 50	0.59	0.09	0.92	0.81
	More than 50	0.98	0.94	1.65	0.14
Health insurance	Yes	0.71	0.07	0.73	0.17
Annual medical checkup	Yes	0.83	0.29	0.83	0.37
Age		1.01	0.18	1.01	0.36
Career in logging		1.01	0.25	1.00	0.60

trend for self-assessment, often claiming that an injury was not severe enough to warrant a trip to the hospital. In the cases where loggers wished to seek medical treatment, a variety of barriers preventing them from doing so, especially those of a financial nature.

Many loggers stated that they could not afford medical treatment, or that they could not sacrifice productive time at work. This was particularly pronounced in instances when loggers lacked medical insurance, as they could not meet the expense of out-of-pocket costs. To compound this, there was evidence of cultural obstacles to medical-seeking behaviors as well.

Some loggers indicated a sense of pride at being able to work through painful occurrences, as indicated in the below quotation:

> *… pain is mind over matter, if you work in the woods, you're gonna pull your muscle in your arm or your shoulder or leg—you don't have to go to the doctor, just keep it iced and elevated. just scrapes and bruises. just the way I was raised.*

Beyond the desire to work through the pain, there was also a consensus that individuals should minimize the amount of time off from work. Loggers' earning are directly proportional to the amount and quality of wood harvested, therefore incentivizing high productivity. Additionally, some felt that filing for workers compensation was enough of an inconvenience that it was not worth the time, particularly as they would likely experience a reduced rate of pay during their recovery time.

This cohort's relationship with pain is sometimes dependent on factors outside of their control. Many stated that cold weather, particularly in winter, exacerbated their discomfort. Others cited the time of dependence of periods of heightened pain on the time of day, particularly when first waking up, or at the end of the work day. This was particularly evident in cases where loggers worked longer days, as there was a tendency to report pain as more pronounced the more hours one worked. Mechanized loggers frequently indicated equipment design and poor ergonomics as a source of body pain, particularly for musculoskeletal disorders such as carpal tunnel syndrome and full body aches from remaining seated for extended periods in a "tight cab."

4 | DISCUSSION

Maine loggers provided the research team valuable insight into their workplace exposures, pain, and traumatic injuries. While injury rates in the logging industry have dropped over recent decades, we found that loggers still experience serious, and sometimes disabling, injuries associated with their work. Some of these injuries were not reflected in common workplace statistics, such as workers' compensation claims. A few loggers noted that the administrative burden of filing claims was not worth the potential benefit. Given logging workplace exposures, it is not surprising that many injuries were due to slips, trips, and falls along with contact with logging equipment and trees/logs.

In this cohort, musculoskeletal pain (MSD) was reported less frequently (60.4%) than levels found by Lynch et al.[3] in the Southern US (74.3%). Similarly, research by Rodriguez et al.[4] showed that Ark-La-Tex region logging machine operators reported repetitive motions, bending and twisting, and cramped, tight conditions contributing to their musculoskeletal pain. Lagerstrom et al.[19] noted that logging equipment operators in Montana and Idaho shared the detrimental impact of extended hours of machinery operation and sitting contributing to lower back pain. Taken together, these studies indicate that loggers around the country are experiencing significant pain due associated with their work tasks and environment.

While having health insurance coverage was associated with a lower risk of reported injury, this opens questions about the relative

TABLE 6 Results of Andersen Gill models.

Level of analysis	Variable	Description	Hazard ratio	95% CI (LL)	95% CI (UL)	*p* Value
Andersen Gill intensity model for any injury						
Univariate	Work role	Work role	1.37	0.95	1.95	0.09
Univariate	Company size	1 (sole operator)	1.09	0.70	1.70	0.69
		2–5		Reference		
		6–10	0.58	0.32	1.05	0.07
		11–25	1.02	0.59	1.76	0.96
		26–50	0.55	0.32	0.95	0.03
		More than 50	1.01	0.60	1.69	0.97
Univariate	Health insurance	Yes	0.72	0.51	1.02	0.06
Univariate	Age	10-year increases	1.12	0.99	1.27	0.08
Univariate	Career in logging	10-year increases	1.12	1.00	1.26	0.05
Univariate	Insurance type	Government	1.60	0.91	2.83	0.10
		None	1.51	1.04	2.20	0.03
		Self-purchased	1.15	0.70	1.90	0.58
		Employer provided		Reference		
Multivariable: Career in logging and age	Insurance type	Government	1.33	0.76	2.34	0.32
		None	1.63	1.12	2.37	0.01
		Self-purchased	1.14	0.69	1.88	0.61
		Employer provided		reference		
	Age	10-year increases	1.14	1.00	1.30	0.05
Multivariable: Career in logging and insurance type	Insurance type	Government	0.26	0.79	2.39	1.38
		None	0.02	1.06	2.22	1.53
		Self-purchased	0.55	0.71	1.92	1.17
		Employer provided		Reference		
	Career in logging	10-year increases	1.01	1.00	1.02	0.04
Andersen Gill intensity model for severe injury						
Univariate	Age	10-year increases	1.16	1.02	1.33	0.03
Univariate	Career in logging	10-year increases	1.14	1.00	1.29	0.05
Multivariable: Age and career in logging	Age	10-year increases	1.19	0.93	1.53	0.17
	Career in logging	10-year increases	0.99	0.77	1.26	0.91

role of health insurance; for example, are loggers with insurance generally more cautious both in health and safety? Beyond financial or cultural considerations to medical seeking behavior, there was a correlation between the age and experience of a logger and the likelihood of that individual suffering an injury or more severe injury. While a worker gains experience and may know how to handle dangerous situations better over time, the more time one spends in the logging profession the greater the duration of risk exposure. In addition, diminished balance, reflexes, and bone weakening could contribute to age being a factor in injury events. Given some loggers reported multiple injuries it seems likely that sustaining an injury increases the risk of re-injuring oneself at a later time. In addition, some workers may be less cautious, thus increasing their risk of reinjury.

The narratives revealed various obstacles preventing loggers from achieving optimal health. Entrenched values that prioritized independence and traditional masculinity seemed to play a large role in the avoidance of emergency care. Financial considerations were also consistently cited as a primary barrier to adequate care and given recent industry trends, this is likely to continue. A volatile industry market can contribute to the need to conserve resources, which can negatively impact the priority for equipment improvements, health insurance coverage, or investment in health and safety.

While younger loggers had lower injury risk overall, the risk of injury was higher among the youngest members of the community when they were also uninsured. The numbers indicated a link between quality of insurance coverage and an individual's risk of injury. There may be a correlation between the uninsured and risk-taking behavior. If a lack of health insurance indicates a lack of priority paid to personal health, then that same lack of health prioritization may carry into everyday activities on the job site, ultimately increasing personal risk. Alternatively, it is also possible that not having health insurance is an indicator of financial status, which could cause greater demands in productivity and risk-taking.

While at first glance company size appeared to have an influence in injury patterns, this did not hold true when the groups were condensed to small, medium, and large companies. Other research has demonstrated a link between company size and injury risk. A paper from the University of Melbourne posits reduced risk among various company sizes is because companies employing 25 or more workers tend to have larger projects with more inherent risk, and as such are more likely to follow and implement safety standards on their work sites.[20,21] The reasons for this dichotomy are uncertain, but the smaller pool of financial resources held by companies of more modest size alongside a lack of managerial pressure to implement safety standards are likely both contributing factors. Mills and Lin draw attention to the fact that smaller operations tend not to include health and safety costs in their budget when initially setting their contract, supporting the idea that smaller companies do not allocate as many resources on safety training and culture within their company.

Improving safety and work conditions for loggers requires long-term vision and commitment from a variety of stakeholders. Interestingly, these injury reports can illuminate ideas for potential interventions or administrative changes. For example, the relative incidents of slips, trips, and falls points to finding ways to eliminate trip hazards, or perhaps improving slip-resistant materials for footwear. Technology such as real-time location sharing technology, and sensors that work regardless of cellular signal, could play a significant role in reducing injuries to bystanders and coworkers.[22] Even pay structures could play a role in safety, as production based pay encourages swift work which can comprise safety. For workers who sustain an injury, investment in rural healthcare networks, paid time off policies, and the streamlining of workers' compensation paperwork would go a long way to improving outcomes and experiences.

5 | CONCLUSIONS

Ultimately, responses to the surveys highlighted a need to emphasize occupational health and safety in the logging community. Implementation of relevant safety programs is key, but it is likely that the benefits of these will not be fully realized until a cultural shift takes place within the industry. The belief that the ability to endure physical discomfort contributes to one's masculinity and value within a company needs to be addressed by the logging industry. The ultimate value of a logging employee should be demonstrated by a company's willingness to prioritize their safety, health, and wellbeing.

AUTHOR CONTRIBUTIONS

Study conception and design: Erika Scott, Paul Jenkins, and Liane Hirabayashi. *Data acquisition and entry*: Liane Hirabayashi, Erika Scott, and Judy Graham. *Data clean up*: Nicole Krupa, Kevin Luschen, and Cristina Hansen-Ruiz. *Quantitative data analyses*: Paul Jenkins, Nicole Krupa, and Erika Scott. *Qualitative data analyses*: Kevin Luschen, Nora Jensen, and Erika Scott. *Manuscript preparation*: Erika Scott, Kevin Luschen, Cristina Hansen-Ruiz, Nora Jensen. The entire team reviewed the final manuscript and made edits.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL AND INFORMED CONSENT

All protocols were approved by the Mary Imogene Bassett Hospital Institutional Review Board (IRB). Each survey contained a study overview and participants' rights section. This section noted that survey answers would be kept confidential and would never be linked to a person's identifiers. Participation was voluntary, and participants could quit at any time. The Principal Investigator's contact information was provided in case study participants had questions. Participants were also provided contact information for the IRB Chairman and Vice-Chairman.

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