Human Factors: The Journal of the Human Factors and Ergonomics Society
http://hfs.sagepub.com/

# Fatal Falls Among Older Construction Workers

Xiuwen Sue Dong, Xuanwen Wang and Christina Daw

*Human Factors: The Journal of the Human Factors and Ergonomics Society* 2012 54: 303 originally published online 22 June 2011
DOI: 10.1177/0018720811410057

The online version of this article can be found at:
http://hfs.sagepub.com/content/54/3/303

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
Human Factors and Ergonomics Society

**Additional services and information for *Human Factors: The Journal of the Human Factors and Ergonomics Society* can be found at:**

**Email Alerts:** http://hfs.sagepub.com/cgi/alerts

**Subscriptions:** http://hfs.sagepub.com/subscriptions

**Reprints:** http://www.sagepub.com/journalsReprints.nav

**Permissions:** http://www.sagepub.com/journalsPermissions.nav

>> Version of Record - May 17, 2012

OnlineFirst Version of Record - Jun 22, 2011

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

What is This?

# Fatal Falls Among Older Construction Workers

**Xiuwen Sue Dong**, **Xuanwen Wang**, and **Christina Daw**, CPWR–The Center for Construction Research and Training, Silver Spring, Maryland

**Objective:** This study examines recent trends and patterns in fall fatalities in the U.S. construction industry to determine whether fatal falls among older workers are different from younger workers in this industry.

**Background:** Falls are the leading cause of fatalities in the U.S. construction industry. Given the increasingly aging workforce in construction, it is important to assess the risk of falls among older construction workers.

**Methods:** Fatality data were obtained from the Census of Fatal Occupational Injuries for the years 1992 through 2008. Denominators for death rates were estimated from the Current Population Survey. Stratified and multivariate analyses were performed to examine whether there are differences in fatal falls between older workers (≥55 years) and younger workers (16-54 years). Fatal falls in nonconstruction industries were excluded from this study.

**Results:** Older workers had higher rates of fatal falls than younger workers; results were significant in 11 of 14 construction occupations. Regression analysis indicated that older decedents had a higher likelihood that work-related death was caused by a fall, after controlling for major demographic and employment factors (odds ratio = 1.50, confidence interval [1.30, 1.72]). Falls from roofs accounted for one third of construction fatal falls, but falls from ladders caused a larger proportion of deadly falls in older decedents than in younger decedents.

**Conclusion:** Older workers have a higher likelihood of dying from a fall. Roofs and ladders are particularly risky for older construction workers.

**Application:** As the construction workforce ages, there is an urgent need to enhance fall prevention efforts, provide work accommodations, and match work capabilities to job duties.

**Keywords:** aging workforce, construction, fall injury, fatality, older workers

Address correspondence to Xiuwen Sue Dong, CPWR–The Center for Construction Research and Training, 8484 Georgia Ave., Ste. 1000, Silver Spring, MD 20910; e-mail: sdong@cpwr.com.

*HUMAN FACTORS*
Vol. 54, No. 3, June 2012, pp. 303–315
DOI: 10.1177/0018720811410057
Copyright © 2012, Human Factors and Ergonomics Society.

## INTRODUCTION

Falls are consistently the leading cause of death from injuries in the U.S. construction industry, accounting for approximately one third of the total fatal injuries in this industry (CPWR–The Center for Construction Research and Training [CPWR], 2008; Dong, Fujimoto, Ringen, & Men, 2009). Out of all the fatal work-related falls in the United States, 50% occur in construction (U.S. Bureau of Labor Statistics [BLS], 2010a), which is disproportionately high given that construction makes up less than 8% of the total workforce. Injuries from falls are a high-priority and focus area in construction safety and health, which is clearly addressed in the National Occupational Research Agenda (NORA) of the U.S. National Institute for Occupational Safety and Health (NIOSH; 2008).

Although younger workers are more likely to have a fall and other types of injury on the job (Salminen, 2004; Shishlov, Schoenfisch, Myers, & Lipscomb, 2011), older workers are more likely to die from their injuries (Jackson & Loomis, 2002; Myers, Layne, & Marsh, 2009; Salminen, 2004). In multiple studies, older age has been found to be an independent factor associated with fatal falls (Chi, Chang, & Ting, 2005; Derr, Forst, Chen, & Conroy, 2001). Older workers not only are more seriously injured by falls but also have serious falls from smaller distances, even at the same level (Agnew & Suruda, 1993).

In recent decades, the labor force in the United States has been rapidly growing older. According to the BLS, the population of workers older than 55 has increased dramatically from 17 million in 1998 to 27.9 million in 2008 and is expected to grow to nearly 40 million in 2018 (Toosi, 2009). Following this trend, construction workers are also aging. The median age of construction workers increased from 34 years in 1985 to older than 41 years in 2009, and the proportion of construction workers ages 45 to 64 years increased from 25% to 34% during

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

this period. The marginal age difference between construction workers and the general workforce widened during the construction boom of 2002 to 2007 and narrowed during the recent economic downturn. The average age of construction workers jumped nearly 2 years from 39.6 in 2007 to 41.4 in 2009 alone (CPWR, 2011).

These trends in aging correspond to the upsurge and subsequent decline in Hispanic workers, who tend to be younger, as a considerable proportion of the construction workforce (Dong & Fujimoto, 2009). Financial concern is another factor driving the aging workforce trends, as older workers may stay in the workforce longer to maintain an income, health insurance, and/or retirement benefits (Garr, 2009). Continual aging trends bring significant concerns about the safety and health of older workers, in particular, those employed in high-risk industries, such as construction.

To provide insight for safety and health interventions, we examined fatal injuries that occurred exclusively in the construction industry by analyzing two large nationally representative data sources. The study hypothesis was that trends and patterns of fatal falls among older workers are different from those of younger workers in the U.S. construction industry.

## METHOD

### Data Sources

Fatality numbers were obtained from the Census of Fatal Occupational Injuries (CFOI), a federal-state cooperative program implemented in all 50 states and the District of Columbia and conducted by the BLS (2010a). Data on deaths resulting from injuries are compiled from death certificates, workers' compensation reports, reports from the Occupational Safety and Health Administration (OSHA), medical examiner reports, newspaper articles, and other sources. Both the death and the work relatedness of the death must be corroborated by at least two data sources or one data source and a follow-up questionnaire. Deaths occurring during a commute to or from work are not considered work related, but vehicle-related deaths during the course of work are included.

The CFOI provides information on major demographics (e.g., age, gender, race, Hispanic origin, foreign-born, region), employment (e.g., industry, occupation, employee status, establishment size, length of service), and information on fatalities (e.g., event, nature, source, body part, location of injury, worker's activities when injury occurred). CFOI data from 1992 to 2008 were used in examining the overall trends in fatal falls. Since there were significant changes in industrial and occupational classification systems in 2003, data from 2003 to 2008 were pooled together for in-depth analyses. The CFOI microdata data files (or research files) were obtained through a data use agreement with the BLS.

Employment and number of hours worked were obtained from the Current Population Survey (CPS) and were used as denominators in rate computations. The CPS is a monthly household survey conducted by the U.S. Census Bureau for the BLS. Each month, basic demographic information is obtained from approximately 60,000 households across the United States, including age, gender, race, Hispanic or Latino ethnicity, geographical region, and so on. For those ages 16 years and older, the survey collects employment information, such as occupation, industry, employment type, and hours worked. All data collected are self-reported by the individual respondents.

### Terms and Definitions

*Older construction workers* were defined as workers ages 55 and older and employed in the construction industry as their main job regardless of occupation or type of employment.

*Construction industry* was identified by the 1987 Standard Industrial Classification (SIC) System Codes 1500 through 1799 and "CCCC" (denoting construction subsectors that could not be categorized in any SIC code; Office of Management and Budget, 1987) for CFOI data from 1992 to 2002. For 2003 to 2008 CFOI data, the North American Industry Classification System Codes 236000 through 238999 (Office of Management and Budget, 2002) were used. Unlike the CFOI, the CPS uses the U.S. Census industry codes, in which the construction industry is coded together, whereas construction trades and extraction occupations are coded by the Census occupational classification codes during the relevant periods.

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

*Occupations* were regrouped as blue-collar occupations, including workers in construction trades, mechanics or repair personnel, precision production workers, and operators; and workers in managerial and professional occupations, clerical, administrative support, and sales and services occupations were combined as white-collar workers. Only workers employed in the construction industry were included in the analyses.

*Race* and *Hispanic origin* were recoded as Hispanic, White non-Hispanic, and others (Black non-Hispanic, Asian non-Hispanic, etc.) in this study.

*Fatal falls* were deaths coded in CFOI by Event Codes 1000 through 1999 under the BLS Occupational Injury and Illness Classification System, which includes all types of falls (e.g., falls to a lower level, falls on the same level, and unspecified falls; BLS, 2010b).

*Fatality site* (or job site) is labeled as *location* in the CFOI data, such as industrial construction sites, residential construction sites, street and highway sites, and public buildings. All other locations (e.g., farms, mines and quarries, recreational places) are grouped into *other*.

*Establishment size* refers to the number of wage-and-salary workers employed at the establishment of the decedent. Self-employed workers were excluded from establishment categories. However, self-employed workers were compared with wage-and-salary workers employed in large establishments (>100 employees) in multivariate analyses.

## Data Analysis

The number of fatalities in construction was identified from the CFOI data for 1992 to 2008 according to the industry definition described previously. Deaths caused by falls were extracted from all fatalities in construction to examine overall trends in fatal falls. The distribution of fatal falls was stratified by major occupation and type of fall. The characteristics of fatal falls were compared between older and younger construction workers. A $\chi^2$ test was used to measure whether injury characteristics between older and younger construction workers were statistically significant at the $\alpha = .05$ level. *T* tests were performed to measure differences in falls by occupation and types of falls between the two age groups.

*Rate* of fatal falls was defined by deaths per 100,000 full-time equivalents (FTEs), assuming a full-time worker works 2,000 hr per year (40 hr × 50 weeks), to capture the length of workplace exposure. FTEs were obtained from the CPS and were calculated on the basis of hours worked reported by respondents and the weighted number of construction employment. Odds ratios (ORs) and 95% confidence intervals (CIs) were also calculated to compare the risk of fatal falls between the two age groups.

A multiple logistic regression analysis assessed critical factors associated with fatalities caused from falls versus fatal injuries resulting from other causes (not falls). If a death was caused by a fall (all types), it was coded as 1; if a death was due to other causes, it was coded as 0. The STEPWISE method in the SAS LOGISTIC procedure was used to select independent variables for the model. The variables selected for the model include age of decedent (dichotomized into age groups: 16–54 years and 55+ years), race-ethnicity, occupation (blue-collar vs. white-collar workers), employment type, establishment size, fatality site, and census region. Since some key variables that could contribute to fatal falls are not provided by the CPS (e.g., establishment size and job site), only CFOI data were used for the regression model. The model fit was assessed with the Hosmer-Lemeshow goodness-of-fit test. All statistical analyses were performed with SAS Version 9.2 (SAS Institute, 2008).

# RESULTS

In construction, the proportion of fall fatalities increased from 28% in 1992 to 36% in 2007 and then dropped to 33% in 2008 with the decline of total construction fatalities (Figure 1). During the same period, the number of fatalities has been rising among construction workers ages 55 and older, and fatal falls in particular have been steadily increasing as a proportion of work-related deaths. Despite the aforementioned decrease in construction fatalities during the recent economic downturn, the proportion of fatal falls in older construction workers was still as high as 38% in 2008 (Figure 2).

Overall, from 2003 to 2008, approximately one fifth of the total fatal falls (520 of 2,432) in the

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

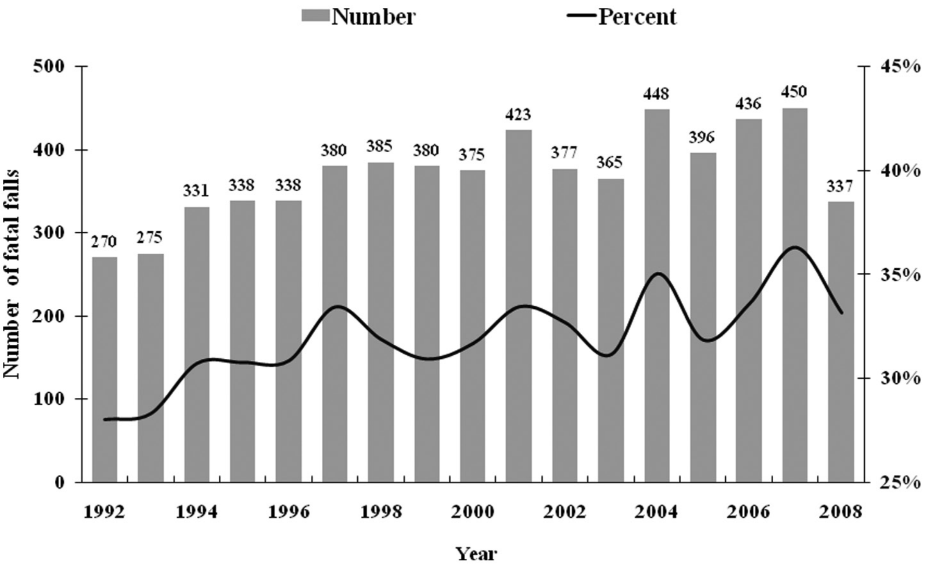


*Figure 1.* Number and percentage of fall fatalities among construction workers, 1992–2008.
*Source.* U.S. Bureau of Labor Statistics, 1992–2008 Census of Fatal Occupational Industries.

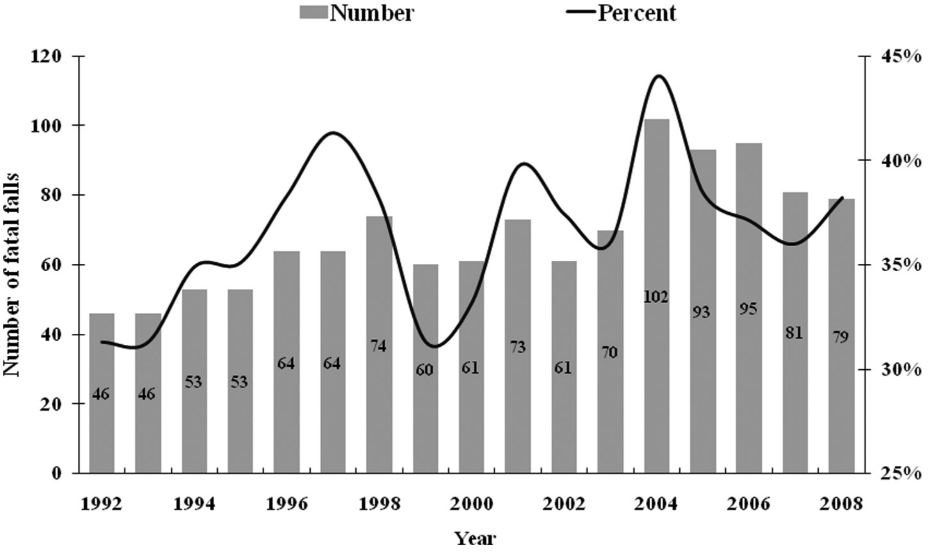


*Figure 2.* Number and percentage of fall fatalities among construction workers ages 55 and older, 1992–2008.
*Source.* U.S. Bureau of Labor Statistics, 1992–2008 Census of Fatal Occupational Industries.

construction industry occurred in workers ages 55 and older (Table 1). Compared with the younger fall decedents, the older decedents were more likely to be self-employed but less likely to be Hispanic or an immigrant: 17.9% of older worker decedents were foreign-born compared with 32.7% of younger workers. The proportion of White non-Hispanic workers was similar across the age categories, whereas Black non-Hispanics accounted for slightly more of the older decedents. The majority of fatal falls by wage-and-salary decedents in construction, 54.4% overall, occurred

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

**TABLE 1:** Characteristics of Fatal Falls in Construction by Age Group, 2003–2008 (in percentages)

| Characteristic | Ages 55 and Older | Ages 16–54 | All Construction | *p*[a] |
|---|---|---|---|---|
| Gender | | | | .409 |
| Male | 99.2 | 99.5 | 99.5 | |
| Race | | | | <.001 |
| White | 88.3 | 82.7 | 83.8 | |
| Black | 7.3 | 5.4 | 5.8 | |
| Other | 4.4 | 11.9 | 10.4 | |
| Hispanic origin | | | | <.001 |
| Hispanic | 12.9 | 34.6 | 29.9 | |
| Foreign-born | 17.9 | 32.7 | 29.5 | <.001 |
| Occupation | | | | <.001 |
| Blue collar | 87.7 | 95.8 | 94.1 | |
| White collar | 12.3 | 4.2 | 5.9 | |
| Self-employed | 32.3 | 15.0 | 18.8 | <.001 |
| Establishment size[b] | | | | <.001 |
| 1–10 employees | 56.0 | 54.1 | 54.4 | |
| 11–19 employees | 10.5 | 11.1 | 11.0 | |
| 20–49 employees | 13.9 | 15.0 | 14.9 | |
| 50–99 employees | 8.1 | 8.1 | 8.1 | |
| 100+ employees | 11.5 | 11.8 | 11.7 | |
| Location | | | | <.001 |
| Industrial construction sites | 33.3 | 45.3 | 42.7 | |
| Residential construction sites | 30.4 | 28.1 | 28.5 | |
| Public building | 8.3 | 6.9 | 7.2 | |
| Street and highway | 1.9 | 2.9 | 2.7 | |
| Other locations | 26.2 | 16.9 | 18.9 | |
| Region | | | | .065 |
| South | 40.9 | 47.8 | 46.3 | |
| Northeast | 20.4 | 17.2 | 17.9 | |
| Midwest | 20.0 | 17.0 | 17.6 | |
| West | 18.7 | 18.0 | 18.1 | |
| Total | 100 ($n$ = 520) | 100 ($n$ = 1,908) | 100 ($N$ = 2,432) | — |

*Source*. U.S. Bureau of Labor Statistics, 2003–2008 Census of Fatal Occupational Injuries.
*Note*. Deaths without age information or of those younger than 16 were included in the total.
[a]*p* values reflect chi-square tests of age group differences for the characteristic variables.
[b]Self-employed workers and cases without establishment size information were excluded.

in small establishments with 1 to 10 employees. The proportion of fatal falls in such small establishments was slightly higher among older workers than younger ones (56% vs. 54%).

Regarding the location of the fatalities, older construction workers were less likely to have fatal falls in industrial construction sites, compared with younger workers (33.3% vs. 45.3%), but at residential construction sites, the two age groups had similar proportions. Together, residential and industrial construction sites accounted for more than two thirds (71.2%) of all fall fatalities. Chi-square tests indicated that the two age groups differed significantly

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

**TABLE 2:** Distribution of Fatal Falls by Occupation and Age Group, 2003–2008 (in percentages)

| Occupation | Ages 55 and Older | Ages 16–54 | All Construction | $p^{a}(H_0 : \mu_{55+} = \mu_{16-54})$ |
|---|---|---|---|---|
| Construction laborer | 17.5 | 24.1 | 22.7 | .001 |
| Carpenter | 15.2 | 14.3 | 14.4 | .588 |
| Foreman | 10.0 | 6.1 | 6.9 | .006 |
| Construction manager | 9.4 | 3.5 | 4.8 | <.001 |
| Roofer | 8.7 | 15.2 | 13.9 | <.001 |
| Painter | 8.3 | 6.0 | 6.5 | .109 |
| Electrician | 4.0 | 3.6 | 3.7 | .650 |
| Brickmason | 2.9 | 2.3 | 2.4 | .531 |
| Plumber | 2.5 | 1.2 | 1.4 | .065 |
| Ironworker | 2.3 | 5.7 | 4.9 | <.001 |
| Heating A/C mechanic[b] | 2.1 | 1.8 | 1.9 | .633 |
| Power line installer | 1.4 | 2.2 | 2.0 | .186 |
| Drywall installer | 1.2 | 2.0 | 1.8 | .141 |
| Sheet metal worker | 1.0 | 1.0 | 1.0 | .945 |
| Other blue-collar worker | 11.0 | 10.3 | 11.6 | 0.902 |
| Other white-collar worker | 2.5 | 0.7 | 1.1 | .004 |
| Total | 100 ($n$ = 520) | 100 ($n$ = 1,908) | 100 ($N$ = 2,432) | — |

*Source*. U.S. Bureau of Labor Statistics, 2003–2008 Census of Fatal Occupational Injuries.
*Note*. Deaths without age information or of those younger than 16 were included in the total.
[a] *p* values reflect *t* tests for differences in the group means.
[b] Full occupation name: heating, air conditioning, and refrigeration mechanics and installers.

for all of the variables except gender and census region.

When segmenting fatal falls by occupation, laborers were the most prevalent occupation (22.7%), followed by carpenters (14.4%) and roofers (13.9%), regardless of their age (Table 2). Stratified by age groups, the *t* tests showed significant differences between older and younger fall decedents for most occupations. Compared with younger decedents, the older group had a notably higher proportion of foremen and construction managers but was less likely to work as construction laborers, roofers, or ironworkers.

Rates of fatal falls varied among occupations but were consistently higher for workers ages 55 and older than for younger workers (Table 3). Roofers, ironworkers, and power line installers were the three occupations with the highest risk of fatal falls for both older and younger workers. Comparing rates in specific construction occupations, the results showed significantly higher odds of fatal falls for older workers than for younger counterparts for 11 of the 14 occupations. The largest excess in fatality rate odds was observed in plumbers (OR = 5.39, CI [2.72, 10.71]), painters (OR = 4.16, CI [2.93, 5.91]), brickmasons (OR = 3.47, CI [1.93, 6.24]), construction managers (OR = 3.43, CI [2.37, 4.95]), and heating and air-conditioning mechanics (OR = 3.34, CI [1.69, 6.58]), yet the number of fatal falls in some of these occupations accounted for a small proportion of the total fatal falls in construction. For roofers—the occupation at highest risk of fatal falls—the rate of fatal falls for older workers was 60.5 per 100,000 FTEs, nearly triple the rate of 23.2 per 100,000 FTEs for younger workers in the same occupation.

Two thirds (66.0%) of fall fatalities occurred from a roof, ladder, or scaffold staging, but the type of fall varied by the age of the decedent

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

**TABLE 3:** Rate of Work-Related Deaths From Falls and Odds Ratio by Selected Occupations, 2003–2008 Average

| | Rate[a] | | |
|---|---|---|---|
| Selected Occupations | Ages 55 and Older (*n* = 520) | Ages 16–54 (*n* = 1,908) | OR [95% CI] |
| Roofer | 60.5 | 23.2 | 2.60 [1.90, 3.56]* |
| Ironworker | 47.8 | 37.2 | 1.29 [0.71, 2.34] |
| Power line installer | 26.9 | 14.0 | 1.92 [0.86, 4.29] |
| Sheet metal worker | 16.2 | 4.9 | 3.33 [1.24, 8.91]* |
| Painter | 15.3 | 3.7 | 4.16 [2.93, 5.91]* |
| Construction laborer | 14.8 | 6.1 | 2.42 [1.93, 3.01]* |
| Brickmason | 13.5 | 3.9 | 3.47 [1.93, 6.24]* |
| Carpenter | 9.9 | 3.4 | 2.93 [2.28, 3.77]* |
| Heating A/C mechanic[b] | 7.3 | 2.2 | 3.34 [1.69, 6.58]* |
| Foreman | 6.8 | 2.5 | 2.67 [1.92, 3.70]* |
| Drywall installer | 6.7 | 3.0 | 2.22 [0.94, 5.25] |
| Electrician | 5.7 | 2.0 | 2.90 [1.78, 4.72]* |
| Construction manager | 4.6 | 1.3 | 3.43 [2.37, 4.95]* |
| Plumber | 4.3 | 0.8 | 5.39 [2.72, 10.71]* |
| All construction | 6.7 | 3.3 | 2.07 [1.87, 2.28]* |

*Source*. 2003–2008 Current Population Survey and Census of Fatal Occupational Injuries.
*Note*. OR = odds ratio; CI = confidence interval.
[a]Rate = number of deaths per 100,000 full-time equivalent workers.
[b]Full occupation name: heating, air conditioning, and refrigeration mechanics and installers.
*$p \leq .05$.

(Table 4). Compared with younger construction workers, fatal falls among older workers were less likely to be from roofs (25.4% vs. 34.3%, $p < .001$) but more likely to be from ladders (22.7% vs. 15.4%, $p < .001$). Falls from building girders accounted for 7.2% of fatal falls in younger decedents but only for 3.3% of fall fatalities in older decedents ($p < .001$). Although deaths caused by falls on the same level accounted for only approximately 1% of the total fatal falls in construction, it is notable that such deaths were more likely to be observed among older decedents than younger decedents ($p = .001$). No significant difference was found between the age groups in fatal falls from scaffold staging.

The multiple logistic regression analysis examined factors associated with construction deaths from falls versus other causes (Table 5). Compared with younger workers, deaths among older workers were approximately 50% more likely to be from falls, after controlling for age, ethnicity, occupation, establishment size, employment type, job site, and census region (OR = 1.50, CI [1.30, 1.72]). Work-related fatal falls were much more likely to occur at residential construction sites than any other location. Fatal falls were also more likely to be observed in blue-collar occupations than in white-collar occupations (OR = 1.48, CI [1.18, 1.85]). Moreover, establishment size appears to be significantly associated with fatal falls: The smaller the size, the higher the odds ratio. Compared with fatalities in wage-and-salary workers employed in large establishments (100 or more employees), deaths among self-employed construction workers were more likely to be caused by falls (OR = 1.79, CI [1.42, 2.27]). The large *p* value from the Hosmer-Lemeshow goodness-of-fit test indicated that the model fit the observed data well (*p* value = .272).

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

**TABLE 4:** Types of Fatal Falls in Construction by Age Group, 2003–2008

| | Ages 55 and Older | | Ages 16–54 | | All Construction | | |
|---|---|---|---|---|---|---|---|
| Type | *n* | % | *n* | % | *n* | % | $p^{a}(H_0 : \mu_{55+} = \mu_{16-54})$ |
| Fall from roof | 132 | 25.4 | 655 | 34.3 | 789 | 32.4 | <.001 |
| Fall from ladder | 118 | 22.7 | 294 | 15.4 | 413 | 17.0 | <.001 |
| Fall from scaffold staging | 79 | 15.2 | 324 | 17.0 | 403 | 16.6 | .334 |
| Fall to lower level, NEC or unspecified | 62 | 12.0 | 223 | 11.7 | 285 | 11.7 | .879 |
| Fall from floor, dock, or ground level | 36 | 6.9 | 137 | 7.2 | 174 | 7.1 | .811 |
| Fall from nonmoving vehicle | 33 | 6.4 | 98 | 5.1 | 131 | 5.4 | .306 |
| Fall from building girders | 17 | 3.3 | 138 | 7.2 | 155 | 6.4 | <.001 |
| Fall on same level | 17 | 3.3 | 12 | 0.6 | 29 | 1.2 | .001 |
| Other | 26 | 4.7 | 27 | 1.5 | 53 | 2.2 | <.001 |
| Total | 520 | 100.0 | 1,908 | 100.0 | 2,432 | 100.0 | — |

*Source*. U.S. Bureau of Labor Statistics, 2003–2008 Census of Fatal Occupational Injuries.
*Note*. Deaths without age information or of those younger than 16 years old were included in the total. NEC = not elsewhere classified.
[a] *p* values reflect *t* tests for differences in the group means.

## DISCUSSION

This study provides evidence that fatal falls are of particular concern for older construction workers. The results strongly support the study hypothesis that fatal falls are different between older and younger construction workers and that falls are an increasingly prominent cause of work-related death as workers age. Compared with younger workers, deaths among older construction workers were approximately 50% more likely to be from fall injuries than other injuries after controlling for major demographic and employment factors. Death rates for fatal falls are significantly higher for older workers than for their younger counterparts in most construction occupations. The highest risk in fall fatalities for both age groups was for the occupations of roofer, ironworker, and power line installer. The rate of fatal falls for roofers was nearly 10 times that of all construction on average (60.5 vs. 6.7 per 100,000 FTEs), and the risk of fatal falls almost tripled for older roofers compared with their younger counterparts.

Although falls from roofs accounted for nearly one third of construction fatal falls, it is notable that falls from ladders accounted for a much larger proportion of deadly falls in the older worker group than in the younger one. This finding is a clear indication that using a ladder remains a particularly risky task for older construction workers.

The high risk of fatal falls among older construction workers suggests that OSHA and NIOSH should ensure that older construction workers are appropriately targeted within their fall prevention capacity. Some successful programs to prevent construction-related falls (such as the Fall-Safe Partnership intervention; Becker, Fullen, Akladios, & Hobbs, 2001) should be enhanced and adjusted specifically with older workers in mind. For example, ladder safety should be emphasized and older workers should be trained or retrained to use ladders properly. Since falls are a highly preventable injury, efforts to reduce or eliminate fatal falls as well as other severe work-related fall injuries would be a significant and practical benefit for the entire construction workforce.

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

**TABLE 5:** Multivariate Logistic Regression on Fatal Falls Versus Other Fatalities, 2003–2008

| Variable | OR | 95% CI | *p* |
|---|---|---|---|
| Age | | | |
| 55+ | 1.50 | [1.30, 1.72] | <.001 |
| 16–54 | 1.00 | [1.00, 1.00] | — |
| Ethnicity | | | |
| Hispanic | 1.23 | [1.08, 1.40] | .002 |
| Other, non-Hispanic | 0.82 | [0.68, 0.99] | .041 |
| White, non-Hispanic | 1.00 | [1.00, 1.00] | — |
| Occupation | | | |
| Blue collar | 1.48 | [1.18, 1.85] | .001 |
| White collar | 1.00 | [1.00, 1.00] | — |
| Employment type | | | |
| Self-employed | 1.79 | [1.42, 2.27] | <.001 |
| Establishment size 1–10[a] | 1.63 | [1.32, 2.02] | <.001 |
| Establishment size 11–19 | 1.44 | [1.09, 1.91] | .011 |
| Establishment size 20–49 | 1.33 | [1.03, 1.72] | .030 |
| Establishment size 50–99 | 1.27 | [0.94, 1.71] | .120 |
| Establishment size 100+[b] | 1.00 | [1.00, 1.00] | — |
| Location | | | |
| Residential construction site | 24.98 | [18.97, 32.89] | <.001 |
| Public building | 22.13 | [16.00, 30.62] | <.001 |
| Industrial construction site | 21.66 | [16.65, 28.17] | <.001 |
| Other locations | 10.84 | [8.24, 14.25 | <.001 |
| Street and highway | 1.00 | [1.00, 1.00] | — |
| Region | | | |
| Northeast | 1.48 | [1.23, 1.79] | <.001 |
| Midwest | 1.17 | [0.97, 1.40] | .095 |
| South | 1.12 | [0.97, 1.30] | .124 |
| West | 1.00 | [1.00, 1.00] | — |
| Overall model evaluation | | | |
| Likelihood ratio | 1521.12 | | <.001 |
| Score | 1242.77 | | <.001 |
| Goodness-of-fit test | | | |
| Hosmer and Lemeshow | 9.90 | | .272 |

*Source*. U.S. Bureau of Labor Statistics, 2003–2008 Census of Fatal Occupational Injuries.
*Note*. OR = odds ratio; CI = confidence interval.
[a.]Establishment size measure was only for wage-and-salary workers.
[b.]Establishments with 100 or more employees were set as the reference group for both self-employed and smaller establishments.

Fatalities at residential sites were more likely to be caused by falls than that at nonresidential sites, indicating the need for better regulations and fall protections for workers in residential construction. Residential construction is usually not regulated by OSHA well, since projects are often small scale with quick-turnaround work and are completed before inspectors are even

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

aware of them (Sa, Seo, & Choi, 2009). Although OSHA fall protection rules have been in effect for many years, these regulations have not been applied to workers engaged in certain residential construction activities until very recently (OSHA, 2010). This study confirms previous findings that lack of specific fall prevention may contribute to the higher rates of fall deaths in residential construction (Kaskutas et al., 2009; Lipscomb, Dale, Kaskutas, Sherman-Voellinger, & Evanoff, 2008; Sa et al., 2009) and supports the recent OSHA enforcement in the residential construction industry.

This study also found that decedents who were employed in small construction establishments or were self-employed were more likely to die from falls compared with decedents employed in larger establishments. According to the U.S. Census Bureau (2010), more than 90% of establishments in residential construction are small establishments with fewer than 10 employees, in which formal skill and safety training may be rare (Sa et al., 2009).

Our estimates from the CFOI data indicate that self-employed workers were more likely to die on residential construction sites. Self-employed workers are not covered per the Occupational Safety and Health Act. Thus, their use of fall protection devices is not enforced, and they may have less rigorous safety practices. This is a problem for the construction industry, in particular, for older workers, given that nearly 40% of construction workers ages 55 and over are self-employed (CPWR, 2011). In addition, self-employed workers often work alone, so if they are injured, help may not be readily available (Mirabelli, Loomis, & Richardson, 2003; Pegula, 2004). To reduce fall injuries, training and policy interventions should also be available for self-employed workers.

It is notable that older construction workers had a higher risk of fatal falls than younger workers even in some occupations (such as plumbers) or activities (such as working on the same level) that have a relatively low risk of fall injuries. Although the causes of injuries are very complicated and diverse, many aging-related factors are cited as contributing to the elevated risk: gradually worsening vision and hearing impairment, chronic medical and musculoskeletal problems, and reduced physical functioning (Welch, Haile, Boden, & Hunting, 2008; Zwerling, Whitten, Davis, & Sprince, 1998). The biomechanics of aging contribute to increased slips and falls; problems include slower reaction times, decreased joint mobility, reduced elasticity of tissues, and loss of strength (Lockhart, Smith, & Woldstad, 2005). Considering that older workers may be more vulnerable to fall hazards, fall prevention interventions should be readily available for all construction worksites and workers.

In terms of region, this study found that falls were higher in the Northeast than in the West. In addition to regional differences in types of construction projects and other factors, this finding suggests that some fall injuries could be attributed to colder weather conditions. Working in the construction industry often means working outdoors. Construction workers who are outside in the Northeast are more likely to be exposed to freezing temperatures, frost, ice, and snow than are their counterparts in the West and the South. If proper precautions are not taken, a construction worker is at a higher risk for slip-and-fall injuries, even fatalities, in adverse weather. In addition to fall protections, appropriate work scheduling in inclement weather may help workers avoid cold, wet, windy, and other risky working conditions.

Construction work brings to light many of the common health and functional deficits among older workers because of its physical demands and high-risk tasks. Older workers not only are at a higher risk for fatal and more serious injuries but also require longer time away from the job if they are injured and have more hospitalizations on average (Derr et al., 2001; Rogers & Wiatrowski, 2005; Shishlov et al., 2011). Researchers have found that increased risk of severe injury begins earlier than what was traditionally thought of as "older" and can be observed as early as in the 40s (Chau et al., 2004). Given the increasingly aging workforce in construction and higher risk for older workers, the construction industry is in need of not only more rigorous safety and prevention measures but also ergonomic solutions (Choi, 2009; Hsiao & Simeonov, 2001). In addition, work accommodations and changes in tasks would allow workers to continue in the same industry

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

but with less risk of serious injury (Bohle, Pitts, & Quinlan, 2010; Costa, Goedhard, & Ilmarinen, 2005). For example, older workers could be assigned less frequently to ladder-based tasks.

European and Asian scholars on aging have addressed the health and safety needs of older workers, including attention to the concept of workability (i.e., matching of job demands to the physical and cognitive capabilities of aging employees, such as revising schedules and tasks; Costa et al., 2005; Ilmarinen, 1999, 2009; Kumashiro, 2008). Assessment of individual workability and associated health problems may reduce disability-related work absences and retirement and, at the same time, prevent severe traumatic injuries, such as falls. Adopting a workability index such as that used in Europe (Tuomi, Ilmarinen, Jahkola, Katajarinne, & Tulkki, 1998) should be a beneficial tool in risk assessments and job assignments from the perspective of injury prevention rather than an excuse of age discrimination. Changes in work and lifestyle are also important for maintaining or improving workability over time (van den Berg, Elders, de Zwart, & Burdof, 2009). Therefore, workplace programs should promote evidence-based individual behaviors, such as leisure-time physical exercise and weight control.

The findings from this study should be taken into account with the study's limitations. One of the major limitations is the lack of reliable denominator data (i.e., hours worked) to estimate rates of fatal falls. Although the rates of fatal falls by hours worked (FTE) were adjusted, the rates could be underestimated since self-reported hours worked in the CPS data may be overestimated (CPWR, 2010). Since the CPS is conducted via telephone, there is likely some undercounting of migrant and mobile workers and those who lack permanent U.S. addresses. For some age groups, this potential undercounting may be of particular concern since immigrants, Hispanics, and very-low-income workers could be relatively younger. Thus, the rates could also be overestimated for some subpopulations.

In addition, the CPS is a sample survey subjected to sampling and nonsampling errors as with other surveys. Moreover, even though basic demographic and employment information from CFOI and CPS were matched for most calculations, some key factors that could affect fatal falls, such as work location and establishment size, were not available in the monthly CPS data. Hence, for the multivariate analysis, only the CFOI data were used. Furthermore, since factors such as safety and health training, fall prevention use, safety climate, workload, work organization factors, and project information were not available in the CFOI or the CPS, differences in the actual risk of fatal falls between older and younger workers may not be fully measured. Further case studies and project-based studies should be conducted to verify the study findings.

Despite the limitations, this study identifies the disparities in patterns and trends of fatal falls between older and younger workers, reveals the increased fall risk for older construction workers, and provides insight for older worker safety in the construction industry. This unique and detailed information may contribute to fall interventions for older workers as well as for the entire construction workforce.

## ACKNOWLEDGMENTS

The authors would like to thank Scott Schneider of Laborers' Health and Safety Fund of North America (LHSFNA) for his insightful review as well as the reviewers of *Human Factors*. In addition, the authors would like to thank Alissa Fujimoto for her editorial support. This study was funded by the U.S. National Institute for Occupational Safety and Health (NIOSH) Grant U60OH009762. The contents of this study are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

## KEY POINTS

- We examined trends in fatal falls in the U.S. construction industry by analyzing two large data sources during a 17-year period (1992–2008).
- Older construction workers, ages 55 and older, had higher rates of fatal falls than did younger workers; results were significant in 11 of 14 occupations.
- Multiple regression analysis indicated that older decedents had a significantly higher likelihood that work-related death was caused by a fall, after controlling for major demographic and employment factors.

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

- As the construction workforce ages, there is an urgent need to enhance fall prevention efforts, provide work accommodations, and match work capabilities to job tasks.

## REFERENCES


Agnew, J., & Suruda, A. J. (1993). Age and fatal work-related falls. *Human Factors*, *35*, 731–736.

Becker, P., Fullen, M., Akladios, M., & Hobbs, G. (2001). Prevention of construction falls by organizational intervention. *Injury Prevention*, *7*(Suppl. 1), i64–i67.

Bohle, P., Pitts, C., & Quinlan, M. (2010). Time to call it quits? The safety and health of older workers. *International Journal of Health Services*, *40*, 23–41.

Chau, N., Gauchard, G. C., Siegfried C., Benamghar, L., Dangelzer J. L., Francais, M., . . . Mur, J.M. (2004). Relationships of job, age, and life conditions with the causes and severity of occupational injuries in construction workers. *International Archives of Occupational and Environmental Health*, *77*, 60–66.

Chi, C.-F., Chang T., & Ting H.-I. (2005). Accident patterns and prevention measures for fatal occupational falls in the construction industry. *Applied Ergonomics*, *36*, 391–400.

Choi, S. D. (2009). Safety and ergonomic considerations for an aging workforce in the U.S. construction industry. *Work*, *33*, 307–315.

Costa, G., Goedhard, W. J. A., & Ilmarinen, J. (Eds.). (2005). *Assessment and promotion of work ability, health and well-being of ageing workers* (International Congress Series 1280). Amsterdam, Netherlands: Elsevier.

CPWR–The Center for Construction Research and Training. (2008). *The construction chart book: The U.S. construction industry and its workers* (4th ed.). Silver Spring, MD: Author.

CPWR–The Center for Construction Research and Training. (2010). *Work-related fatal and nonfatal injuries among U.S. construction workers, 1992–2008*. Silver Spring, MD. Retrieved from http://www.cpwr.com/rp-cpwrreports2.html

CPWR–The Center for Construction Research and Training. (2011). [Calculations of Current Population Survey data by the CPWR Data Center].

Derr, J., Forst L., Chen, H.Y., & Conroy, L. (2001). Fatal falls in the US construction industry, 1990 to 1999. *Journal of Occupational and Environmental Medicine*, *43*, 853–860.

Dong, X., & Fujimoto, A. (2009). *Hispanic employment in construction* (CPWR Data Brief Vol. 1, No. 1). Silver Spring, MD: Center for Construction Research and Training.

Dong, X., Fujimoto, A., Ringen, K., & Men, Y. (2009). Fatal falls among Hispanic construction workers. *Accident Analysis & Prevention*, *41*, 1047–1052.

Garr, E. (2009). *Older Americans in the recession: More are staying in the workforce, more are losing their jobs* (Economic Policy Institute Issue Brief No. 251). Washington, DC: Economic Policy Institute.

Hsiao, H., & Simeonov, P. (2001). Preventing falls from roofs: A critical review. *Ergonomics*, *44*, 537–561.

Ilmarinen, J. E. (1999). *Ageing workers in the European Union*: *Status and promotion of work ability, employability and employment.* Helsinki, Finland: Finnish Institute of Occupational Health, Ministry of Social Affairs and Health, Ministry of Labor.

Ilmarinen, J. E. (2009). Work ability: A comprehensive concept for occupational health research and prevention [Editorial]. *Scandinavian Journal of Work, Environment & Health*, *35*, 1–5.

Jackson, S. A., & Loomis, D. (2002). Fatal occupational injuries in the North Carolina construction industry, 1978–1994. *Applied Occupational and Environmental Hygiene*, *17*, 27–33.

Kaskutas, V., Dale, A. M., Nolan, J., Patterson, D., Lipscomb, H. J., & Evanoff, B. (2009). Fall hazard control observed on residential construction sites. *American Journal of Industrial Medicine*, *52*, 491-499.

Kumashiro, M. (Ed.). (2008). *Promotion of work ability towards productive aging: Selected papers of the 3rd International Symposium on Work Ability*. London, UK: CRC Press.

Lipscomb, H. J., Dale, A. M., Kaskutas, V., Sherman-Voellinger, R., & Evanoff, B. (2008). Challenges in residential fall prevention: Insight from apprentice carpenters. *American Journal of Industrial Medicine*, *51*, 60–68.

Lockhart, T. E., Smith, J. L., & Woldstad, J. C. (2005). Effects of aging on the biomechanics of slips and falls. *Human Factors*, *47*, 708–729.

Mirabelli, M. C., Loomis, D., & Richardson, D. B. (2003). Fatal occupational injuries among self-employed workers in North Carolina. *American Journal of Industrial Medicine*, *44*, 182–90.

Myers, J. R., Layne, L. A., & March, S. M. (2009). Injuries and fatalities to U.S. farmers and farm workers 55 years and older. *American Journal of Industrial Medicine*, *52*, 185–194.

National Institute for Occupational Safety and Health. (2008). *National Occupational Research Agenda (NORA): National construction agenda for occupational safety and health research and practice in the U.S. construction sector*. NORA Construction Sector Council. Retrieved from http://www.cdc.gov/niosh/nora/comment/agendas/construction/pdfs/ConstOct2008.pdf

Occupational Safety and Health Administration. (2010). *Compliance guidance for residential construction* (STD 03-11-002). Retrieved from http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=4755

Office of Management and Budget. (1987). *Standard Industrial Classification manual*. Springfield, VA: National Technical Information Service.

Office of Management and Budget. (2002). North American Industry Classification System. Retrieved from http://www.census.gov/eos/www/naics/

Pegula, S. M. (2004). Occupational fatalities: Self-employed workers and wage and salary workers. *Monthly Labor Review*, *127*, 30–40.

Rogers, E., & Wiatrowski, W. J. (2005). Injuries, illnesses, and fatalities among older workers. *Monthly Labor Review*, *128*(10), 24–30.

Sa, J., Seo, D.-C., & Choi, S. D. (2009). Comparison of risk factors for falls from height between commercial and residential roofers. *Journal of Safety Research*, *40*, 1–6.

Salminen, S. (2004). Have young workers more injuries than older ones? An international literature review. *Journal of Safety Research*, *35*, 513–521.

SAS Institute. (2008). *SAS/STAT 9.2 user's guide* (Vols. 1–7). Cary, NC: Author.

Shishlov, K. S., Schoenfisch, A. L., Myers, D. J., & Lipscomb H. J. (2011). Non-fatal construction industry fall-related injuries treated in US emergency departments, 1998–2005. *American Journal of Industrial Medicine*, *54*, 128–135.


Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012

Toosi, M. (2009). Labor force projections to 2018: Older workers staying more active. *Monthly Labor Review*, *132*(11), 30–51.

Tuomi, K., Ilmarinen, J., Jahkola, A., Katajarinne, L., & Tulkki, A. (1998). *Work Ability Index* (2nd rev. ed.). Helsinki, Finland: Finnish Institute of Occupational Health.

U.S. Bureau of Labor Statistics. (1992–2008). *Injuries, illnesses and fatalities: Census of Fatal Occupational Injuries*. Retrieved from http://www.bls.gov/iif/oshfat1.htm

U.S. Bureau of Labor Statistics. (2010a). *Injuries, illnesses and fatalities: Census of Fatal Occupational Injuries*. Retrieved from http://www.bls.gov/iif/oshfat1.htm

U.S. Bureau of Labor Statistics. (2010b). *Occupational Injury and Illness Classification System, 2010*. Retrieved from http://www.bls.gov/iif/oshoiics.htm

U.S. Census Bureau. (2010). County business patterns. Retrieved from http://www.census.gov/econ/cbp/

van den Berg, T. I., Elders, L. A., de Zwart, B. C., & Burdorf, A. (2009). The effects of work-related and individual factors on the Work Ability Index: A systematic review. *Occupational and Environmental Medicine*, *66*, 211–220.

Welch, L. S., Haile, E., Boden, L. I., & Hunting, K. L. (2008). Age, work limitations and physical functioning among construction roofers. *Work*, *31*, 377–385.

Zwerling, C., Whitten, P. S., Davis, C. S., & Sprince, N. L. (1998). Occupational injuries among older workers with visual, auditory, and other impairments: A validation study. *Journal of Occupational and Environmental Medicine*, *40*, 720–723.

Xiuwen Sue Dong is the Data Center director for CPWR–The Center for Construction Research and Training. Her research covers construction safety and health surveillance, health services, costs of occupational injuries and illnesses, the aging workforce, and safety and health disparities. She currently serves as the principal investigator for several projects funded by the U.S. National Institute for Occupational Safety and Health. She is the principal author of *The Construction Chart Book: The U.S. Construction Industry and Its Workers* and many other publications. She has a doctoral degree in public health and a master's degree in labor economics.

Xuanwen Wang is a research analyst at the CPWR Data Center. She has a doctoral degree in economics and experience with public health studies, survey research, occupational safety and health surveillance, and large health care databases. She is the coauthor of several prominent CPWR publications.

Christina Daw is a research analyst at the CPWR Data Center. She has both doctoral and master's degrees in public health. She has analytical experience with several large databases and more than 10 years of experience with federal grant-funded health care programs.

*Date received: January 3, 2011*
*Date accepted: April 11, 2011*

Downloaded from hfs.sagepub.com at CDC CTR FOR DISEASE CONTROL on July 17, 2012