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# Not Quite Out of the Woods

## *Overall Health and Chronic Disease Risk Factors among Maine Logging Workers*

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**Objective:** This research reports on the health status, including chronic disease risk factors, among Maine loggers. **Methods:** Loggers completed a survey and health screenings were held across Maine, collecting data on a variety of health endpoints. **Results:** Seventy-five loggers participated. The majority were men (97.1%) with a median age of 46, and a mean BMI of 30.6 $kg/m^2$ (SD 4.9). Nearly half of those screened (45.9%) had blood pressure at the level of stage II hypertension. Loggers with at least a single joint abnormality were 38.4%. The health screening cohort was similar to the non-health screening cohort for many attributes. **Conclusions:** Future research should focus on tailored interventions to improve cardiovascular and musculoskeletal risk factors among loggers.

**Keywords:** forestry, health assessment, logging, longitudinal cohort, Maine

## INTRODUCTION

Logging remains one of the most dangerous civilian occupations in the United States, with a fatality rate in 2019 nearly 20 times that of an average worker (68.9 vs 3.5 per 100,000 FTE).[1] According to the Bureau of Labor Statistics, between the years of 2006 to 2015 non-fatal logging injury and illness rates were in overall decline, though they still exceeded those of private industry by 40%.[2] Changes in technology and mechanization, especially in the Northeast, have substantially reduced some workplace hazards. While all have welcomed a safer work environment, the increase in mechanization has influenced the health of logging workers in new, and perhaps unexpected, ways.

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Authors' Contributions: Dr Scott, Dr Jenkins, and Ms Hirabayashi were involved in the conception and design of this research. Dr Scott, Ms Hirabayashi, and Ms Graham were responsible for health screening logistics and data acquisition. Ms Krupa was responsible for cleaning these data and creating SAS datasets. Dr Scott completed these analyses, with assistance from Dr Jenkins and Ms Hirabayashi. Dr Scott authored the majority of the manuscript, assisted by Ms Hirabayashi, Ms Graham, and Dr Jenkins. The entire team reviewed the final manuscript and made edits.

Institution and Ethics Approval and Informed Consent: All protocols were approved by the Institutional Review Board of the Mary Imogene Bassett Hospital (Bassett Medical Center).

Clinical significance: While logging is recognized as one of the most dangerous occupations in the United States, we discovered that cardiovascular risk factors, especially hypertension and obesity are a growing concern among logging equipment operators. Improving modifiable cardiovascular risk factors among loggers should be a priority for this industry.

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The logging industry is vital to the economy in the state of Maine. As some of the most significant employers in the region, a recent analysis estimated that Maine's logging and associated trucking industry contributed $619,000,000 in total output, and another 9000 full and part-time jobs to the state's economy in 2017.[3] Maine has a higher concentration of logging equipment operator jobs than anywhere else in the United States.[4] Although logging is an important force in Maine's economy, the Bureau of Labor Statistics projects a 13% decline in logging jobs from 2006 to 2026.[4] This decline was also predicted by several studies, which indicated loggers would not encourage their children to enter the logging profession.[5,6]

There has been a substantial shift from conventional hand harvesting to mechanized logging in Maine.[7] Conventional logging involves felling trees using a chainsaw and dragging the logs out of the forest with a skidder.[8] Manual felling of trees is a physically demanding job that requires endurance and stamina, and places the worker at high risk of injury from the falling tree, limbs, and chainsaw. Conversely, mechanized logging places the equipment operator in a seated, sedentary position for the vast majority of the day, not only during work hours but also during long commutes.[9,10] Traumatic injury rates are lower in mechanized logging versus conventional logging, but other important health issues such as back and neck pain, have been associated with logging equipment operators.[11,12] Kim et al found that logging machinery posed threats to health and safety but mostly through injury, musculoskeletal disorders, and exposure to diesel exhaust.[12] Much of the work in US logging health and safety research has used self-reported data or administrative databases.[11–19] While some global investigations have taken a more holistic view of logger health,[20–22] little evidence exists of studies going beyond surveys and questionnaires to collect physical health measures of US logging workers.

While not completely analogous, we can look to other workers who have similar job tasks, especially for heavy equipment operations. For example, long-haul truckers operate tractor-trailers and are sedentary for extended periods of time, and combating obesity and chronic health issues have been a focus for these workers.[23–26] Chronic diseases, especially heart disease, contribute to the largest healthcare expenditures in the United States and these are major issues for employers, as well.[27–29] Research has shown that improving modifiable cardiovascular risk factors greatly reduces the risk of coronary heart disease.[30] Most importantly, these conditions affect the quality of life for an individual and can have a negative impact on their ability to work and enjoy their free time.[31]

We have taken a broad approach to characterize the overall health of Maine loggers by combining self-report with physical measures. The baseline characteristics of this unique cohort have been described in a previous report.[9] This approach is congruent with the understanding that work affects many aspects of life, including chronic disease and overall well-being.[32] Unique to our study were in-person physical health assessments, accomplished by setting up ''pop-up'' health screenings during logger safety training and outreach events. This paper presents the overall health status of a cohort of logging workers, who were part of a larger longitudinal study involving Maine loggers.

## MATERIALS AND METHODS

Enrollment of the baseline cohort and administration of the initial survey has been described in detail elsewhere.[9] The entire larger study entailed seven surveys spaced at 3-month intervals, a health questionnaire, and an in-person physical health assessment. Briefly, we enrolled English-speaking participants between March 2018 and May 2019 using a variety of methods including telephone, postal mail, and in-person recruitment. A contact list of loggers was developed from several sources including CLP trained loggers, PLC, and an extensive business telephone directory internet search for logging businesses in the state of Maine. In total, 1738 loggers were invited to complete the initial survey. Telephone calls followed a standard call protocol of two mornings, two afternoons, two evenings, and one-weekend phone call. For mailings, an initial mailing was followed by a second mailing 6 weeks after the first for non-responders. Lastly, some loggers were enrolled in person. Data quality assurance was performed before entering into REDCap,[33,34] the electronic data capture system. The following methods describe the in-person health assessment and health questionnaire.

### Enrollment

Ahead of the screenings, we contacted study participants via postal mail and telephone to schedule participants for the health screening. In addition to providing advanced sign-ups, we also provided walk-in appointments for health screenings. If a logger had not yet been enrolled in the overall study, they were invited to participate in the health screening, and fill out the initial survey at the same time.

### Health Screening Logistics

Five health screenings were held across the state of Maine in spring 2019. Four were hosted in logging company garages in conjunction with existing safety training organized by the PLC. Each of the safety training had approximately 80 to 100 loggers in attendance. The fifth screening was a 2-day event at the 2019 Northeast Logger Expo in Bangor, Maine. Screening stations were assembled on-site and data were collected for the physical measures listed in Table 1.

### Data Collection

Participants completed an informed consent document, answered a health questionnaire, and proceeded through the screening stations in a pre-determined pattern. Trained technicians and medical staff conducted all data collection and recorded data on paper forms. Protocols for obtaining data are available from the authors. In addition, personal health information for each participant was recorded on a "Logger Health Score Card" form, which the loggers were invited to keep for their own records. Loggers received a $25 gift card for their participation. After each screening, the research team followed up with a phone call to any logger who presented with serious health concerns, had no medical insurance, or who did not have a primary healthcare provider, to connect them with resources in their local areas.

### Data Management and Analysis

We reviewed the paper forms for quality assurance before entering all data into a secure online database in REDCap, linked to the overall study.[33,34] These data were exported from REDCap for statistical analysis in SAS 9.4 (Cary, NC). Categorical variables were summarized as frequencies and proportions. Continuous variables were summarized using means and standard deviations, or medians and interquartile ranges. In the event of missing data, the sample size for given variables was noted. The relationship between continuous variables was measured using Spearman Correlation.

We compared endpoints between the sub-group who completed a health screening versus those who did not. Because the distribution of these continuous variables had a tendency to be skewed to the right, the Wilcoxon rank-sum test was used to make these comparisons instead of the *t* test. Comparisons between groups with more than two levels were made using one-way analysis of variance (ANOVA) or the Kruskal–Wallis one-way ANOVA by ranks if the assumptions for parametric ANOVA were not satisfied. Categorical variables, such as gender, were compared using chi-square or Fisher exact test, as dictated by assumptions.

Sample-based proportions were compared to population values, such as those from the NHANES, using the binomial test of a single hypothesized population proportion.

The Institutional Review Board of the primary institution approved all protocols.

**TABLE 1.** Physical Measures

| Station | What was Measured | Scale |
|---|---|---|
| Vitals | Blood pressure | mm/hg |
| | Heart rate | Beats/min |
| Body measures | Height | Inches (in.) |
| | Weight | Pounds (lbs.) |
| | BMI | Weight/height squared |
| | Waist/hip measurement | Waist (in.)/hip (in.) |
| Peak expiratory flow | Lung function | Liters/min |
| Vision | Distance | 20/XX |
| | Peripheral | Angle |
| | Color ability | Can distinguish red/yellow/green |
| Hearing | Low frequency average (speech) | dB |
| | High frequency average | dB |
| Cholesterol | Total cholesterol | mg/dL |
| | HDL | mg/dL |
| | Ratio (total/HDL) | n/a |
| Glucose | Total glucose (g/dL) | g/dL |
| Carbon monoxide | CO in exhaled breath | PPM |

| Station | What was Examined | Specifics |
|---|---|---|
| Provider exam | HEENT | Eyes (cornea, extraocular movement, pupils), thyroid, lymph nodes, Mallampati score |
| | Chest | Breath sounds, heart rhythms, heart size, heart sounds/murmurs |
| | Extremities | Edema, lower extremity pulse, missing digits |
| | Skin | Rash, infection, lesion |
| | Neurological | Fiber testing, pin prick, vibration (applied/dampened), ankle reflex |
| | Joint exam | Normal, abnormal, warm swollen, deform, crepitus, decreased range of motion |

BMI, body mass index; CO, carbon monoxide, HDL, high-density lipoprotein; HEENT, head, eyes, ears, neck, throat; PPM, parts per million.

## RESULTS

Seventy-five loggers participated in a health screening. The majority of those participating were men (97.1%) and the median age was 46. The mean body mass index (BMI) among screened

**TABLE 2.** Blood Pressure, Glucose and Cholesterol

| Blood Pressure | Systolic mm Hg | and/or | Diastolic mm Hg | N (%) |
|---|---|---|---|---|
| Normal | <120 | and | <80 | 6 (8.1) |
| Elevated | 120–129 | and | <80 | 8 (10.8) |
| Hypertension1 | 130–139 | or | 80–89 | 26 (35.1) |
| Hypertension2 | ≥140 | or | ≥90 | 34 (45.6) |

| Variable | N | | Mean (SD) |
|---|---|---|---|
| Glucose (non-fasting) | 72 | g/dL | 106.6 (26.1) |
| HDL (non-fasting) | 71 | mg/dL | 42.6 (8.9) |
| Total cholesterol (non-fasting) | 71 | mg/dL | 157.8 (33.2) |
| Cholesterol ratio (total/HDL) (non-fasting) | 71 | n/a | 3.8 (0.9) |

HDL, high-density lipoprotein.

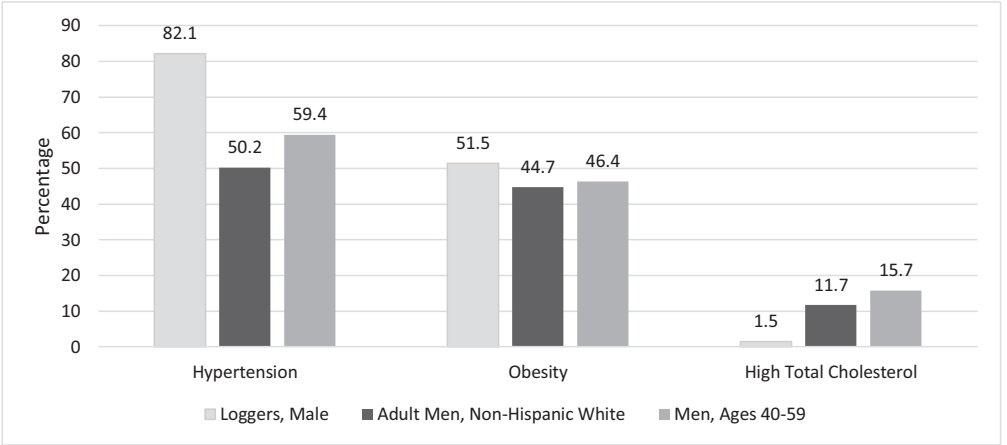
loggers was 30.6 kg/m$^2$ (SD 4.9) with a waist-hip ratio of 0.95 (SD 0.07). While 68.9% of loggers self-reported having normal blood pressure, measuring blood pressure using an automated cuff revealed that only 10.8% had normal blood pressure at the time of the screening. Further, nearly half of those screened (45.9%) had blood pressure at the level of stage II hypertension (Table 2). The percentage of loggers with hypertension was significantly higher than comparable groups within NHANES ($P \leq .0001$),[35] however, there was no statistically significant difference in obesity rates ($P = .3758$) (Fig. 1).[36] This group of loggers had a much lower rate of high cholesterol compared to the national data ($P = .0075$).[37] Mean resting heart rates were within the normal range at 72 beats per minute (SD 12.3). Further, mean measures for non-fasting glucose, total cholesterol, high-density lipoprotein (HDL), and cholesterol ratios were all within normal ranges (Table 2). Mallampati scores, a visualization of the openness of the airway, can be found in Table 3. Peak expiratory flow—a measure of lung function—were on average within normal ranges at 505.5 (SD 105.2) liters/minute. The median estimated 10-year risk for atherosclerotic cardiovascular disease (Framingham) was 2% (IQR 9). The 16.2% of screened loggers who smoked consumed, on average, one pack per day (IQR 0.4) and had smoked for a median of 19.7 years (IQR 24).

The percentage of loggers with at least a single joint abnormality (eg, warm/swollen, deformed, crepitus, or decreased range of motion), as determined by a healthcare provider, was 38.4%. Joint abnormalities by location can be found in Figure 2. When testing sensitivity using the monofilament or pinprick technique on the foot, loggers perceived these sensations between 92.2% and 95.5% of the time (Fig. 3). Vibration sensitivity was slightly lower at 77.5% (right) and 76.4% (left) for applied vibration by tuning fork, and 72.9% (right) and 75.0% (left) for vibration by dampened tuning fork (Fig. 4).

Hearing exams revealed the majority had normal hearing in the speech frequencies (left 80.3%, right 81.7%), but fewer had normal high-frequency hearing (left 46.5%, right 57.7%) (Table 4). Median corrected distance vision was 20/25 (25th quartile 20/15, 75th quartile 20/30), with 95.4% having a peripheral vision to 85°. Ninety percent (90.8%) of loggers could distinguish the colors red, yellow, and green. The majority of loggers rated their diets as good (51.4%) or fair (33.8%), with few (10.8%) rating them as very good or excellent. Approximately two-thirds (65.3%) of loggers reported drinking alcohol, with the median weeknight consumption at a drink per night (IQR 2.0) and median weekend consumption at 3 drinks per night (IQR 3.75). When asked, ''in a typical week, how many times do you take medication to help you fall or stay asleep?'' it was evident that very few loggers used such medication, as only 8.5% reported using sleep aid medication. Further, the median time for loggers to fall asleep at bedtime was reported to be 11.3 minutes (IQR 17.5).

## Correlations

There was no significant correlation between Mallampati scores and hypertension ($P = .2377$), however, Mallampati scores were significantly associated with higher BMI ($P = .0038$) and age ($P = .0045$). There was a significant difference in BMI across the four levels of hypertension (omnibus $P = .0103$) Post-hoc pairwise




Comparison Data from NHANES[35-37]

Hypertension - Systolic blood pressure greater than or equal to 130 mmHg or diastolic blood pressure greater than or equal to 80 mmHg
Obesity – BMI greater or equal to 30
High Total Cholesterol – Serum total cholesterol greater than or equal to 240 mg/dL

**FIGURE 1.** Comparison of hypertension, obesity, and high total cholesterol between loggers and a comparative national sample.

**TABLE 3.** Mallampati Score

| Class | Visual Description | N (%) |
|---|---|---|
| I |  | 34 (45.3) |
| II |  | 23 (30.7) |
| III |  | 10 (13.3) |
| IV |  | 8 (10.7) |

comparisons showed that the significant overall $F$ test was mainly contributed to by a near significant ($P = .04$) difference in BMI between the hypertensive type I (29.1) and the hypertensive type II (32.6).

How representative in the health screening cohort compared to the overall study cohort?

Health screening participants worked in the logging industry for fewer years (21.8) than those who did not participate (26.1 years, $P = .0085$). Work commute times differed slightly between the two groups, with those participating in health screenings traveling 55 minutes one-way, and those not participating commuting 66 minutes one-way ($P = .0403$). Health screening participants were also less likely to have had an annual check-in in the last year over non-health screening participants (51.9% vs 64.7%, $P = .0361$). However, the health-screening cohort was not statistically significantly different from the non-health screening cohort for many attributes, including company size, gender, age, type of logging (eg cut-to-length, whole-tree harvest, and conventional), percentage of work time involved in transportation and business administration, work-related injury and illness rates, reported musculoskeletal pain, medical insurance coverage, filing of workers' compensation claims, and start/stop times of the workday.

## DISCUSSION

While much of the scientific literature focuses on the safety risks of logging,[14,16,19,38] chronic health is an important concern for the industry. This first of its kind research in the United States, shows that, like many Americans, loggers are susceptible to, and struggle with, common health conditions such as obesity and hypertension. These workers also face significant barriers to health, chief among them working in remote locations, lengthy commutes, long workdays, and living in rural areas with limited services. Further, the industry has experienced retirements and needs to 1) maintain the health of its current workforce and 2) make a career in logging an attractive option for younger workers. Loggers deserve the ability to physically perform their job duties but most importantly be healthy enough to enjoy time away from work, including retirement. This research adds substantial information to the literature about Maine loggers' health risk factors.

Cardiac risk factors are a top concern in this cohort, based on our findings of obesity, hypertension, Mallampati scores, and self-reported diet. Our results are consistent with data showing a higher prevalence of hypertension among blue-collar workers.[39] The financial impact of chronic disease to US employers is also substantial, with additional costs per employee with hypertension or obesity estimated to exceed $1729 and $1369, respectively (adjusted to 2021 dollars).[27,40] Beyond financial impact, such risk factors also greatly contribute to absenteeism.[41]

A recent meta-analysis found pooled effect size for hypertension due to noise exposure, along with evidence of a dose–response relationship.[42] The relationship between noise and cardiac risk factors is hypothesized to involve a stress response through the autonomic nervous and endocrine systems.[43] Given our data on high-frequency hearing loss and hypertension in this cohort, it will be important to assess noise exposure during work-related tasks to identify potential areas for intervention.

Musculoskeletal disorder (MSD) issues are also prevalent in this population, as evidenced by self-report[9] and by the clinician's exam during the health screening. Interestingly, self-reported MSD and abnormal joints (documented in the health screening) are similar with approximately four out of every 10 loggers experiencing issues. These rates are lower than those reported among logging equipment operators in the Deep South[11] and Intermountain range of Montana and Idaho.[15]

Not all health outcomes were cause for concern. The results of mean cholesterol, glucose, and lung function among this cohort were well within the normal range. The healthy total cholesterol values and good total to HDL cholesterol ranges for the vast majority of loggers were much better than the average US male. Further, visual acuity is high among this group. While the mean BMI of the health screening cohort was within the obese range, their waist/hip ratios came in just under 1.0, the ideal for men. Future research should consider analyzing body fat percentage, understanding that there are inherent limitations to BMI as a marker for health.[44]

Beyond a means to collect research data, a positive consequence of the health screenings was that loggers frequently expressed gratitude for having the opportunity to get a thorough no-cost checkup. Loggers also appreciated that the research and the medical community were interested in their profession and well-being. Further, there was a community benefit in connecting loggers without health insurance or a primary provider to resources in their local communities.

Many attributes were similar between loggers who participated in health screenings and those who did not. Given the similarities in age, gender, company size, work tasks, health insurance coverage, reported MSD, work-related injury, or illness, we are confident that the results can be generalized to the overall cohort and further to the logging workforce of Maine. The average time in the industry differed between the health screening cohort versus the non-health screening group, but we feel that with over 20 years of experience in either group, the results are still useful and applicable to the broader industry. Our research has demonstrated that the overall cohort was geographically distributed around the state, and mirrored the general demographics of the state's logging workforce.[9]

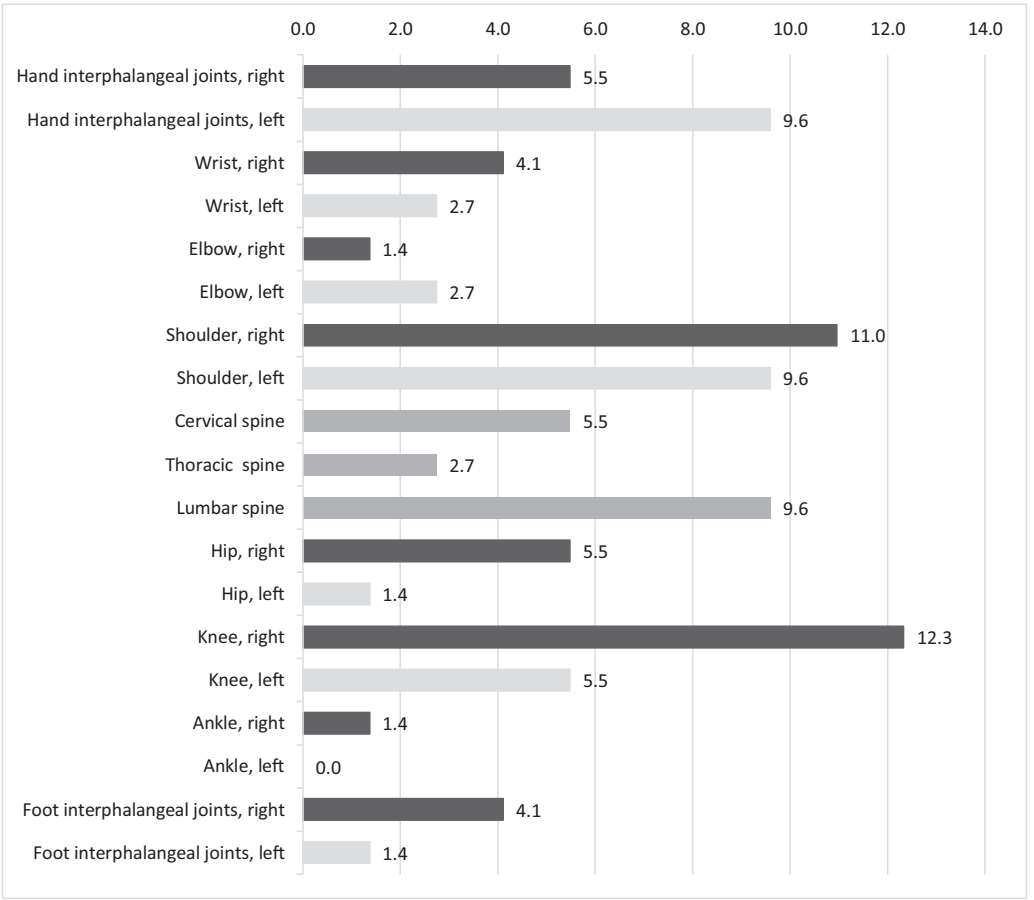



**FIGURE 2.** Percentage of abnormal joints by bodily location.

## Limitations

Health screenings were held in various locations around the state (Rumford, Bangor, Waltham, Lincoln, and Fort Kent) but we recognize that screening locations were not convenient for all loggers to attend. Unfortunately, the plan to host additional screenings in new locations in spring 2020 was canceled due to the COVID-19 pandemic. The temporary nature of setting up a screening in non-clinic space limited the methods and types of data we captured. To keep the screening relatively brief for the participant and to limit the chance of equipment failure, we opted for

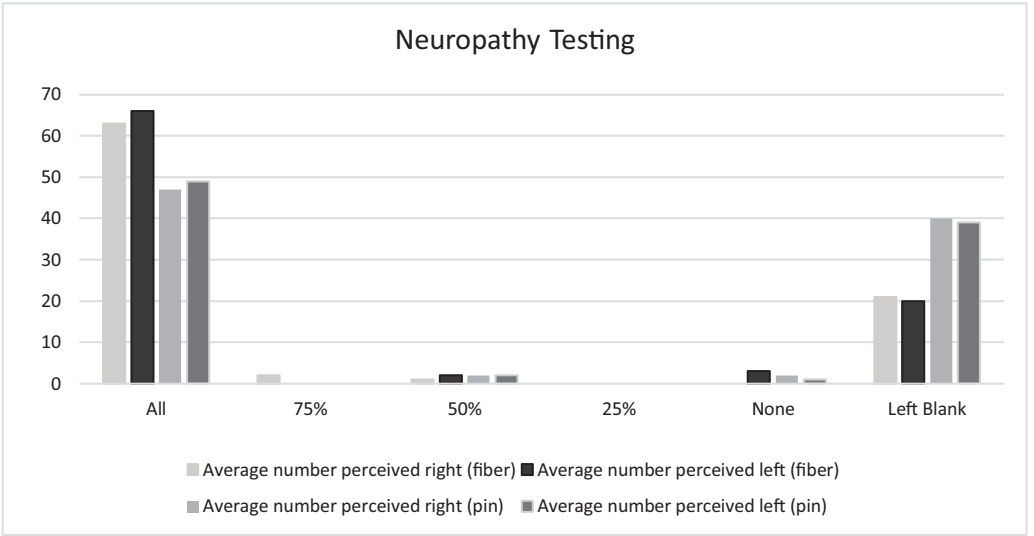



**FIGURE 3.** Sensation perceived during neuropathy testing.

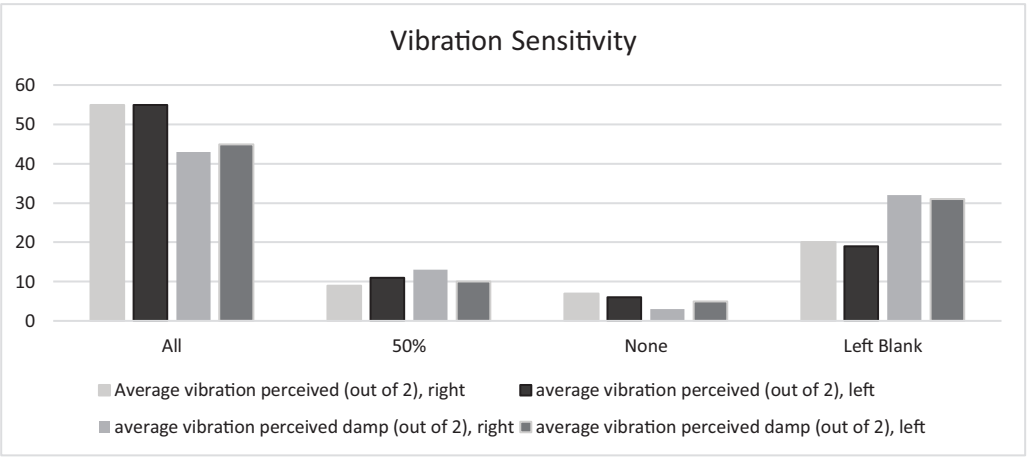



**FIGURE 4.** Sensation perceived during vibration sensitivity testing.

**TABLE 4.** Audiometry Results

| Range/Ear | Categories | Percentage |
|---|---|---|
| Speech frequency average left ear | 1-Normal | 80.3 |
| | 2-Mild loss | 15.5 |
| | 3-Moderate loss | 4.23 |
| | 4-Moderately severe | 0.0 |
| | 5-Severe loss | 0.0 |
| Speech frequency average right ear | 1-Normal | 81.7 |
| | 2-Mild loss | 15.5 |
| | 3-Moderate loss | 1.4 |
| | 4-Moderately severe | 0.0 |
| | 5-Severe loss | 1.4 |
| High Frequency average left ear | 1-Normal | 46.5 |
| | 2-Mild loss | 21.1 |
| | 3-Moderate loss | 15.5 |
| | 4-Moderately severe | 11.3 |
| | 5-Severe loss | 5.6 |
| High Frequency average right ear | 1-Normal | 57.7 |
| | 2-Mild loss | 14.1 |
| | 3-Moderate loss | 14.1 |
| | 4-Moderately severe | 9.9 |
| | 5-Severe loss | 4.2 |

N = 71

simple yet effective measures—for example, capturing lung function using a peak flow meter instead of conducting a complete spirometry test, or collecting non-fasting random blood glucose and total/HDL cholesterol instead of A1C and fasting bloodwork. We acknowledge that ''white coat syndrome'' may have impacted the blood pressure measurement for some loggers, though this can only be verified through a more extensive study with a 24-hour monitor.[45] It is unknown whether the loggers perceived the research team as clinical healthcare staff, or if the setting of the screening (mostly inside logging equipment garages) was more or less conducive to accurate readings. Compared to the overall cohort, the health screening cohort skewed more heavily toward logging equipment operators over hand fallers.

## CONCLUSIONS

In addition to safety-related to acute trauma and long-term repetitive motion morbidity, more attention should focus on the impact of chronic disease, especially heart disease, in the logging industry. Given that improving modifiable cardiovascular risk factors has been shown to greatly reduce the risk of coronary heart disease,[30] future research should focus on tailored interventions to improve these risk factors among loggers. Such research should strongly consider the impact of logging work organization, realities of rural living, and workplace hazards that may contribute to chronic diseases, such as noise and vibration.

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