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Quantitative and Narrative Analysis of Dump Truck-Related Injuries and Fatalities in the United States

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Abstract: Dump truck safety recommendations have been implemented by companies, but a comprehensive study of risk factors associated with dump truck injuries and fatalities has not been performed. Published research specifically focusing on dump truck injuries is limited. The purpose of this descriptive study was to characterize risk factors associated with dump truck-related inspection cases reported by the OSHA in the United States. Dump truck inspections during 2016–2020 were obtained from the online OSHA IMIS database. Pearson's chi-square test and logistic regression were performed. An intraclass correlation coefficient (ICC) using PROC MIXED and a generalized linear mixed model was calculated on 122 closed dump truck-related inspection cases. One half of dump truck worker fatalities resulted in a serious OSHA violation, whereas three quarters of nonfatal dump truck worker injuries resulted in an 'other' or no OSHA violation; 22% of fatalities involved the dump truck backing up. A nonfatal injury narrative often involved the words 'finger', 'tailgate', and 'bed', whereas the words 'trailer', 'asphalt', 'load', and 'loader' were mentioned more often in fatalities. A fatal dump truck injury was three times more likely to be associated with a serious OSHA violation compared to a nonfatal dump truck injury. Industries should provide initial and refresher worker safety training to dump truck drivers and other employees who work within the dump truck hazard zone, particularly employees who utilize dump trucks for working with asphalt or around power lines, and employees who repair dump trucks.

Keywords: dump truck; injuries; IMIS; OSHA serious violation; run over

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1. Introduction

Dump truck injuries among construction and extraction workers accounted for 809 deaths over a 10-year period from 2011 to 2020 [1]. In a study of dump truck-related construction fatal incidents (n = 829) using Census of Fatal Occupational Injury (CFOI) data from 1992 to 2007, 41% of the fatalities were among dump truck drivers, approximately 31% were fatally struck by dump trucks, 8% were killed maintaining dump trucks, and 3% were caught between the lowering dump and the truck frame [2]. From these analyses, there are approximately 100 worker deaths per year nationally in only the construction and extraction industry, underscoring the importance of identifying current risk factors for dump truck injuries across industries and developing targeted injury prevention trainings.

Published research specifically focusing on dump truck injuries is limited. Surveillance and simulation studies assessing panel framework design and technological prevention through design have been evaluated on their ability to alleviate the burden of injuries

and fatalities from dump trucks [3,4]. This includes struck by, tip overs, and crushing job hazards identified by the NIOSH [1]. A review of dump truck-involved fatalities by McCann and Cheng from 1992 to 2007 [2] recommended required seat belt use, the use of backup alarms, spotters, etc., and enforcing worker safety practices such as lockout/tagout procedures to reduce injuries and fatalities. Additional hazards include working near power lines. Prevention recommendations have been developed to prevent electrocutions while operating a dump truck on work sites that involve performing a hazard assessment, requiring a spotter when working near power lines, and maintaining a safe distance from high voltage lines [5]. More recently, Wang, Liu, and Cai [4] found that head injuries were minimized via simulation when truck instrument panels were constructed of softer paneling material and construction and at a longer fixing distance. In addition to these studies, case reports conducted by state-based Fatality Assessment and Control Evaluation (FACE) programs supported by NIOSH have documented and qualitatively elaborated on industry risk factors and prevention efforts [6,7].

While hundreds of dump truck-related injuries and fatalities happen on U.S. roadways alone, nationally representative data sources that comprehensively assess dump truck injuries available for assessing risk factors across industries are lacking. The Occupational Safety and Health Administration (OSHA) administers the online Integrated Management Information System (IMIS) that records catastrophe and fatality inspections. The IMIS is updated by the OSHA area and state 18b plan offices on a daily basis. IMIS dump truck-involved catastrophes (injuries) and fatalities are reported by local federal and state OSHA offices where the injury incident occurred and not by where the employer is located. The IMIS maintains records of details of the catastrophes and fatalities but does not contain prevention recommendations for use by employers.

Dump truck safety recommendations have been implemented by companies, but a comprehensive study of the current risk factors associated with dump truck injuries and fatalities across industries has not been performed to better target injury prevention interventions. The purpose of this descriptive study was to identify the exposure factors and other risk factors associated with dump truck-related fatal and nonfatal injuries and to identify the dump truck injury-related factors associated with serious OSHA violations.

2. Methods

2.1. Data Source

All work-related fatalities and catastrophes are reportable to the OSHA. If a work-related fatality/catastrophe occurred on a highway or public street, occurred on a transportation system (commercial or public) or involved a hospitalization for diagnostic testing or observation, the fatality/catastrophe is not required to be reported to the OSHA [8]. If a fatality/catastrophe occurred in a construction work zone on a highway or public street, it is reportable to the OSHA and can be included in the IMIS database. All employers under an OSHA jurisdiction must report fatalities/catastrophes to the OSHA. A fatality is required to be reported to the OSHA within 8 h, and a work-related inpatient hospitalization, amputation or loss of an eye are required to be reported to the OSHA within 24 h.

Data for 2016–2020 were obtained from the online OSHA IMIS database. The date range search was from 1 January 2016–31 December 2020. An IMIS search data range is a 5-year default, and the largest span of time for a search is 10 years. The end date of the search was 31 December 2020 because the year 2020 had the most complete set of closed cases. Only closed cases were included in the study; open cases were not included in the study. An open case is the date when the inspection was started, and additional information on that case can be added at any time until the case is closed when a final order is entered in the case.

Available data fields within the IMIS include information such as establishment name, employer ID, site address, worksite city address, employer mailing address, type of business, ownership, job title, classification of event, fatality status, catastrophe status, event date, number of fatalities and injuries, number of non-hospitalized injuries, type of event, and event description. Industry was coded in the IMIS using North American Industry Classification System (NAICS) industry codes. Occupation was coded in the IMIS using the Standard Occupational Classification (SOC) system. Dump truck catastrophe and fatality reports were identified through a narrative keyword search for 'dump truck' and 'dump' on the keyword category search page.

2.2. Study Population

The study population comprised closed OSHA inspections of dump truck catastrophes (defined by the OSHA as a hospitalization of three or more employees following a workplace injury incident or exposure incident) and fatalities reported in the IMIS. Open cases were not included in the study, since an open case may not be accurate in terms of the OSHA violations that were levied and agreed upon between parties.

2.3. Case Inclusion Criteria

There were 376,059 total inspections performed during the study period. Total inspections include programmed inspections (~45% of total inspections), complaints inspections (~22% of total inspections), referrals (~20% of total inspections), other unprogrammed inspections (~10% of total inspections), and fatality/catastrophe inspections (~3% of total inspections). There were 890 fatality/catastrophe cases in FY 2016, 837 in FY 2017, 941 in FY 2018, 919 in FY 2019, and 1508 in FY 2020 [9]. The number of fatality/catastrophe cases totaled 5095 cases available to search for those involving a dump truck. A search was performed in the IMIS fatality/catastrophe database from 1 January 2026 to 31 December 2020 using the following search terms: dump truck and all federal and state offices. Based on the initial search criteria, 183 cases were identified. To refine the search, only closed cases were included in the study, and duplicate cases were removed after case review. Inspection cases were included in the study if a dump truck was involved either in the catastrophe or fatality. If a dump truck was mentioned in the narrative as a vehicle on site but with no involvement in the catastrophe of fatality, it was not included in the study. Based on the inclusion criteria, a total of 122 inspection cases were included in the study for analysis out of 5095 total fatality/catastrophe inspections (2.4% of all fatality/catastrophe cases involved a dump truck). Event type and injury type categories were identified using IMIS-assigned keywords under the IMIS Enforcement Data Processing Manual [10]. Geographic regions of occurrence of the dump truck-related fatal and nonfatal injuries were grouped into regions based on U.S. census regions [11].

2.4. Serious vs. Other and No Violations

The OSHA classifies a 'serious' violation as "when the workplace hazard could cause an accident or illness that would most likely result in death or serious physical harm, unless the employer did not know or could not have known of the violation". An 'other' violation is classified by the OSHA as "a violation that has a direct relationship to job safety and health, but is not serious in nature, is classified as "other-than-serious" [12]. IMIS data variables included in the study were 'serious' and 'other'. Blank cells were considered 'none'.

2.5. Statistical Analysis

The primary outcome of interest was whether a dump truck-related catastrophe (nonfatal injury) or fatality OSHA inspection case resulted in a serious OSHA violation.

Descriptive analyses and a Pearson's chi-square test were utilized to evaluate demographic and injury characteristic differences between fatal and nonfatal (catastrophe) injury groups. Statistically significant covariates included in the initial logistic regression model were geographic region, union status, OSHA violation type, ownership, injury event type, injury type, and exposure source. Due to the size of the data set, there was a significant collinearity between the injury type, exposure source, and event type categories. It was determined that dump truck-related electrocution inspection cases were a major source of data collinearity, so the injury type and exposure source variables were excluded from further analysis.

To determine whether the nesting structure should be statistically accounted for (i.e., case within state of incident), an intraclass correlation coefficient (ICC) was calculated using PROC MIXED using the restricted maximum likelihood estimation (REML) method to construct a null model featuring serious OSHA violation as the outcome, case within state of incident as the nesting structure, and no covariates. The results obtained from the null model contained case-level and state-level variance estimates with the general ICC calculation represented as (var(state))/(var(state)+var(case)) [13]. ICC values above 0.2 (ICC = 0.205; [4,5]) indicated that the state of incident had an appreciably non-zero effect on the variability of events being serious (relative to non-serious) OSHA violations. This indicates that events that happened within state were more similar to one another compared to events that happened in other states. Given this result, a multivariable generalized linear mixed effects model was calculated using PROC GLIMMIX while nesting the OSHA investigations by state and including relevant covariates. The covariates in this model were fatality, union status, ownership and injury event type. Point estimates for each covariate were exponentiated to provide an odds ratio and 95% confidence interval.

Statistical significance was determined with a threshold p-value less than 0.05. The Hosmer–Lemeshow goodness-of-fit test ($p = 0.49$) indicated an adequate fit for the final model. Predictive accuracy was measured by c-statistics (0.70). All analyses were conducted in SAS® Enterprise Guide v9.2.

2.6. Word Clouds

Word clouds are used to generate visuals based the analysis of word frequencies mentioned in the narrative text and to identify themes. Words clouds were generated using freewordcloudgenerator.com. Words with less than 5 appearances were omitted from the word clouds as well as the following words: 'dump', 'truck', 'company', 'also', 'employee', 'employer', 'months when injuries occurred (June, July etc.)', 'treated/treatment' and 'approximately'. Specific for the fatal injury word cloud, 'working' was also omitted.

3. Results

Dump truck workers injured on the job were primarily aged 55 years and older for both nonfatal and fatal injury groups (see Table 1). One quarter of the nonfatal dump truck injuries occurred in workers under 35 years of age compared to 17% in the fatal injury group. The higher percentage of nonfatal injuries in the younger age group could be due to unfamiliarity with a dump truck vehicle and resultant injuries such as hand and amputation injuries from the tailgate and caught between/caught in injuries.

Unsurprisingly, almost all fatal and nonfatally injured workers were male. Almost half (46%) of the fatally injured workers were construction inspectors, laborers, helpers, flaggers, and operators compared to 36% in the nonfatally injured group. The high percentage of fatal injuries among the construction inspectors, laborers, helpers, flagger, and operators may have been the result of struck-by injuries since laborers, flaggers, and helpers are more likely to be exposed directly to moving dump trucks.

Table 1. Demographic characteristics of dump truck-related injuries, 2016–2020.

Demographic Characteristic	Fatal (n = 88)	Nonfatal (n = 34)	X^2 *p*-Value
Age			0.486
18–34	15 (17%)	9 (26%)	
35–54	30 (34%)	11 (32%)	
55+	43 (49%)	14 (41%)	
Sex			0.375
Male	86 (98%)	34 (100%)	
Female	2 (2%)	0 (0%)	
Occupation			0.109
Construction inspectors, laborers, trades, helpers, flaggers; operators: heavy equipment, excavating and loading machine, grader, dozer, scraper, industrial truck, tractor equipment, paving, surfacing, tamping equipment	31 (46%)	10 (36%)	
Truck driver: heavy/tractor trailer, heavy, light	17 (25%)	6 (21%)	
Highway, machinery maintenance workers; Automobile mechanics; Driver-sales workers; motor transportation occupations	9 (13%)	2 (7%)	
Laborers, except construction	4 (6%)	7 (25%)	
Concrete and terrazzo finishers; roofers; surveyor; telephone installers and repairers; farmers except horticultural; groundskeepers and gardeners; managers and administrators, nec; operating engineers	6 (9%)	3 (11%)	
Geographic Region			<0.001
South	50 (57%)	6 (18%)	
Midwest	15 (17%)	4 (12%)	
Northeast	13 (15%)	8 (26%)	
West	10 (11%)	16 (47%)	
Union Status			0.007
Union	12 (14%)	12 (35%)	
Nonunion	76 (86%)	22 (65%)	
Industry			0.123
Construction	48 (55%)	21 (62%)	
Services	15 (17%)	9 (26%)	
Trade, transportation and utilities; manufacturing; agriculture, forestry, and fishing; mining	25 (28%)	4 (12%)	
OSHA Violation Type			0.004
Serious violation	46 (52%)	8 (24%)	
Other violation only/none	42 (48%)	26 (74%)	
Company Ownership			0.027
Private sector	82 (93%)	27 (79%)	
Public sector and self-employment	6 (7%)	7 (21%)	

One quarter of the fatally injured were truck drivers, which was similar to the nonfatally injured group. In the nonfatally injured group, one quarter of those injured were laborers (non-construction) in contrast with only 6% observed in the fatally injured group. The fatally injured truck drivers could be due to backing the dump truck on uneven surfaces, being run over by the truck, or working on the vehicle and being injured by the truck bed.

Over one half of the dump truck-related fatalities occurred in the southern region (57%) compared to only 18% of nonfatal injuries that occurred in the southern region. In contrast, almost one half of the nonfatal injuries occurred in the western region; only 11% of the fatal injuries occurred in the west. One quarter of the nonfatal injuries occurred in the northeast region. Nonunionized companies were overly represented in fatal dump truck crashes in this sample. For both groups, most of the nonfatal and fatally injured were nonunion employees, although 35% of the nonfatal dump truck injuries occurred among union workers. Over one half of the injuries in both fatal and nonfatal groups occurred in the construction industry. One quarter of the nonfatal injuries were among services industry workers, and 28% occurred among 'trade, transportation and utilities' workers, 'agriculture, forestry, and fishing' workers, and 'mining' workers. One half of the dump truck worker fatalities resulted in a serious OSHA violation, whereas three quarters of the nonfatal dump truck worker injuries resulted in an 'other' or no OSHA violation. Almost all the fatalities occurred in privately owned companies; in the nonfatal group, one quarter occurred among workers employed by local or state government entities.

Approximately 60% of the dump truck worker fatalities were 'struck by' incidents, whereas 47% of the nonfatal injuries were due to 'caught between/caught in' events (see Table 2). Most fatal injuries were due to crushing and blunt force trauma, whereas most nonfatal injuries were fractures/sprains and amputations. Twenty-two percent of the fatalities involved the dump truck backing up, which were followed by being run over (13%). The nonfatalities were dispersed in regard to source; the highest percentage (9%) involved a tailgate failure. When the exposure source was categorized, almost three quarters of the dump truck-related fatalities involved the vehicle in operation compared to 29% of the nonfatalities. Comparatively, 41% of the nonfatalities involved equipment failure.

The multivariable mixed effect model was nested by the state of the incident. Injury severity was significantly associated with serious OSHA violations in dump truck-related catastrophe or fatality OSHA inspection cases. Specifically, there was a 34% (95% CI: 1.08, 1.66) increased likelihood of the dump truck case resulting in a serious OSHA violation if there was a fatal injury versus cases that resulted in nonfatal injuries (see Table 3). Associations with serious OSHA violations and union status, ownership, and injury event type were not statistically significant ($p > 0.05$).

Table 2. Dump truck-related injury characteristics, 2016–2020.

Injury Characteristic	Fatal (n = 88)	Nonfatal (n = 34)	X^2 *p*-Value
Injury Event Type			0.016
Struck by	52 (59%)	12 (35%)	
Caught between/caught in	19 (22%)	16 (47%)	
Road departure; electric shock; falling object/fall	17 (19%)	6 (18%)	
Injury Type			<0.001
Crush; blunt force trauma	70 (80%)	6 (18%)	
Electrocution; traumatic brain injury; burn/asphyxiation	14 (16%)	4 (12%)	
Fracture/sprain; amputation	4 (5%)	24 (71%)	

Table 2. *Cont.*

Injury Characteristic	Fatal (n = 88)	Nonfatal (n = 34)	X^2 *p*-Value
Exposure Source			<0.001
Backing dump truck	27 (22%)	5 (4%)	
Run over	16 (13%)	2 (2%)	
Lowered bed	10 (8%)	1 (1%)	
Overturn	4 (3%)	0	
Raised bed struck powerline	7 (6%)	1 (1%)	
Dump truck and other vehicle	3 (2%)	1 (1%)	
Falling object	3 (2%)	0	
Ejection	2 (2%)	0	
Jack failure	2 (2%)	0	
Tailgate failure	1 (1%)	11 (9%)	
Backing vehicle into dump operator	1 (1%)	0	
Dump truck step	1 (1%)	1 (1%)	
Dump truck and other object	1 (1%)	1 (1%)	
Dump operator struck by other vehicle	1 (1%)	0	
Pickup truck struck by dump truck in work zone	1 (1%)	0	
Rear-ended	1 (1%)	0	
Jumped from dump truck	1 (1%)	0	
Two dump trailers	1 (1%)	0	
Brake failure	0	2 (2%)	
Hot asphalt	0	2 (2%)	
Slippery dump bed	0	2 (2%)	
Unguarded dump trailer attachment	0	2 (2%)	
Protruding object on ground	0	1 (1%)	
Moving object in bed	0	1 (1%)	
Exposure Source Categories			0.002
Cargo related	3 (3%)	5 (15%)	
Equipment failure	13 (15%)	14 (41%)	
Equipment in operation; fall; struck power lines	9 (10%)	5 (15%)	
Vehicle in operation	63 (72%)	10 (29%)	

Narrative word clouds generated for fatal and nonfatal dump truck-related injuries showed that for nonfatal injuries, the event narrative most often involved the words ‘finger’, ‘tailgate’, ‘bed’, ‘construction’, ‘hospitalized’, ‘a.m.’, ‘transported’ and ‘back’ (Figure 1). In the fatal injury event narratives, the words ‘killed’, ‘struck’, ‘a.m.’, ‘operating’, ‘trailer’, ‘crushing’, ‘asphalt’, ‘coworker’, ‘construction’, ‘head’, ‘load’, ‘loader’, and ‘injuries’ were mentioned most often.

Table 3. Mixed-effects model predicting the probability that an OSHA enforcement inspection of a dump truck-related catastrophe or fatality will result in a serious OSHA violation.

	Exponentiated Estimate	95% Confidence Interval	*p*-Value
Injury Severity			
Nonfatal			Reference
Fatal	1.34	1.08–1.66	0.009
Union Status			
Nonunion Workers			Reference
Union Workers	0.92	0.72–1.17	0.486
Ownership			
Public Sector and Self-Employment			Reference
Private Sector	1.10	0.81–1.48	0.547
Injury Event Type			
All Other †			Reference
Struck By	0.94	0.75–1.18	0.585
Caught Between/Caught In	1.05	0.81–1.36	0.698

† Excluding "struck by" and "caught between/caught in" incidents.

Figure 1. Dump truck-involved fatal and nonfatal injury narrative word clouds.

4. Discussion

The results of this study show that fatal dump truck-related injuries were more likely to result in a serious OSHA violation for the involved company. This was after nesting within the state of the incident and accounting for relevant covariates that included union status, ownership, and injury event type. While union status was not a significant predictor of a serious OSHA violation, nonunionized companies were overly represented in fatal dump truck injuries in this sample. The reason for the elevated number of nonunionized companies in the sample is unclear but could be due to the high number of fatalities that occurred in the southern region. The southern region historically has lower union representation compared to the other regions of the U.S. This finding highlights the need for enhanced safety training of workers, particularly in private nonunion industries, who work in environments that involve dump trucks. Last, based on the word cloud analysis, enhanced safety training is needed for those who work near dump trucks that are backing up and unloading hot asphalt as well as for those working around trailers, loaders, and pavers who were struck by the equipment. In addition, being caught between the truck bed and the truck frame and being electrocuted after the raised bed struck a power line were identified as exposure factors that more often resulted in worker fatalities.

There were higher percentages of struck-by injuries, crushings, and injuries due to the dump truck backing and/or being run over by the dump truck that resulted in fatalities compared to the nonfatal injury group. Similar to recommendations by McCann and Cheng [2], standard operating procedures for those working around backing dump trucks should always involve the use of a spotter(s) while the dump truck is backing up. Spotters, cameras to view the back of the truck, proximity detection systems, tag-based systems that utilize electronic sensing devices worn by workers on site, and internal traffic control plans are all recommended by the OSHA for truck-backing safety [14]. While the OSHA states provide these safety solutions and the use of spotters is a proven solution, there are no OSHA standards that require any of these safety solutions. Based on this study's results, the OSHA should consider the establishment of truck-backing standards in the future.

The use of hazard zone creation tools and databases to create a hazard zone around a backing dump truck may be examined for worker safety training development [15]. A study by Awolusi et al. (2015) [16] validated a hazard zone creation tool with dump trucks to create a hazard zone and increase awareness for workers of the truck-backing hazard. To evaluate the hard zone that was created, location-based data on the dump truck were used. In addition, power line contact alarms such as the one developed by the National Institute for Occupational Safety and Health [17] should be considered by dump truck owners and businesses. Box-up alarms and high volt alerts for use on dump trucks have been manufactured and are available for use by dump truck operators.

Last, dump truck worker trainings on bed repair standard operating procedures and avoidance of being caught between the raised bed and the truck frame should be regular worker safety training topics. A number of safety companies offer safety training on dump truck repair. Nonfatal dump truck-related injuries most frequently involved hand and finger injuries such as fractures and amputations due to lowering and raising the tailgate. Worker safety trainings on tailgate safety and tailgate repair are warranted.

Both fatal and nonfatal dump truck-related injuries occurred more often in workers who were 55 years of age and older. Number of years on the job was not an available data field, but the reasons for older worker injury susceptibility could be due to factors related to increased inurement to repetitive job activities that result in increased distraction. For example, hearing loss due to long-term exposure to construction noise and reduced physical mobility due to muscle and tendon overuse caused by repetitive job activities over time may also be risk factors for older workers' dump truck-related injuries. These declines could additionally be compounded by both age- and health-related declines in both sensory and physical functioning [18]. Further analysis of dump truck injuries among older adult truck drivers and older adult workers in the dump truck hazard zone is needed as the proportion of workers older workers is expected to continue to rise in 2030 [19]. While older adults continue to participate in the labor force in old age and bring necessary years of experience and skill to many occupations, a survey of older workers from 2023 revealed a large proportion of surveyed workers between the ages of 50 and 70 reported difficult working conditions [20]. Further research assessing on-the-job risk factors and age-specific injuries can assist with implementing targeted interventions such as promoting aging-friendly workplaces (e.g., providing age-inclusive management training for supervisors; use self-paced work, rest breaks, and less repetitive tasks) that are universally designed for older adults and will benefit workers of all ages [21].

In addition to both industry and driver characteristics, the region and state where the dump truck injuries and fatalities occurred was of importance. Over one half of the dump truck-related fatalities occurred in the southern region, and a significant proportion of the total variance was explained by clustering by state. While more research is needed with larger, more representative U.S. state samples, this finding could be partially explained by

enhanced OSHA reporting and inspection of dump truck-related fatalities or to an increase in the actual number of dump truck fatalities occurring in southern states. Given this study was not a complete census of all dump truck injuries in the U.S., the southern region may have been overrepresented. Another reason for this finding may be that many of the southern states are OSHA-approved federal plans (12 of the 17 southern states) and not OSHA-approved state plan states. OSHA state-plan occupational safety and health regulations must be at least as stringent as OSHA federal-plan states; state-plan states are tailored to state-specific needs and many have more stringent OSHA regulations than federal-plan states.

The reporting of OSHA inspections by all states was not available in the IMIS data system. One possible solution is to recommended that all states be required to submit work-related highway incident data to the OSHA IMIS. This would allow for more comprehensive understanding of geographic variations in dump truck-related fatalities, especially in the context of other relevant predictors such as union status and ownership.

There are a number of limitations to the current study. This study represented OSHA inspections of dump truck-related catastrophes and fatalities and did not represent a complete census of all dump truck-related injuries nationwide. Injuries that occur on the roadway are not required to be reported to OSHA for inspection and entry in IMIS, but states are required to submit roadway incident data into OSHA injury and illness records [22,23]. This also contributed to a smaller available sample size of cases, limiting the ability to detect significant effects of relevant covariates that significantly differed across fatal versus nonfatal injuries. In addition, the coding of the narratives was performed through keyword searches, which could have resulted in the missed identification of additional risk factors for dump truck-related injuries.

5. Conclusions

In conclusion, this study showed that after accounting for state of occurrence, union status, ownership, and injury event type, fatal dump truck-related injuries were more likely to result in a serious OSHA violation. Nonunionized companies incurred more fatal dump truck injuries, although union status was not a predictor of a serious OSHA violation, and the elevated number of fatal injuries illustrates the need for enhanced dump truck worker safety training in private nonunion industries. In addition, enhanced safety training is needed for those who work near hot asphalt dump trucks and those that are backing up and near power lines as well as for those working around trailers, loaders, and pavers. An overall company safety program that addresses all of the hazards that we identified in this study is needed in industries that utilize dump trucks.

Based on the study results, the following are safety recommendations when working around dump trucks:

1. Industries that employ dump trucks in their work activities should provide initial and refresher worker safety training to dump truck drivers and to other employees who work within the dump truck hazard zone. Initial training on familiarization with the dump truck vehicle tail gate and bed and associated trouble shooting is needed to prevent injuries. Construction inspectors, laborers, helpers, flagger, and operators may also benefit from targeted safety training on the dump truck hazard zone and exposure to moving trucks to prevent injuries such as struck-by injuries. Dump truck drivers could benefit from safety training on safely backing the dump truck on uneven surfaces preventing run-overs by the dump truck, and repairing the vehicle.
2. Enhanced worker training is specifically recommended for employees that utilize dump trucks for working with asphalt, and for working around power lines, as well as for employees involved in the repair of truck beds and tailgates.

3. Fatal dump truck-related injuries were associated with serious OSHA violations. It is imperative for companies to implement rigorous safety policies and procedures to reduce the risk of fatal and nonfatal injuries. Serious OSHA violations can damage a company's reputation, incur financial losses, and result in increased regulatory oversight. OSHA standards should be established to increase safety when working around dump trucks such as the use of dump truck spotters, proximity detection systems, tag-based systems, and internal traffic control plans.

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