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# Deaths from External Causes of Injury Among Construction Workers in North Carolina, 1988–1994

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**Records from the Office of the North Carolina Chief Medical Examiner were used to describe 3955 deaths, both on and off the job, between 1988 and 1994 from external causes of injury (E-codes) among individuals whose usual occupation was in the construction trades. For the calculation of rates, population sizes were estimated using 1980 and 1990 census data. Deaths from injuries occurred at an average rate of 226 per 100,000 population; 213 per 100,000 for non-work-related fatalities and 13 per 100,000 for work-related fatalities. Overall, deaths were most often from guns or motor vehicle accidents. Work-related deaths were most often caused by motor vehicles (21%); falls (20%), most commonly from roofs or scaffolds; and machinery (15%), electrocutions (14%), and falling objects (10%). Three major causes of work-related motor vehicle accidents were identified including injuries to pedestrians in highway work zones and in backovers on construction sites, and injuries to drivers caused by shifting loads while transporting construction materials. The circumstances surrounding deaths involving scaffolding document the need for training and safety procedures for erecting, moving, and disassembling scaffolds, but also for safe work practices on scaffolds. Training and safety procedures to avoid electrocutions must involve workers who are not in the electrical trades, as these deaths often occurred among individuals who were not electricians or linemen. Significant differences were observed in the proportion of victims having elevated blood-alcohol levels depending on whether the injury was work-related; 57 percent of victims were impaired at the time of fatal non-work-related injuries compared to 5 percent of work-related injuries. Interventions to treat and prevent alcohol abuse among construction workers could have a significant public health impact in the prevention of premature death from injury, particularly outside the workplace.**

**Keywords** External Causes of Injury, E-Code Deaths, Construction Workers, Fatalities

A number of studies, based on analyses of death certificate data, have documented excess accidental and violent deaths among construction workers.[1–3] These deaths include traumatic fatalities from falls, transportation accidents, and accidental poisonings, as well as homicides and suicides. Our recent proportionate mortality study among North Carolina construction workers between 1988 and 1994 revealed excess deaths from multiple external causes of injury (E-codes) including transportation accidents (PMR = 106), accidental poisonings (PMR = 136), accidental falls (PMR = 132), 'other accidents' (PMR = 126), and homicides (PMR = 141) for male construction workers, and the magnitude of these excesses varied among construction subtrades.[4]

Proportionate mortality studies of construction workers also show excess deaths due to alcohol-related causes including alcoholism, cirrhosis of the liver, and esophageal cancer.[2,4] Alcohol may also play a role in some deaths from external causes of injury. Alcohol has been reported to be a risk factor for serious falls[5,6] and trauma resulting from violence, both as a perpetrator and as a victim.[7] Although there is evidence that alcohol may contribute to work-related injuries, these data are contradictory and relatively little is known about the role of alcohol and drugs in workplace injuries. These discrepancies suggest substance abuse plays different roles in different settings.[8,9] The interaction of alcohol and other risk factors in accidental deaths may be particularly important.[10–12]

Death certificate data lack information on the circumstances of death which might provide greater insight into their causes and preventive strategies. Some of these deaths occurred while the victim was working and could have been prevented by interventions in the workplace. From a broader public health perspective, it is also important to gain better understanding of the circumstances surrounding deaths from external causes of injury among construction workers, regardless of whether they occur while working or not.

North Carolina has an extensive database available through the Office of the Chief Medical Examiner (OCME). Deaths resulting from "violence, poisonings, accidents, suicides, or

homicide; occurring suddenly when the deceased has been in apparent good health; occurring in jail, prison, a correctional institute or in police custody; or occurring under any suspicious, unusual or unnatural circumstances" must be reported to the State Medical Examiner's Office.[13] In an attempt to capture all accidental deaths that occur in the workplace, each report filed by a county examiner is reviewed by a forensic pathologist in the central office before a trained coder does final coding as to whether the death occurred 'on the job' or was the result of 'an injury at work.' These data provide an opportunity to explore more fully the excesses of accidental deaths among construction workers described in several mortality studies, and specifically those deaths included in our previous proportionate mortality study of construction workers in North Carolina.[4] The N.C. OCME records from 1988–1994 routinely include toxicology screens for blood alcohol. Although these data do not provide information which allows the characterization of drinking behaviors of these victims or their peers who were not injured, the data do provide the opportunity to identify the number of deaths in which the blood alcohol level of the victim might have played a significant contributing role.

## METHODS

Electronic data were obtained from the North Carolina Office of the Chief Medical Examiner (OCME), for deaths between 1988 and 1994 among individuals whose primary employment was listed on the death certificate as construction (defined by the Standard Industrial codes 15, 16, and 17). All deaths resulting from external causes of injury (ICD-9 codes E800–E999) were identified. Frequencies of death were calculated by five-year age groups, sex, calendar year, underlying cause of death, and by subtrade classification as used in our previous PMR study.[4] Each death was categorized by whether the injury causing death occurred on the job or not. The proportion of deaths attributed to the workplace by the OCME was calculated for each cause of death allowing an assessment of how likely each E-code diagnosis of cause of death reflects an occupational injury among construction workers.

North Carolina construction industry population sizes were estimated by trade using data from the 1980 and 1990 U.S. census using linear modeling for intracensal year estimates. These denominator estimates were used to calculate trade specific rates. Census estimates are based on the report of occupation in one of the trades of the construction industry in the census year, while occupation coded on the death certificate is the usual occupation of the decedent as reported by the next of kin. For this reason, analyses of rates were limited to deaths among individuals under the age of 65 years in an attempt to define numerators and denominators in a comparable manner.

The distribution of blood alcohol levels of the victims was described for different causes of death and by whether the death was coded as having occurred on the job or as a result of an injury at work. These analyses were limited to deaths which occurred within six hours of the injury (51% of deaths) to avoid interpretative problems from tests of individuals whose death had not occurred in proximity to their injury.

Based on the preliminary analyses of the electronic data, more detailed descriptive information from the narrative records at the OCME was abstracted and reviewed for work-related motor vehicle accidents (E810–E819), poisonings (E850–E858), suicides (E950–E959), and homicides (E960–E969); all falls (E880–E888, E929.3), and all 'other accidents' (E916–E928, E929.8, E929.9). The latter category includes codes the National Institute for Occupational Safety and Health (NIOSH) has described as "fatalities usually work-related."[2]

The information contained in the narrative data are variable but include autopsy reports (when performed), the medical examiner's evaluation of the underlying cause of death and any contributing factors, reports from the Department of Motor Vehicles and the Department of Labor, as well as relevant newspaper clippings describing the injury.

In reviewing the narrative material on work-related motor vehicle deaths, the goal was to determine the activity of the person at the time of the accident, whether the victim was a pedestrian, the type of vehicle involved, circumstances contributing to the event, and a description of work site conditions. A review was made of the narrative data on all falls to determine if deaths from falls coded as not work-related occurred while the victim may have been doing construction activities although not considered to be on the job. A description was sought of the circumstances of the fall, what the person fell from, the distance involved, and any description of the work site, including safety equipment.

The category of deaths classified as 'other accidents' includes a variety of different external causes of injury including falling objects, electrocutions, non-agricultural machinery, guns, sharp instruments, explosions, fights, cave-ins, burns, tractors, and agricultural machinery. In a manner similar to falls and motor vehicles, the narrative material was reviewed to determine more detail regarding the circumstances of death, the site of the accident and the activity of the person and others at the site at the time. As with falls, the latter review included work-related and non-work-related deaths.

## RESULTS

Between January 1, 1988 and December 31, 1994 3955 deaths from external causes of injury were identified through the electronic data from the OCME among individuals whose usual occupation was in the construction trades . There were 211 deaths (5.3%) coded as having occurred on the job. The vast majority of all deaths were among males (98.9%), with only 45 deaths among women. No deaths among women occurred on the job. The ages of death of the victims ranged from 15–95 years, with a mean of 37.5 and a median of 35 years. Obviously, more of the work-related deaths occurred among individuals under the age of 65 years, but the distribution by age of deaths from injuries sustained on and off the job are similar (Figure 1).

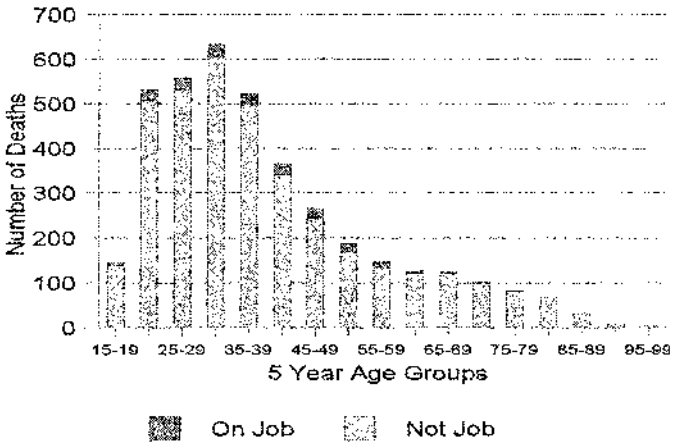


**FIGURE 1**
E-Code deaths among male construction workers by 5-year age groups and whether on job or not North Carolina, 1988–1994.

Deaths from injuries occurred at an average rate of 226 per 100,000 population; 213 per 100,000 for non-work-related fatalities, and 13 per 100,000 for work-related fatalities. Frequency of deaths and estimated rates by trade are presented in Table I. Construction laborers had the greatest number of deaths related to injuries sustained on the job, followed by operating engineers and construction engineers. The highest rates of work-related deaths occurred among welders and cutters, followed by operating engineers and construction laborers. The highest rates of non-work-related deaths from injury occurred among roofers and welders and cutters. For several of the sub-trades, the rates are based on small numbers, particularly for work-related deaths. In addition to occupations not well described, the 'all other' category includes a wide range of jobs including janitorial, helpers, woodworking production, sheet metal, and truck drivers, to name a few. It is of note that the 'all other' category included 13 work-related deaths among truck drivers or transportation workers, and seven were coded as laborers outside the construction trades.

The underlying causes of death are presented in Table II by categories of E-codes, with the percentage of each category coded as on the job. The most common cause of death was motor vehicle accidents, accounting for nearly 30 percent of the deaths. This was followed by homicides (23.4%) and suicides (20.3%). The most common underlying causes of work-related deaths included 'other accidents' (46.9%) , falls (20.4%), and motor vehicle accidents (18.5%). Greater than 50 percent (51.6%) of the deaths for which the underlying cause was 'other accidents' were coded as job-related, as were 25.6 percent of the accidental falls and 21.7% of the non-traffic motor vehicle accidents. Forty-five percent (44.5%) of the work-related deaths occurred in a health care facility, indicating time to at least transport the individual after the event.

Using data from deaths that occurred within six hours of the injury, alcohol levels were analyzed for 2,016 deaths (51%).

**TABLE I**
Frequency and crude rates of deaths from injuries among construction workers by trade, work-related and non-work-related deaths, North Carolina, 1988–1994

| | Work-related | | Non-work-related | |
|---|---|---|---|---|
| Trade | Frequency | Crude rate[A] | Frequency | Crude rate[A] |
| Carpenters | 11 | 4.5 | 693 | 283.4 |
| Construction laborers | 36 | 21.1 | 582 | 339.0 |
| Painters, plasterers | 11 | 11.5 | 305 | 309.9 |
| Brick masons | 5 | 7.3 | 177 | 257.9 |
| Electricians | 15 | 17.9 | 105 | 125.1 |
| Plumbers | 7 | 12.0 | 130 | 217.4 |
| Concrete and terrazzo | 0 | — | 41 | 178.8 |
| Mechanics and repairers | 5 | 9.5 | 44 | 84.4 |
| Drywall installers | 0 | — | 74 | 248.4 |
| Roofers | 7 | 16.3 | 161 | 384.5 |
| Insulators | 0 | — | 22 | 202.3 |
| All other craft workers | 5 | 16.6 | 51 | 167.0 |
| Welders and cutters | 5 | 27.1 | 63 | 342.2 |
| Operating engineers | 16 | 24.6 | 115 | 176.4 |
| Construction supervisors | 12 | 8.7 | 76 | 55.6 |
| Construction engineers | 17 | 5.9 | 200 | 70.8 |

[A]Rates are per 100,000; work-related death rates are based on 152 deaths, and non-work-related deaths are based on 2839 deaths that occurred among individuals of working age (< 65 years) in these specific trade categories. The category "all other" was not included because census estimates were not available for all codes including construction not classified and occupation missing.

Overall, 53.1 percent of these individuals had blood alcohol levels exceeding the legal limit, including 56.5 percent (1065/1884) of non-work-related fatalities and 4.5 percent (6/132) of fatalities related to injury on the job. The greatest percentages of impairment were among those 30–34 years old and 40–44 years old.

There was tremendous variability when looking at the underlying cause of death and the percentage of victims who were legally impaired (Table III). Ninety-three percent (92.9%) of individuals who died from an accidental poisoning by solid or liquid were legally impaired, which is not surprising because the vast majority of these were alcohol-related poisonings. Ninety-three percent (92.9%) of the railway deaths involved legal impairment of the decedent; 72.7 percent of deaths from legal interventions; 66.7 percent from fire/flames; 61.2 percent of homicides; 60.2 percent of motor vehicle accidents; and 53.8 percent of deaths from submersion, suffocation, and foreign bodies. The six work-related deaths in which the victim was impaired included three motor vehicle injuries, one fall from a scaffold, one 'other accident' involving a tractor roll-over, and one homicide.

## Cause-Specific Analyses

*Transportation-Related Deaths*

There were 1281 transportation accidents. In sixty-four percent (64%) of the deaths, the decedent was the driver, followed by 16 percent pedestrians, and 14 percent who were in the right front seat. These deaths most commonly involved a passenger car (46%), trucks with two axles (15%), pickups (9%), and motorcycles (7%). (Note: The type of vehicle is not recorded for pedestrian deaths.) Non-work-related and work-related transportation deaths are presented by categories of external source of injury in Table IV. Overall, 3.4 percent (n = 44) of the transportation accidents were coded as having occurred on the job. The on-the-job motor vehicle deaths most often involved a motor vehicle collision with a pedestrian (n = 13), followed by motor vehicle driver collision, for example, loss of control (n = 12), and motor vehicle driver collision with non-moving motor vehicle (n = 9).

From the narrative descriptions of the motor vehicle deaths that occurred on the job, 13 injuries appeared to have occurred while the victim was transporting materials to the job site. In five of the cases (38.5%) shifting of the load being carried was described as having contributed to the accident. These involved loads of shingles, gravel, and electrical equipment. The other two involved a cement truck and a truck transporting heavy equipment. Two workers were killed when the equipment they were operating was hit from behind by another vehicle. These involved deaths of workers operating a concrete curbing machine and a sweeper tractor. The area of work in these two cases was not defined as a construction zone per se.

The work-related fatal injuries to pedestrians predominantly involved two distinct conditions. Six deaths (50%) occurred in highway work zones. Five of the cases involved a car or a truck that lost control hitting workers in the work zone. In the remaining work zone fatality the worker was backed over by a

**TABLE II**

Underlying cause of death from external causes of injury among construction workers, work-related and non-work-related causes, North Carolina, 1988–1994

| Cause of death | Frequency | | Percent work-related for each cause |
|---|---|---|---|
| | Overall (% of total) | Work-related (% of total) | |
| (E800.0–E807.9) Railway | 46 (1.2) | — | |
| (E810.0–E819.9) Motor vehicle | 1168 (29.5) | 39 (18.5) | 3.3 |
| (E820.0–E825.9) Motor vehicle non-traffic | 23 (0.6) | 5 (2.4) | 21.7 |
| (E826.0–E829.9) Other road vehicles | 3 (0.1) | — | |
| (E830.0–E839.9) Water transportation | 29 (0.7) | — | |
| (E840.0–E838.9) Air and space | 7 (0.2) | — | |
| (E850.0–E858.9) Accidental poisoning by drugs | 119 (3.0) | — | |
| (E860.0–E869.9) Accidental poisoning by solid and liquid | 101 (2.6) | 1 (0.5) | 1.0 |
| (E870.0–E876.9) Medical misadventures | 5 (0.3) | — | |
| (E878.0–E879.9) Surgical/medical procedures | 5 (0.3) | — | |
| (E880.0–E888.9, E929.3) Accidental falls | 168 (4.2) | 43 (20.4) | 25.6 |
| (E890.0–E899.9, E929.4) Fire/flames | 115 (2.9) | 1 (0.5) | 0.9 |
| (E900.0–E909.9, E929.5) Accidents due to natural and environmental factors | 45 (1.1) | 3 (1.4) | 6.6 |
| (E910.0–E915.9) Submersion, suffocation, and foreign bodies | 130 (3.3) | 9 (4.3) | 6.9 |
| (E916.0–E928.9, E929.8, E929.9) Other accidents[A] | 192 (4.9) | 99 (46.9) | 51.6 |
| (E929.0, E929.1) Late effects of motor vehicle accident | 5 (0.1) | — | |
| (E930.0–E949.9) Drugs/medical and biologic substance adverse effects | 1 (0.0) | — | |
| (E950.0–E959.9) Suicide/self-inflicted injury | 802 (20.3) | 4 (1.9) | 0.5 |
| (E960.0–E969.9) Homicide | 924 (23.4) | 5 (2.4) | 0.5 |
| (E970.0–E978.9) Legal intervention | 17 (0.4) | — | |
| (E980.0–E989.9) Injury undetermined whether intentional (some poisoning, firearm deaths) | 50 (1.2) | 2 (0.9) | 0.0 |
| Totals | 3955 (100.0) | 211 (100.0) | 5.3 |

[A] "Other accidents" includes deaths involving machinery, electrocution, falling objects, cave-ins, explosions, guns, etc.

**TABLE III**

Percentage of deaths from external causes among construction workers in which victim was legally impaired by alcohol[A] by cause of injury, North Carolina, 1988–1994

| External cause of injury | Frequency of injury | Percent legally impaired |
|---|---|---|
| (E800.0–E807.9) Railway | 28 | 92.9 |
| (E810.0–E819.9) Motor vehicle | 723 | 60.2[B] |
| (E820.0–E825.9) Motor vehicle non-traffic | 10 | 30.0 |
| (E826.0–E829.9) Other road vehicles | 0 | — |
| (E830.0–E839.9) Water transportation | 16 | 50.0 |
| (E840.0–E838.9) Air and space | 2 | 0 |
| (E850.0–E858.9) Accidental poisoning by drugs | 38 | 34.2 |
| (E860.0–E869.9) Accidental poisoning by solid and Liquid | 28 | 92.9 |
| (E870.0–E876.9) Medical misadventures | 3 | 0 |
| (E878.0–E879.9) Surgical/medical procedures | 2 | 0 |
| (E880.0–E888.9, E929.3) Accidental falls | 43 | 23.3[C] |
| (E890.0–E899.9, E929.4) Fire/flames | 33 | 66.7 |
| (E900.0–E909.9, E929.5) Accidents due to natural/environmental factors | 11 | 27.3 |
| (E910.0–E915.9) Submersion, suffocation, and foreign bodies | 52 | 53.8 |
| (E916.0–E928.9, E929.8, E929.9) Other accidents | 111 | 11.7[D] |
| (E929.0, E929.1) Late effects of motor vehicle accident | 0 | — |
| (E930.0–E949.9) Drugs/medical and biologic substance adverse effects | 0 | 0 |
| (E950.0–E959.9) Suicide/self-inflicted injury | 388 | 41.2 |
| (E960.0–E969.9) Homicide | 502 | 61.2[E] |
| (E970.0–E978.9) Legal intervention | 11 | 72.7 |
| (E980.0–E989.9) Injury undetermined whether intentional | 15 | 33.3 |
| Total | 2016 | 53.1 |

[A] Analyses limited to deaths within six hours of injury; included 132 work-related deaths.
[B] Three deaths on the job.
[C] One death on the job.
[D] One death on the job.
[E] One death on the job.

**TABLE IV**

Frequency of transportation deaths by external cause of injury construction workers, North Carolina, 1988–1994

| External cause of injury | Frequency | | Total (%) |
|---|---|---|---|
| | Non-work-related | Work-related | |
| E800.0–E807.9 Railway | 46 | 0 | 46 (3.6) |
| E810.0–E819.9 Motor vehicle (MV) | 1129 | 39 | 1168 (91.2) |
| E820.0–E825.9 Motor vehicle non-traffic | 18 | 5 | 23 (1.8) |
| E826.0–E829.9 Other road vehicles | 3 | 0 | 3 (0.2) |
| E830.0–E838.9 Water transport | 29 | 0 | 29 (2.3) |
| E840.0–E845.9 Air and space | 7 | 0 | 7 (0.5) |
| E929.0, E929.1 Late effects of motor vehicle accident | 5 | 0 | 5 (0.4) |
| Totals | 1237 | 44 | |

co-worker. Others in the work area heard a warning beeper but the victim did not appear to notice it. Six other pedestrian incidents involved backovers on construction sites. In none of these cases was a warning signal mentioned. The other pedestrian death involved an individual who was hit by a truck while helping a tractor trailer driver back out of a driveway. A variety of other circumstances were involved in the remaining work-related motor vehicle deaths; none were specific to any construction-related work (e.g., crossing center line to avoid collision when following too close, falling asleep, losing control).

*Falls*

The distribution of falls by external cause of injury is presented in Table V by work-relatedness. Twenty-six percent (26%) were reported as having occurred on the job (n = 43). Eighty-one percent (81%) of the falls from scaffolds were on the job, as were 55 percent of the falls from buildings, and 44 percent of falls from ladders. Work-related falls among these construction workers most often involved falls from or out of buildings, falls from scaffolds, and falls from ladders. These falls were often described as having resulted from a trip or a slip. Forty-five percent of falls 'from or out of a building' were not work-related.

*Work-related falls.* Falls involving scaffolds were responsible for 15 (30.4%) of the work-related falls. (Two additional deaths, that were not identified in coded data as having involved a scaffold, were identified from the narrative review). In four instances the scaffold collapsed, fell, or was unsteady, contributing to the injury. In one case the worker was thought to have died from debris falling on him from above, where the scaffold had been attached to the building. The circumstances surrounding fatal falls from scaffolds are described in Table VI. Nine deaths (20% of work-related falls) were related to falls from a roof, and four of these involved residential work. Circumstances surrounding falls from roofs are described in Table VII. In two additional cases workers fell through openings, one that had been covered by 5/8-inch plywood and one a skylight. Although we do not know the extent to which fall protection was used, in only one case was there any mention of personal protective equipment. In this case, the worker was described as having on a harness that had been unbuckled.

*Non-work-related falls.* Three falls (3%) that were not coded as work-related involved the victims doing construction activities at home; a mason and a carpenter each working on their own roofs at home, and a retired carpenter who fell from a ladder while working on his home. The remaining non-work-related falls were the results of a variety of circumstances, most often involving a fall at home. These falls often did not involve heights and the victims were less likely to die immediately than in the work-related falls from elevations. The victims of non-work-related falls tended to be older than those who died from a fall at work. Fifty-percent (50%) of those dying from a fall at work were under age 40, whereas only 23 percent of those dying from a fall away from the work site were under age 40. From the narrative reviews, blood alcohol levels were reported in proximity to the fatal fall in 61 cases (48.9%), including reports from the emergency room among individuals who did not die shortly after injury (and would not have been included in the analyses of blood alcohol levels previously described). It is of note that 43 percent of these individuals (n = 26) were legally impaired.

**TABLE V**
E-code deaths from falls North Carolina construction workers, 1988–1994

| External cause of injury | | Frequencies | | |
|---|---|---|---|---|
| | | Non-work-related | Work-related | Total (%) |
| E880.9 | Fall from stairs/steps | 9 | 0 | 9 (5.4%) |
| E881.0 | Fall from ladder | 5 | 4 | 9 (5.4%) |
| E881.1 | Fall from scaffolding | 3 | 13 | 16 (9.5%) |
| E882 | Fall from or out of building | 17 | 21 | 38 (22.6%) |
| E883.0 | Accident from diving/jumping into water | 3 | 0 | 3 (1.8%) |
| E884.1 | Fall from cliff | 4 | 0 | 4 (2.4%) |
| E884.2 | Fall from chair or bed | 7 | 0 | 7 (4.2%) |
| E884.9 | Fall from one level to another, other | 10 | 1 | 11 (6.6%) |
| E885 | Fall same level from slip/trip/stumble | 8 | 1 | 9 (5.4%) |
| E886 | Fall same level from collision, push, shove | 2 | 0 | 2 (1.2%) |
| E887 | Fracture, cause unspecified | 1 | 0 | 1 (0.6%) |
| E888 | Other and Unspecified fall | 52 | 3 | 55 (32.7%) |
| E929.3 | Late effects of fall | 4 | 0 | 4 (2.4%) |
| Totals | | 125 | 43 | |

**TABLE VI**

Descriptions of work-related falls from scaffolds, North Carolina construction workers, 1988–1994

- Laborer slipped and fell 30 feet to concrete.
- Painter working between second and third floors. Scaffold collapsed on one end. Worker fell to ground and was crushed by bricks falling from above. Bricks were from building where scaffold was attached.
- Welder fell 60 feet from scaffold to concrete floor.
- Construction carpenter fell from a scaffold sustaining head injury. Confirmed to have had myocardial infarction (MI) which may have contributed to the fall. His head injury precluded use of anti-thrombolytic therapy. Died from MI one week later.
- Brick mason fell from third floor from scaffold into trench beside building.
- Brick mason fell 30 feet from scaffold; while "fishing up materials" took a misstep and fell.
- Carpenter washing a brick wall at a new home. Co-worker reported scaffold became unsteady. Co-worker jumped off. Victim fell 25 feet.
- Brick mason fell 70 feet from scaffold against silo and to the ground.
- Carpenter fell 8 feet off scaffold onto concrete base.
- Construction worker fell while erecting scaffold. Pulling plywood across top of iron bar; lost balance and fell 35 feet to ground. Plywood was for planking for next level.
- Two experienced carpenters were on scaffold inside building. Found after having fallen 30 feet to cement floor. Scaffold fell. No cause determined.
- Brick mason fell from scaffold 25–30 feet (2 stories). Reported to have stumbled and fallen off scaffold onto a pile of bricks.
- Disassembling scaffold at church work site. Lost balance and fell, hitting head several times. Hit concrete after fall of 25–30 feet. Blood alcohol level was 130 mg/dl.
- On scissor's lift painting the top of folding door. Folding door was opened from the inside, throwing the victim off the lift 20 feet.

**TABLE VII**

Descriptions of work-related falls from roofs, North Carolina construction workers, 1988–1994

- Self-employed builder fell off house under construction, falling about 40 feet, landing on a woodpile.
- Roofer fell off roof of a house 40 feet onto concrete driveway.
- Owner of log home business was on the second floor of an unfinished house. He was coming down a ladder and fell to the ground. Fall estimated to be 20 feet.
- Roofer working on new construction (commercial). On his second day on the job he and another man slipped off the roof and fell 40–50 feet. Landed on his hand and head sustaining fractures to neck, head, and chest trauma.
- Owner of building construction company. After lunch break crew had begun to cover rafters with plywood sheeting. Co-worker heard a popping sound and the line of rafters began to fall over "like dominoes" toward the wall of the building. The outside wall was blown outside the foundation. The victim was found under a stack of plywood sheets (estimated weight 3000 pounds). Victim had been seen on the roof and had jumped as the rafters were falling.
- Roofer was repairing a metal roof. As he finished he stepped through a skylight and fell, landing on his head.
- Roofer working on garage roof. Trying to nail a 2 × 4 to the roof, slipped and fell onto concrete driveway, sustaining a skull fracture. As he fell he had tried to grab ladder.
- Roofer working in windy conditions on new construction site. Victim picked up a piece of material which acted like sail, causing him to loose his balance. He fell 45 feet off the roof onto his side.
- Construction worker on roof was seen drinking water. He turned blue, his eyes rolled back in his head, he fell off roof 17–19 feet. No significant medical findings were reported.

*"Other Accidents"*

The specific underlying causes of death for the category "other accidents" are presented in Table VIII. There were 192 deaths in the category "other accidents," with over 50 percent of those occurring on the job or as the result of a job-related injury. However, the proportions of deaths that were job-related were quite different depending on the underlying cause of death. Overall, these deaths were most frequently caused by falling objects (n = 41, 21%), electrocution (n = 40, 21%), non-agricultural machinery (n = 34, 18%), and guns (n = 33, 17%).

*Work-related 'other accidents'.* From review of the narrative data, 102 deaths from "other accidents" that appeared to be job-related were identified (three additional from review). These work-related deaths most often involved machinery (n = 38) (excluding agricultural), electrocutions (n = 29), and falling objects (n = 23).

The machinery involved in these deaths involved a variety of equipment including backhoes, earth-moving equipment, cranes, steam rollers, forklifts, bulldozers, graders, and rock crushers. Two deaths involved individuals being backed over by earth-moving equipment, very similar to the backover motor vehicle deaths on construction sites.

Of the 29 electrocutions identified that occurred on the job, all but one appeared to have been related to construction work. This one exception involved a brick mason who was helping his brother repair equipment at a dry cleaner. Although this was not his usual job it was deemed a work-related fatality. It is of note that at least two of the electrocutions that were not considered work-related occurred while the individual was doing a task similar to his regular work but away from the job site. One involved a carpenter remodeling his own home who was electrocuted while operating a reciprocating saw under the house. The other



**TABLE VIII**

"Other accidents" (E916–928, E929.8, E929.9) among construction workers total and work-related North Carolina, 1988–1994

| External cause of injury | Frequency | | Percent of category work-related |
|---|---|---|---|
| | Total | Work-related | |
| (E916.– ) Struck accidentally by falling object | 42 | 23 | 54.8 |
| (E917.9) Struck accidentally by other object | 2 | 1 | 50.0 |
| (E919.0) Agriculture machine accident | 15 | 4 | 26.7 |
| (E919.1) Mining and earth drilling machinery | 1 | 1 | 100.0 |
| (E919.2) Lifting machines and appliances | 19 | 19 | 100.0 |
| (E919.4) Woodworking and forming machine | 1 | 1 | 100.0 |
| (E919.7) Earth moving, scraping and excavating machine | 12 | 11 | 91.7 |
| (E919.8) Other machinery accident | 7 | 5 | 71.4 |
| (E919.9) Unspecified machinery accident | 1 | 1 | 100.0 |
| (E920.1) Powered hand tool accident | 2 | 0 | 0 |
| (E920.3) Knives, swords, and dagger accidents | 1 | 0 | 0 |
| (E920.8) Cutting/piercing instrument accident | 3 | 0 | 0 |
| (E921.8) Pressure vessel explosion | 1 | 1 | 100.0 |
| (E922.0) Handgun accident | 18 | 1 | 5.3 |
| (E922.1) Shotgun accident | 7 | 0 | 0 |
| (E922.2) Hunting rifle accident | 8 | 0 | 0 |
| (E923.2) Explosive gases accident | 3 | 2 | 66.7 |
| (E923.9) Explosive material accident | 1 | 0 | 0 |
| (E924.0) Hot liquids and vapors | 1 | 0 | 0 |
| (E924.8) Other hot substance accident | 1 | 0 | 0 |
| (E925.0) Domestic wiring/appliance | 10 | 5 | 50.0 |
| (E925.1) Electric power generating plants/distribution stations/transmission lines | 19 | 15 | 79.0 |
| (E925.2) Industrial wiring/appliances | 5 | 4 | 80.0 |
| (E925.8) Other electric current | 3 | 2 | 66.7 |
| (E925.9) Unspecified electric current | 3 | 3 | 100.0 |
| (E928.9) Unspecified accident | 5 | 0 | 0 |
| (E929.9) Late effects of unspecified accident | 1 | 0 | 0 |
| Total | 192 | 99 | 51.6 |

involved a painter trying out a new bucket truck at the home of his employer. He was electrocuted when he raised himself into high-voltage wires. From the narrative reviews it was clear that 12 of the 29 electrocutions (41.3%) occurred among individuals who were not doing electrical work. These individuals were painters, roofers, plumbers, pipe layers, a dump truck driver, and individuals employed in heating and air conditioning work. One death involved a stucco application foreman who was electrocuted when a metal scaffold he was moving came in contact with power lines.

Over half (59%) of the construction-related electrocutions involved conductive equipment coming in contact with a power line or source. These pieces of equipment included buckets from a work truck (n = 7), ladders (n = 4), a scaffold, backhoe, dump truck bed, drill, and conduit pipe. This was followed equally in frequency (n = 4) by what appeared to be improperly installed equipment, all in residential construction with failure to have adequate grounds when working in a crawl space, boomed vehicle contacting a power line, and direct contact with a power line.

The most common objects involved in the work fatalities from falling objects were trees or limbs (n = 9, 39%). In one case the worker was described as a logger but in all others the work seemed to be related to construction. These events usually involved a limb or tree falling on the victim while an area was being cleared but also involved a log falling off a loader on a construction site. Six deaths (26%) involved the collapse of a structure—brick wall, concrete slab near an area of excavation, roof on new construction, chimney and fireplace, steel platform and a billboard. Two deaths involved cranes; in one case the worker was reducing the length of the crane and it collapsed on him and in the other, the boom of a crane broke off the base and struck the victim in the face. One death coded as having been caused by a falling object involved an individual who was behind a dump truck that dumped a large load of rock on him. The victim had tire marks on him, making this death very similar to the backovers classified as motor vehicle injuries. There were two work-related cave-ins identified among these work-related deaths. In both cases, the worker was digging in a ditch 18–20 feet deep when the dirt wall collapsed. There was no mention of any shoring or sloping to prevent the cave-in.

*Non work-related "other accidents".* The non-work-related "other accidents" were different in many ways from the work-related injuries. The underlying cause of death was most commonly a gun, followed by falling objects, agricultural machinery (tractors), electrocutions, and sharp cutting instruments. Eight of the gunshot deaths involved hunting accidents. The falling object deaths that were not on the job also involved most frequently a tree or limb hitting the deceased; this was followed closely by cars, trucks, or vans that fell on the decedent while he was working underneath them. These two causes accounted for 83 percent of the non-work-related deaths from falling objects. Tractor accidents, most often involving a roll over, accounted for 11 non-work-related deaths. Electrocutions accounted for 10 non-work-related deaths. As described earlier, in at least two cases the individual was doing construction work on his own home or at his employer's home when electrocuted.

*Poisonings*

Of 220 poisoning deaths, 54.1 percent (n = 119) were drug-related and 41.4 percent (n = 91) were alcohol-related. Medical history was reported as significant for alcoholism for 82 (37%) individuals and intravenous drug use for 52 (24%). The death of a 44-year-old male welder on a construction site was the only work-related poisoning. The records in the OCME reported the worker had climbed into a 36-inch gas pipeline to check a weld. When he did not return, other workers crawled into the pipe and were also overcome. The pipeline had been flushed with liquid nitrogen several days before. The Occupational Safety and Health Administration (OSHA) report described a confined-space entry without an appropriate plan, and the victim was thought to have been overcome from breathing nitrogen fumes that had displaced the oxygen in the pipe.

*Homicides and Suicides*

Of the 924 homicides, 70.1 percent (n = 653) involved injuries from gunshots, and a handgun specifically was involved in 38 percent (n = 347). The next most common weapon used in the homicides was a cutting/piercing instrument, accounting for 18.3 percent of the deaths due to homicide (n = 169). There were five work-related homicides, all of which involved guns—two a handgun, two a shotgun, and one an unspecified firearm. One occurred when a homeowner shot someone doing masonry work on his home after accusing him of stealing tools. One involved an employee of a cable company who was working near a residence; he was accused of trespassing and was shot by the resident. The other homicides on the job occurred on non-construction weekend jobs.

In a pattern very similar to homicides, 78 percent (n = 623) of suicides involved a gun, with a handgun being used in 41 percent (n = 326) of these deaths. The next most common means of death was hanging (10.2%). Four suicides occurred on the job (two from handguns, one hanging, one fire).

## DISCUSSION

In this descriptive study, electronic records from the North Carolina Office of the Chief Medical Examiner (OCME) were used to describe deaths between 1988 and 1994 from external causes among individuals whose usual occupation was in the construction trades. Narrative records provided supplementary information for work-related motor vehicle accidents, suicides, homicides, and one poisoning; all falls; and all deaths from "other accidents."

Welders and cutters had the highest rate of work-related fatalities from injuries. In our analyses of non-fatal work-related injuries in North Carolina residential construction this group also had the highest risk.[14]

The most common causes of work-related fatalities among these workers were "other accidents" (46.9%), specifically, machinery, electrocutions, and falling objects; falls (20.4%); and motor vehicle accidents (18.5%). Non-fatal work-related injuries among construction workers most commonly involve struck-by injuries, and overexertion resulting in musculoskeletal injuries and falls, in that order. Struck-by injuries include a few of the causes of fatal injuries included in the "other accidents" category. However, non-fatal struck-by injuries, though very common, tend to be of a non-serious nature. Falls, particularly those from elevations, are also responsible for a significant burden in terms of cost and lost work time of non-fatal injuries in construction.[14,15]

In our analyses, 52 percent of the deaths from "other accidents" were related to injuries sustained at work—the most likely of any E-code category to be related to work. These injuries involve a variety of means of death including falling objects, electrocutions, explosions, a variety of machinery, cave-ins, sharp instruments, and guns. This category corresponds very closely to fatalities that the National Institute of Occupational Safety and Health (NIOSH) has described as "fatalities that are usually work-related."[2] Omitting deaths from firearms (not included in their listing) the percentage that is work-related goes up to 61 percent.

Electrocutions among these workers were the fourth leading cause of death from injuries on the job, which is consistent with reports of the National Safety Council for overall work-related deaths in the United States. However, electrocutions accounted for a greater proportion of deaths of these construction workers (13%) than the estimated six to seven percent of occupational deaths estimated to be due to electrocution in the United States by the Bureau of Labor Statistics and NIOSH, respectively.[14]

Our findings related to deaths from external causes and the excess deaths for alcohol-related diseases seen in our PMR study (PMR for alcoholism = 145) indicate a problem of excess alcohol consumption among this group of construction workers. Blood alcohol levels were above the legal limit in North Carolina for over 57 percent of non-work-related fatalities due to injury, and for 5 percent of those that occurred on the job. The findings from work-related deaths are not unlike those reported by Sneizek and Horigan[15] for all industries also using data from the North Carolina Medical Examiner's database, in which he found blood alcohol levels elevated above 100 mg% (legal limit at the time of his analyses) in 7 percent of occupational fatalities between 1978 and 1984. Shannon et al.[16] reported that 2 percent of occupational fatalities tested in Ontario in 1986–1989 had evidence of legal impairment from alcohol, excluding homicides and most accidents on roadways.

Alcohol has been reported to be a risk factor for serious falls.[5,6] Our findings related to falls are consistent with the relationship of fatal falls to alcohol impairment described in a review article that reported the percentage of fatal falls related to alcohol exposure ranging very broadly from 21 percent–77 percent.[17] Poisoning deaths among these construction workers were largely the result of alcohol and/or drug abuse. Forty-one percent of the suicide victims were legally impaired, as were 62 percent of the homicide victims. Although we lacked information about the perpetrators, the findings are consistent with reports of alcohol as a risk factor for trauma resulting from violence.[7] All of these findings are consistent with reports from national data sources that construction workers as a group have high rates of alcohol and substance abuse.[18]

The rates for work-related deaths that we obtained, which averaged 13 per 100,000 workers over the seven-year period, are consistent with other national estimates of fatal work-related injuries among U.S. construction workers[19] but are approximately 20 percent lower than those reported for North Carolina by NIOSH based on analyses of National Traumatic Occupational Fatality (NTOF) data[20] for 1990–1994. However, our rates were based on deaths from one source of information, from coding on the death certificate of usual occupation, and the denominators were based on population estimates from census data representing individuals who are currently working in the trade. In addition, in interpreting our rates by subtrade it must be kept in mind that some of these rates are based on very small numbers of deaths.

The potential misclassification of coded usual occupation on death certificates has been discussed relevant to cancer epidemiology and other chronic diseases for which long-term exposures are of particular relevance.[21,22] For the study of fatal occupational injuries, "usual occupation" is of no relevance, and it becomes important to have information on occupation at the time of death. Based on the narrative record reviews for select causes of work-related deaths (motor vehicles, falls, "other accidents," and poisonings) 92 percent were likely related to construction work among these individuals whose usual occupation was considered construction. In a few circumstances the individual was doing farm work or a weekend second job at the time of death (with notation that the person was usually employed in the construction trades). This indicates that the use of usual occupation coded on death certificates for analyses of work-related deaths from external causes of injury among construction workers is reasonably specific. However, from this review, we have no information on how sensitive the method may be because we have no measure of construction-related deaths in which the individual's usual occupation was not in the construction trades.

## CONCLUSIONS AND RECOMMENDATIONS

These findings from purely descriptive data document areas that are fertile ground for prevention efforts. Despite efforts made to improve safety for individuals who work at elevations, there is clearly a need for better fall protection for construction workers, including workers doing residential construction. Fifty percent of the deaths from falls on the job involved a scaffold or a fall from a roof. In only one instance was there any mention of the use of fall protection equipment among workers who sustained

these fatal falls. The circumstances surrounding injuries involving scaffolds document the need not only for training and safety procedures for erecting and disassembling the scaffolds but also for safe work practices on the scaffolding.

Three major causes of transportation accidents that were job-related were identified from review of the narrative records—injuries to pedestrians in highway construction work zones and in backovers on construction sites, and injuries to drivers caused by shifting loads while transporting construction materials. NIOSH has issued an *ALERT*[23] bulletin on preventing motor vehicle injuries among workers. Even though those recommendations are relevant to the prevention of some of these construction-related deaths, the information from our descriptive review points to the need for specific interventions relevant to the construction trades. These interventions should focus on safety in highway work zones, on the prevention of backovers on construction sites, and in the safe loading and transportation of materials. Highway work zone accidents place more than one worker at risk of serious, if not fatal, harm. In the deaths we reviewed, the use of barriers and traffic control efforts failed to adequately protect the workers. In two backovers, witnesses reported that the vehicle did have a warning beeper signal; in the others there was no mention in the medical examiner record. There can be competing noise on construction sites, including highway work zones, which could impair the workers' abilities to hear warning beepers. Construction workers are also at risk for noise-induced hearing loss[24] that might also contribute to their risk for this type of injury. The data we had available did not provide information that allows us to determine how much these factors may have contributed to the deaths. Work-related deaths from machinery, falling objects and motor vehicle accidents involving pedestrians, all involved to some extent backovers of workers on construction sites. These deaths most often involved trucks but also earth-moving equipment. Backover deaths should be preventable, but we must pay attention to heavy equipment as well as to motor vehicles such as trucks. Warning signals and training of workers are important elements for prevention of these deaths.

Deaths from electrocutions often did not involve electricians or linemen. The high proportion of on-the-job electrocutions caused by conductive equipment, including scaffolding, contacting a power line, or from improperly installed equipment, particularly on residential construction sites, indicates the need for safety training and planning specifically to avoid these hazards. NIOSH has recommended the use of a lookout person, observing required clearance distances or lowering equipment before transport.[14] However, the risk must be appreciated in order for these things to be in place.

Although worker training and risk communication are important preventive measures, additional engineering and human factors research is needed to address several of the causes of construction worker deaths identified in this report. For example, many backover deaths could be prevented by application of warning signals; however, more effective detection and warning systems which provide positive feedback to the driver have been shown to be more effective.[27] Likewise, electrocutions caused by ladders, scaffolds, and equipment contacting overhead power lines could be more effectively prevented through development and application of detectors which would sense proximity to power line hazards and provided operator feedback.[28–32] Finally, innovative engineering solutions for prevention of occupational falls are needed, including research and evaluation of fall protection measures that can be included at the design and planning stages of construction projects.[33]

Although relatively few of the job-related deaths seem to have been caused by alcohol impairment, these data provide considerable evidence that a significant number of deaths from external causes of injury were likely related to alcohol impairment. Effective treatment and prevention programs could have a great effect on the prevention of fatal injuries and other alcohol-related disorders, documented in excess among certain subtrades of this construction workforce.[4] The North Carolina construction workforce is essentially non-unionized, and the nature of the work is often transient. Workers often do not have health insurance benefits through their employment. All of these things make it more difficult to implement or evaluate preventive services on a group level and, therefore, present significant challenges in addressing the needs of this population of workers.

The mean age at death for these construction workers who died from external causes of injury was 37.5 years, and the median age was 35 years. These deaths from preventable causes represent a significant number of years of potential life lost. Beyond this potentially measurable human cost, significant costs were incurred for medical care for the treatment of some of these injuries. No appreciation can begin to be made for the cost in human suffering to these workers and their families from the repercussions of these preventable traumatic events.

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