Analysis of Text From Injury Reports Improves Understanding of Construction Falls

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Objective: *We combined payroll data, coded workers' compensation (WC) data, and text descriptions of injuries from the construction of Denver International Airport to create a more comprehensive picture of falls from height (FFH) than is typically available from WC data. Text descriptions were coded to identify circumstances surrounding falls. Slips/trips preceded one third of FFH, often involving motor vehicles or heavy equipment. Another third involved movement or collapse of work surfaces, usually ladders or scaffolds.* ***Conclusions:*** *The significant contribution of motor vehicles and heavy equipment to FFH, particularly those preceded by slips/trips, was not apparent from coded data. Heavy equipment engineering modifications are called for and workers in street/roadway construction/site development need fall protection training. Text analyses allow exploration of factors not identified at the time of data collection and better understanding of the context in which injuries occur.* (J Occup Environ Med. *2004;46:1166–1173*)

Falls from height often result in severe injuries to construction workers. They are responsible for a disproportionate share of costs and lost work time compared with other injuries.[1–4] Emergency department surveillance has shown that 64% of injuries to urban construction workers serious enough to require hospitalization were the result of falls.[5] Analyses of death certificates between 1980 and 1989 revealed that in construction, occupational falls accounted for 2798 deaths, representing nearly half (49.6%) of fatal occupational falls across all U.S. industries.[6]

WC data are a useful source of information on occupational falls but they are limited. Alone, they provide no information on the underlying population at risk. WC information is typically limited to coded data based on the First Report of Injury (FRI) filled out by administrative staff, the injured worker, or supervisor in the process of filing a compensation claim. Many claims are coded as "fall to a lower level" or "fall from elevation," lacking detail necessary to understand the surface from which the person fell or the circumstances surrounding the injury.[2,7]

The Denver International Airport (Denver, CO), built between 1989 and 1994, was the largest construction project in the world at the time. In total, 2843 contracts were awarded to 769 contractors without prequalification based on prior health and safety records. The work involved over 32,000 employees. An Owner Controlled Insurance Program (OCIP) provided WC and lia-

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bility coverage for the project and an on-site medical clinic and physician referral system managed the 4634 injuries sustained. Contractors reported monthly payroll and job classification based on National Council of Compensation Insurance (NCCI) codes. These job classifications define specific types of work such as iron and steel erection under 3 stories or concrete construction rather than types of workers or trades. In addition, brief text information from first reports of injury was available, as were reports of injury investigations conducted by safety personnel or supervisors shortly after injuries occurred. We describe the use of these data to gain a more comprehensive understanding of falls from height (FFH) than is typically available from coded WC data.

Materials and Methods

Administrative data from the building of the Denver International Airport (DIA) were used to calculate the rates and costs associated with work-related falls sustained in the building of the airport. Details of the coded data sources and conversion of audited payroll data to hours worked and type of work have been previously reported.[8,9] Payment data included medical, wage replacement, and impairment payments adjusted to 1992 dollars.

We used text descriptions from First Reports of Injury (FRI) associated with the filing of a WC claim and accident investigation reports (AIR) completed by on-site safety personnel or supervisors to better understand the circumstances surrounding these injuries and to identify injury prevention opportunities. Coding of the text data involved the use of a qualitative software package (N5)[10] to import and code the available text. Basic information on the type of injury such as a fall as well as the initial energy exchange leading to injury were coded from text descriptions when available. The mechanism of injury event (MOIE) was used to code common circumstances surrounding the initial energy exchange; specifically, falls were assigned to subcategories designating whether the fall had begun with a slip or trip, a collapse of a work surface, or some other distal cause. Factors in the text determined to contribute to the injury were categorized using a modification of Haddon's matrix[11] designed to distinguish contributions of agent (tools, equipment), humans (worker, coworker), environmental and organization factors. Some of these factors were created to specify the surface from which the worker fell. The qualitative codes assigned to each injury were then exported to SAS version 8.12[12] and merged with the administrative data; the administrative variables were likewise exported to N5, so that each analysis package contained both the administrative and text-derived data.

Analyses

Initial analyses used information available from the original administrative data sources. We identified falls from height using modified ANSI codes; the American Standard Method of Measuring and Recording Injury Experience of the American National Standards Institute (ANSI) was accepted in 1927 by employers and the Bureau of Labor Statistics as the standard for recording and reporting work injuries.[13] These codes have been used by all states participating in the supplemental data system of the BLS since 1976, and they form the basis for comparisons of WC data on injuries. Codes include a designation for body part injured, nature of injury (cut, sprain, fracture), the type of event causing the injury (fall, overexertion), and the source of injury (ladder, power saw).

We generated descriptive statistics on the construction domain (7 major categories comprising several activities, eg, site preparation and building construction) in which the injuries occurred and the surfaces from which the workers fell. Overall injury rates and rates for specific types of work were calculated per 200,000 hours worked. Confidence intervals were constructed as described by Haenzel et al.[14] assuming a Poisson distribution. The distribution and sum of payments for medical care and paid lost wages and impairment (together referred to as indemnity payments) were calculated as were payment rates per $100 of payroll.

We incorporated the textual data into 3 kinds of analyses:

- To assess the accuracy of the administrative data in capturing falls from height, we compared falls from height recorded in the administrative dataset with those identified from review and coding of text data from FRI and AIR. Individual records were reviewed for cases in which the coding was not in agreement.
- We examined the distributions of broad categories of factors identified as contributing to falls from height (victim, coworker, equipment or materials, environmental and organizational issues) by the most distal energy exchange. For example, we looked at factors contributing to falls from surfaces that moved or collapsed separately from falls that began with a slip. Similarly, the surfaces from which the workers fell were examined separately for these different distal causes.
- To identify opportunities for prevention, we looked for common patterns of factors contributing to, or circumstances surrounding, these falls from height focusing on high-cost falls and falls that resulted in death. The process was facilitated through the generation of text reports using the qualitative software.

Results

Administrative Data

We identified 290 falls from height in the coded administrative data; these represented 6.3% of all injuries incurred in the construction of the airport. Three falls resulted in death from multiple injuries; 2 occurred on the same day. Workers injured in falls from height ranged from 18 to 70 years of age; the mean age of those who fell from height was 37.4 years.

Over 66% of the surfaces from which these workers fell were coded in the administrative data only as "fall to a different level" or "other," providing little detail about the surface from which the fall occurred (Table 1).

Falls from height resulted in 83,722 paid lost days from work (mean, 288.7); in Colorado, lost work time payments begin after the third shift away from work. Payments for medical care, wage replacement, and impairment exceeded $8 million (Table 2), equivalent to payments of 27 cents for every hour worked or $540 for every full-time worker at DIA per year.

Frequencies of injuries from falls from height, injury rates, and payment rates are presented by type of work in Table 3. Overall, falls from height occurred at a rate of 1.9 (95% confidence interval, 1.6–2.1) per 200,000 hours worked; the payment rate was $3.48 per $100 of payroll. Concrete construction accounted for the greatest number of falls and its fall injury and payment rates were among the highest. Workers in carpentry and glass installation also experienced high fall injury rates, but the payment rates for these types of work were well below the overall mean, indicating that their falls were not as severe as those occurring in other types of work. Iron and steel erection over 2 stories exhibited high rates of injury and payment rates that exceeded the overall rate. Although fall rates were relatively low in street/road construction, the frequency was second and payments were nearly $5.00 for every $100 of payroll. The payment rate for roofing work was the highest, over 4 times higher than the overall workforce, and the rate of injury was also among the highest. However, roofing work constituted a relatively small number of the hours worked at DIA, and these high rates are a reflection of 2 costly falls.

Text Data From Injury Reports and Investigations

An FRI, AIR, or both were available for 4148 of the 4634 injuries (89.5%) incurred at DIA. Of the 290 falls from height mentioned in the administrative data, there were 217 (75%) with an FRI, an AIR, or both. Based on the text analyses, we found an additional 10 injuries from falls from height; these were originally

TABLE 1
Surfaces From Which Falls From Height Occurred, Denver International Airport Construction (according to coded administrative data)

Description	Frequency (%)
Different level	185 (63.8)
Ladder/scaffold	76 (26.2)
Motor vehicle	11 (3.8)
Shaft/opening/excavation	8 (2.8)
Miscellaneous/other	10 (2.5)
Total	290 (100.0)

TABLE 2
Workers' Compensation Payments Associated With Falls From Height, Denver International Airport Construction (using coded administrative data)

Direct Costs	Mean (median)	Total
Medical	$9126 ($891)	$2,646,554
Wage replacement and impairment	$19,017 ($0)	$5,515,020
Total	$28,687 ($1097)	$8,319,301

TABLE 3
Injury and Payment Rates* By Type of Work; Falls From Height, Denver International Airport Construction

Trade	Frequency	Injury rate (95% confidence interval)	Cost rate
Insulation	2	2.6 (0.31—9.4)	0.09
Masonry	4	1.1 (0.30—2.8)	0.30
Carpentry	24	3.9 (2.5—5.8)	1.30
Concrete construction	57	3.5 (2.7—4.6)	3.70
Concrete/bridges	1	0.81 (0.02—4.5)	0.08
Street road/construction	44	1.7 (1.2—2.3)	4.99
Iron/steel >2 stories	18	4.3 (2.5—6.8)	4.53
Metal/steel installation	6	2.8 (1.0—6.1)	1.46
Painting	2	1.2 (0.15—4.3)	3.36
Plumbing	19	2.1 (1.3—3.3)	0.17
Pipefitting	6	1.4 (0.51—3.1)	0.08
Sheet metal	6	1.9 (0.70—4.1)	0.53
Drivers	1	1.1 (0.03—6.1)	0.03
Electrical wiring	34	1.8 (1.3—2.5)	0.43
Conduit construction	4	1.7 (0.14—4.4)	0.03
Low volt specialty	1	0.59 (0.02—3.3)	0.27
Roofing	2	3.3 (0.04—11.9)	16.4
Elevator construction	3	2.6 (0.53—7.6)	0.49
Glass installation	9	4.1 (1.9—7.8)	0.64
Superintendent	10	0.71 (0.34—1.3)	0.06
Inspectors	2	0.68 (0.08—2.5)	0.00
Engineers/architech	4	0.69 (0.19—1.8)	0.01
Heavy equipment	18	2.2 (1.3—3.5)	2.32
Clerical	3	0.43 (0.09—1.3)	0.15
Overall†‡	280	1.9 (1.6—2.1)	3.48

*Injury rates are per 200,000 hour; payment rates are per $100 of payroll.
†No falls from height were identified in boiler making, plastering/finishing, stone crushing, pile driving, crane hoisting, iron/steel erection under 2 stories or electrical power line work.
‡Remaining falls in "other" category.

TABLE 4
Surfaces From Which Falls From Height Occurred, Denver International Airport construction (identified from text data in First Reports of Injury and Injury Investigations)

Surface	Fall preceded by slip/trip (*n* = 71)	Fall preceded by collapse/ movement of work surface (*n* = 68)	Other falls (*n* = 88)	Overall (*n* = 227)
Ladder	11 (15.5%)	29 (42.6%)	18 (20.5%)	58 (25.6%)
Scaffold	8 (11.3%)	12 (17.6%)	10 (11.4%)	30 (13.2%)
Motor vehicle or heavy equipment	26 (36.6%)	—	11 (12.5%)	37 (16.3%)
Work surface, through opening	2 (2.8%)	9 (13.2%)	6 (6.8%)	17 (7.5%)
Work surface, unsecured		4 (5.9%)		4 (1.8%)
Wall			7 (8.0%)	7 (3.1%)
Decking			3 (3.3%)	3 (1.3%)
Concrete forms			4 (4.5%)	4 (1.8%)
Stilts	4 (5.6%)		1 (1.1%)	5 (2.2%)
Airport specific surfaces (telecar tracks, baggage handling equipment, conveyor)	4 (5.6%)	2 (2.9%)	4 (4.5%)	10 (4.4%)
Ground near hole or embankment			6 (6.8%)	6 (2.6%)
Miscellaneous other	15 (21.1%)	12 (16.2%)	13 (14.8%)	40 (17.6%)
Unable to determine	1 (1.4%)		5 (5.7%)	6 (2.6%)

coded as injuries in which the worker was struck by or against something ($n = 7$), caught ($n = 1$), a temperature-related exposure ($n = 1$), and a cut ($n = 1$).

Surfaces from which these workers fell are presented in Table 4 according to the circumstances leading to the fall (slip/trip, collapse of work surface, or miscellaneous other circumstances). Overall, falls most commonly occurred from ladders, motor vehicles, or heavy equipment and scaffolds (55.1%). Ladders accounted for 42.6% of falls preceded by the collapse or movement of a work surface, followed by scaffolds (17.6%) and openings (13.2%). Among falls preceded by a slip or trip, workers most often fell from motor vehicles or heavy equipment (36.6% of such falls); falls preceded by a slip or trip from ladders or scaffolds were less frequent (26.8%).

In Figure 1, the construction domains where falls from height occurred are presented according to the precipitating event. The vast majority (71%) of injuries occurred in building construction. A greater proportion of falls in the airfield, roadways, and site development domains were preceded by a slip than by collapse of a work surface, whereas

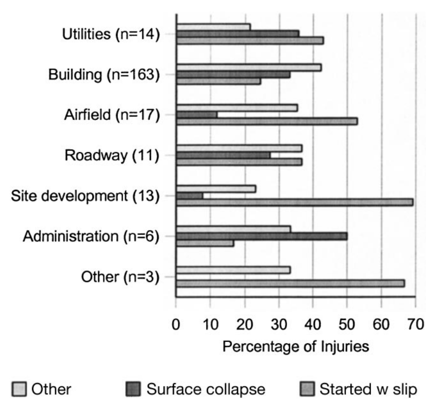

Fig. 1. Construction domain where falls from height occurred by initiating event, Denver International Airport construction.

those that occurred in building construction were more frequently associated with collapse of a work surface.

The distribution of factors contributing to falls from height are presented in Table 5. An average of 2.7 factors was identified in the text data for each fall. It is important to recognize that contributing factor codes were assigned based only on information documented in the FRIs or AIRs. The most common victim-related factor was inappropriate action, usually a reference to the worker failing to pay attention to the task or carelessness. Occasionally there were references to the worker being tired, having worked overtime, or working rapidly at the time of injury. Safety infractions captured site-specific policy violations, including failure to tie off or use appropriate railings on scaffolding.

Scaffold or ladder injuries preceded by collapse or movement of the work surface included ladders that collapsed, "kicked back" or slipped, shifted, or tipped. Use of inappropriate or damaged ladders was documented in some injury reports; for example, 1 mentioned a worker inappropriately using only the top portion of an extension ladder. Injury reports also identified scaffold problems, including collapse of planking and failure to have railings in place. Also documented were falls occurring while dismounting the scaffolding. Falls were also associated with openings that were covered but not secured.

All falls preceded by slipping in the site development, roadway, and airfield construction domains ($n = 22$) were from heavy equipment, motor vehicles, or a pipeline. Over one third ($n = 12$; 36.4%) of the falls from motor vehicles or heavy equipment occurred as the worker was dismounting the equipment; only one occurred as the worker was mount-

TABLE 5

Factors Identified as Contributing to Falls From Height; Denver International Airport Construction (identified from text data from First Reports of Injury and Injury Investigations)

Contributing factors	Fall preceded by slip/trip (n = 71)	Fall preceded by collapse/movement of work surface (n = 68)	Other falls (n = 88)	Overall (n = 227)
Victim				
Inappropriate action	12 (5.6)	10 (5.7)	26 (10.9)	48 (7.8)
Safety infraction	14 (7.0)	6 (3.5)	4 (1.7)	24 (3.9)
Speed of work (hurrying)	2 (1.0)	—	3 (1.3)	5 (0.8)
Fatigue	3 (1.5)	—	—	3 (0.5)
Inexperience	2 (1.0)	1 (0.5)	2 (0.8)	5 (0.8)
Coworker				
Inappropriate action	—	3 (1.7)	8 (3.5)	11 (1.8)
Safety infraction	1 (0.1)	—	1 (0.4)	2 (0.3)
Materials/object	15 (7.5)	27 (15.6)	28 (11.7)	70 (11.4)
Equipment (excludes motor vehicles)				
Altered	1 (0.1)	9 (5.3)	2 (0.8)	12 (2.0)
Failure	1 (0.1)	22 (12.7)	4 (1.7)	27 (4.4)
Personal protective equipment	—	—	1 (0.4)	1 (0.2)
Structure				
Altered	—	1 (0.5)	—	1 (0.2)
Failed	—	4 (2.3)	2 (0.8)	6 (1.0)
Stairs	—	1 (0.5)	—	1 (0.2)
Floor conditions	15 (7.5)	12 (6.9)	20 (8.4)	47 (7.7)
Other	7 (3.5)	10 (5.8)	13 (5.4)	30 (4.9)
Scaffold or ladder	21 (10.5)	38 (0.5)	26 (10.8)	85 (13.9)
Motor vehicle/heavy equipment	23 (11.4)	—	10 (4.2)	33 (5.4)
Work area condition				
"Tight area"	—	1 (0.5)	—	1 (0.2)
Poor lighting	1 (0.1)	—	1 (0.4)	2 (0.3)
Slippery surface (not weather-related)	16 (8.0)	1 (0.5)	5 (2.1)	22 (3.6)
Ground conditions	33 (16.4)	10 (5.8)	36 (15.1)	79 (12.9)
Environmental				
Weather	3 (1.5)	—	5 (2.1)	8 (1.3)
Terrain (slope, conditions, and so on)	3 (1.5)	1 (0.5)	4 (1.7)	8 (1.3)
Walking surface (indoor)	6 (3.0)	—	15 (6.3)	21 (3.4)
Nonterrain slippery	16 (8.0)	1 (0.5)	5 (2.1)	22 (3.6)
Step up	1 (0.1)	7 (4.0)	1 (0.4)	9 (1.5)
Organizational				
Housekeeping	4 (2.0)	1 (0.5)	—	5 (0.8)
Tools/equipment	—	1 (0.5)	—	1 (0.2)
Training	—	1 (0.5)	—	1 (0.2)
Proximity of other workers	—	—	2 (0.8)	2 (0.3)
Unfinished work	1 (0.1)	5 (2.9)	10 (4.2)	16 (2.6)
Poor lighting	—	—	1 (0.4)	1 (0.2)
Total different contributing factors	201(100%)	173(100%)	239(100%)	613(100%)

ing the equipment. In contrast, falls preceded by slipping in building construction involved a wide variety of surfaces, including ladders, stilts, scaffolds, motor vehicles, and concrete forms, for example. In a number of cases, the worker was described as slipping or losing footing while climbing or descending ladders or scaffolding; sometimes this was related to carrying something, but often such specific details were missing from the text descriptions.

There was documentation of failure to use proper personal protective equipment (PPE) or its misuse in 14 falls. In three cases, the worker disconnected PPE to move from one tie off point to another; another worker had ascended a ladder and was reaching for his lanyard behind him when he fell. In one case, the worker was wearing appropriate equipment and reported thinking he was tied off. We were able to identify three falls, resulting in relatively minor injuries, in which the worker was tied off and the fall was arrested by his PPE; the injuries resulted from striking something rather than from the PPE itself.

High-Cost Falls

Seven falls resulted in WC payments of over $200,000. Three of these high-cost claims, including the most costly injury on-site, involved falls from heavy equipment. Little detail was available on these three falls other than a description of the worker having slipped before the fall. Two others involved falls from ladders. In one case, the worker slipped as he was descending the ladder while carrying his lunch box. In the other case, the ladder had been set against a pipe without being secured properly; the ladder fell over as the worker tried to get onto the ladder to descend. For another high-cost fall, it was difficult to understand from the available text why the worker had fallen, although there were detailed descriptions of his having been in a closed, dark stairway with considerable delay in finding and getting him to medical care. The final high-cost claim resulted in death and is described in more detail subsequently.

Fatalities

There were three fatal falls from height stemming from two separate events both involving collapse of a surface. These were the only deaths that occurred throughout the project. As would be expected, the Occupational Safety and Health Administration (OSHA) investigated these events and produced more detailed information about the circumstances surrounding each fatality.

The first incident involved the collapse of a 3-point suspension scaffold being used as two men sanded and painted the interior of an aviator fuel tank. One worker was tied off and survived; the other was not tied off and fell 20 feet to his death. Contributing factors identified included a mix of human and organizational issues: 1) lack of training in operational procedures to follow in the event of a problem with equipment, 2) use of a hoist that was not approved for the amount of weight involved, 3) use of a suspended scaffold wire roping that should have been inspected, and 4) failure to use a fall arrest system while working on a suspended scaffolding.

The second incident involved two ironworkers on the sixth floor of the airport office building. One worker was seated on a beam that was being connected to a column, whereas the other was standing at the base of the column at the top of a sheer concrete wall. The base of the column had been secured by temporary tack welds to an embedded steel plate. The column was seated about 1 inch away from the proper position and was being pulled by tensioning a cable guy wire, using a come-along, when the tack welds at the base of the column broke. One man, tied off to the column that collapsed, fell to his death. The second worker was tied off to a horizontal beam suspended from a crane. He grabbed the column as it started to fall. His lanyard slipped off the end of the horizontal beam and he fell 35 feet. Again, both human and organizational factors were identified that contributed to these two fatalities: 1) structural steel members had been allowed to be erected and left unbraced (only tack welds); and, 2) the decision to tie off to the horizontal beam supported by a crane resulted in the lanyard slipping and the worker falling.

Discussion

In these analyses, text data, obtained primarily from first reports of injury and injury investigations, were catalogued with text analysis software and used in conjunction with administrative data to study construction falls from height. The project's administrative data provided coded information on mechanism of injury, which allowed identification of the vast majority of falls from height. Data on lost workdays and WC payments associated with the injuries, contained in the administrative database, provided measures of severity that can help establish priorities for prevention. By combining these measures with payroll and estimates of hours worked by type of work, we were able to identify types of work with particularly high rates of falls from elevations and those with high payment rates. Although from the perspective of public health importance, an argument can clearly be made for focusing prevention on types of work with high frequencies of falls from height, frequency is not the only measure that should be considered. High *rates of injury* imply high-risk work conditions or behaviors that should be identified and modified if possible, whereas *payment rates* reflect severity and/or frequency.

In our analyses, workers in concrete construction and street and road construction incurred large numbers of fall-related injuries, and we also observed high fall injury and payment rates for these 2 types of work making them prime targets for further work to identify and quantify risk and focus prevention efforts. Workers in iron and steel erection over two stories incurred fewer injuries from falls from height than workers in a number of other types of work, but we found high injury and payment rates for this group, which probably indicated high-risk work and more severe injuries. Payment rates are not a perfect indicator of severity; only one of the deaths entailed payments over $200,000, whereas six injuries not resulting in death incurred payments at this level, documenting that WC payments for fatalities can be lower than those for nonfatal injuries.

A wide range of circumstances is relevant in understanding the sequence of factors contributing to construction falls and translating that understanding into recommendations for prevention. The administrative data were greatly lacking in depth of information; for the majority of falls, we could not even discern the surface from which the worker fell. The contributions of ladders as well as motor vehicles and heavy equipment, obvious in the brief text data, were significantly underrecognized in the administrative data. Although the contribution of ladders to the burden of falls from height is well documented,[2,15] the same is not the case for motor vehicles and heavy equipment. Information available from the FRIs and AIRs was more abundant but still lacked clarity at times. The methods we used to code circumstances surrounding the injury were easier to apply to reports richer in information such as the text data abstracted from OSHA reports on fatalities.

Limitations

There are a number of limitations, or drawbacks, to our approach. First, it is tedious and time-consuming to enter, code, and analyze text data such as these. Our retrospective analyses used data that were available from a single construction project. The injury investigations were performed by safety staff at the time of construction and were not designed for epidemiologic purposes; the text data were often limited to only a few lines of information. In some reports, it was clear that the focus was on understanding how better to respond to that particular injury rather than on the circumstances surrounding the injury itself. An example of this was a report with detailed information from multiple sources about why there had been a significant delay in finding and evacuating the injured person but no description of the injury itself or how it occurred.

Administrative data on hours worked were available in aggregate from contractors' payroll data. They provided information that is useful in targeting higher-risk types of work, but they did not allow us to identify personal risk factors or work exposure information beyond the broad designation of type of work. The very high rate of falls from height among roofers is likely a partial reflection of the vast majority of their work being performed at height. A rate based on hours worked at height might actually demonstrate that they control their daily risk better than other types of work, but this level of exposure information is difficult to acquire for the construction trades.

Industry attention to fall protection has improved since the time of this project, including promulgation of the federal OSHA standard for fall protection in 1994. However, a number of elements of the current fall protection standard for the construction industry were part of the safety policies on this construction site, including requirements that workers be tied off when working at heights above 6 feet.

Strengths and Contributions

Despite these limitations, the approach we used has some notable advantages, and our analyses make a number of contributions to understanding factors contributing to falls from height. Although for some injuries, the administrative and text data were too sparse to be helpful in developing prevention approaches, the combination of text and coded administrative data was useful. The process allowed the management of standard quantitative data in a statistical program designed for that purpose while maintaining a linkage to more complex, unstructured text. The text software allowed rapid retrieval of text reports from single or combined categories of assigned codes.

The information gained by combining text reports with administrative data goes beyond largely descriptive analyses by broad mechanisms of injury that are possible in typical coded WC data. For example, we could discern which falls were preceded by a slip, and in many cases the surface or object from which the person had slipped, as well as falls that resulted from collapsing work surfaces and factors that contributed to the collapse. We could identify situations in which poor work practices such as failure to use personal protective equipment had contributed to the fall and situations where PPE had likely lessened injury severity. The involvement of a person well versed in construction (KG) was crucial in retrospective analyses of text data such as these; the ability to understand construction terminology and brief descriptions of activities or events was critical to much of the coding and analyses.

Conclusions

A significant proportion of falls, including some of the more costly injuries, particularly in site development, roadway, airfield, and utilities construction, were preceded by victim slips or trips. Many of these were associated with falls from motor vehicles or heavy equipment. These falls present prevention challenges different from those in building construction, and the injury reports often contained only simplistic recommendations for the victim to be more careful on heavy equipment. The falls often occurred as the victim was dismounting equipment, often were influenced by weather and occurred in situations in which standard fall prevention practices and use of personal protective equipment were not in place. The information we were able to collect about these falls present opportunities for engineering advances such as alteration in ladders used to mount and dismount equipment, incorporating nonslip materials on ladders and work surfaces of heavy equipment, built-in tie-off anchors, and so forth. The findings also demonstrate the importance of fall prevention training for operators of heavy equipment.

The data on collapses or unstable surfaces point to continued need for appropriate selection and use of work practices on ladders and scaffolding,[2,16,17] as well as attention to both covering openings and adequately securing coverings.

Text analyses, even from fairly brief reports, allow an improved understanding of work activities, behaviors of victims and coworkers, and work conditions associated with injuries. In this study, the incorporation of text data into analyses provided fairly detailed information about injuries sustained on a large construction site, information that is particularly difficult to acquire for workers whose job sites change on a daily basis. We found that the use of a modified version of Haddon's matrix as a conceptual model provided a framework to identify points of intervention at multiple levels: personal, organizational, environmental, and tools/equipment. Although information obtained from close-ended questions and coded data are easier to enter, manipulate, and analyze than text descriptions, there are a number of advantages to incorporation of text into data collection and analyses. Text allows the identification and exploration of factors that may not be recognized as important at the time of injury reporting,[18] and potentially better understanding of the context in which injury occurred. This process moves beyond much injury epidemiology, which has focused on identifying high-risk groups, sometimes according to factors that are not modifiable such as age or gender and does not necessarily provide information necessary to recognizing prevention opportunities.[19] The use of text data could be improved significantly through the use of a standard format for prospective data collection with routine quality control. Guiding investigators to consider the point of initial energy exchange and multiple contributing factors or points of intervention, as is possible with the use of Haddon's matrix, could lead to much more useful information than is provided by currently used methods. Data collected in such a manner would have helped considerably in our analyses of these falls. Defined areas of possible intervention would be routinely considered as data about injuries were collected, resulting in information more appropriate for formal hypothesis-testing activities.

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