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Association between occupational injury and early termination of employment among manufacturing workers

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ASSOCIATION BETWEEN OCCUPATIONAL INJURY AND EARLY
TERMINATION OF EMPLOYMENT AMONG MANUFACTURING WORKERS

by

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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This is to certify that the Master's thesis of

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the thesis requirement for the Master of Science degree
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Dedicated to the blue collar workers of America

ABSTRACT

Employee turnover is a complex problem with many intertwining contributors. The association between employment duration and occupational injury has been frequently studied and, in general, newly hired employees experience greater injury rates compared to more established employees. However, few studies have explored the converse, i.e., occupational injury as a predictor of employment duration. In this study we hypothesized that employees who sustained an injury during the initial stages of employment were more likely to terminate employment early than employees who were not injured.

A cohort of all employees of a large manufacturing facility in the US Midwest hired during a four-year period (2012-2016) was created (n=3765) using information available in the employer's human resources database. Information regarding occupational injuries during the same time period was extracted from a databased maintained by the facility's on-site occupational health center.

Employment duration was the outcome variable, dichotomized as (i) working <60 days or (ii) working ≥60 days. The 60-day threshold was based on the employer's internal estimation of the duration of employment required to recover training costs. The primary exposure variable was a first-time visit to the occupational health center within the first 60 days of employment, categorized as (i) no visit, (ii) a visit within 1-20 days, or (iii) a visit within 21-60 days. A secondary independent variable incorporated the nature of injury, classified as repetitive strain, acute sprain/strain, or other occupational injury types. Covariates included demographics (e.g., age, gender, and race/ethnicity), shift

placement (e.g. first, second, third), and nature of assigned job (e.g., assembly, fabrication, maintenance). Incidence rates of first-time visits were calculated (i) across the full study period and (ii) for a reduced period that included only the first 60 days of employment. Logistic regression was used to estimate adjusted associations between the primary/secondary independent variables and the dependent variable.

Of the 3765 employees, 1184 (31.5%) worked less than 60 days. About two-thirds were male, about half were white/Caucasian, and the overall mean age was 33.8±10.8 years. Between 2012 and 2016, 1105 first-time visits to the occupational health center were recorded for all new hires with an overall incidence rate (IR) of 47/100 person-years (PY). The IR for repetitive strain was 18/100PY. Of the 1105 first-time visits, 408 occurred within the first 60 days of employment with an overall IR of 85/100PY and an IR for repetitive strain of 36/100PY. Employees who visited the occupational health center in the first 20 days of employment were more likely to terminate prior to the 60-day threshold (adjusted odds ratio: 1.7; 95% confidence interval: 1.3-2.4). Elevated associations were seen for all nature of injury categories which occurred within 20 days when compared to non-injured employees.

Overall, the results suggest that experiencing an occupational injury (particularly a repetitive strain injury) within the first 20 days of employment is associated with termination before 60 days. Our results may not be generalizable to all manufacturing enterprises, and we do not make a distinction between voluntary and involuntary termination. However, the results indicate that

employers should examine policies and practices to minimize the burden of injury

among new employees and reduce turnover. In the case of the study facility, an

extended or modified work hardening program could maximize new employees'

adaptation to the physical demands of manufacturing work.

PUBLIC ABSTRACT

Employee turnover within a business is complex with many underlying factors contributing to the problem. Newly hired employees are generally at a higher risk of sustaining an occupational injury compared to employees with longer tenure. However, few studies have examined occupational injury as a precursor to ending employment. Manufacturing environments place workers at increased risk of injury. Musculoskeletal related injuries are of particular importance in the manufacturing industry as a result of high paced assembly work, non-neutral working postures and highly repetitive job tasks. The goal of this study was to explore the possibility of occupational injury, including musculoskeletal injury, as a predictor of employee turnover within a manufacturing setting.

A cohort of newly hired employees from 2012-2016 at a large Midwestern manufacturing facility was identified with demographic and job characteristic information from the employer's human resources data base. By using this information along with coinciding occupational health center data relating to employee nurse visits, an analysis of the association between occupational injury and duration of employment was performed.

The results in this study suggested that occupational injury experienced within the first 20 days of employment (specifically repetitive strain) was associated with an employment duration of less than 60 days. These results suggest that employers should examine policies and interventions to minimize

the occurrence of occupational injuries among newly hired employees to

potentially reduce the occurrence and impact of turnover.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Occupational Injuries

Occupational injuries are a well-known public health problem throughout the United States manufacturing industry. The manufacturing industry involves the mechanical or chemical transformation of materials or substances into products and consumer goods. These processes place manufacturing workers in environments involving hazardous machinery, vehicles, chemicals and physically demanding work. In 2005 the manufacturing industry accounted for 21 percent of all nonfatal occupational injuries and illnesses as well as 8 percent of all occupational fatalities (U.S. Bureau of Labor Statistics, 2005).

In 2016, the manufacturing industry accounted for 13% of all nonfatal occupational injuries and illnesses requiring days away from work. Of the manufacturing industries' 118,050 injuries requiring days away from work in 2016, 30% were musculoskeletal related injuries including sprains, strains or tears (U.S. Bureau of Labor Statistics, 2017).

Work-related Musculoskeletal Disorders

Musculoskeletal disorders (MSDs) are defined, generally, as a range of non-acute conditions affecting muscles, tendons, ligaments, joints, spinal discs,

peripheral nerves and blood vessels (Punnett, 2014). While pathophysiologic mechanisms are quite diverse, symptoms can manifest rapidly and only last a short duration or persist and develop into chronic, debilitating disorders. A large emphasis has been placed on MSDs in the past several decades due to their high frequency of occurrence. For example, 55% of United States adults in 2012 reported experiencing a musculoskeletal pain or disorder (Clarke, Nahin, Barnes, & Stussman, 2016).

Musculoskeletal disorders are common in virtually all industry sectors, comprising 31% of the reported non-fatal occupational injuries and illnesses which required days away from work in 2016. Work-related MSDs also tend to require greater amounts of time away from work than nonfatal injuries and illnesses of other types (median days away: 12 for MSDs vs 8 for other) (U.S. Bureau of Labor Statistics 2016).

The manufacturing sector currently employs approximately 8.5 percent of the total non-agricultural working population (U.S. Bureau of Labor Statistics 2016). In 2015, the manufacturing sector had a higher incidence rate of MSDs (33.4/10,000 worker-years) compared to the rate across all industry sectors (29.8/10,000 worker-years). In addition, the incidence rate of MSDs classified by the Bureau of Labor Statistics as "repetitive strain" was greater in manufacturing (5.5/10,000 worker years) compared to the rate across all industry sectors (2.2/10,000 worker years) (U.S. Bureau of Labor Statistics, 2016).

Musculoskeletal disorders are considered to be a severely underreported injury in the manufacturing industry. One study observed that while 69% of

aerospace manufacturing workers experienced low back pain, only 27% reported the complaint to the onsite occupational health center (Jefferson & McGrath, 1996). Another study observed that 53% of all workers experiencing work-related hand and arm disorder symptoms did not report them to the onsite occupational health center. Employees stated discomfort being an unavoidable aspect of the job and fear of disciplinary action as reasons for not reporting the symptoms (Pransky, Snyder, Dembe, & Himmelstein, 1999).

Occupational physical risk factors commonly associated with work-related MSDs include repetitive work patterns, forceful muscular exertions, non-neutral working postures, and mechanical vibration (Punnett, 2004). The manufacturing environment routinely exposes employees to these risk factors through machine-paced assembly line work, non-ideal work station design, heavy lifting and the frequent use of pneumatic and electric power tools. Consequently, it has been suggested that work-related MSDs are the predominant occupational health problem facing manufacturing workers, which is consistent with national statistics suggesting higher rates of MSDs than other injury types among manufacturing workers (Waters, 2004).

The aim of manufacturing optimization rationale is to decrease non-value added time, which in turn increases the efficiency of production (Dombrowski & Mielke, 2013; Wild, 1995). Adopting this concept within a manufacturing setting can lead to reduced employee breaks to create a more efficient production flow. This can then lead to increased exposure time for employees and decreased restorative break frequency which are known risk factors for the development of

adverse musculoskeletal health outcomes (Bernard & Putz-Anderson, 1997;

Wells, Van Eerd, & Hägg, 2004).

In addition to occupational physical risk factors, personal characteristics

have also been associated with MSDs. For example, MSD risk generally

increases with age (Holmström & Engholm, 2003). Increased rates of MSDs are

also associated with gender and obesity, as well as socioeconomic variables

such as race/cultural background, income level, and geographic location of

residence (Kortt & Baldry, 2002). Tobacco use is also associated with increased

rates of MSDs (Smith, Mihashi, Adachi, Koga, & Ishitake, 2006).

In addition to occupational physical risk factors and personal

characteristics, previous studies have observed strong relationships between job

stress and MSD risk (Carayon, Smith, & Haims, 1999; Devereux, Vlachonikolis,

& Buckle, 2002). Other occupational psychosocial risk factors, such as perceived

social support and job dissatisfaction, are also associated with MSDs (Menzel,

2007).

Early Employment

The initial period of employment is the time during which the employee

adapts to the working conditions and familiarizes themselves with the

organization and job processes. It is well-documented that employees who are

new to a job experience higher injury and occupational fatality rates compared to

more established employees. This association has been observed across

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multiple industries characterized by hazardous working conditions. A 2007 study examining Mine Safety and Health Administration data observed that of 86,398 reported injuries, 28% occurred to employees with less than one year of experience (Groves, Kecojevic, & Komljenovic, 2007). Similarly, McCall and Horwitz (2005) observed that more than 50% of trucking-related accidents involved drivers in their first year employment.

Evidence also suggests that less than one year of employment increases the risk of occupational injury. For example, Bentley, Parker, Ashby, Moore, and Tappin (2002) observed that 32% of injuries among forestry workers occurred among those with less than six months of employment. In addition, the odds of injury among commercial loggers with less than 60 days of employment was more than double that of those who had worked at least 60 days (Bell & Grushecky, 2006). Less than 1 month of job tenure was also significantly associated with an increased risk of all injury types (RR=6.14, 95%CI=5.90-6.38) and repetitive strain injuries (RR=1.58, 95%CI=1.12-2.23) across all Ontario work sectors (Breslin & Smith, 2006).

Employee Retention

High turnover rates have been shown to be harmful to a business (Glebbeek & Bax, 2004). Employee turnover within a business can have profound economic effects due to training costs for the replacement employees. Studies have estimated the costs for the recruitment and training of a new

employee to be 30- 60% of the employee's annual wage for unskilled workers, and up to 100% of their yearly wage for specialized skilled positions (Hinkin & Bruce, 2000; Ramlall, 2003).

In the manufacturing sector, employees with longer tenure who have produced more units tend to operate at a higher production capacity and therefore have a lower per unit production cost (Argote & Epple, 1990). With longer tenure employees being less likely to be injured as well as operating at a higher production capacity and lower per unit production cost, it is obvious that employee retention is a key contributor to a business' success.

Factors affecting the retention and turnover of employees have included gender, age, marital status, education, promotion frequency and differences in pay grade (Huang, Lin, & Chuang, 2006). Other evidence shows that employees who perceive the company as supportive and have higher levels of career satisfaction are more likely to be retained (Van Scotter, 2000).

Injury and Turnover

A small body of research has examined the association between sustaining an occupational injury and employee turnover among healthcare workers. A sample of 1331 nurses located throughout 30 nursing homes based in New England completed self-administered questionnaires at 0, 6, 12 and 18 months of work. Injury information was dichotomized as yes/no and was taken at 6 and 12 months, while job loss was recorded as involuntary, voluntary or still

employed through human resources data management systems. When comparing employees who reported injuries to the group reporting no injuries, injured employees had a slightly elevated risk of overall job loss (including voluntary and involuntary) within the following 6 month period with an adjusted relative risk (RR) of 1.31 (95% CI=0.93-1.86). When comparing the same groups, injured employees had a significantly higher risk of involuntary job loss within the subsequent 6 months (RR: 2.19, 95% CI=1.27-3.77) (Okechukwu, Bacic, Velasquez, & Hammer, 2016).

Similarly, Brewer, Kovner, Greene, Tukov-Shuser, and Djukic (2012) examined the association between occupational injury and turnover among newly licensed registered nurses. Among the 1653 nurses in their study sample, 40% had experienced at least one self-reported sprain or strain within one year and 19% of those with a sprain/strain terminated employment within two years. In contrast to those experiencing other injury types (e.g., needle sticks), those with sprains or strains were significantly more likely to experience job loss. These associations suggest that employees who are injured are at an increased risk of turnover.

Costs of Occupational Injuries

There is a consensus that the total economic burden of occupational injuries in the United States is extremely high, with estimates ranging from $119-$250 billion (J Paul Leigh, 2000; J. Paul Leigh, 2011; Miller & Galbraith, 1995;

Rivara & Thompson, 2000; Waehrer, Dong, Miller, Haile, & Men, 2007).

Estimations for the annual economic burden of occupational injuries and

illnesses include estimations of direct, indirect and quality of life costs. Direct

costs can include property damage, hospitalization, physician and rehabilitation

costs, and home health care, emergency transport and coroner services. Indirect

costs include productivity losses, household production losses, and

administration costs. Quality of life costs are regularly derived by applying

inflation rates to previous studies which have placed an economic value on pain

and suffering (Waehrer et al., 2007). These models estimating occupational

injury/illness costs only offer an estimation of the entire economic burden of

occupational injuries/illnesses, which regularly include costs which are not

directly attributable to the business/facility itself.

Within a business the allocation of resources takes on a competitive

nature. This results in prioritizing these problems due to limited funds or

resources within the business. Therefore, when proposing different intervention

and prevention systems to address injuries, a convincing business case directed

towards upper management is needed to gain sufficient support.

Objectives

The primary purpose of this study was to examine the association

between occupational injuries and employment duration among manufacturing

workers. The following two objectives were explored:

I)	Examine the association between injuries occurring within less than or equal to 60 days of employment and the likelihood of working past 60 days from the date of hire.

II)	Examine the associations between injuries occurring within 0-20 and 21-60 days of employment and the likelihood of working past 60 days from the date of hire.

Adding to the current body of research examining the associations between injury and employee turnover, the results of these analyses could provide insight to work organization decisions among new hires in manufacturing based businesses. Providing further information as a direct influencer of employee turnover could motivate businesses to improve safety and ergonomic culture, which in turn could increase productivity and reduce costs associated with employee turnover.

CHAPTER II

DETERMINING THE ASSOCIATION BETWEEN EARLY INJURIES AND EARLY TERMINATION WITHIN A MANUFACTURING FACILITY

Methods

Study Overview

The purpose of this study was to examine the association between occupational injury and early termination of employment among newly hired workers employed by a large manufacturer of household appliances in the US Midwest. A cohort of all newly hired workers from January 1st, 2012- November 25th, 2016 was identified using the employer's human resources records database. Occupational injury data from the same time period were extracted from a separate database maintained by an on-site occupational health center. The two datasets were merged using an employee identification number unique to each newly hired worker. The employer redacted all personal identifiers from the merged dataset. Written approval from the employer was obtained for use of the merged (de-identified) dataset, and, as a result, the University of Iowa Institutional Review Board determined that the study did not meet criteria for human subject's research.

<u>Study Facility and Setting</u>

The study facility employed approximately 2,300 workers at a given time and occupied approximately 2.5 million ft^2 of production space. The facility operated five days per week (Monday – Friday) and used three standard shifts to achieve continuous (24 hour) production. The daily production total for the facility was roughly 5,000 units per day across three main assembly lines and one premium product line during the study period from 2012 to 2016. Employees were represented by a labor union. Employment at the manufacturing facility did not require any additional skills beyond passing of a drug screening test and the ability to understand English. The human resources onboarding processes and new hire basic safety training occurred during the first four hours of each of the first two days of employment. During the second four hours of each of the first two days of employment, new hires were placed at their corresponding job stations and shadowed a current employee to learn the production processes. After the first two days of employment, workers were expected to transition to full-time production activities. This onboarding process was specific to this manufacturing facility.

<u>Outcome Variable</u>

In all study analyses the outcome variable was "early termination of employment," dichotomized as (i) terminating employment before 60 calendar

days from the date of hire or (ii) maintaining employment for at least 60 calendar days from the date of hire. The 60-day threshold was based on the employer's internal probationary phase end date of 60 days. After the 60 day probationary phase, newly hired employees gained access to additional employee benefits such as employer-provided prescription safety glasses, access to an on-site pharmacy, and the ability to internally apply to a different job assignment.

The internal probationary period coincides with previous estimates of training costs for "unskilled workers" placed in jobs not requiring specific trade skills or advanced degrees, which ranged from $1,500 to $7,000 per new hire (Hinkin & Bruce, 2000). New hires at the study facility earn a minimum initial wage of $15.00/ hour and are expected to work 40 hours/ week. Assuming 2,000 work hours per year, the initial wage results in annual earnings of $30,000. When the midpoint ($4,250) of the previously stated training rate for unskilled workers ($1,500-$7,000) is used as the estimated cost associated with training each new hire; the estimated training costs equate to 14.1% of a new hire's annual earnings (i.e., $4,250/$30,000). Approximating this value as 15% of an employee's annual income, and assuming the value of labor returned to the employer is equivalent to the pay rate, a new hire would need to work 300 hours (i.e., 15% x 2,000 hours), or 7.5 40-hour work weeks. Therefore, the employer can consider eight 40-hour work weeks, generally occurring within 60 calendar days, as the target in order to ensure full recovery of the training costs.

<u>Study Population</u>

The study sample consisted of 3843 employees hired from January 1st, 2012 through November 25th, 2016. For employees who were hired multiple times during the study period, only the first instance was included in the final dataset (resulting in exclusion of 9 records). No data were gathered from the facility to account for previous instances of hire which occurred before January 1st, 2012. Employees hired between September 26th, 2016 and November 25th, 2016 were also excluded (n=69 records) in order to ensure all employees in the final dataset had the potential to work to the 60-day benchmark. Therefore, the final dataset included human resources records for 3765 study participants.

<u>Exposure Variables and Covariates</u>

Exposure Variables

Exposure variables were derived using information available in the database maintained by the on-site occupational health center. Employer policies required the immediate reporting of occupational injuries as well as signs and symptoms consistent with musculoskeletal health outcomes to the onsite occupational health center. Nursing staff were required to document all visits to the occupational health center, including the name and employee number of the employee visiting, the date of the visit, the nature of the injury/incident which brought the employee to the center, and the gross body part/area affected.

The primary exposure variable was a visit to the occupational health center within the first 60 calendar days from the date of hire (i.e., "early nurse visit," dichotomized as yes/no), regardless of the nature of injury/incident and the gross body part/area affected. Secondary exposure variables included (i) "nature of injury," classified as *repetitive strain, acute sprain/strain, struck/caught/injured by, cut/puncture/scrape, slip/trip/fall, temperature extreme* and *other* (e.g., chemical burns, allergic reactions, foreign objects in eye, and instances where there was no physical injury visible to the nursing staff), and (ii) "gross body part/area" affected, classified as *torso, lower extremities, head/eye, lower back, shoulder/arm, wrist/hand, upper back/neck* and *other* (e.g., heat stress). *Torso* injuries included those affecting the abdominal muscles and chest muscles (but not the back), while *lower extremity* injuries included those affecting the hips, knees, ankles, feet, thighs or calves. The secondary exposure variables (i.e., nature of injury/incident and gross body part/area affected) were also dichotomized based on the 60-day benchmark (e.g., repetitive strain within the first 60 days of employment or no repetitive strain within the first 60 days of employment).

Demographic Variables

Demographic variables available in the human resources records database included employee gender (male and female), age and race/ethnicity. Age was an included as a continuous variable. Race/ethnicity was categorized as

White/Caucasian, Black/African-American, Hispanic/Latino and *other* (including

Asian/Pacific Islanders, Alaskan Natives and American Indians).

Job Assignment Variables

      The human resources records database included information about the

work shift to which each new hire was assigned, categorized as *first* (7:00am –

3:30pm, Monday – Friday), *second* (3:30pm – 11:30pm Monday - Friday), *third*

(11:30pm – 7:00am Monday – Friday), and *other* (e.g., those assigned to the

premium product assembly line who worked 5:00am – 3:30pm, Monday –

Thursday).

      In addition, information was available concerning each employee's job

classification (i.e., job title) and assigned department within the study facility. A

department may be conceptualized as an organizational unit consisting of a

group of production tasks under the supervision of one or more specific team

leaders. Job title and department information was then used to assign a "nature

of work" to each newly hired employee, categorized as *assembly, fabrication,*

inspection, material handling, and *maintenance.* It was against union policy to

rotate workers between natures of work.

      Assembly work was machine-paced and cyclic. Workers in the assembly

category performed one or more production tasks according to a standard

sequence of steps, with a cycle time typically on the order of 35 seconds.

Assembly work involved a range of manual activities, including manipulation and

installation of parts and the use of both manual and powered hand tools (electric and pneumatic).

Fabrication work involved the operation of in-house machinery and fabrication equipment (e.g. press machines, foam insulation machines, routing machines). Fabrication work was often cyclic, but self-paced rather than machine-paced (in contrast to assembly work). Fabrication areas received parts orders from the assembly lines, and workers would feed raw material into the equipment and either manipulate manual controls or operate digital interfaces.

Inspection work involved the testing and visual inspection of the completed products or sub-assemblies in order to ensure quality. Inspection work generally occurred at the end of assembly lines and, like assembly work, was both cyclic and machine-paced. In contrast to assembly work, however, inspection work did not require the same volume of parts manipulation and installation or tool use.

Material handling generally involved the transport of parts from the fabrication areas and supplies from the warehouse to the assembly lines via powered industrial vehicles. Finally, *maintenance* work involved electrical work, powered industrial truck repair, tool and die installation, along with fabrication equipment repair.

Mean Daily High Temperature

The facility was not air conditioned and, during the summer months, large fans were used to promote air flow for cooling. During initial discussions about

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the current project, the employer expressed a strong desire to examine the association between temperature and early termination of employment. The employer had hypothesized that higher temperatures increased the likelihood that a newly hired employee would fail to meet the 60-day benchmark. Unfortunately, detailed records of indoor air temperature were not available. As a proxy, daily high temperature (ambient) data were obtained for each day of the study observation period using publicly available sources (WeatherUnderground.com, 2009). From these data, the average daily high temperature was calculated during the first 60 calendar days from the date of hire (for employees working at least 60 days from the date of hire) or during the full duration of employment (for employees terminated prior to 60 days from the date of hire). Quartiles were created based on the empirical distribution: 8-52°F, 52.1-67.1°F, 67.2-78.6°F, and 78.7-95.5°F.

Statistical Analyses

Distributions of all exposure variables (early nurse visit, nature of injury, and gross body part/area) and covariates (gender, age, race/ethnicity, shift, nature of work, and mean daily high temperature) were described by early termination of employment status. Age was described using the mean and standard deviation. All other variables were described using observation frequencies and proportions.

For each newly hired employee, information about the date of hire, the number of days worked, and visits to the occupational health center was used to

estimate the incidence rates. Incidence rates are calculated by the number of occurrences of the injury being dived by the total observation time.

The incidence rate of nurse visits across the full observation period of the study was calculated. If an employee was injured, observation time was censored on the date of the first visit to the occupational health center.

The incidence rate of nurse visits during the first 60 days of employment from the date of hire was also estimated. For this, observation time was censored on the date of the first injury. Observation time was also censored at 60 days from the hire date for employees who were employed longer than 60 days. This censoring was utilized because employees are only exposed to an early injury during the first 60 calendar days of their employment. Incidence rates for certain outcomes, such as repetitive strain and acute sprains/strains, were also calculated.

Unadjusted associations between each exposure variable and covariate and early termination status were then estimated using logistic regression. Due to small cell sizes, a number of exposure variable or covariate categories were collapsed in order to allow stable estimation of logistic regression parameters. Final formulations of each exposure variable and covariate for which categories were collapsed are discussed in the following sections, along with definitions of the referent category used in logistic regression modeling.

Nature of Injury

Occupational health nurse visits classified as *struck/injured by, cut/puncture, slip/trip/fall, heat-related,* and *other* were combined into a new category defined as *occupational injuries*. Thus, the final formulation of the nature of injury independent variable included four categories: *repetitive strain, acute sprain/strain, occupational injuries,* and a referent category of *no early nurse visit*.

Gross Body Part Affected

Occupational health nurse visits classified as those affecting the *torso, lower extremity, head/eye,* and *other* were combined into a new *other body areas* category. Thus, the final formulation of the gross body part/area affected included six categories: the new *other body areas* category, *lower back, shoulder/arm, wrist/hand, upper back/neck,* and a referent category of *no early nurse visit.*

Nature of Work

The majority of employees in the study sample were placed into *assembly* work upon hire. The nature of work categories *fabrication, inspection, material handling,* and *maintenance* were combined into a new referent category. Thus, the final formulation of the nature of work was dichotomous: the new *referent* category and *assembly*.

<u>Multivariable Models</u>

Multivariable logistic regression models were then developed to estimate adjusted associations between each exposure variable (early nurse visit, nature of injury, and gross body part/area affected) and early termination status. Separate models were constructed for each exposure variable. Each initial model included the exposure variable of interest and any covariate associated with early termination status with $p<0.2$ in the unadjusted analyses. Covariates with more than two categories (e.g., race/ethnicity and mean daily high temperature) were included if the association with early termination status was $p<0.2$ for any level of the variable. A modified backward elimination procedure was used to obtain final multivariable logistic regression models. Specifically, the least significant covariate with $p>0.05$ was removed first, followed by the next least significant covariate with $p>0.05$ until all covariates with $p>0.05$ were removed. Any covariate whose removal resulted in a change of the independent variable parameter estimate of $>10\%$ was considered a confounder and returned to the model before the next covariate was removed, regardless of its p-value. Therefore, each final model included the independent variable and any covariate that was either associated with early termination status (with $p\leq0.05$) or a confounder of the association between the independent variable and early termination status, regardless of its p-value.

Secondary logistic regression analyses were performed to more fully

explore the associations between (i) early nurse visits and (ii) nature of injury and

early termination of employment. Although the employer used the 60-day

benchmark as the criterion for early termination of employment, newly hired

employees unaccustomed to the physical demands of manufacturing work and

the manufacturing environment may be more likely to experience injuries during

the initial stages of employment. Thus, the early nurse visit exposure variable,

which was dichotomous in the primary analyses, was categorized as visits

occurring from *1-20* days from the date of hire, from *21-40* days from the date of

hire, and from *41-60* days from the date of hire. Because of a small number of

observations of early nurse visits occurring from *41-60* days from the date of hire

among those who terminated employment early, the *21-40* and *41-60* days from

the date of hire categories were combined. Thus, the reformulated early nurse

visit variable included three categories: early nurse visit occurring from *1-20* days

from the date of hire, early nurse visit occurring from *21-60* days from the date of

hire, and a referent category of *no early nurse visit.* Unadjusted and adjusted

associations between the re-categorized early nurse visit variable and early

termination of employment were estimated using logistic regression in a manner

identical to that described previously.

The nature of injury exposure variable was re-categorized using a similar

approach. Specifically, a reformulated nature of injury variable was constructed

using seven categories: *occupational injuries from 1-20 days* from the date of

hire, *occupational injuries from 21-60 days* from the date of hire, *repetitive strain from 1-20 days* from the date of hire, *repetitive strain from 21-60 days* from the date of hire, *acute sprain/strain from 1-20 days* from the date of hire, *acute sprain/strain from 21-60 days* from the date of hire, and a referent category of *no early nurse visit* within the first 60 days from the date of hire. Unadjusted and adjusted associations between the re-categorized nature of injury variable and early termination of employment were estimated using logistic regression in a manner identical to that described previously. Conceptually, the new categorization scheme is similar to including an interaction term in the logistic regression model, but allows for estimation of parameters for each level of the variable rather than a single parameter for the interaction term.

Results

Distributions of demographic and job characteristic variables are provided in Table 1. Of the 3765 newly hired employees in the study population, 2581 (68.6%) were employed longer than 60 days and 1184 (31.5%) worked 60 days or less (i.e., early terminations). About two-thirds (67.9%) of the employees were male. The overall mean age was 33.8 ± 10.8 years. The predominant race/ethnicity category was white/Caucasian (54.8%), followed by black/African-American (39.2%), and small proportions of those identifying as Hispanic/Latino (2.7%) or other race/ethnicity designations (3.4%). Larger proportions of employees were placed into the first (34.7%) and second (43.6%) shifts

compared to third (18.8%) and other (3.0%) shifts. The vast majority of employees (87.2%) were placed into assembly positions.

Employees contributed a total of 860,305 person days (2357 person years [PY]) of observation during the study period (January 1st, 2012- November 25th, 2016). The number of days of observation any single employee contributed ranged from one to 1788. During this time, a total of 1105 first-time visits to the occupational health center were recorded with an overall incidence rate (IR) of 46.8 visits per 100PY. Of the 1105 first-time visits, 458 (41.4%) were classified as occupational injuries (IR = 19.4/100PY), 433 (39.2%) as repetitive strain (IR = 18.3/100PY), and 214 (19.4%) as acute sprain/strain (IR = 9.0/100PY). The gross body part/area affected was most commonly the wrist/hand (29.3%), followed by the shoulder/arm (25.6%), the lower back (10.8%), and the upper back/neck (7.1%), with other body parts/areas accounting for the remainder (27.1%).

Of the 1105 first-time visits to the occupational health center, 408 (36.9%) occurred during the first 60 calendar days from the date of hire (i.e., early nurse visits). The observation days contributed from each employee was restricted at 60 calendar days and at the date of the first injury resulting in a contributed observation period of 174,604 days (478 years). The overall incidence rate of early nurse visits was 85.3 visits per 100PY. Of the 408 early nurse visits, 162 (39.7%) were classified as occupational injures (IR = 33.8/100PY), 173 (42.4%) as repetitive strain (IR = 36.2/100PY), and 73 (17.9%) as acute sprain/strain (IR = 15.3/100PY). The gross body part/area affected was most commonly the

wrist/hand (31.6%), followed by the shoulder/arm (23.8%), the lower back (10.0%), and the upper back/neck (7.8%), with other body parts/areas accounting for the remainder (26.7%).

Demographic and Job Characteristic Variables and Early Termination Status

Unadjusted associations between all demographic and job characteristic variables and early termination status are provided in Table 1. Males were less likely to terminate early than females (OR = 0.74, $p<0.01$), and those identifying as Black/African-American (OR = 0.68, $p<0.01$) and other racial/ethnic groups (OR =0.55, $p<0.01$) were less likely to terminate early than those identifying as White/Caucasian. No association between age and early termination status was observed. Compared to those placed into first shift, employees placed into the "other" shift category were less likely to terminate early (OR= 0.08, $p<0.01$), although only a small number of employees (n=4) both worked in the other shift and terminated early. Compared to all other natures of work (i.e., fabrication, inspection, material handling, and maintenance), employees engaged in assembly work were more likely to terminate early (OR 10.91, $p<0.01$).

Early Injury and Early Termination Status

Associations between nature of injury, and gross body part/area affected and early termination status are provided in Table 2. Recall that in these

analyses, the timing of the visit to the occupational health center within the first 60 days from the date of hire was not considered. In general, employees with an early nurse visit were less likely to terminate early than employees without an early nurse visit, although neither the unadjusted nor adjusted associations were statistically significant (OR = 0.91, p=0.41, OR = 0.83, p=0.14 respectively).

When considering the nature of injury, those with early nurse visits classified as general occupational injuries were less likely to terminate early than those without an early nurse visit (adjusted OR = 0.64, CI = 0.44-0.93), while the associations between repetitive strain (OR= 1.09, 95% CI=0.79-1.51) and acute sprain/strain (OR=0.99, 95% CI=0.60-1.64) and early termination status were not statistically significant. Employees who sustained repetitive strain and acute sprains/strains were more likely to terminate early compared to those with general occupational injuries, as seen in Table 3.

Compared to employees with no early nurse visits, those with visits related to the upper/back neck (OR=1.90, 95%CI=0.90-4.00) and wrist/hand (OR=1.33, 95%CI=0.86-2.05) had elevated, but not statistically significant associations with early termination.

Subset Analyses

Changing the reference category from "no early nurse visit" to employees classified as sustaining a general occupational injury in the multivariable logistic regression models allowed for a comparison of the associations between different injured groups. When compared to general occupational injuries

employees had elevated odds of early termination if they sustained a repetitive strain injury (OR=1.54 95%, CI = 0.95-2.48) or an acute sprain/strain injury (OR=1.40, 95%CI=0.76-2.58).

When compared to employees who sustained injuries in the head, legs and torso those who experienced a wrist/hand injury (OR=2.19, 95%CI=1.20-3.99) and upper back/neck injury (OR=3.52, 95%CI=1.48-8.37) had a higher odds of early termination

Stratified Injury Occurrence Associations

Workers injured within the first 20 days of employment were at greater odds of early termination (OR=1.72, 95%CI=1.25-2.37), while employees injured between 21 and 60 days of employment had reduced odds of early termination (OR=0.40, 95%CI=0.27-0.57). Employees who experienced a general occupational injury within the first 20 days of employment only showed a significant association of increased odds of early termination in the unadjusted analysis (OR=1.74, 95% CI=1.05-2.89).While employees who sustained an occupational injury between 20 and 60 days had significantly decreased odds of early termination (OR=0.27, 95% CI=0.15-0.5) only in the adjusted analysis. Employees with repetitive strain injuries occurring in the first 20 days had statistically increased odds of early termination (OR=2.01, 95%CI=1.27-3.18). While employees with repetitive strain injuries which occurred between 20 and 60 days had significantly decreased odds of early termination (OR=0.49, 95%

CI=0.28-0.84). Employees with wrist/hand injuries (OR=2.23, 95% CI=1.35-3.67) and upper back/ neck injuries (OR=3.15, 95% CI=1.35-3.67) which occurred within the first 20 days had significantly increased odds of early termination. Employees with injuries which occurred between 20 and 60 days of employment had a significant decreased odds of early termination when the injuries affected the lower back (OR=0.28, 95% CI=0.08-0.95), shoulder/ arm (OR=0.38, 95% CI=0.18-0.79), wrist/ hand (OR=0.43, 95% CI=0.23-0.83) or were categorized as other (OR=0.28, 95% CI=0.11-0.49).

Discussion

This study examined the association between occupational injury and early termination of employment among a sample of 3765 newly-hired manufacturing workers. Early termination, defined as an employment duration of 60 days or less from the date of hire, was captured using the employer's human resources records. Occupational injury, defined as a visit to the on-site occupational health center, was captured using the occupational health center's records. Early termination was frequent, with nearly one-third of the study sample terminating employment within the first 60 days. High rates of employee turnover in manufacturing environments are common. For example, Argote and Epple (1990) observed that, over a 60 day period, 15% of employees were new to an aircraft manufacturing facility.

In this study, employees who sustained an early injury (visited the occupational health center at any time within the first 60 days) were shown to have a slightly decreased odds of early termination (OR=0.83, 95%CI=0.66-1.06). This is an interesting finding because previous research among healthcare workers has observed that injured employees are more likely to experience job loss than uninjured workers (Brewer et al., 2012; Okechukwu et al., 2016). Okechukwu et al used a sample of 1331 nursing home workers and administered questionnaires at 0, 6, 12 and 18 months of work. Injury information was dichotomized as yes/no and was taken at 6 and 12 months, while job loss was recorded as involuntary and voluntary. When comparing employees who reported injuries to the group reporting no injuries, injured employees had elevated associations (OR=1.31, 95% CI=0.93-1.86) with overall job loss within the following 6 month period. When comparing the same groups injured employees had significantly higher risk of involuntary job loss within the subsequent 6 months (OR: 2.19, 95% CI=1.27-3.77).

A related association between employment duration and injury risk has also been frequently observed among occupational groups in multiple sectors, i.e., that newly hired employees experience greater rates of occupational injury in comparison to more established employees (Bentley et al., 2002; Chi, Chang, & Ting, 2005; McCall & Horwitz, 2005). For example, Bell and Grushecky (2006) observed that commercial logging operators with less than 60 days of employment were more likely to experience an injury than those with more than 60 days of employment (OR=2.19, 95% CI=1.51-3.12).

Significant associations were observed when exposure to early injury was categorized into two groups; experiencing an injury between 0-20 days and 21-60 days. Employees who experienced an injury within the first 20 days had significantly increased odds of early termination (OR=1.72, 95% CI=1.25-2.37), while employees injured between 21-60 days were shown to have significantly decreased odds of early termination (OR=0.40, 95% CI=0.27-0.57). General positive associations between early termination and injuries occurring within the first 20 days were present in all categories of nature of injury and gross body part, however not all were statistically significant (Table 4). Specifically, employees who sustained repetitive strain injuries within the first 20 days of employment had significantly increased odds of early termination (OR=2.01, 95%CI=1.27-3.18).

Statistically significant negative associations between early termination and injuries occurring between 21 and 60 days were present in all nature of injury categories and all gross body part categories, except for upper back/neck injuries (Table 5).This trend could be conceptualized as longer tenure employees who have already worked past 20 days, are more prone to continuing their employment regardless of injury status.

Employees who sustained upper/back and neck injuries always had elevated or significantly increased odds of early termination, regardless of when the injury occurred. This strong association observed between upper back and neck injuries and early termination could be caused by the smaller sample size (n=32) compared to the other gross body part categories.

The results of this study should be interpreted in the context of the study's methodological strengths and limitations. A strength of the study was that the cohort was generated from the facility's human resources data, which captured all employees hired during the study period and, therefore, minimizing threats to internal validity common to epidemiological studies (e.g., selection bias and error in the ascertainment of the outcome variable).

The occupational health center data provided a substantial amount of information relating to employee nurse visits. Classification of nature of injury and gross body part affected was generated by the occupational health center's diagnosis and record keeping for safety department record keeping. With several different onsite clinicians employed, a limitation of the study was that the classification of injury information was subject to misclassification (i.e. rear deltoid injuries being classified into upper back/neck or shoulder/arm injuries, or repetitive strain injuries being classified as acute sprain/strain). Any misclassification of exposure was likely non-differential, resulting in attenuation of the observed associations between the exposure and outcome.

Another limitation of the study was that the date of the early injury occurrence was not taken into account, besides it being dichotomized into occurring before 60 days or not. This would result in all injuries occurring before 60 days being treated identically. For example, an injury occurring on day 2

would be treated the same as an injury occurring on day 58, even though the employee injured on day 2 has substantially greater opportunity to terminate employment prior to 60 days in comparison the employee injured on day 58. The possible effect of essentially dichotomizing both the exposure and outcome variables on the observed associations is not immediately clear. Further exploration of the data using survival analysis techniques (e.g., Cox regression) may provide more accurate estimates of the exposure-outcome relationship.

Facility policy encouraged the immediate reporting of injuries to the occupational health center. Repetitive strain injuries slowly onset over time due to their pathology, presenting difficulties in accurately identifying a true "start date" for the injury. Delayed and underreporting of occupational injuries is a well-documented occurrence in occupational environments (Pransky et al., 1999). Delayed reporting and underreporting of occupational injuries most likely occurred within the study facility, more likely occurring differentially among workers in the first 60 days of employment. This would result in more homogeneous exposed and unexposed groups than reported. Underreporting of injuries would result in injured workers being categorized as non-injured. Increased delayed reporting occurring in the first 60 days would result in early injuries being labeled as non-early injuries and therefore result in exposed employees being categorized as non-exposed. The systematic categorization of exposed employees being labeled as non-exposed would result in an underestimate of the association between the exposure and outcome.

In this study, reporting an injury was the exposure variable and early termination of employment was the outcome variable, which is reversed from the associations examined in the existing literature (Bell & Grushecky, 2006; Bentley et al., 2002; Chi et al., 2005; McCall & Horwitz, 2005). The experience of early termination may vary among those visiting the occupational health center for an injury and those who did not visit for reasons unrelated to injury occurrence. However, the relatively limited data available did not allow for a more robust exploration of additional factors.

The data did not differentiate between voluntary and involuntary termination of employment. In addition, no information was available concerning the specific wages earned at the time of hire or as employment progressed, particularly for those assigned to non-assembly positions. It is possible that the most physically demanding jobs at the study facility were also associated with the lowest levels of compensation. Over time, a worker may have been assigned to jobs with different physical demands (i.e., job change) even though his/her job classification (i.e., assembly) may not have changed. Other factors associated with the employee turnover but not addressed in this study include marital status, education level, and promotion frequency, as well as factors associated with the workplace psychosocial environment, such as supervisor/co-worker support and overall levels of job satisfaction (Huang et al., 2006).

The inclusion of all hires in the study sample limits the possible effects of survivor bias. However, changes in hiring practices may have occurred during the study period that did not allow optimal minimization of the healthy worker

effect. For example, workers more susceptible to injury (particularly repetitive strain) might be more likely hired during periods of labor shortage than during periods of labor surplus. The healthy worker effect attenuates measures of association, even when an internal referent group is used (Arrighi & Hertz-Picciotto, 1994).

Conclusions

Models estimating occupational injury/illness costs are very crude and only offer an estimation of the entire economic burden of occupational injuries/illnesses, which regularly include costs which are not directly attributable to the business/facility itself. By using the 60 day threshold in this study we are able to analyze employee turnover in a way that makes it directly relatable to the facility's "bottom line" value placed on each employee. Turnover problems are very complex and there is no single solution to decreasing turnover. Numerous points of intervention exist. This study theorized that one specific approach that may improve turnover rates are policies that reduce occupational injuries (specifically repetitive strain injuries). Implementing interventions to counteract injuries among the manufacturing population is a uniquely controllable factor that businesses have at their disposal to attempt to decrease turnover.

Overall, the results suggest that experiencing an occupational injury within the first 20 days of employment is strongly associated with early termination. The results may not be generalizable to all manufacturing operations. However, the

results indicate that employers should examine policies and practices to minimize

the burden of injury among new employees and reduce turnover. In the case of

the study facility, an extended or modified work hardening program could

maximize new employees' adaptation to the physical demands of manufacturing

work.

CHAPTER III CONCLUSIONS

Conclusions

Turnover problems within an organization are highly complex with multiple contributing factors, meaning there are multiple points of intervention. New hires have been associated with a higher risk of injury, and injuries have been associated with higher turnover rates which in turn would generate more new hires. These previously observed associations create a theoretical positive feedback loop. Statistical associations, however, do not necessarily indicate casual pathways between variables. Therefore, where exactly the association between injury and turnover fits into the previously mentioned theoretical loop is open to interpretation.

Survivor bias and the healthy worker effect are forms of selection bias common to occupational epidemiological research where; (i) employees most susceptible to a particular occupational health outcome may have selected out of the population prior to study observation (i.e., the available employees represent a population of survivors) and (ii) persons seeking employment tend to be healthier, in general, than persons not seeking employment. Survivor bias, in particular, is problematic in epidemiologic studies of musculoskeletal outcomes. Potential survivor bias was managed as a consequence of capturing the employment experience of all new hires over a four-year timeframe, which is an important strength of this study. However, although strong associations were

observed between exposure to an occupational injury and employment duration, it is not known if injury was the primary reason for terminating employment or if (and to what extent) other factors (both work-related and not work-related) contributed to termination decisions. Thus, an interpretation of the study results could be that employees who terminated early were predisposed to turnover due to other factors. Also, the greater proportion of early termination among those with early injuries (compared to those without early injuries) may reflect ongoing natural selection process, where employees who terminated early were at a higher risk of injury from either the actual physical demands or psychological perception of the work load. Whatever the case, these conjectures rely somewhat on speculations relating to employee work ethic and commitment.

The main objective of this study was to examine the association between occupational injuries and duration of employment among newly hired manufacturing workers. The study facility experienced a high rate of turnover in general, with 32% of newly hired employees working less than 60 days. Of the 3765 newly hired employees included in the study sample, 408 experienced a first time nurse visit within the first 60 days of employment. Of the total 1105 nurse visits reported by the study cohort 37% occurred within the first 60 days of employment. The incidences rates were also greater during the first 60 days of employment than during the full period of observation. These observations reinforce previous research suggesting that newly hired employees are at a higher risk of injury (Bell & Grushecky, 2006; Bentley et al., 2002; Breslin & Smith, 2006; Groves et al., 2007; McCall & Horwitz, 2005).

Early employment periods have been clearly linked to an increased risk of injury. Studies done in nursing populations show that injuries are also associated with an increased risk of turnover (Brewer et al., 2012; Okechukwu et al., 2016). The results of this study expand the evidence base regarding the association between injury and turnover among manufacturing workers. In this study, employees who were injured within the first 20 days (repetitive strain, in particular) had significantly increased odds of termination before reaching 60 days of employment. Although these results may not be generalizable to all manufacturing enterprises, they indicate that employers should examine interventions to minimize the burden of injury as a potential solution to reducing employee turnover.

Because employees who experienced repetitive strain injuries experienced the greatest odds of early termination, we would recommend to the employer to examine the possibilities of implementing an extended new hire training program. For example, a modified work hardening program may maximize the potential for new hires to adapt to the physical demands of manufacturing work during the early periods of employment prior to full production activities. Alternatively, the observed results suggest the possibility that increased or improved secondary prevention efforts, i.e., ensuring injured workers are afforded time and opportunity to recover and safely return to full work activities.

The data available in the facility's human resources and occupational health center databases did not allow the analysis to consider account for

numerous factors associated with early termination, occupational injury, or both. The employer could also benefit by gathering marital status from the human resources onboarding process along previous history of musculoskeletal disorder and height and weight measurements during occupational health center visits to allow for more in depth future analyses of injuries and turnover.

Finally, the dichotomous form of the outcome variable (i.e., working past 60 days or not past 60 days) did not take the time of the injury occurrence into account. As such, the use of logistic regression may not have been the most optimal analytic approach. Future studies could, for example, use survival analysis (e.g., Cox regression) to more fully account for the number of days from the date of hire on which injuries occurred.

TABLES:

Table 1: Demographic and Job Characteristics frequency and percentage data with unadjusted associations and p-value, by early termination. Age reported as mean (sd), all others reported as frequency (%).

Variable	Worked > 60 days[1] (n=2581)	Worked ≤ 60 days[2] (n=1184)	OR [95% CI]	p
Demographics				
Age	34.0 (10.7)	33.6 (11.3)	1.00 [0.99, 1.01]	0.42
Male gender	1808 (70.0)	750 (63.3)	0.74 [0.64, 0.85]	<0.01
Ethnicity				
White/Caucasian	1341 (52.0)	721 (60.9)	-REF-	-REF-
African-American	1080 (41.8)	394 (33.3)	0.68 [0.59, 0.79]	<0.01
Hispanic/Latino	62 (2.4)	40 (3.4)	1.20 [0.80, 1.80]	0.38
Other[3]	98 (3.8)	29 (2.4)	0.55 [0.36, 0.84]	<0.01
Job characteristics				
Shift				
First	893 (34.6)	409 (34.5)	-REF-	-REF-
Second	1105 (42.8)	538 (45.4)	1.06 [0.91, 1.24]	0.44
Third	473 (18.3)	233 (19.7)	1.08 [0.88, 1.31]	0.47
Other[4]	110 (4.3)	4 (0.3)	0.08 [0.03, 0.22]	<0.01
Nature of work				
Assembly	2122 (82.2)	1161(98.0)	10.91 [7.14, 16.69]	<0.01
Reference Group	459 (17.8)	23 (2.0)	-REF-	-REF-
Fabrication	199 (7.7)	4 (0.3)		
Inspection	67 (2.6)	9 (0.8)		
Material handling	134 (5.2)	9 (0.8)		
Maintenance	59 (2.3)	1 (0.1)		
Temperature Quartiles (°F)				
1 (8° – 52°)	633 (24.5)	296 (25.0)	-REF-	-REF-
2 (52.1° – 67.1°)	665 (25.8)	268 (22.6)	0.86 [0.71, 1.05]	0.14
3 (67.2° – 78.6°)	633 (24.5)	310 (26.2)	1.05 [0.86, 1.27]	0.64
4 (78.7° – 95.5°)	650 (25.2)	310 (26.2)	1.02 [0.84, 1.24]	0.84

[1]Indicates the employee worked past 60 days of employment

[2]Indicates early termination / the employees was terminated before 60 days of employment

[3]Inclusive of Asian/Pacific Islanders, Alaska natives, American Indians

[4]Other shifts include those working four 10-hr days, Mon-Thurs (premium product line

Table 2: Early nurse visit descriptive variable frequencies and percentages from the full cohort with unadjusted and adjusted associations by early termination status (Referenced to non-injured employees).

Variable	Worked > 60 days (n=2581) N (%)	Worked ≤ 60 days (n=1184) N (%)	Unadjusted	Adjusted[5]
***Nature of injury*[6]**				
No early nurse visit	2294 (88.9)	1063 (89.8)	-REF-	-REF-
General Occupational[1]	122 (4.7)	40 (3.4)	0.71 [0.49, 1.02]	0.64 [0.44, 0.93]
Repetitive Strain	115 (4.5)	58 (4.9)	1.09 [0.79, 1.51]	1.02 [0.73, 1.43]
Acute sprain/strain	50 (1.9)	23 (1.9)	0.99 [0.60, 1.64]	0.88 [0.52, 1.51]
***Gross Body Part Affected*[7]**				
No early nurse visit	2294 (88.9)	1063 (89.8)	-REF-	-REF-
Other Injuries	86 (3.3)	23 (1.9)	0.52 [0.17, 1.53]	0.49 [0.30, 0.79]
Torso[2]	10 (1.5)	5 (0.4)		
Lower Extremity[3]	41 (14.2)	10 [0.8]		
Head/ Eye	32 (1.2)	5 (0.4)		
Other[4]	3 (1.0)	3 (0.2)		
Lower Back	31 (1.2)	10 (0.8)	0.75 [0.37, 1.55]	0.76 [0.36, 1.60]
Shoulder/ Arm	71 (2.7)	26 (2.1)	0.91 [0.54, 1.54]	0.77 [0.48, 1.24]
Wrist/ Hand	82 (3.2)	47 (3.9)	1.33 [0.86, 2.05]	1.10 [0.75, 1.60]
Upper back/ Neck	17 (0.6)	15 (1.2)	1.90 [0.90, 4.00]	1.89 [0.90, 3.97]

[1]Inclusive of injuries resulting from struck/injured by, cut/puncture, slip/trip/fall, heat related and other

[2]Inclusive of the abdominals and chest

[3]Inclusive of entire lower extremity; hip, knee, ankle, foot, thigh and calves

[4]Includes injuries with no localized gross body part effected such as heat stress, and where the employee was labeled as having no injury.

[5]Adjusted associations for variables, each sub analysis controlled for specific confounders based on backwards selection process

[6]Adjusted for employee age, gender, race, shift, nature of work and temperature quartile

[7]Adjusted for employee age, gender, race, shift, nature of work and temperature quartile

Table 3: Early nurse visits descriptive variable frequencies and percentages of the early injured cohort with unadjusted and adjusted associations by early termination status (referenced to different injured reference groups).

Variable	Worked > 60 days (n=2581) N (%)	Worked ≤ 60 days (n=1184) N (%)	OR [95% CI] Unadjusted	Adjusted[3]
Nature of injury[4]				
General Occupational[1]	122 (4.7)	40 (3.4)	-REF-	-REF-
Repetitive Strain	115 (4.5)	58 (4.9)	1.54 [0.95, 2.48]	1.62 [0.99, 2.66]
Acute sprain/strain	50 (1.9)	23 (1.9)	1.40 [0.76, 2.58]	1.37 [0.72, 2.62]
Gross Body Part Affected [5]				
Reference Group[2]	86 (3.3)	23 (1.9)	-REF-	-REF-
Lower Back	31 (1.2)	10 (0.8)	1.21 [0.39, 5.40]	1.57 [0.64, 3.84]
Shoulder/ Arm	71 (2.7)	26 (2.1)	1.37 [0.53, 5.92]	1.56 [0.80, 3.02]
Wrist/ Hand	82 (3.2)	47 (3.9)	2.58 [0.80, 8.31]	2.19 [1.20, 3.99]
Upper back/ Neck	17 (0.6)	15 (1.2)	3.63 [0.98, 13.77]	3.52 [1.48, 8.37]

[1]Inclusive of injuries resulting from struck/injured by, cut/puncture, slip/trip/fall, heat related and other
[2]Inclusive of torso, lower extremity, head/eye and other injuries
[3]Adjusted associations for variables, each sub analysis controlled for specific confounders based on backwards selection process
[4]Adjusted for employee age, race/ethnicity, nature of work and shift
[5]Adjusted for employee race/ethnicity, nature of work and shift

Table 4: Unadjusted and adjusted associations of descriptive injury variables by exposure to injury before 20 days and between 20 and 60 days (referenced to non-injured employees).

Variable	Injured before 20 days		Injured between 20 – 60 days[1]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Early Injury[2]	1.88 [1.39, 2.55]	1.72 [1.25, 2.37]	0.91 [0.73, 1.14]	0.40 [0.27, 0.57]
Nature of injury[2]				
No early nurse visit	-REF-	-REF-	-REF-	-REF-
General Occupational[1]	1.74 [1.05, 2.89]	1.65 [0.97, 2.81]	0.71 [0.49, 1.02]	0.27 [0.15, 0.50]
Repetitive Strain	2.20 [1.42, 3.42]	2.01 [1.27, 3.18]	1.09 [0.79, 1.51]	0.49 [0.28, 0.84]
Acute sprain/strain	1.88 [0.94, 3.75]	1.65 [0.79, 3.46]	0.99 [0.60, 1.64]	0.47 [0.21, 1.07]
Gross Body Part [3]				
No early nurse visit	-REF-	-REF-	-REF-	-REF-
Other Injuries	1.30 [0.69, 2.47]	1.26 [0.58, 2.19]	0.28 [0.13, 0.58]	0.23 [0.11, 0.49]
Lower Back	2.56 [0.79, 6.45]	2.49 [0.81, 7.56]	0.26 [0.08, 0.87]	0.28 [0.08, 0.95]
Shoulder/ Arm	1.74 [0.92, 3.29]	1.62 [0.84, 3.15]	0.38 [0.18, 0.78]	0.38 [0.18, 0.79]
Wrist/ Hand	2.32 [1.44, 3.74]	2.23 [1.35, 3.67]	0.52 [0.28, 0.98]	0.43 [0.23, 0.83]
Upper back/ Neck	3.61 [1.18, 11.06]	3.15 [1.35, 3.67]	1.21 [0.47, 3.10]	1.32 [0.49, 3.57]

[1]Note both associations for injuries between 20 and 60 days are adjusted for gender, race/ethnicity, shift, nature of work, and temperature quartile

[2]Nature of injury for the group injured before 20 days was adjusted for age, gender, race/ethnicity, shift, nature of work and temperature quartile

[3]Gross body part affected for the group injured before 20 days was adjusted for gender, race/ethnicity, shift, nature of work, and temperature quartile

Table 5: Descriptive injury variable frequencies and percentages by early termination status and injury occurrence date, with unadjusted and adjusted associations.

Dependent variable	Worked > 60 days (n=2581)	Worked ≤ 60 days (n=1184)	OR (unadj)	OR (adj)
Early nurse visit (dichotomous)[1]	287 (11.1)	121 (10.2)	0.91 [0.73, 1.14]	0.91 [0.73, 1.14]
Early nurse visit (categorized)[2]				
No early nurse visit	2294 (88.9)	1063 (89.8)	-REF-	-REF-
Visit between 0-20 days	94 (3.6)	82 (6.9)	1.88 [1.39, 2.55]	1.72 [1.25, 2.37]
Visit between 21-60 days	193 (7.5)	39 (3.3)	0.91 [0.73, 1.14]	0.40 [0.27, 0.57]
Nature of injury[3]				
No early nurse visit	2294 (88.9)	1063 (89.8)	-REF-	-REF-
General occupational (0-20)[4]	35 (1.4)	27 (2.3)	1.67 [1.00, 2.77]	1.57 [0.92, 2.66]
General occupational (21-60)[5]	87 (3.4)	13 (1.1)	0.32 [0.18, 0.58]	0.28 [0.15, 0.51]
Repetitive strain (0-20)	41 (1.6)	40 (3.4)	2.11 [1.35, 3.27]	1.89 [1.94, 2.99]
Repetitive strain (21-60)	74 (2.9)	18 (1.5)	0.52 [0.31, 0.88]	0.51 [0.30, 0.86]
Acute sprain/strain (0-20)	18 (0.7)	15 (1.3)	1.80 [0.90, 3.58]	1.69 [0.82, 3.50]
Acute sprain/strain (21-60)	32 (1.2)	8 (0.7)	0.54 [0.25, 1.18]	0.49 [0.22, 1.11]

[1] Adjusted for gender, race/ethnicity, shift, nature of work, and temperature quartile.

[2] Adjusted for employee gender, shift, race/ethnicity and nature of work

[3] Adjusted for gender, age, race/ethnicity, shift, nature of work and temperature quartile

[4] (0-20) indicates that the nurse visit occurred within the first 20 days of employment

[5] (21-60) indicates that the nurse visit occurred within 21-60 days of employment

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