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# Lessons Learned from Ohio Workers' Compensation Claims to Mitigate Hazards in the Landscaping Services Industry

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## Abstract

**Background—**The landscaping services industry is one of the more dangerous in the U.S., with higher rates of both fatal and nonfatal injuries than the all-industry average. This study uses claims from the Ohio Bureau of Workers' Compensation (OHBWC) database to identify high rates of occupational injuries and illnesses in this industry in Ohio. The causes of those illnesses and injuries are highlighted to identify common factors.

**Methods—**The OHBWC database includes injured-worker industry identification, occupation, business size, demographics, diagnoses, and free-text descriptions of injury circumstances. We identified landscaping service industry claims from 2001 to 2017, and describe annual claim counts and rates.

**Results—**Over the 17-year period, 18,037 claims were accepted, with "Struck by object or equipment" and "Overexertion involving outside sources" being the most common events or exposures. Sprains and fractures were the most prevalent of the more serious lost-time (LT) injuries. Free-text descriptions of claims indicate that arborist work and loading/unloading of work vehicles and trailers are particularly hazardous. Younger and shorter-tenured workers were injured most frequently, although the average workers' age was higher for LT claims.

The total cost of claims to the OHBWC from the landscaping services industry for 2001 – 2017 was over $226,000,000. Almost $214,000,000, or 94.4%, was for LT injuries and illnesses, even though LT claims comprise only 18% of total claims.

**Conclusions—**Targeted improvements in landscaper safety could come from controlling events leading to LT claims. Engineering controls and improved training are strongly recommended to reduce falls, overexertion, and struck-by injuries.

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**Keywords**

Landscaping; groundskeeping; arborist; injury; worker's compensation

## Introduction

The landscaping services industry is one of the more dangerous in the U.S., with higher rates of both fatal and nonfatal injuries than average.[1] The most current data from the U.S. Bureau of Labor Statistics (BLS) show that the rate of nonfatal occupational injuries and illnesses involving days away from work per 10,000 full-time workers in all private industry in 2018 was 89.7, while the rate for the landscaping services industry (NAICS code 56173) was 176.8.[2] The rate of fatal occupational injuries for the landscaping services industry, 1.70 per 10,000 full-time workers, was five times as high as that for all private industry, 0.34 per 10,000 full-time workers.[3] Rates of total U.S. Occupational Safety and Health Administration (OSHA) recordable injuries, as well as rates of cases with at least one day away from work with or without job restriction or transfer (more severe), have been decreasing steadily since 2003. That is also true for the landscaping services industry.[2] However, rates of cases with days away from work, job restriction, or transfer are declining particularly slowly for the landscaping services industry compared to general private industry.[2]

Landscaping services industry work is almost exclusively outdoors, and workers face hazards from heat, cold, sun exposure, poisonous plants, and animal, insect, and spider bites. Workers operate outdoor power equipment such as lawnmowers, chain saws, leaf blowers, chipper/shredders, and string trimmers, which produce loud noise, vibration, combustion exhaust, and flying debris. Injuries incurred while using these machines include sprains, fractures, lacerations, and potentially serious eye injuries.[4]

The landscaping services industry comprises a large and unique workforce. This industry includes workers who perform landscape construction, tree care services, lawn and cemetery care, right of way maintenance, seasonal property maintenance (such as snow removal), and weed control (except crop). There were over 102,000 landscaping services firms (North American Industry Classification System (NAICS) code 56173), employing approximately 720,700 workers in the U.S. in 2017.[5] Occupations of landscaping services workers may include landscaper, groundskeeper, arborist, lawn care worker, pesticide applicator, or greenhouse worker, among others. Landscaping services workers differ from the average U.S. worker in that they are predominantly male and young. According to the BLS Current Population Survey, women made up 10.5% of this industry in 2019, although women made up 47% of the total workforce. Hispanic workers made up 42.7% of landscaping services industry workers, as compared to 17.6% of the total U.S. workforce.[6] While the median age for all employed people in the U.S. has been approximately 42 years old from 2011 – 2019, the median age for landscaping services industry workers was 40.9 in 2019. This median age has risen from 38.1 in 2011.[6]

Workers in the landscaping services industry perform many tasks that involve lifting, carrying, pushing, pulling, loading, and unloading heavy objects and materials, such as

equipment, live nursery stock, wood, brick, block, ornamental stone, topsoil, and mulch.[4] This can lead to sprains, soft tissue injuries, and disc disorders. Workers often climb into and out of vehicles and trailers when loading and unloading and are at risk of falling. Arborist work can involve climbing trees and working from ladders and aerial work platforms, leading to risks for falls from height and contact with electrical wires. Trees and tree limbs can also fall on ground crew members at tree care worksites.[4]

## Small business considerations

Most firms in this industry are relatively small and may have few safety and health resources. Over 70% of landscaping services establishments (NAICS code 56173) had fewer than five employees in 2017.[5] Despite having such a large presence in the workforce, small businesses may face greater challenges when managing health and safety and typically have higher rates of fatal and non-fatal incidents.[7] The short lifespan of small businesses may not allow for the development of a health and safety component for their business.[7] Small businesses typically have fewer resources to train workers and management on recognizing and controlling hazards[7] and employers without experience in health and safety may have difficulty finding or understanding resources.[8] Safe work interventions can be expensive, time-consuming, or require additional training and resources to implement.[9] Small businesses are also more likely to employ young and temporary workers, who have been shown to have higher rates of injuries due to lack of experience with job tasks and unfamiliarity in recognizing hazards.[10,11]

## Prior research

Relatively few studies have focused on hazards in the landscaping services industry. A survey of the peer-reviewed literature turned up three articles on noise, heat stress, and UV exposures to university groundskeepers in North Carolina;[12-14] four articles on injuries and fatalities among landscapers and arborists;[15-18] one study of fatalities associated with the use of wood chippers, mostly for workers in the landscaping services industry;[19] a study of injuries and illnesses in arborists and gardeners in northeastern Italy;[20] and six surveys or observations of safety knowledge and behaviors among landscapers, groundskeepers, and arborists.[21-26] Several studies from related industries and non-occupational settings were also found.

The objective of the present study is to characterize hazards in the landscaping services industry through the comparison of injury scenarios leading to medical-only (MO) and lost-time (LT) workers' compensation (WC) claims. Claims from the Ohio Bureau of Workers' Compensation (OHBWC) database are described to help identify areas where occupational injuries and illnesses remain high in the landscaping services industry in the state of Ohio and to highlight the causes of those illnesses and injuries. Measures to reduce injuries and illnesses are proposed.

## Methods

### Data Source

In the state of Ohio, all public and private employers with less than 500 employees, except sole proprietorships and partnerships, are required to be insured by the OHBWC. Large employers and sole proprietorships can also choose to be insured by the OHBWC. Approximately two-thirds of Ohio workers and 99% of its businesses are insured by OHBWC.[27] This provides a rich source of historical data on occupational injuries and illnesses. To utilize the WC data from Ohio and other states for the improvement of workplace safety and health, the NIOSH Center for Workers' Compensation Studies (CWCS) was established in 2013.[28]

Data in the OHBWC database include identification of an injured worker's industry, occupation, diagnoses, and a free-text description of the circumstances of the injury incident. All injuries or illnesses in this dataset were assigned International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes in the OHBWC system. Claims are defined as medical-only (MO) or lost-time (LT) by the OHBWC. The MO claims are those with only medical treatment expenses and/or seven or fewer days away from work. The LT claims involve eight or more days away from work and can be considered the more serious injuries. This differs from the system used by BLS, which classifies more severe "days away from work" (DAFW) cases as those with at least one day away from work with or without job transfer or restriction.[1] This study focused primarily on incidents leading to LT claims.

The method described in Wurzelbacher et al.[27] was used to estimate the number of full-time equivalent (FTE) employees insured by OHBWC in this industry each year. These numbers were used as denominators to calculate rates of injury and illness. In summary, OHBWC claims data were linked via the employer's federal tax identification number with Ohio's unemployment insurance (UI) data from the Ohio Department of Job and Family Services, that includes the employer's industry (NAICS) code and number of employees quarterly. BLS National Labor Productivity and Costs (LPC) survey data on hours worked per employee were used to adjust UI data and estimate FTE. The methods used in the current analyses do differ slightly in that BLS LPC data now represent hours worked rather than hours paid.[29]

### Costs

Not all the claims in this database were closed, or fully paid-out. The OHWBC actuarial system uses a factor-adjusted valuation method to estimate ultimate claim costs.[30] Factor-adjusted costs for indemnity (partial wage replacement) and medical payments were totaled for each claim. Indemnity was only rarely paid for MO claims. Other administrative costs were not available in the OHBWC system, and these are not included as part of projected costs.

## Study population

This study examined accepted claims limited to OHBWC-insured, private-sector landscaping services industry employees, identified by NAICS code 56173, for injuries and illnesses that occurred from 2001 – 2017, the most recent years for which OHBWC data are available. While many public employees may be involved in landscaping work, they are identified by NAICS using general codes for public employees rather than by specific occupation, which makes their identification challenging. Therefore, we have excluded public employees from this study. Methods differed slightly for single-location and multiple-location employers, and these methods were described in more detail in a prior study.[27]

To be accepted, a claim must be filed completely and be proven to be work-related. During the time period studied, claimants had 2 years from the date of injury to file a claim. The OHBWC accepted 88 – 90% of claims filed between 2011 and 2018.[31] The OHBWC dataset contains information on worker gender, age, education level, and in some cases, time since they were hired, but not race or ethnicity.

## Data coding and processing

The manner in which the injury or illness was produced or inflicted by the source of injury or illness is termed the event or exposure. Bertke et al.[32] developed a machine learning algorithm that was used to code each OHBWC claim according to the BLS Occupational Injury and Illness Classification System (OIICS version 2.01) 2-digit event/exposure categories[33] based on the free-text incident description. LT claims with the lowest probability of accurate coding or high costs were manually reviewed to increase the accuracy of coding of these events and exposures. For NAICS 56173, 19.6% (649/3,311) of LT claims for 2007 – 2017 were manually reviewed. Among those manually reviewed, 373 (57%) agreed at the 2-digit level; 483 (74%) at the 1-digit level. The estimated accuracy was adjusted, with the assumption that manually-coded events and exposures were 100% accurate. This resulted in an estimated accuracy of 80% at the 1-digit event/exposure level and 67% at the 2-digit level.

The ICD-9-CM diagnosis codes were grouped into 57 broad diagnosis categories developed by OHBWC and NIOSH. For claims with multiple diagnoses, the ICD-9-CM code that an OHBWC algorithm determined would most restrict a worker's return to work was used for further analyses.[34]

Because the claims data are population rather than sample data, traditional statistical analysis is not applicable. However, we chose to perform statistical analyses to assist in identifying specific differences among years, claim types (MO or LT), and injury causes or injury types. Specifically, we performed a 3-way analysis-of-variance (ANOVA) to determine how claim rates (injury counts divided by FTE estimates) for injury causes or types differed between claim types and injury years. Analysis was performed using SAS® Version 9.4.

### Free-text descriptions of incidents

The brief free-text descriptions of the incidents, reported by the injured worker, a surrogate, or a medical provider, were particularly helpful in determining some of the circumstances leading to occupational injury or illness in the landscaping services industry. The free-text descriptions were searched using a range of keywords that were thought to be relevant to this industry. Supplemental Table S1 lists keywords used in searching the free-text description of claims. Searches were also performed for groups of related keywords. The groups of related keywords used in searches are listed in Supplemental Table S2. Reading through the text identified common misspellings that were then included in the search, and sometimes the necessity for leading or trailing blank characters, to avoid including unwanted words; for example, it was not intended to count occurrences of "street" when counting occurrences of "tree."

### Human subjects

This study was internally reviewed by NIOSH, and it was determined that it did not constitute human subjects research. Rather, the study involved the analysis of coded and previously collected WC administrative claims data.

## Results

Claims from the landscaping services industry (NAICS 56173) were included in this study if they could be reliably matched to UI data on NAICS and employee count. Included claims totaled 18,037 (Excluded claims totaled 132.); 14,726 were MO and 3,311 were LT. Ninety-four percent of both MO and LT claims for which gender was reported (17,821 of 18,037 claims) were filed for men, reflecting the high proportion of men in this industry. Ohio is a state with four seasons, and many more claims have been filed in spring, summer, and fall than in the winter months. The largest number of claims were for incidents in June, July, and August.

Just as in the national data from the BLS, the numbers of MO claims in the landscaping services industry have fallen since 2001, while the numbers of LT claims have fallen more slowly. The percent of claims that are LT has increased from 16.2% in 2001 to 21.5% in 2017. Total (MO + LT) claims decreased dramatically from 2001 to 2009 and have been relatively flat since. LT claims have also not decreased since 2009.

Figure 1 illustrates the rates of MO and LT claim filings to the OHBWC per 100 FTE for the landscaping services industry compared to all private industry. As in BLS data,[2] rates of occupational injuries and illnesses are far higher for the landscaping services industry than for all private industry in the OHBWC database.[35] In 2017, rates of MO claims were 1.4 times as high as for all private industry, and rates of LT claims were 1.8 times as high. After increasing from 2009 to 2010, rates of accepted LT claims have improved from 2010 to 2017.

### Free-text descriptions of incidents

The highest frequency for a group of related keywords in the free-text descriptions of OHBWC LT claims in the landscaping services industry was for the keywords, "foot," "knee," "ankle," "leg," or "toe." They were the second-most frequently-found for MO claims. These descriptions included objects dropped on feet and toes; objects and equipment striking legs, feet, and ankles; slipping or feet becoming caught on an object; mower injuries; burns; overexertion injuries; feet run over by vehicles and equipment; and injuries from uneven ground, such as stepping into a hole. See Table 1 for the top 3 keywords or groups of keywords found in free-text descriptions of MO and of LT claims.

The keywords occurring second-most-frequently for LT claims were "fell" and "fall." Many of these claims involved falls from trucks and trailers, objects falling on workers, falls from ladders or trees, slips and trips resulting in falls, and falls while mowing. Objects falling on workers in some of these claims included trees and parts of trees, tailgates, equipment, and landscaping materials. Poor footing contributed to some of the falls, such as walking on a slope, on wet grass, or on ice.

The third-highest frequency for keywords mentioned in the free-text of LT claims was for the keywords: "truck," "trailer," or "tailgate." Only 13% of these LT claims were for "Roadway incidents involving motorized land vehicle"; most incidents occurred while working in, on, or around a truck or trailer. These included pinching or smashing fingers in tailgates or trailer hitches, injuries while hooking or unhooking trailers, falls from trucks or trailers, tailgates falling on feet and legs, and injuries sustained while loading or unloading equipment and material into or out of trucks and trailers.

Many of the WC claims in this industry involve injuries to the hand, finger, pinky, or thumb. Although this group of keywords was the fifth-most-frequently found for LT injuries, it was the most-frequently found for MO claims. Injuries and illnesses of the hand, finger, pinky, and thumb resulting in claims included those from being smashed in tailgates or between objects, carpal tunnel syndrome, injuries that occurred when moving materials or equipment, and injuries inflicted by powered equipment, including lawnmowers, chipper/shredders, log splitters, hedge trimmers, and snow blowers.

### Event or exposure

Table 2 compares the events or exposures resulting in MO and LT claims to the OHBWC for 2001 – 2017 that occurred at the highest overall rates in the landscaping services industry. The highest rates for both MO and LT claims were for “Struck by object or equipment,” and “Overexertion involving outside sources.” The third-highest rate for LT claims was for "Falls to lower level."

### Injury or illness diagnoses category

The highest rate for an injury or illness diagnosis category in the landscaping services industry, for MO claims filed in 2001 through 2017, was for “Open wounds.” Table 3 compares the 16 injuries and illnesses resulting in claims to the OHBWC that occurred at the highest overall rates during 2001 – 2017. Because LT claims did not result primarily from

one or a few injury or illness types, the category of "Other injury" (a sum of 34 less-frequent injuries) occurred at the highest rate, followed by "Sprains – back."

Sprains and fractures of various types were five of the ten most-often reported injuries for LT claims. (Table 3) If sprains of all different parts of the body were counted as one injury, it would be the most prevalent injury for LT claims. The most likely event to cause a sprain injury was “Overexertion involving outside sources.” The rate of claims for total sprain injuries is declining proportionately to the rate of decline of total injuries in this industry.

If fractures of all parts of the body were added together, they would be the second-highest LT injury. Claims for fractures are not declining as fast as claims for sprains. The rate of LT claims for fractures increased steeply from 2009 to 2010, and they have been declining on average since then. The event most often cited for LT fracture injuries was “Struck by object or equipment,” followed by “Falls to lower level.”

### Statistical analysis of events/exposures and injury types

ANOVA tests showed that there were several events or exposures and injury types that had large differences in claim rates between MO and LT claims. Specifically, the events and exposures "Animal and insect related incidents," "Exposure to other harmful substances," "Struck against object or equipment," and "Struck by object or equipment" had much higher injury rates in MO than in LT claims. While there were no events or exposures that had higher injury rates in LT versus MO claims, the ratios of MO to LT claim rates due to "Caught in or compressed by equipment or objects," "Falls on same level," "Falls to lower level," "Overexertion involving outside sources," and "Roadway incidents involving motorized land vehicle" were smaller. For injury or illness types, "Contact dermatitis and other eczema," "Contusion," "Open wounds," " Poisoning and toxic effects," and "Superficial injury" had rates that were at least 10 times greater in MO than in LT claims, while "Disc disorders" and "Fracture - lower extremity" had higher rates in LT than MO claims. The ANOVA results also showed a decline in injury rates over time, although the decline was less pronounced over the years 2010 to 2017 than in earlier years. See Table S3 in the Supplemental Material for the results of the ANOVA.

### Company size

Most claims submitted to the OHBWC from the landscaping services industry were from small companies. Eighty-three percent of claims were filed by companies with fewer than 50 full-time equivalent (FTE) employees. However, 87% of the FTEs insured worked for these companies.

From 2001 to 2017, the rates of MO claims filed with the OHBWC from the landscaping services industry have decreased for all sizes of companies (See Figure 2.). From 2005 to 2017, the highest rates of filing of MO claims have been for the largest companies, those with 50 – <250 FTEs. From 2001 to 2004, the rates were marginally higher for companies with >10 - <50 FTEs.

The rates of LT claims by year did not strongly correlate with company size, although the smallest companies showed the highest rates of LT claims for 2015 to 2017 (Figure 3). From

2001 to 2010, the rate of LT claims for companies with 50 - <250 FTEs varied from 0.9 to 2.0 claims/100 estimated FTE; after 2011, claim rates slowly decreased. Of the LT claims in this industry from 2001 to 2017, 89% were filed by companies with 50 or fewer FTEs, roughly the same percentage as FTEs insured. Claim rates for companies with 250 or more FTEs are not shown in Figures 2 and 3, due to the small number of insured companies of this size.

### Worker age and job tenure

When LT claims were separated by worker age, the highest number of total claims came from workers aged 25 - 34 (32%). Workers aged 35 - 44 had the second highest number of claims from 2001 to 2017 (25%). The age distribution was similar across all company sizes.

The mean age of injured workers in the landscaping services industry who filed MO claims with the OHBWC from 2001 to 2017 was 31.8 years old, and 35.9 for a worker with a LT claim. The mean age of an injured worker in the landscaping services industry filing an MO claim with the OHBWC has increased steadily from 29.5 years old in 2001 to 34.2 in 2017, while the mean age for an LT claim has increased from 33.6 to 37.9. As outlined in Table 4, the percentage of injured workers in the age group, 20 – 24 years, is much smaller for LT than for MO claims, while the percentages for the age groups from 35 – 54 years are much higher for LT than for MO claims.

Of the 18,037 claims filed, 11,268 claims (62.5%) were missing data on tenure in the current job. Tenure in the current job, or job tenure, is the number of days that a worker had been employed by the current employer on the day that the injury or illness occurred. A total of 3,648 claims for which data were available were from the first year in the job (53.9% of claims with data on job tenure); 1,988 of the claims (29.4%) occurred within in the first 90 days with the employer. For LT claims, 40.0% were missing data on job tenure. As outlined in Table 5, the smaller the company, the higher the percentage of MO and LT claims filed within the first 90 days of job tenure.

### Cost of occupational injuries and illnesses

The total cost of claims to the OHBWC from the landscaping services industry for 2001 – 2017 was calculated at over $226,000,000. Almost $214,000,000, or 94.4%, was for LT injuries and illnesses alone, even though LT claims make up only 18% of total claims. Because of differences in insurance policies with certain companies, some claims resulted in zero cost for the OHBWC.[30] See Table 6 for a comparison of nonzero claim costs for MO and LT claims. The median cost of a nonzero MO claim was $435, while the median cost of a nonzero LT claim was $14,899.

## Discussion

Recent OHBWC data from the landscaping services industry provide a reasonable approximation of national trends. See Table S4 in the Supplemental Material for a comparison of rates of all recordable occupational Injury and illness between the BLS and the OHBWC data for the landscaping services industry and all private industry by year. The rates for all private industry were very similar. The rates for the landscaping services

industry were higher for the OHBWC versus the BLS in 2003 but were nearly identical by 2017.[2]

## Free-text descriptions of incidents

The landscaping services industry is hazardous, and examining the free-text descriptions of WC claims helps to shed light on the incidents leading to injuries and illnesses. Arborist work is a particularly hazardous part of this industry. Examination of the free-text description of each claim illustrates that many of the injuries and illnesses in the landscaping services industry happen to arborists. The keywords, “tree,” "branch," "wood," "limb," or “log,” were the fourth-most-frequently found for LT claims. They were the most frequently found group of keywords for LT claims due to "Struck by object or equipment." (Table 1) Although most of the occurrences of these keywords pertain to arborist work, some of the injuries occurred from running into trees or branches while performing other work.

Interestingly, the keywords: "truck," "trailer," and "tailgate" occurred more frequently than “tree,” "branch," "wood," "limb," and “log,” for LT claims." "Truck," "trailer," and "tailgate" were the second-most frequently found group of keywords for sprain injuries. It appears that loading and unloading work trucks and trailers may be an underestimated source of injuries in this industry. A Canadian study published in 2003 described falls from non-moving trucks as a known cause of serious workplace injuries, although that study concerned tractor-trailers, which are infrequently used in landscaping.[36] They recommended implementing engineering controls, modifying risky workplace practices, and increased prevention education to reduce falls. A NIOSH study in the mining industry reported that entering and exiting mobile equipment poses a fall hazard.[37] It was noted that egress from mobile equipment poses a greater risk for injury than ingress, and that factors contributing to the greater hazard of egress included moving in a backward direction and carrying items in their hands. Stairs were described as safer than a ladder for egress and poor traction was often a factor in falls.

The free-text descriptions of claims related to the human back were challenging to decipher and quantify. The word, "back," occurs in many other uses, such as "back up," "backyard," "back of the …," and "back to …" It was necessary to count 85 different phrases involving "back" to develop a reasonable estimate of the occurrence of the human back in the text. See Table S5 in the Supplemental Material. The OHBWC has provisions for coding the part of the body that is injured, but those data were not included in the information shared with NIOSH. Phrases involving the human back were the most frequent group of keywords found for “Overexertion involving outside sources” events. (Table 1)

## Event or exposure

**Overexertion Involving outside sources—**“Overexertion involving outside sources” was the most-frequent event resulting in LT claims, and statistical analysis of the data showed that the rate of this event for LT claims was relatively high compared to MO claims. (Table 2) This category applies to cases in which the injury or illness resulted from excessive physical effort directed at an outside source of injury or illness. The effort may

involve lifting, pulling, pushing, turning, wielding, holding, carrying, or throwing, and may be repetitive.[33]

Many of the free-text descriptions of incidents of “Overexertion involving outside sources” involved tasks such as lifting, pushing, pulling or carrying items, such as landscaping stones, wood, wheelbarrows, bags of mulch, trees or tree branches, trailers, or tailgates. Some documented injuries involved digging or shoveling. Use of backpack-style leaf blowers and sprayers was also cited among these injuries, while some occurred when pulling a starter cord.

The word, “lift,” was the second-most-frequently found keyword or group of keywords in both MO and LT "Overexertion involving outside sources" claims, after phrases involving the human back. (Table 1) LT claims due to “Overexertion involving outside sources” have been decreasing year-to-year at a much faster rate than other events and exposures leading to LT claims. The reason is unknown, but it is possible that increased use of mechanized equipment, such as liftgates, compact loaders, and skid-steers, for moving heavy loads has been responsible for the improvement. The occurrence of phrases involving the human back and occurrences of the word “lift” have also decreased steeply from 2001 to 2017, giving support to the theory that increased use of mechanized equipment, or possibly better lifting techniques, is responsible for the improvement.

**Struck by Object or Equipment—**“Struck by object or equipment” is the second-highest event or exposure for LT claims and causes the highest rate of MO claims to the OHBWC from the landscaping services industry. (Table 2) This event category can include being struck by a vehicle if it is not on a roadway and not in transport mode, being struck by a falling or flying object, or being injured by a handheld object or by equipment.[33] In the landscaping services industry, this category often includes injuries from landscaping equipment such as lawnmowers, hedge trimmers, string trimmers, and chain saws.

“Struck by object or equipment” injuries can also occur from falling trees or branches, often to arborists. The most commonly found group of keywords in free-text descriptions for LT "Struck by object or equipment" claims were "tree," "branch," "wood," "limb," or "log." (Table 1) The second-most frequent keyword found in the free-text description of these LT claims was "cut." These claims cited injuries while performing tasks such as cutting trees, branches, brush, hedges, or grass and lacerations to different parts of the body, primarily the foot, knee, ankle, leg, or toe (third-most frequent), and the hand, fingers, thumb or pinky (fourth-most frequent).

**Falls to lower level—**"Falls to Lower Level" were the third-leading cause of LT claims, and statistical analysis of the data showed that this event occurred at a relatively high rate for LT claims compared to MO claims. (Table 2) Unsurprisingly, the related keywords "fell" and "fall" were most frequently found. Somewhat more surprising, the next-highest-frequency group of keywords were "truck," "trailer," and "tailgate." Many of these claims involved falls from trucks and trailers. The keywords, "tree," "branch," "wood," "limb," or "log" and "ladder," were mentioned less frequently. Falls from trucks and trailers appear to cause more LT injuries than falls from trees or ladders.

**Other events and exposures—**Interestingly, MO claims due to “Exposure to other harmful substances” have decreased greatly from 2001 to 2017. Statistical analysis of the data showed that the rate of this event was far higher for MO than for LT claims. This category includes exposure to caustic, noxious or allergenic substances; drugs; or infectious agents. In the landscaping services industry, many of these claims involved exposure to poison ivy, poison oak or poison sumac, plants that were mentioned in 487 of the 951 MO claims. Other claims involved exposure to chemicals. It is unclear why the number of claims in this area would decrease from 2001 to 2017. It is possible that filing of such claims is being discouraged by employers. Workers may also be increasingly wearing long sleeves, long pants, and gloves, which would help to reduce exposure.

### Injury or illness diagnoses category

**Sprains—**The incidence of “Sprains – back,” specifically, has decreased steeply from the beginning to the end of the time period studied, both for MO and for LT claims. Most of the events causing “Sprains – back” were “Overexertion involving outside sources.” It is unclear why these injuries have been decreasing, but as mentioned earlier, it is possible that increased use of mechanized equipment and better lifting techniques have been responsible for the improvement.

A search of the free-text description for sprain injuries showed that the keywords most often mentioned in LT and MO claims were the same. "Foot," "knee," "ankle," "leg," and "toe" appeared most frequently, followed by "truck," "trailer," or "tailgate." Many sprain injuries occurred when exiting a truck, particularly the bed of a truck, either purposely or accidentally. Despite the steep decrease in back sprains, phrases pertaining to the human back were found third-most frequently.

**Fractures—**“Fracture – upper extremity” and “Fracture – lower extremity” accounted for most LT fracture claims. Statistical analysis of the data showed that "Fracture – lower extremity" occurred at a high relative rate for LT claims compared to MO claims. The keywords most frequently counted in free-text descriptions of LT fractures were "fell" or "fall," indicating that many severe fractures occurred as the result of falls or of having objects fall on workers. Second-most-frequently mentioned were the keywords "foot," "knee," "ankle," "leg," and "toe." “Hand," "finger," "pinky," and "thumb," were found third-most frequently. For LT "Fracture – lower extremity" specifically, the third-highest frequency was for "truck," "trailer," or "tailgate," suggesting that work on or around trucks and trailers contributes heavily to these injuries.

**Open wounds—**“Open wounds” were by far the injury for which the most MO OHBWC claims were filed in 2001 – 2017, but it was the third-highest injury for LT claims, after all sprains and all fractures. Statistical analysis of the data showed that the rate of “Open wounds” injuries was far higher for MO than for LT claims. The top two events leading to both MO and LT “Open wounds” injuries were “Struck by object or equipment” and “Struck against object or equipment.” The category of “Struck against object or equipment” applies to injuries produced by forcible contact or impact between the injured person and the source of injury when the *motion producing the contact is primarily that of the injured person*.[33]

In the landscaping services industry, many of these events occurred while working with outdoor power equipment and manual tools. These included lawnmowers, hedge trimmers, pruners, chainsaws, and other saws. Some events involved stepping on nails, broken glass, or wires, or running into obstructions, shrubs, or trees.

The keyword "cut" was most frequently found in free-text descriptions of both MO and LT "Open wounds" injuries (Table 1). Some "Open wounds" were inflicted while using tools and equipment for cutting tasks and some occurred after slipping, tripping, or falling. Many “Open wounds” injuries involved the hand, finger, pinky, or thumb. One of these four words appeared second-most frequently. Next-most frequent for LT "Open wounds" were the keywords "tree," "branch," "wood," "limb," or "log," suggesting that many of these injuries occurred during arborist work (Table 1).

**Disc disorders—**"Disc disorders" may include herniated or displaced discs, disc degeneration, spinal stenosis, sciatica or unspecified backache. Disc disorders were not among the top ten injuries or illnesses in total 2001 – 2017 claims to the OHBWC, but they were the fourth-highest injury or illness among LT claims, after all sprains, all fractures, and open wounds. Statistical analysis of the data showed that the rate of LT "Disc disorders" was higher than the rate of MO "Disc disorders." The majority of disc disorders were due to "Overexertion involving outside sources."

Phrases referring to the human back were the most frequently found group of related keywords for LT "Disc disorders" claims. Surprisingly, the group of keywords, "truck," "trailer," or "tailgate," were the next-most-commonly found. These claims included roadway incidents and injuries incurred while loading and unloading tools, materials, and equipment. The word, "lift," was found third-most frequently. Like "Sprains-back", LT "Disc disorders" claims have decreased from 2001 to 2017.

Similarly, WC claims for overexertion back injuries among drywall installers in Washington state have also declined sharply in recent years.[38,39] Interviews with a small group of carpentry industry and trade experts revealed that stockers are increasingly being asked to place materials nearer the installation location and that apprentices are being taught to use partners for heavy tasks. There has also been some increased use of assistive devices. NIOSH recommendations have been credited for some of this improvement.[38,40] However, it is also possible in some cases that fewer WC claims are being filed for this type of injury, even when it does occur.[39]

## Company size

The majority of claims were reported by smaller companies (>0-<50 estimated FTE); this is expected given that the majority of companies in the landscaping services industry are small businesses.[5] Companies with 50-<250 estimated FTE showed higher rates of MO claims since 2005; however, the rate of LT claims was similar for all company sizes. This could mean that there is underreporting for less serious injuries in smaller companies or that smaller companies experience more injuries that cause a loss of time from work. It is possible that smaller companies are hiring more vulnerable workers and/or may not be providing adequate training before starting work.

### Worker age and job tenure

The average age of injured workers in the landscaping services industry filing claims with the OHBWC has increased, year by year, just as the average age of all workers in this industry has increased. This is reflective of an aging workforce in the U.S., but it may also indicate that this type of work is increasingly unattractive to young people. It is also possible that the growing use of mechanized equipment such as compact loaders for heavy lifting tasks is making it possible for workers to continue working in this industry longer.

The average age of an injured worker is lower than the average age of all workers in this industry, indicating that, as found in other studies,[41-43] younger workers are more likely to be injured on the job. The average age of injured workers filing a LT claim is higher than that of injured workers with an MO claim. Older workers may be injured more seriously when they experience an incident on the job. As has been observed in other studies, they may also take longer to recover due to aging factors.[44,45]

As in other industries, inexperienced workers in the landscaping services industry have been much more likely to be injured on the job.[11,46,47] All sizes of companies have more than half of MO claims for workers in their first year on the job. For both MO and LT claims, the smaller the company size, the higher the fraction of injured workers with 90 days or less on the job. Smaller companies may employ more seasonal workers or have higher turnover. They may also provide less training or supervision to new workers.

### Cost of occupational injuries and illnesses

The cost of occupational injuries and illnesses includes lives disrupted and destroyed as well as dollars spent, but the dollars are easier to quantify. The 100 most expensive WC claims to the OHBWC for 2001 – 2017 were all LT claims and totaled over $90,000,000. The top events and exposures leading to these claims were "Struck by object or equipment" (27), "Overexertion involving outside sources" (19), and "Falls to lower level" (19). Thirty-five of the 100 most-expensive claims were fractures and twenty-two were disc disorders.

One of the keywords, "tree," "branch," "wood," "limb," or "log," was found in the free-text descriptions of 34 of these claims. "Fell" or "fall" were found in 30 of the most expensive claims. "Truck," "trailer," or "tailgate" occurred in 17 claims. Severe injuries can be experienced while doing tree work. Objects falling on workers, falls from height, contact with powered equipment, and vehicular incidents have also resulted in devastating injuries.

## Limitations

This study is subject to several limitations. By studying only workers' compensation claims filed in the state of Ohio, we may not be seeing a balanced picture of the nationwide landscaping services industry. Sole proprietorships, partnerships, and companies with 500 or more employees are not required to be insured by the OHBWC and may not be found in this dataset. We may be overlooking many injuries and illnesses in sole proprietorships and partnerships in the landscaping services industry.

Workers' compensation claims may not have been filed for some occupational injuries and illnesses in this industry.[48] This is particularly true for chronic conditions such as back pain, carpal tunnel syndrome, lung disorders, and hearing loss,[49] and for less serious injuries.[50,51]

Workers' compensation data may capture more occupational injuries and illnesses than BLS data,[52] but several studies have shown declining reporting of occupational injuries and illnesses to the workers' compensation system.[53-55] Workers instead resort to other public or private healthcare coverage for treatment of occupational injuries and illnesses.[50,56] Barriers to filing WC claims include being unaware of their eligibility, being unaware that their condition is work-related, delays in reimbursement, concerns over job loss or retaliation, negative experiences of coworkers, pressure from coworkers, especially where safety incentives are involved, and fear of stigma.[54,57,58] Most landscaping services firms are small companies, which have been more likely to underreport.[58,59] Therefore, actual rates of injuries and illnesses may be higher than those reported here. However, at least for recent years, the rate of accepted claims to the OHBWC for the landscaping services industry seems to mirror the BLS incidence rate for nonfatal injuries and illnesses (Table S4), while for earlier years the rate of WC claims was substantially higher than BLS rates.

Many of the events or exposures listed for these claims were obtained by auto-coding, using the free-text descriptions of the claims.[32] Although the auto-coding method was verified, its accuracy was less than 100%, resulting in some of the claims being incorrectly classified. The accuracy of auto-coding improved with increasing numbers of claims in that category. Because this study looks only at the most frequently reported events or exposures, the accuracy should be better than the averages reported. Manual coding is the gold standard for accuracy, but manual coding for this dataset was only performed on a portion of LT claims for the years 2007 – 2017 and for the 25% of claims that had the lowest assignment probabilities.

Race and ethnicity were not recorded for injured workers in this database. That made it impossible to compare injury and illness rates between different racial and ethnic groups. Several earlier studies reported that injuries and fatalities among Hispanic workers have been increasing in this industry from year to year.[60,61]

Much of the data had missing values for the length of tenure in the current job for injured workers. To draw conclusions on the relationship between job tenure and likelihood of occupational injury, it is necessary to assume that data are missing proportionally among all worker age groups. The percent of missing data was calculated for each age group of injured employees and found to be similar for all ages 70 and younger. This may be less of a problem when discussing LT claims, as a smaller percentage of LT claims were missing job tenure.

## Conclusions

Although the landscaping services industry remains dangerous, lessons learned from the data presented here offer many opportunities for reducing the risk of injuries. Most of the claims recorded were preventable. Preventing occupational injuries and illnesses, especially

LT injuries and illnesses, would avoid a great deal of pain and suffering, save significant expense, and improve worker morale. Even as the rates of LT claims are slowly decreasing, the percent of claims in the landscaping industry that are LT are increasing over time. Many of the most devastating injuries involved objects falling onto workers' heads or legs, falls from height, roadway incidents, becoming entangled in machinery, overturning a mower, or lifting something heavy.

Arborist work is widely recognized as particularly dangerous, and 34 of the 100 most expensive claims in the current study mentioned "tree," "branch," "wood," "limb," or "log." These keywords were the ones most often found in free text descriptions of LT claims due to "Struck by object or equipment." (Table 1) However, loading and unloading tools, materials, and equipment into and out of trucks and trailers may be less recognized as a serious hazard in the landscaping services industry. The keywords, "truck," "trailer," or "tailgate" occurred in 17 of the 100 most expensive claims, and occurred third-most frequently for all LT claims, ahead of "tree," "branch," "wood," "limb," or "log."

Improvement over time was noted in the rate of claims due to "Overexertion involving outside sources," especially in a reduction of claims for "Sprains – back" and "Disc disorders." Improved lifting techniques and the increased use of mechanized equipment may be responsible for the improvement.

Large differences were not observed between smaller and larger companies, with the possible exception that smaller companies may be underreporting MO injuries (Figure 2). Companies with ten or fewer employees have experienced the highest rate of injury among workers in their first 90 days of employment (Table 5). These companies may need to provide more training and/or supervision to new employees.

NIOSH promotes the “Hierarchy of Controls” when endeavoring to control exposure to occupational hazards.[62] When hazards cannot be eliminated, or substitutes cannot be found for the hazardous condition, engineering controls are the next most preferable option. When engineering controls such as safer equipment are not available or possible, administrative controls such as improved training and procedures and personal protective equipment (PPE) can be used.

Engineering controls, in the form of safer tools and equipment, could have great impact in reducing many types of serious injuries. Tailgates, frequently dump truck tailgates, were often mentioned in the free-text description of claims. It is very easy to slam hands and fingers in tailgates, and that has been the cause of many fractures, as observed in this dataset. A dump truck tailgate can weigh up to 1,000 pounds and is usually designed to swing freely. Dump truck tailgates that stick can slam open or closed unexpectedly, causing serious injury. Improving safety features of tailgates would help to avoid these injuries.

"Falls to lower level" were the third-most frequent event leading to a LT claim, and statistical analysis of the data showed that this event leads to a relatively higher rate of LT claims compared to MO claims. It is evident from the frequent occurrence of the keywords, "truck," "trailer," or "tailgate" in the free text of these LT claims, that in many cases, injured workers are falling from trucks and trailers. Due to the nature of the work in the landscaping

services industry, it is necessary to load and unload tools, equipment, and material into and out of vehicles and trailers. It is often necessary for personnel to enter vehicles and trailers to accomplish this. Many serious worker injuries have occurred when exiting or falling out of trucks, dump trucks, and trailers. Improved safety features on trucks, trailers, and ramps, procedures, and training for performing this loading and unloading are needed.

Safety features of tools and equipment should be left in place and not defeated. These include interlock switches, discharge chutes and deflector shields, and guards protecting belts and chains. Some of the claims in this dataset were for injuries experienced when tools and equipment failed, such as bucket trucks, ramps, mowers, ropes, and tailgates. Applying preventive maintenance and keeping necessary components in good repair can help to protect the safety and health of employees.

Higher rates of injury among young workers and those in their first 90 days of job tenure may indicate that a lack of training leads to some injuries. Training materials are available on the OSHA website;[4] from OSHA Training Institute Education Centers;[63] from community colleges and universities; from professional organizations including the National Association for Landscape Professionals (NALP), the Professional Grounds Management Society (PGMS), the Tree Care Industry Association (TCIA), and the International Society of Arboriculture (ISA); from state and local providers such as the OHBWC Division of Safety and Hygiene;[64] and from many commercial providers.

Important subjects for worker training might include where to stand and where not to stand when tree work is taking place and how to inspect the worksite and identify hazards such as unstable trees, steep slopes, overhead power lines, holes, and obstructions. Driving safety, safe lifting, and ladder safety would also be important topics. Training should also stress that a stick or other implement should always be used to clear clogs from lawnmowers, augers, and chipper/shredders. Following such guidance could have averted many of the injuries leading to the WC claims in this dataset.

When other controls fail or are not available, wearing the appropriate PPE can help to prevent worker injuries. Required PPE, such as eye protection, hearing protection, and helmets, should always be worn for specified tasks. Given the large number of claims for injuries to hands, fingers, pinkies, and thumbs, wearing gloves for certain tasks could help prevent injury. Sturdy, non-slip footwear could also help to prevent some slips and falls, especially in wet or icy conditions. PPE is recognized as being sometimes uncomfortable or inconvenient.[26] Consistency and supervisor reinforcement will be necessary to ensure compliance.

In summary, most injuries identified in this analysis of landscaping services WC claims could likely have been prevented through known control approaches. The greatest improvements in landscaper safety would come from reductions in the most common injury causes, especially for LT claims. Engineering controls and improved training are likely to be the best approaches to prevent injuries due to falls, overexertion, and "Struck by objects or equipment." Engineering controls do not appear to be available for some of the injuries and

illnesses found in these WC claims. Innovative solutions may be needed to prevent some of the incidents leading to claims.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## References

1. BLS. Injuries, Illnesses, and Fatalities 2020; http://www.bls.gov/iif/. Accessed 05 March 2021.
2. BLS. Survey of Occupational Injuries and Illnesses Data 2021; https://www.bls.gov/iif/soii-data.htm/#summary. Accessed 05 March 2021.
3. BLS. Census of Fatal Occupational Injuries (CFOI). Injuries, Illnesses, and Fatalities 2021; http://www.bls.gov/iif/oshcfoi1.htm. Accessed 05 March 2021.
4. OSHA. Landscape and Horticultural Services. Safety and Health Topics 2020; https://www.osha.gov/SLTC/landscaping/hazards.html. Accessed 24 July 2020.
5. U.S. Census Bureau. All Sectors: Summary Statistics for the U.S., States, and Selected Geographies: 2017. 2020; https://data.census.gov/cedsci/table?q=number%20of%20landscaping%20firms&tid=ECNBASIC2017.EC1700BASIC&n=N0500.00. Accessed 05 March 2021.
6. BLS. Labor Force Statistics from the Current Population Survey. 2020; https://www.bls.gov/cps/tables.htm. Accessed May 8, 2020.
7. Breslin FC, Kyle N, Bigelow P, et al. Effectiveness of health and safety in small enterprises: a systematic review of quantitative evaluations of interventions. J Occup Rehabil. 2010;20(2):163–179. [PubMed: 19908131]
8. Brosseau LM, Li SY. Small business owners' health and safety intentions: a cross-sectional survey. Environ Health-Glob. 2005;4:23.
9. Eakin JM, Lamm F, Limborg HJ. International perspective on the promotion of health and safety in small workplaces. In: Frick K, Jensen PL, Quinlan M, Wilthagen T, eds. Systematic Occupational Health and Safety Management – Perspectives on an International Development. Oxford, England: Pergamon; 2000:227 – 247.
10. Headd B The characteristics of small-business employees. Monthly Labor Review, US Bureau of Labor Statistics. 2000;April 2000.
11. Breslin FC, Dollack J, Mahood Q, Maas ET, Laberge M, Smith PM. Are new workers at elevated risk for work injury? A systematic review. Occup Environ Med. 2019;76(9):694–701. [PubMed: 31147382]

12. Balanay JA, Kearney GD, Mannarino AJ. Noise exposure assessment among groundskeepers in a university setting: A pilot study. J Occup Environ Hyg. 2016;13(3):193–202. [PubMed: 26554597]
13. Balanay JAG, Kearney GD, Mannarino AJ. Assessment of Occupational Noise Exposure among Groundskeepers in North Carolina Public Universities. Environ Health Insights. 2016;10:83–92. [PubMed: 27330303]
14. Beck N, Balanay JAG, Johnson T. Assessment of occupational exposure to heat stress and solar ultraviolet radiation among groundskeepers in an eastern North Carolina university setting. J Occup Environ Hyg. 2018;15(2):105–116. [PubMed: 29090983]
15. Ball J, Vosberg S. A Survey of United States Tree Care Companies: Part I - Safety Training and Fatal Accidents. Arboriculture & Urban Forestry. 2010;36(5):224–229.
16. Buckley JP, Sestito JP, Hunting KL. Fatalities in the landscape and horticultural services industry, 1992–2001. Am J Ind Med. 2008;51(9):701–713. [PubMed: 18546239]
17. Nevarez J OSHA compliance issues: OSHA heat stress fatality investigation of a Latino landscaping worker. J Occup Environ Hyg. 2013;10(6):D67–70. [PubMed: 23611143]
18. Ball J, Vosberg S, Walsh T. A Review of United States Arboricultural Operation Fatal and Nonfatal Incidents (2001–2017): Implications for Safety Training. Arboriculture & Urban Forestry. 2020;46(2):67–83.
19. Zhu J, Gelberg K. Occupational fatal injuries associated with mobile hand-fed wood chippers. Am J Ind Med. 2018;61(12):978–985. [PubMed: 30325542]
20. Bortolini L, Cividino SR, Gubiani R, Cecchini M, Delfanti LM, Colantoni A. Urban green spaces activities: A preparatory groundwork for a safety management system. J Safety Res. 2016;56:75–82. [PubMed: 26875168]
21. Kearney GD, Balanay JA, Mannarino AJ. Safety behavior and work safety climate among landscaping and groundskeeping workers in North Carolina: A pilot study. Work. 2017;56(1):45–53. [PubMed: 28128785]
22. Kearney GD, Xu X, Hight A, Arcury TA. Case study. Behavior and perception of using safety gear among commercial landscapers: a pilot study. J Occup Environ Hyg. 2013;10(7):D79–85. [PubMed: 23706148]
23. Day AK, Stapleton JL, Natale-Pereira AM, Goydos JS, Coups EJ. Occupational sunscreen use among US Hispanic outdoor workers. BMC Res Notes. 2015;8:578. [PubMed: 26477041]
24. Arcury-Quandt AE, Gentry AL, Marin AJ. Hazardous materials on golf courses: experience and knowledge of golf course superintendents and grounds maintenance workers from seven states. Am J Ind Med. 2011;54(6):474–485. [PubMed: 21360723]
25. Dozier H, Machtmes K. Arborists in Louisiana, U.S.: A Baseline Assessment of Safety and Professionalism. J Arboriculture. 2005;31(5):228 – 234.
26. Julius AK, Kane B, Bulzacchelli MT, Ryan HD 3rd. Compliance with the ANSI Z133.1 - 2006 safety standard among arborists in New England. J Safety Res. 2014;51:65–72. [PubMed: 25453178]
27. Wurzelbacher SJ, Al-Tarawneh IS, Meyers AR, et al. Development of methods for using workers' compensation data for surveillance and prevention of occupational injuries among State-insured private employers in Ohio. Am J Ind Med. 2016;59(12):1087–1104. [PubMed: 27667651]
28. NIOSH. NIOSH Center for Workers' Compensation Studies (CWCS). 2020; https://www.cdc.gov/niosh/topics/workercomp/cwcs/default.html. Accessed June 2, 2020.
29. BLS. Labor Productivity and Costs. 2020; https://www.bls.gov/lpc/#tables. Accessed 20 August 2020.
30. Wurzelbacher SJ, Meyers AR, Bertke SJ, et al. Comparison of cost valuation methods for workers' compensation data. Paper presented at: Use of Workers' Compensation Data for Occupational Safety and Health: Proceedings from June 2012 Workshop; 2013, 2012; Cincinnati, OH.
31. OHBWC. Annual Reports, 2013 - 2018. Columbus, OH 2020; https://www.ic.ohio.gov/news/reportsnewsletters.html. Accessed 25 September 2020.
32. Bertke SJ, Meyers AR, Wurzelbacher SJ, Measure A, Lampl MP, Robins D. Comparison of methods for auto-coding causation of injury narratives. Accident Anal Prev. 2016;88:117–123.
33. BLS. Occupational Injury and Illness Classification Manual. In: U.S. Department of Labor BLS, ed. 2.01 Washington, D.C. 2012.

34. Beery L, Harris JR, Collins JW, et al. Occupational injuries in Ohio wood product manufacturing: a descriptive analysis with emphasis on saw-related injuries and associated causes. Am J Ind Med. 2014;57(11):1265–1275. [PubMed: 25123487]
35. Wurzelbacher SJ, Meyers AR, Lampl MP, et al. Workers' compensation claim counts and rates by injury event/exposure among state-insured private employers in Ohio, 2007-2017. Journal of safety research. In press.
36. Jones D, Switzer-McIntyre S. Falls from trucks: a descriptive study based on a workers compensation database. Work. 2003;20(3):179–184. [PubMed: 12775923]
37. Pollard J, Kosmoski C, Porter WL, Kocher L, Whitson A, Nasarwanji M. Operators' views of mobile equipment ingress and egress safety. Int J Ind Ergonom. 2019;72:35–44.
38. Schoenfisch AL, Lipscomb H, Marshall S, Cameron W, Richardson D, Casteel C. Work-related injuries among union drywall carpenters in Washington State, 1989-2008. Am J Ind Med. 2013;56(10):1137–1148. [PubMed: 23861237]
39. Schoenfisch AL, Lipscomb HJ, Marshall SW, et al. Declining rates of work-related overexertion back injuries among union drywall installers in Washington State, 1989-2008: Improved work safety or shifting of care? Am J Ind Med. 2014;57(2):184–194. [PubMed: 24038384]
40. NIOSH. Preventing Injuries from Installing Drywall. Cincinnati, Ohio 2006; https://www.cdc.gov/niosh/docs/wp-solutions/2006-147/pdfs/2006-147.pdf?id=10.26616/NIOSHPUB2006147. Accessed 20 July 2020.
41. Centers for Disease Control and Prevention (CDC). Occupational Injuries and Deaths Among Younger Workers --- United States, 1998--2007. MMWR Morb Mortal Wkly Rep. 2010; 59(15): 449–455. [PubMed: 20414187]
42. Pek S, Turner N, Tucker S, Kelloway EK, Morrish J. Injunctive safety norms, young worker risk-taking behaviors, and workplace injuries. Accident Anal Prev. 2017;106:202–210.
43. NIOSH. Young Drivers at Work. Motor Vehicle Safety at Work 2019; https://www.cdc.gov/niosh/motorvehicle/topics/youngdrivers/default.html. Accessed 23 July 2020.
44. Pransky GS, Benjamin KL, Savageau JA, Currivan D, Fletcher K. Outcomes in work-related injuries: A comparison of older and younger workers. Am J Ind Med. 2005;47(2):104–112. [PubMed: 15662646]
45. Algarni FS, Gross DP, Senthilselvan A, Battié MC. Ageing workers with work-related musculoskeletal injuries. Occup Med. 2015;65(3):229–237.
46. Breslin FC, Smith P. Trial by fire: a multivariate examination of the relation between job tenure and work injuries. Occup Environ Med. 2006;63(1):27–32. [PubMed: 16361402]
47. Morassaei S, Breslin FC, Shen M, Smith PM. Examining job tenure and lost-time claim rates in Ontario, Canada, over a 10-year period, 1999-2008. Occup Environ Med. 2013;70(3):171–178. [PubMed: 23123355]
48. Rosenman KD, Kalush A, Reilly MJ, Gardiner JC, Reeves M, Luo Z. How much work-related injury and illness is missed by the current national surveillance system? J Occup Environ Med. 2006;48(4):357–365. [PubMed: 16607189]
49. Luckhaupt SE, Calvert GM. Work-relatedness of selected chronic medical conditions and workers' compensation utilization: National health interview survey occupational health supplement data. Am J Ind Med. 2010;53(12):1252–1263. [PubMed: 20721967]
50. Sears JM, Bowman SM, Adams D, Silverstein BA. Who pays for work-related traumatic injuries? Payer distribution in washington state by ethnicity, injury severity, and year (1998–2008). Am J Ind Med. 2013;56(7):742–754. [PubMed: 23460116]
51. Shannon HS, Lowe GS. How many injured workers do not file claims for workers' compensation benefits? Am J Ind Med. 2002;42(6):467–473. [PubMed: 12439869]
52. Wuellner SE, Adams DA, Bonauto DK. Unreported workers' compensation claims to the BLS Survey of Occupational Injuries and Illnesses: Establishment factors. Am J Ind Med. 2016;59(4):274–289. [PubMed: 26792563]
53. Fan ZJ, Bonauto DK, Foley MP, Silverstein BA. Underreporting of work-related injury or illness to workers' compensation: individual and industry factors. J Occup Environ Med. 2006;48(9):914–922. [PubMed: 16966958]

54. Azaroff LS, Davis LK, Naparstek R, Hashimoto D, Laing JR, Wegman DH. Barriers to use of workers' compensation for patient care at Massachusetts community health centers. Health Serv Res. 2013;48(4):1375–1392. [PubMed: 23445431]

55. Nicholson VJ, Bunn TL, Costich JF. Disparities in work-related injuries associated with worker compensation coverage status. Am J Ind Med. 2008;51(6):393–398. [PubMed: 18381597]

56. Sears JM, Bowman SM, Blanar L, Hogg-Johnson S. Industrial Injury Hospitalizations Billed to Payers Other Than Workers' Compensation: Characteristics and Trends by State. Health Serv Res. 2017;52(2):763–785. [PubMed: 27140591]

57. Spieler EA, Burton JF Jr. The lack of correspondence between work-related disability and receipt of workers' compensation benefits. Am J Ind Med. 2012;55(6):487–505. [PubMed: 22271439]

58. Leigh JP, Marcin JP, Miller TR. An estimate of the U.S. Government's undercount of nonfatal occupational injuries. J Occup Environ Med. 2004;46(1):10–18. [PubMed: 14724473]

59. Friedman LS, Forst L. The impact of OSHA recordkeeping regulation changes on occupational injury and illness trends in the US: a time-series analysis. Occup Environ Med. 2007;64(7):454–460. [PubMed: 17303676]

60. Centers for Disease Control and Prevention (CDC). Work-Related Fatalities Associated with Tree Care Operations --- United States, 1992--2007. MMWR Morb Mortal Wkly Rep. 2009;58:389–393. [PubMed: 19390505]

61. Wiatrowski WJ. Fatalities in the Ornamental Shrub and Tree Services Industry. 2005; https://www.bls.gov/opub/mlr/cwc/fatalities-in-the-ornamental-shrub-and-tree-services-industry.pdf. Accessed 3 August 2020.

62. NIOSH. Hierarchy of Controls. Workplace Safety & Health Topics 2015; https://www.cdc.gov/niosh/topics/hierarchy/default.html. Accessed 24 July 2020.

63. OSHA. OSHA Training Institute Education Centers. Training 2020; https://www.osha.gov/otiec/. Accessed 24 July 2020.

64. OHBWC. Safety & Training. 2020; https://info.bwc.ohio.gov/wps/portal/gov/bwc/for-employers/safety-and-training. Accessed 25 September 2020.

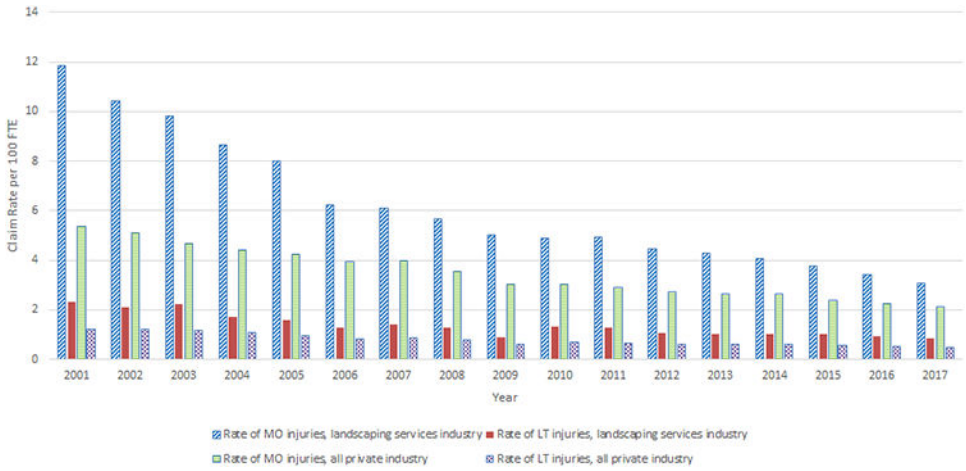


**Figure 1.**

Rates of MO and LT claims to the OHBWC per 100 full-time equivalent employees (FTEs) insured in the landscaping services industry, compared to OHBWC rates for all private industry, by year.

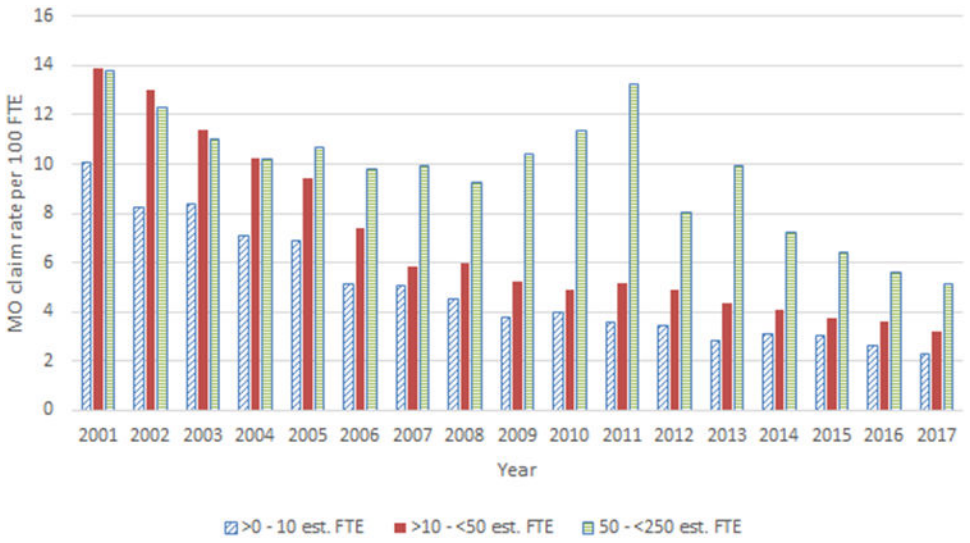


**Figure 2.**

Rates of MO claims per 100 full-time equivalent employees (FTEs) filed to the OHBWC from the landscaping services industry from 2001 to 2017, by company size.

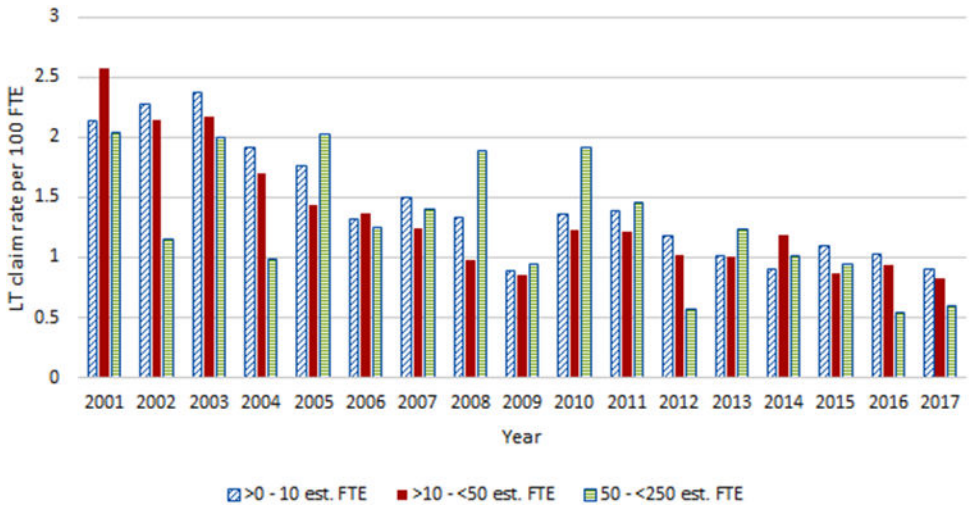


**Figure 3.**

Rates of LT claims per 100 full-time equivalent employees (FTEs) filed to the OHBWC from the landscaping services industry from 2001 to 2017, by company size.

**Table 1.**

Top 3 most frequently found keywords or groups of related keywords in each category for MO and LT landscaping services industry claims to the OHBWC, 2001 to 2017

| Frequency for the given category | Keyword or group of keywords (count) | |
|---|---|---|
| | **MO** | **LT** |
| **All Claims** | | |
| #1 | Hand, finger, pinky, or thumb (3,259) | Foot, knee, ankle, leg, or toe (823) |
| #2 | Foot, knee, ankle, leg, or toe (2,741) | Fell or fall (786) |
| #3 | Head, neck, eye, face, nose, ear, chin, or cheek (2,546) | Truck, trailer, or tailgate (741) |
| **Event or Exposure – Struck by object or equipment** | | |
| #1 | Cut (1,654) | Tree, branch, wood, limb, or log (258) |
| #2 | Head, neck, eye, face, nose, ear, chin, or cheek (1,647) | Cut (240) |
| #3 | Hand, finger, pinky, or thumb (1,585) | Foot, knee, ankle, leg, or toe (214) |
| **Event or Exposure – Overexertion involving outside sources** | | |
| #1 | Phrases involving the human back (699) * | Phrases involving the human back (251) * |
| #2 | Lift (591) | Lift (235) |
| #3 | Truck, trailer, or tailgate (413) | Shoulder, elbow, wrist, or arm (163) |
| **Injury or Illness – Open wounds** | | |
| #1 | Cut (1,844) | Cut (149) |
| #2 | Hand, finger, pinky, or thumb (1,757) | Hand, finger, pinky, or thumb (130) |
| #3 | Foot, knee, ankle, leg, or toe (759) | Tree, branch, wood, limb, or log (92) |
| **Injury or Illness - Sprains** | | |
| #1 | Foot, knee, ankle, leg, or toe (1,055) | Foot, knee, ankle, leg, or toe (269) |
| #2 | Truck, trailer, or tailgate (870) | Truck, trailer, or tailgate (240) |
| #3 | Phrases involving the human back (851) * | Phrases involving the human back (215) * |

* See Table S3 in the Supplemental Information.

**Table 2.**

Claim rates and percentages of events and exposures for MO and LT claims to the OHBWC from the landscaping services industry for 2001 to 2017.

| Event or Exposure | Claim Rate per 100 FTEs (percent of claims) | |
|---|---|---|
| | MO | LT |
| Animal and insect related incidents | 0.373 (6) | 0.004 (1) |
| Caught in or compressed by equipment or objects | 0.297 (5) | 0.111 (8) |
| Exposure to other harmful substances | 0.409 (6) | 0 (0) |
| Falls on same level | 0.295 (5) | 0.099 (7) |
| Falls to lower level | 0.282 (5) | 0.171 (12) |
| Other cause * | 0.299 (5) | 0.087 (6) |
| Other exertions or bodily reactions | 0.208 (3) | 0.068 (5) |
| Overexertion involving outside sources | 0.841 (14) | 0.316 (23) |
| Roadway incidents involving motorized land vehicle | 0.143 (2) | 0.087 (6) |
| Slip or trip without fall | 0.217 (4) | 0.072 (5) |
| Struck against object or equipment | 0.584 (9) | 0.057 (4) |
| Struck by object or equipment | 2.237 (36) | 0.301 (22) |

* The category of "Other cause" includes the lower-frequency events and exposures: Exposure to temperature extremes; Contact with objects and equipment, unspecified; Blank; Rubbed or abraded by friction or pressure; Nonroadway incidents involving motorized land vehicles; Repetitive motions involving microtasks; Jumps to lower level; Pedestrian vehicular incidents; Overexertion and bodily reaction, unspecified; Exposure to electricity; Intentional injury by person; Injury by person—unintentional or intent unknown; Needlestick without exposure to harmful substance; Exposure to radiation and noise; Explosions; Fires; Multiple types of overexertions and bodily reactions; Fall or jump curtailed by personal fall arrest system; Transportation incident, unspecified; Struck, caught, or crushed in collapsing structure, equipment, or material; Animal and other non-motorized vehicle transportation incidents; and Rubbed, abraded, or jarred by vibration.

**Table 3.**

Claim rates and percentages of injury types in claims to the OHBWC from the landscaping services industry for 2001 to 2017.

| Injury Type | Claim Rate per 100 FTEs (percent of claims) | |
|---|---|---|
| | MO | LT |
| Contact dermatitis and other eczema | 0.324 (5) | 0 (0) |
| Contusion | 0.792 (13) | 0.064 (5) |
| Crushing injury | 0.084 (1) | 0.042 (2) |
| Disc disorders | 0.012 (0) | 0.102 (7) |
| Diseases of the nervous system and sense organs | 0.11 (2) | 0.019 (1) |
| Foreign body, eye | 0.134 (2) | 0.038 (0) |
| Fracture - lower extremity | 0.061 (1) | 0.128 (9) |
| Fracture - upper extremity | 0.218 (4) | 0.135 (10) |
| Open wounds | 1.666 (27) | 0.118 (9) |
| Other injury * | 0.457 (7) | 0.322 (24) |
| Poisoning and toxic effects | 0.316 (5) | 0.014 (0) |
| Soft tissue/enthesopathy | 0.081 (1) | 0.051 (4) |
| Sprains – neck | 0.093 (2) | 0.037 (1) |
| Sprains - lower extremity | 0.505 (8) | 0.128 (9) |
| Sprains - upper extremity | 0.338 (6) | 0.097 (7) |
| Sprains-back | 0.561 (9) | 0.154 (11) |
| Superficial injury | 0.428 (7) | 0.004 (1) |

* The category of "Other injury" includes the 34 lower-frequency injuries: Burn; Cellulitis or abscess; Dislocation; Sprains – other; Fracture - neck and trunk; Hernia of abdominal cavity; Intracranial injury; Other and unspecified effects of external cause; blank; Amputation; Fracture – head; Injury to Nerves and spinal cord; Carpal tunnel syndrome; Certain traumatic complications and unspecified injuries; Diseases of musculoskeletal and connective Tissue NEC; Fracture – other, NEC; Other diseases of the skin and subcutaneous tissue; Other joint disorders; Other mental disorders; Knee derangement; Internal injury of chest, abdomen, pelvis, and blood vessels; Foreign body, not eye; Symptoms signs and ill-defined conditions NEC; Diseases of the respiratory system; Spinal osteoarthritis; Endocrine, nutritional and metabolic diseases; Death, cause unknown; Mental disorders from brain damage; Diseases of the circulatory system; Pneumoconiosis, resp. cond. due to external agents; Diseases of the digestive systems NEC; Diseases of the genitourinary system; Infectious and parasitic diseases; and Complications of surgical and medical care, NEC.

**Table 4.**

Numbers and percentages of MO and LT claims to the OHBWC from the landscaping services industry for 2001 to 2017, by age of injured worker.

| | Claims by age (Percent of claims with known age) | |
|---|---|---|
| **Injured worker age group** | **MO** | **LT** |
| 14-17 years | 148 (1) | 15 (0) |
| 18-19 years | 919 (6) | 90 (3) |
| 20-24 years | 3590 (24) | 495 (15) |
| 25-34 years | 5119 (35) | 1075 (32) |
| 35-44 years | 2789 (19) | 838 (25) |
| 45-54 years | 1458 (10) | 588 (18) |
| 55-64 years | 573 (4) | 184 (6) |
| 65+ years | 92 (1) | 26 (1) |
| unknown | 37 | 0 |

**Table 5.**

Numbers and percentages of MO and LT claims to the OHBWC from the landscaping services industry for 2001 to 2017, by job tenure of injured worker and company size.

| | **Claims by Job Tenure (Percent of claims with known job tenure for that company size)** | | |
|---|---|---|---|
| **Job Tenure** | **Company size** | | |
| **MO claims** | **>0 – 10 estimated FTE** | **>10 - <50 estimated FTE** | **50 - <250 estimated FTE** |
| ≤ 90 days | 571 (31) | 600 (29) | 212 (27) |
| 91-365 days | 407 (22) | 509 (25) | 206 (26) |
| Year 1-2 | 246 (13) | 280 (14) | 116 (15) |
| Year 2-3 | 133 (7) | 153 (7) | 48 (6) |
| Year 3-4 | 98 (5) | 112 (5) | 32 (4) |
| Year 4-5 | 63 (3) | 68 (3) | 27 (3) |
| > 5 years | 307 (17) | 347 (17) | 138 (18) |
| unknown | 4053 | 4126 | 1698 |
| | | | |
| **LT claims** | | | |
| ≤ 90 days | 304 (30) | 203 (27) | 49 (22) |
| 91-365 days | 230 (23) | 212 (28) | 53 (24) |
| Year 1-2 | 114 (11) | 94 (13) | 27 (13) |
| Year 2-3 | 73 (7) | 53 (7) | 18 (9) |
| Year 3-4 | 66 (7) | 32 (4) | 12 (7) |
| Year 4-5 | 44 (4) | 22 (3) | 10 (4) |
| > 5 years | 171 (17) | 132 (18) | 38 (21) |
| unknown | 711 | 478 | 125 |

**Table 6.**

Factor-adjusted costs for MO and LT claims to the OHBWC from the landscaping services industry for 2001 to 2017.

| | Factor-Adjusted Cost* (Number of nonzero claims) | |
|---|---|---|
| **Cost Type** | **MO Claims** | **LT claims** |
| Median indemnity cost of claims for which nonzero indemnity was paid | $1,923.30 (202 of 14,726 claims) | $8,343.42 (2,563 of 3,311 claims) |
| Median medical cost of claims for which nonzero medical cost was paid | $430.80 (13,429 of 14,726 claims) | $7,887.11 (3,281 of 3,311 claims) |
| Median total cost of nonzero claims | $435.21 (13,435 of 14,726 claims) | $14,899.47 (3,303 of 3,311 claims) |

*Because of the way certain insurance policies are written, some claims resulted in zero cost to the OHBWC.