# Risks of a lifetime in construction Part I: Traumatic injuries

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**Background** *Estimates of occupational risk are typically computed on an annual basis. In contrast, this article provides estimates of lifetime risks for fatal and nonfatal injuries among construction workers. A companion paper presents lifetime risks for occupational illnesses.*

**Methods** *Using 2003–2007 data from three large data sources, lifetime risk was computed based on the number of fatal and nonfatal injuries per 100 FTEs for a working lifespan of 45 years.*

**Results** *For a working life in construction, the risk of fatal injuries were approximately one death per 200 FTE, and the leading causes were falls and transportation incidents. For nonfatal injuries resulting in days away from work, the adjusted lifetime risk was approximately 78 per 100 FTEs, and the leading causes were contact with objects/ equipment, overexertion, and falls to a lower level.*

**Conclusions** *Lifetime risk estimates help inform both workers and policymakers. Despite improvements over the past decades, risks in construction remain high. Am. J. Ind. Med.*


***KEY WORDS: lifetime risk; construction; fatalities; nonfatal injuries; working lifespan; falls; contact with objects/equipment; overexertion***

## INTRODUCTION

Hazards of working life are usually described as relative risks based on annual injury rates. While such cross-sectional studies are useful, they tend to understate risks since they only reflect certain time points [Robinson, 1986]. Longitudinal cohort studies can improve on these deficiencies [Schubauer-Berigan et al., 2009; Neitzel et al., 2011], but those studies are difficult to maintain due to reasons such as investigators losing interest/funding or participants leaving the cohort. Consequently, there have been very few longitudinal studies of occupational risks [Arndt et al., 2005]. Additionally, most studies present risks as relative rather than absolute risks, which makes it difficult for the general population to understand from a public health perspective.

It is well recognized that the construction industry is one of the largest and most dangerous industries in the U.S. [Ringen et al., 1995; National Research Council, 2009; CPWR, 2013]. Despite injury reductions due to continuous intervention efforts, the construction industry still reports more fatalities than any other industry (U.S. Bureau of Labor Statistics (BLS), 2013a). Moreover, deaths and injuries from falls represent a major and persistent problem in construction (BLS, 2013a). The nonfatal injury rate in construction also has been higher than in other goods-producing industries in most years. The rate of cases with days away from work in construction was about 40% higher than that of all private industries (BLS, 2013b). Therefore, construction is regarded as one of five "high risk professions" given special consideration in Paragraph 9001 of the 2010 Patient Protection and Affordable Care Act (Pub.L. 111–148; 124 Stat. 119, codified). While the Act does not define what "high risk" is, presumably it is based on the experience of the last

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generation of workers in the specified industries. Due to the high risks construction workers have experienced and will continue to face, exploring the risks during a worker's lifespan could further illuminate the high risks in this industry in order to set priorities for developing interventions.

Construction is also a dynamic and complex industry sector that consists of mainly small employers. In 2009, there were more than 700,000 establishments in the industry; about 83% employed less than 10 workers, and 99% employed less than 100 workers [U.S. Census Bureau, 2010]. Changes in the economy and housing market in the U.S. have made construction safety and health more complicated and unpredictable than ever before. In 2006, the number of occupational fatalities in construction peaked at almost 1,300, but dropped to about 800 by 2010 (Appendix I). In part, the decline reflected the impact of the economic downturn (BLS, 2011). The construction workforce significantly expanded from 7.0 million in 1992 to 11.8 million in 2007, and then fell to 9.1 million by 2010 due to the recession.

The most dramatic change in the construction industry has been the growth of Hispanic workers since the early 1990s. The number of Hispanic construction workers increased from about 700,000 in 1992 to nearly 3 million in 2007 [CPWR, 2013]. The subsequent economic downturn seriously affected Hispanic employment in construction. During the recession, about one of three Hispanic construction workers lost employment [CPWR, 2013]. With the economic recovery, Hispanic reemployment and new entry in the workforce are expected to grow [Pew Hispanic Center, 2012]. Hispanic construction workers tend to be inexperienced young immigrants who do not speak English very well, are less-educated, take low-skilled jobs, and are more likely to suffer from work-related injuries than their non-Hispanic counterparts [Brunette, 2004; Dong and Platner, 2004; CPWR, 2013; CDC, 2008; Dong et al., 2009, 2010a,b, 2011, 2013]. Although the ethnic disparities in safety and health risks among construction workers have been well-documented, the magnitude of risks that Hispanic construction workers face over a working life has never been examined.

The construction industry, like many other industries, is aging [CPWR, 2013]. The workforce has steadily increased in average age, but new and younger workers will enter the industry as the baby boomer generation transitions into retirement and overall employment increases in the next decade (BLS, 2013c). Introducing young workers to the risks of their work in a more meaningful way should help them better understand the risks they face and engage them in finding solutions to make the industry safer, and perhaps accelerate the significant improvements that have been achieved in recent decades.

Although it has been shown in other areas of public health that presenting risks over a lifetime can have a significant effect on shaping public policy priorities, including breast cancer [Phillips et al., 1999], hypertension [Vasan et al., 2002], dementia [Seshadri et al., 1997], cardiovascular disease [Wilkins et al., 2012], and diabetes [Narayan et al., 2011], few attempts have been made to present risks in this manner in occupational safety and health. There is only one published report on lifetime risks in the construction industry (Fosbroke et al., 1997), and it was limited to incomplete data on occupational fatalities since it was performed before the Census of Fatal Occupational Injuries (CFOI) data were available.

This study presents a significantly broader perspective on risks, by stratifying lifetime risk in construction according to occupation, leading cause, and ethnicity for both fatal and nonfatal occupational injuries. The findings of this study will provide new risk assessments that should inform the formation of construction safety and health policies, and provide a frame of reference for job seekers who intend to work in the construction industry.

## MATERIALS AND METHODS

To estimate lifetime risk in the construction industry, this study focused on fatal and nonfatal traumatic injuries by analyzing three large nationally representative datasets.

*Census of Fatal Occupational Injuries* (CFOI; http://www.bls.gov/iif/oshcfoi1.htm). The CFOI is a federal-state cooperative program that has been implemented in all 50 states and the District of Columbia since 1992. Data on deaths resulting from injuries at work are compiled from government sources, such as death certificates, workers' compensation reports, Occupational Safety and Health Administration (OSHA) reports, and medical examiner reports. Both the death and the work-relatedness of the death must be corroborated by at least two data sources or a single data source and a follow-up questionnaire. States are allowed to revise the reports within 1 year. 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 calculations of fatality rates include the public and private construction sectors and self-employed workers, unless otherwise noted. Thus, the numbers presented here may differ from those in the U.S. Bureau of Labor Statistics' (BLS) publications that include only deaths in the private sector.

*Survey of Occupational Injuries and Illnesses* (SOII; http://www.bls.gov/respondents/iif). The SOII provides the numbers of nonfatal injuries and illnesses. The SOII is a federal-state program in which employer reports are collected annually from private industry establishments and processed by state agencies cooperating with the BLS. The sample of workplaces selected by the BLS for participation in the SOII consists of approximately 230,000 private industry establishments each year. Self-employed workers, farms with fewer than 11 employees, private households, and federal government agencies are not covered in the SOII data collection.

*Current Population Survey* (CPS; http://www.census.gov/cps). The CPS is a monthly survey of households conducted by the U.S. Census Bureau for the BLS. Estimates from the CPS are based on a scientific sample of about 60,000 housing units per survey. Each month, interviewers contact the sampled units to obtain basic demographic information about everyone living at the address, including age, gender, race, and Hispanic origin. For those aged 16 years or older, the survey collects detailed information on employment, including occupation, industry, and number of hours worked.

When calculating rates, the number of injuries from the CFOI and SOII were used as numerators, while the number of construction workers and hours worked from the CPS were used as denominators. Nonfatal injury risk estimates only cover injuries resulting in days away from work (DAFW) among wage-and-salary construction workers in the private sector. The SOII only provides detailed information on DAFW cases, and such injuries are major concerns for workplace interventions. The SOII data on public sector workers are available after 2008, and thus are not included in the study. To match the data from the SOII, self-employed workers and workers in the public sector were excluded from the CPS estimates. While self-employed workers constituted almost 30% of the construction workforce, less than 5% of construction workers were employed in the public sector.

The following formula developed by OSHA has been used to calculate working lifetime risks (WLTR) for U.S. industries by several researchers [Fosbroke et al., 1997; Drudi, 1998; Sygnatur, 1998]. Lifetime risk was assumed to be a 45-year working life in these studies, including estimates for the construction industry [Fosbroke et al., 1997], in which: $WLTR = (1-(1-R)^{y}) \times 100$

- **R** = probability of a worker having a work-related injury in a given year
- **1–R** = probability of a worker *not* having a work-related injury in a given year
- $^{y}$ = years of exposure to work-related injury
- $\mathbf{(1–R)}^{y}$ = probability of surviving $^{y}$ years without a work-related injury
- $\mathbf{1–(1–R)}^{y}$ = probability of having a work-related injury over $^{y}$ years of employment

For this current study, the above formula and tabulation methods were adopted assuming a working life for a construction worker would be 45 years, the same as the overall U.S. workforce considering the average age of construction workers was close to the overall U.S. workforce in 2010 [CPWR, 2013], and the trend of the aging workforce (BLS, 2012, Banerjee, 2001; Gendell, 2008).

The average annualized rate for 2003–2007 was used as the basis for estimating lifetime risk. This time period was selected for several reasons. Starting in 2003, the 1987 Standard Industrial Classification (SIC) system had been replaced with the North American Industry Classification System (NAICS; BLS, 2010), while the 1990 Census Occupational Classification System switched to the 2000 Standard Occupational Classification System (SOC; BLS, 2004a). In addition, OSHA had changed reporting criteria for nonfatal injuries and illnesses since 2002. Using data from 2003 onward allows multiple years of data to be more comparable and easily combined by the same classifications. In addition, by using the average data from a 5-year period from 2003 to 2007, yearly data fluctuations are minimized and the reliability in deriving "lifetime risk" estimates increases. Furthermore, this time period was selected because both fatal and nonfatal injury rates have declined significantly over past decades and estimates using this time period would better capture the current risk in construction. If data from 1992 were included, the estimated risk would be higher and the effects of recent construction interventions would not be accounted for in the computations. Finally, the end date of 2007 was used to avoid distortions resulting from the national economic crisis that began in 2007 and worsened through 2010 (National Bureau of Economic Research, 2010), which led to a steep decline in employment and significant demographic distortions in the construction labor force. In particular, Hispanic, non-union, and younger workers were disproportionately affected [CPWR, 2013a] and therefore, injury data during the economic downturn may not reflect the real risk in the construction industry.

To standardize reporting, risks were measured as the number of injuries per 100 FTEs (assuming 2,000 hr worked per year; Northwood, 2009). Given injury variances among construction subgroups [Dong et al., 2010a,b; CPWR, 2013], injury risk was stratified by occupation and Hispanic ethnicity. Because non-Hispanic is a broader category including other minorities (e.g., Asian, black, etc.), White, non-Hispanic was determined to be the best comparison group for Hispanic workers to estimate ethnic disparities in construction. Inclusion of other ethnic groups in the comparison may add little statistical strength and increase variance because of the small number of workers in each of these groups.

Considering substantial evidence that nonfatal injuries are underreported, [Leigh et al., 2004; Rosenman et al., 2006; Friedman and Forst, 2007; Boden and Ozonoff, 2008; Committee on Education and Labor, 2008; Ruser, 2008; Boden and Ozonoff, 2010; Oleinick and Zaidman, 2010], particularly in the construction industry [Welch et al., 2007; Dong et al., 2011], risks were adjusted assuming that the trends of both fatal and nonfatal injuries would be similar [Leigh et al., 2004; Dong et al., 2011]. The adjustment used the year 1992 as the basis for two reasons. One of the reasons is that beginning in 1992, the BLS has collected a comprehensive count of work-related deaths in the CFOI

(BLS, 2004b). The second reason is that the increase in Hispanic employment started in the early 1990s, and the number of nonfatal injuries was less inaccurate then considering that recent studies found that nonfatal injuries among Hispanic construction workers are more likely to be underreported (Dong et al., 2010a, 2010b, 2011). This method assumed that a shift in the organization of work and interventions would have similar effects on both fatal and nonfatal injuries in construction over time.

Based on these assumptions, if the number of nonfatal injuries reported in 1992 (n = 17,715) was accurate and increased at the same rate as fatal injuries, the number of nonfatal injuries among Hispanic construction workers in 2006 would be around 59,000 (17,715*3.3) instead of the 33,930 cases reported (Appendix I). This calculation did not take into account the changes in OSHA injury and illness record-keeping rules during the time period. In addition, the rates of DAFW injuries were also adjusted for missing values for ethnicity (about 25%) in the SOII as well as the difference in FTEs between estimates from the CPS data and the numbers from the SOII published by the BLS (about 10%; CPWR, 2008). Additionally, 95% confidence intervals (CIs) of lifetime risk were computed based on the upper and lower FTE estimates (Appendices II and III). Since falls remain the leading cause of death in the construction industry, the risk of fatal falls were examined in detail.

# RESULTS

## Fatal Injuries

Between 2003 and 2007, a total of 6,228 construction workers died at job sites (Table I). If the risk remained the same, the death rate would be 0.506% over a 45-year working life in construction; or about 1 death per 200 full-time construction workers. Furthermore, falls are the leading cause of death in construction. Therefore, the lifetime risk of fall-related fatalities would be 17% for construction workers on average.

Table II summarizes the lifetime risk of traumatic fatalities in the construction industry and the differences in cause-specific fatality risks for Hispanic and white, non-Hispanic workers. Over a 45-year working life, 0.56 fatalities would occur per 100 full-time Hispanic workers (95% CI: 0.55–0.59%). The lifetime risk of fatalities for Hispanic workers would be about 20% higher than for white, non-Hispanic workers (0.56% vs. 0.47%); the disparity would be primarily for falls (0.22% vs. 0.15%) and transportation-related injuries (0.13% vs. 0.08%). The lifetime risk of fall-related fatalities would be about 47% higher for Hispanic construction workers than for their white, non-Hispanic counterparts. However, it appears that Hispanic construction workers would have a lower risk of contact with objects/equipment compared to their white, non-Hispanic counterparts (0.11% vs. 0.14%).

Table III shows that the risk of fatalities among construction trades would vary greatly, ranging from 0.24% among drywall installers to 3.11% among ironworkers. The difference between these two occupations was more than 10-fold. Similarly, the risk of fatal falls differed by trade (Table IV). Ironworkers, roofers, and power installers had the greatest risks (1.93, 1.16, and 0.54%); which were about 20, 12, and 6 times higher than for a construction manager (0.09%), respectively. Truck drivers (0.04%) and operating engineers (0.03%), who typically drive large movable equipment, had a lower risk of fatal falls. Only a small proportion of construction fatalities were among public sector employees. Analyses of fatality trends with and without the public sector in construction were similar, and thus were not reported separately.

**TABLE I.** Lifetime Risk[a] of Fatalities by Leading Causes in Construction

| Leading causes | Deaths (2003–2007) | Annual rate[a] Point estimate | Annual rate[a] 95% Confidence interval Lower | Annual rate[a] 95% Confidence interval Upper | Lifetime risk[a] Point estimate | Lifetime risk[a] 95% Confidence interval Lower | Lifetime risk[a] 95% Confidence interval Upper |
|---|---|---|---|---|---|---|---|
| Falls | 2,095 | 0.00379 | 0.00354 | 0.00408 | 0.17 | 0.16 | 0.18 |
| Transportation accidents | 1,679 | 0.00304 | 0.00284 | 0.00327 | 0.14 | 0.13 | 0.15 |
| Contact with objects and equipment | 1,195 | 0.00216 | 0.00202 | 0.00233 | 0.10 | 0.09 | 0.10 |
| Exposure to harmful substances or environments | 897 | 0.00162 | 0.00152 | 0.00175 | 0.07 | 0.07 | 0.08 |
| Assaults and violent acts | 188 | 0.00034 | 0.00032 | 0.00037 | 0.02 | 0.01 | 0.02 |
| Fires and explosions | 160 | 0.00029 | 0.00027 | 0.00031 | 0.01 | 0.01 | 0.01 |
| All causes | 6,228 | 0.01127 | 0.01052 | 0.01213 | 0.51 | 0.47 | 0.54 |

*Source*: Fatal injury data were generated by the authors with restricted access to BLS CFOI data.
[a]Deaths per 100 FTEs. The lifetime risk assumes a working time of 45 years.

**TABLE II.** Lifetime Risk[a] of Fatalities by Leading Causes and Hispanic Ethnicity in Construction

| | Hispanic | | | | White, non-Hispanic | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 95% Confidence interval | | | | 95% Confidence interval | |
| Leading Causes | Deaths (2003–2007) | Lifetime Risk[a] | Lower | Upper | Deaths (2003–2007) | Lifetime risk[a] | Lower | Upper |
| Falls | 626 | 0.22 | 0.22 | 0.23 | 1,284 | 0.15 | 0.15 | 0.15 |
| Transportation Incidents | 351 | 0.13 | 0.12 | 0.13 | 719 | 0.08 | 0.08 | 0.09 |
| Contact with Objects and Equipment | 320 | 0.11 | 0.11 | 0.12 | 1,179 | 0.14 | 0.14 | 0.14 |
| Exposure to Harmful Substances or Environments | 210 | 0.08 | 0.07 | 0.08 | 594 | 0.07 | 0.07 | 0.07 |
| Assaults and Violent Acts | 37 | 0.01 | 0.01 | 0.01 | 126 | 0.01 | 0.01 | 0.02 |
| Fires and Explosions | 31 | 0.01 | 0.01 | 0.01 | 103 | 0.01 | 0.01 | 0.01 |
| All Causes | 1,579 | 0.56 | 0.55 | 0.59 | 4,014 | 0.47 | 0.47 | 0.48 |

*Source*: Fatal injury data were generated by the authors with restricted access to BLS CFOI data.
[a]Deaths per 100 FTEs. The lifetime risk assumes a working time of 45 years.

## Nonfatal Injuries With Days Away From Work

Table V displays the risk of nonfatal injuries involving days away from work in construction. Between 2003 and 2007, the annual rate of DAFW injuries was 2.3% (95% CI: 2.24–2.37%). The lifetime risk of DAFW injuries based on SOII data was about 65% for the overall construction industry, and the adjusted risk was 78%. Unadjusted injury rates for white, non-Hispanic workers were higher than for

**TABLE III.** Lifetime Risk[a] of Trade-Specific Fatalities in Construction

| | | | 95% Confidence interval | |
|---|---|---|---|---|
| Trade | Deaths (2003–2007) | Lifetime risk[a] | Lower | Upper |
| Ironworker | 170 | 3.11 | 2.44 | 4.31 |
| Power installer | 83 | 2.61 | 1.88 | 4.26 |
| Roofer | 354 | 1.42 | 1.26 | 1.64 |
| Truck driver | 247 | 1.10 | 0.97 | 1.27 |
| Laborer | 1,538 | 1.04 | 0.99 | 1.10 |
| Welder | 97 | 0.88 | 0.73 | 1.12 |
| Helper | 90 | 0.75 | 0.63 | 0.93 |
| Operating engineer | 265 | 0.73 | 0.66 | 0.82 |
| Foreman | 494 | 0.49 | 0.46 | 0.52 |
| Electrician | 345 | 0.49 | 0.45 | 0.53 |
| Construction manager | 458 | 0.43 | 0.41 | 0.46 |
| Sheet metal worker | 34 | 0.42 | 0.34 | 0.54 |
| Brickmason | 90 | 0.39 | 0.34 | 0.45 |
| Heating | 116 | 0.37 | 0.33 | 0.42 |
| Painter | 231 | 0.37 | 0.34 | 0.40 |
| Plumber | 179 | 0.32 | 0.29 | 0.35 |
| Carpenter | 526 | 0.32 | 0.30 | 0.33 |
| Drywall | 60 | 0.24 | 0.21 | 0.27 |
| All construction | 6,228 | 0.506 | 0.472 | 0.544 |

*Source*: Fatal injury data were generated by the authors with restricted access to BLS CFOI data.
[a]Deaths per 100 FTEs. The lifetime risk assumes a working time of 45 years.

**TABLE IV.** Lifetime Risk[a] of Trade-Specific Fall Fatalities in Construction

| | | | 95% Confidence interval | |
|---|---|---|---|---|
| Trade | Deaths (2003–2007) | Lifetime risk[a] | Lower | Upper |
| Ironworker | 105 | 1.93 | 1.51 | 2.68 |
| Roofer | 288 | 1.16 | 1.02 | 1.33 |
| Power installer | 17 | 0.54 | 0.39 | 0.89 |
| Laborer | 481 | 0.33 | 0.31 | 0.34 |
| Welder | 33 | 0.30 | 0.25 | 0.38 |
| Sheet metal worker | 19 | 0.23 | 0.19 | 0.30 |
| Helper | 25 | 0.21 | 0.18 | 0.26 |
| Brickmason | 132 | 0.21 | 0.18 | 0.24 |
| Painter | 48 | 0.21 | 0.19 | 0.23 |
| Carpenter | 313 | 0.19 | 0.18 | 0.20 |
| Drywall | 41 | 0.16 | 0.14 | 0.19 |
| Foreman | 141 | 0.14 | 0.13 | 0.15 |
| Heating | 39 | 0.13 | 0.11 | 0.14 |
| Electrician | 80 | 0.11 | 0.11 | 0.12 |
| Construction manager | 98 | 0.09 | 0.09 | 0.10 |
| Plumber | 25 | 0.04 | 0.04 | 0.05 |
| Truck driver | 9 | 0.04 | 0.04 | 0.05 |
| Operating engineer | 9 | 0.03 | 0.02 | 0.03 |
| All construction | 2,095 | 0.17 | 0.16 | 0.18 |

*Source*: Fatal injury data were generated by the authors with restricted access to BLS CFOI data.
[a]Deaths per 100 FTEs. The lifetime risk assumes a working time of 45 years.

**TABLE V.** Lifetime Risk[a] of Nonfatal Injuries Involving Days Away from Work (DAFW)

| | | Annual rate of DAFW injuries[a] | | | Lifetime risk of DAFW injuries[b] | | |
|---|---|---|---|---|---|---|---|
| | | | 95% Confidence interval | | | 95% Confidence interval | |
| Variable | DAFW Injuries (2003–2007) | Point estimate | Lower | Upper | Point estimate | Lower | Upper |
| Cause | | | | | | | |
| Contact with object or equipment | 267,960 | 0.819 | 0.797 | 0.842 | 37.06 | 36.27 | 37.89 |
| Overexertion | 139,590 | 0.427 | 0.415 | 0.439 | 21.39 | 20.87 | 21.92 |
| Fall to lower level | 101,080 | 0.309 | 0.301 | 0.318 | 15.98 | 15.58 | 16.39 |
| Fall on same level | 63,910 | 0.195 | 0.190 | 0.201 | 10.42 | 10.15 | 10.7 |
| Transportation incidents | 29,500 | 0.090 | 0.088 | 0.093 | 4.95 | 4.82 | 5.08 |
| Exposed to harmful substance | 26,570 | 0.081 | 0.079 | 0.084 | 4.47 | 4.35 | 4.59 |
| Slip, trip, loss of balance—without fall | 22,100 | 0.068 | 0.066 | 0.069 | 3.73 | 3.63 | 3.83 |
| Repetitive motion | 12,650 | 0.039 | 0.038 | 0.040 | 2.15 | 2.09 | 2.21 |
| Ethnicity | | | | | | | |
| White, non-Hispanic | 427,470 | 2.442 | 2.393 | 2.475 | 72.84 | 72.24 | 74.35 |
| Hispanic | 146,920 | 2.064 | 1.958 | 2.113 | 84.05 | 83.55 | 85.29 |
| All construction | 754,220 | 2.305 | 2.243 | 2.370 | 77.84 | 76.91 | 78.78 |

The number of injuries includes less than 3% of occupational illnesses and excludes the self-employed and the public sector.
[a]Injuries per 100 FTEs. The estimates were adjusted for rates by ethnicity due to missing information on ethnicity for some cases.
[b]Injuries per 100 FTEs. The lifetime risk assumes a working time of 45 years.

Hispanic workers, while the opposite was found after adjustments according to the CFOI data. After adjustment, the results indicate that about 37% of construction workers can experience serious injuries from contact with equipment, while 21% experience serious injuries due to overexertion during their entire working life.

Trade-specific injury risks also indicated that rates are higher after adjustment (Table VI). In general, trade-specific risks had a wide range. Helpers, an occupation with the least skills and training requirements, had the highest injury risk. Overall, construction trades workers had a risk of injury at least three times greater than the risk for construction managers.

## DISCUSSION

Using multiple years of national data, we estimated that working in construction for 45 years, the risk of fatal injuries is approximately 1 death per 200 FTEs, and the risk of serious (DAFW) injuries is as high as 78%. The findings suggest that risks in construction remain high given that OSHA considers a lifetime risk of 1 death in 1,000 workers to be a significant level of risk [Stayner, 1992; Adkins, 1993].

The estimates indicate that there are significant variations between occupations. The lifetime risk of fatal injuries for ironworkers is about 10 times the risk for plumbers. The results also show that the unadjusted nonfatal injury risk for Hispanic workers was lower than for white, non-Hispanic workers, while Hispanic workers had a higher

**TABLE VI.** Lifetime Risk[a] of Trade-Specific Injuries Involving Days Away from Work (DAFW) in Construction

| Trade | Injuries (2003–2007) | Lifetime risk[a] | Adjusted lifetime risk[a] | 95% Confidence interval Lower | Upper |
|---|---|---|---|---|---|
| Helper | 28,160 | 95.88 | 98.03 | 96.11 | 99.31 |
| Sheet metal worker | 13,850 | 91.66 | 94.92 | 90.73 | 98.15 |
| Ironworker | 8,370 | 89.99 | 93.67 | 87.77 | 98.21 |
| Laborer | 173,030 | 81.91 | 87.69 | 86.22 | 89.14 |
| Truck driver | 20,950 | 75.73 | 81.83 | 77.10 | 86.78 |
| Carpenter | 121,010 | 73.05 | 79.39 | 77.51 | 81.32 |
| Heating | 26,050 | 72.11 | 78.30 | 74.05 | 82.81 |
| Roofer | 19,720 | 69.75 | 76.90 | 72.12 | 82.06 |
| Plumber | 43,790 | 69.62 | 76.10 | 72.84 | 79.56 |
| Electrician | 47,290 | 62.02 | 68.55 | 65.58 | 71.75 |
| Power installer | 2,120 | 60.02 | 66.55 | 53.85 | 84.69 |
| Welder | 7,520 | 59.55 | 66.40 | 59.03 | 75.39 |
| Brickmason | 12,260 | 57.61 | 64.72 | 59.19 | 71.19 |
| Operating engineer | 18,680 | 56.66 | 63.20 | 58.76 | 68.24 |
| Drywall | 12,150 | 53.21 | 60.84 | 55.75 | 66.8 |
| Foreman | 37,710 | 52.83 | 59.26 | 56.29 | 62.53 |
| Painter | 16,530 | 38.95 | 45.47 | 42.26 | 49.19 |
| Construction manager | 6,680 | 12.74 | 16.64 | 15.35 | 18.16 |

The number of injuries includes less than 3% of occupational illnesses and excludes the self-employed and the public sector.
[a]Injuries per 100 FTEs. The lifetime risk assumes a working time of 45 years.

fatal injury risk than white, non-Hispanic workers (see Tables II and IV). The findings confirm previous reports on underreporting of nonfatal injuries [Leigh et al., 2004; Rosenman et al., 2006; Welch et al., 2007; Dong et al., 2010a, 2011]. Reasons for underreporting differ at the organizational and individual level (Pransky et al., 1999; Probst et al., 2008; Dong et al., 2011). In general, companies with a poor safety climate had significantly higher rates of underreporting than companies with positive safety climate (Probst et al., 2008). Underreporting may be more common among Hispanic construction workers since they are more likely to be employed by small businesses, which tend to have worse health and safety records [Nelson et al., 1997; Okun et al., 2001; Dong et al., 2011]. Other obstacles to injury reporting among Hispanic workers, particularly new Hispanic immigrants, include lack of English proficiency, being unfamiliar with the workers' compensation system, and fear of negative consequences (e.g., losing their job) [Menzel and Gutierrez, 2010; Dong et al., 2013; Moore et al., 2013].

As with any study, this study has both strengths and limitations. A major strength was the use of nationally representative data for fatal and nonfatal injuries that had a good representation of construction trades by race/ethnicity. The traditional way of estimating occupational risk is using cross-sectional data on an annualized basis, which tends to understate risk [Robinson, 1986]. Estimating occupational risk based on the entire working life presents a more complete picture than a snapshot, and is relatively easy for people to understand, which may help young workers to consider safety and health risks when they make choices about jobs and careers in the construction industry, as well as inform policymakers regarding research and prevention priorities and options. Additionally, ethnic disparities in fatal and nonfatal injuries are more evident when presented in terms of lifetime risk as opposed to an annual rate.

A principal limitation in expressing risk based on lifetime experience was the assumption of constant injury and fatality rates to derive risk over 45 years, which does not account for potential changes in injury rates across workers' lifespans. In most occupational settings, safety and health performance has improved and risks have declined over time. This is also true in the construction industry. If future injury or fatality rates are substantially lower than those found for 2003–2007, this study will overestimate lifetime risks in construction. Similarly, this study reported leading causes of fatalities based on the data during the study period. However, some leading causes may decline more than others. For instance, between 1992 and 2009, rates of deaths from falls and electrocutions declined respectively by 21.3% and 54.9%, and overall deaths rates for the two most affected trades, electrical installation workers and ironworkers, declined by over 70% [CPWR, 2011]. Therefore, the use of 2003–2007 rates may represent conservative lifetime risk estimates. Additionally, the denominators based on self-reported hours worked are more likely to be overestimated, which would lead to underestimation of risks. It should also note that these estimates are average risks and should not be interpreted as individual risks.

The estimated lifetime risk of nonfatal injuries is less accurate than fatal injuries even after adjustment. The ethnic information was missing for many nonfatal cases. The risk assessments were adjusted assuming the missing information was random and normally distributed for all ethnicities. However, we lack the data to verify this assumption. In addition, while the 1992 data was used as the basis to adjust the estimates for risks of nonfatal injuries, it is difficult to know whether the nonfatal and fatal injury data were equally accurate at that time. If any of the assumptions were different from the actual situations, the lifetime risk estimates could be either overestimated or underestimated. Also, this study only focused on work-related injuries because only less than 3% of the construction cases in the SOII data were illnesses. Moreover, a worker may experience multiple injuries from different causes during their working life, while the model used for this study only counted the probability of a one-time injury. Thus, the risk of nonfatal injuries may be underestimated for some high-risk construction trades susceptible to multiple injuries over time.

## CONCLUSION

This study estimated lifetime risk of fatal and nonfatal injuries among construction workers assuming a working life of 45 years. The results indicate that the lifetime risk of nonfatal injuries among construction workers is about 78% (78 per 100 FTEs), and 1 death per 200 FTEs. The risks remain high in construction given that OSHA considers 1 death per 1,000 workers as a high-level risk.

To the extent that occupational safety and health policies are driven by occupational injury and illness (OII) data, policy options could differ if lifetime risks were considered. Future interventions and efforts should focus on high-risk occupations, such as ironworkers and roofers, as well as Hispanic workers and leading causes of work-related deaths such as falls to a lower level.

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## REFERENCES

Adkins CE. 1993. Occupational safety and health. In: Burke TA, Tran NL, Roemer JS, and Henry CJ, editors. Regulating risk: The science and politics of risk. Washington, DC: ISIC Press. pp. 23–24.

Arndt V, Rothenbacher D, Daniel U, Zschenderlein B, Schuberth S, Brenner H. 2005. Construction work and risk of occupational disability: A ten year follow up of 14,474 male workers. Occup Environ Med 62:559–566.

Banerjee S. 2001. Retirement age expectation of older Americans between 2006 and 2010. Employee Benefit Res Inst Notes 13(12):2–12.

Boden L, Ozonoff A. 2008. Capture-recapture estimates of nonfatal workplace injuries and illnesses. Ann Epidemiol 18:500–506.

Boden L, Ozonoff A. 2010. Researcher judgment and study design: Challenges of using administrative data. Am J Ind Med 53(1):37–41.

Brunette MJ. 2004. Construction safety research in the United States: Targeting the Hispanic workforce. Injury Prev 10:244–248.

Centers for Disease Control and Prevention (CDC). 2008. Work-related injury deaths among Hispanics—United States, 1992–2006. MMWR 57(22):597–600.

Committee on Education and Labor, U.S., House of Representatives. 2008. Hidden tragedy: underreporting of workplace injuries and illnesses. A majority staff report by The Committee on Education and Labor. Washington, DC: U.S. House of Representatives.

CPWR—The Center for Construction Research and Training. 2011. CPWR Data Center calculations based on Census of Fatal Occupational Injuries (CFOI) data. Silver Spring, MD: CPWR.

CPWR—The Center for Construction Research and Training. 2013. The construction chart Book: the U.S. construction industry and its workers, 5th edition. Silver Spring, MD: CPWR—The Center for Construction Research and Training. http://www.cpwr.com/publications/construction-chart-book

Dong X, Fujimoto A, Ringen K, Men Y. 2009. Fatal falls among Hispanic construction workers. Accident Anal Prev 41:1047–1052.

Dong X, Fujimoto A, Ringen K, Stafford E, Platner JW, Gittleman JL, Wang X. 2011. Injury underreporting among small business establishments in the construction industry. Am J Ind Med 54:339–349.

Dong X, Men Y, Ringen K. 2010a. Work-related injuries among Hispanic construction workers—Evidence from the Medical Expenditure Panel Survey. Am J Ind Med 53:561–569.

Dong X, Platner JW. 2004. Occupational fatalities of Hispanic construction workers from 1992 to 2000. Am J Ind Med 45:45–54.

Dong X, Wang X, Daw C. 2010b. Fatal and nonfatal injuries among Hispanic construction workers. CPWR Data Brief 2(2):1–19. Available online http://www.cpwr.com/pdfs/Hispanic_Data_Brief3.pdf

Dong X, Wang X, Largay J, Waddoups CJ, Fujimoto A. 2013. The impact of language barriers on healthcare utilization among Hispanic construction workers. In: Jackson OT and Evans KA, editors. Health disparities: Epidemiology, racial/ethnic and socioeconomic risk factors and strategies for elimination. Hauppauge, NY: Nova Science Publishers, Inc. pp. 161–176.

Drudi D. 1998. Fishing for a living is dangerous work. U.S. Bureau of Labor Statistics: Compensation and working conditions summer: 3–7. http://www.bls.gov/iif/oshwc/cfar0025.pdf

Fosbroke DE, Kisner SM, Myers JR. 1997. Working life time risk of occupational fatal injury. Am J Ind Med 31:459–467.

Friedman L, Forst L. 2007. The impact of OSHA recordkeeping regulation changes on occupational injury and illness trends in the U.S.: A time-series analysis. Occup Environ Med 64:454–460.

Gendell M. 2008. Older workers: Increasing their labor force participation and hours of work. Monthly Labor Review 131(1): 41–54.

Leigh P, Marcin J, Miller T. 2004. An estimate of the U.S. government's undercount of nonfatal occupational injuries. J Occup Environ Med 46:10–18.

Menzel NN, Gutierrez AP. 2010. Latino worker perceptions of construction risks. Am J Ind Med 53(2):179–187.

Moore JT, Cigularov KP, Sampson JM, Rosecrance JC, Chen PY. 2013. Construction workers' reasons for not reporting work-related injuries: An exploratory study. Int J Occup Saf Ergon 19(1):97–105.

Narayan KMV, Williams D, Gregg EW, Cowie CC, editors. 2011. Diabetes public health: From data to policy. Oxford: University Press.

National Bureau of Economic Research (NBER). 2010. Business cycle dating committee. http://www.nber.org/cycles/sept2010.html

National Research Council (NRC). 2009. Construction research at NIOSH. Washington, DC: The National Academy Press.

Neitzel RL, Stover B, Seixas NS. 2011. Longitudinal assessment of noise exposure in a cohort of construction workers. Ann Occup Hyg 55:906–916.

Nelson NA, Kaufman J, Kalat J, Silverstein B. 1997. Falls in construction: Injury rates for OSHA-inspected employers before and after citation for violating the Washington State Fall Protection Standard. Am J Ind Med 31(3):296–302.

Northwood J. 2009. Change to hours-based fatality rates in the Census of Fatal Occupational Injuries. http://www.bls.gov/opub/cwc/sh20100121ar01p1.htm

Okun A, Lentz TJ, Schulte P, Stayner L. 2001. Identifying high-risk small business industries for occupational safety and health interventions. Am J Ind Med 39(3):301–311.

Oleinick A, Zaidman B. 2010. The law and incomplete database information as confounders in epidemiologic research on occupational injuries and illnesses. Am J Ind Med 53(1):23–36.

Pew Hispanic Center. 2012. The demographics of the jobs recovery employment gains by race, ethnicity, gender and nativity. http://www.pewhispanic.org/files/2012/03/PHC-Labor-report-FINAL_3-21-12.pdf

Phillips K, Glendon G, Knight JA. 1999. Putting the risk of breast cancer in perspective. N Engl J Med 340:141–144.

Pransky G, Snyder T, Dembe A, Himmelstein J. 1999. Under-reporting of work-related disorders in the workplace: a case study and review of the literature. Ergonomics 42:171–182.

Probst TM, Brubaker TL, Barsotti A. 2008. Organizational injury rate underreporting: the moderating effect of organizational safety climate. J Appl Psychol 93:1147–1154.

Ringen K, Englund A, Welch L, Weeks JL, Seegal JL. 1995. Why construction is different. Occup Med 10(2):255–259.

Robinson J. 1986. A new approach to causal inference in mortality studies with a sustained exposure period—Application to control of the healthy worker survivor effect. Math Model 7:1393–1512.

Rosenman K, Kalush A, Reilly M, Gardiner J, Reeves M, Luo Z. 2006. How much work-related injury and illness is missed by the current national surveillance system? J Occup Environ Med 48(4):357–365.

Ruser J. 2008. Examining evidence on whether BLS undercounts workplace injuries and illnesses. Month Lab Rev 131(8):20–32.

Schubauer-Berigan MK, Daniels RD, Pinkerton LE. 2009. Radon exposure and mortality among white and American Indian uranium miners: An update of the Colorado Plateau cohort. Am J Epidemiol 15:718–730.

Seshadri S, Wolf PA, Beiser A. 1997. Life-time risk for developing dementia and Alzheimer's disease. Neurology 49:1498–1504.

Stayner L. 1992. Methodological issues in using epidemiologic studies for quantitative risk assessment. In: Clewell I, editor. Conference on chemical risk assessment in the Department of Defense (DOD): Science, policy, and a practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Sygnatur EF. 1998. Logging is perilous work. U.S. Bureau of Labor Statistics: Compensation and working conditions, winter: 3–9. http://www.bls.gov/iif/oshwc/cfar0027.pdf

U.S. Bureau of Labor Statistics. 2004a. Standard Occupational Classification (SOC) user guide. http://www.bls.gov/soc/2000/soc-guide.htm

U.S. Bureau of Labor Statistics. 2004b. Jacobs. EE editor. Handbook of U.S. labor statistics, 7th edition. Part Nine: Occupational Safety and Health. Lanham, MD: Bernan Press. pp. 400–401.

U.S. Bureau of Labor Statistics. 2010. North American Industry Classification System (NAICS). http://www.bls.gov/bls/naics.htm

U.S. Bureau of Labor Statistics. 2011. National Census of Fatal Occupational Injuries in 2010. http://www.bls.gov/news.release/archives/cfoi_08252011.pdf

U.S. Bureau of Labor Statistics. 2013a. National Census of Fatal Occupational Injuries in 2012 (Preliminary Results). http://www.bls.gov/news.release/pdf/cfoi.pdf

U.S. Bureau of Labor Statistics. 2013b. Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work, 2012. http://www.bls.gov/news.release/pdf/osh2.pdf

U.S. Bureau of Labor Statistics. 2013c. Employment projections: 2012–2022. http://www.bls.gov/news.release/ecopro.nr0.htm

U.S. Census Bureau. 2010. County Business Patterns, 2009. http://www.census.gov/econ/cbp/

Vasan RS, Beiser A, Seshadri S, Larson MG, Kannel WB, D'Agostino RB, Levy D. 2002. Residual lifetime risk for developing hypertension in middle-aged women and men: The Framingham Heart Study. JAMA 287:1003–1010.

Welch L, Dong X, Carre F, Ringen K. 2007. Is the decrease in injury and illness rates in construction due to changes in reporting? Int J Occup Environ Health 13:39–3945.

Wilkins JT, Ning H, Berry J, Zhao L, Dyer AR, Lloyd-Jones DM. 2012. Lifetime risk and years lived free of total cardiovascular disease. JAMA 308:1795–1801.

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**APPENDIX I.** Fatal and DAFW Injuries in the U.S. Construction Industry, 1992–2010

| | Hispanic Construction Workers | | | | Total Construction | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Deaths | 1992 (Baseline), % | DAFW Injuries | 1992 (Baseline), % | Deaths | 1992 (Baseline), % | DAFW Injuries | 1992 (Baseline), % |
| 1992 | 108 | 100.0 | 17,700 | 100.0 | 963 | 100.0 | 209,600 | 100.0 |
| 1993 | 109 | 100.9 | 18,000 | 101.7 | 971 | 100.8 | 204,800 | 97.7 |
| 1994 | 116 | 107.4 | 17,700 | 100.1 | 1,077 | 111.8 | 218,800 | 104.4 |
| 1995 | 146 | 135.2 | 19,000 | 107.2 | 1,098 | 114.0 | 190,600 | 90.9 |
| 1996 | 137 | 126.9 | 19,700 | 111.3 | 1,095 | 113.7 | 182,300 | 87.0 |
| 1997 | 167 | 154.6 | 21,300 | 120.5 | 1,136 | 118.0 | 189,900 | 90.6 |
| 1998 | 215 | 199.1 | 23,000 | 129.7 | 1,207 | 125.3 | 178,300 | 85.1 |
| 1999 | 225 | 208.3 | 29000 | 162.2 | 1,228 | 127.5 | 193,800 | 92.5 |
| 2000 | 278 | 257.4 | 26,000 | 149.3 | 1,183 | 122.9 | 194,400 | 92.8 |
| 2001 | 282 | 261.1 | 29,700 | 167.7 | 1,264 | 131.3 | 185,700 | 88.60 |
| 2002 | 245 | 226.9 | 26,000 | 146.7 | 1,153 | 119.7 | 163,700 | 78.10 |
| 2003 | 261 | 241.7 | 26,800 | 151.0 | 1,171 | 121.6 | 155,400 | 74.1 |
| 2004 | 312 | 288.9 | 28,000 | 158.0 | 1,278 | 132.7 | 153,200 | 73.09 |
| 2005 | 321 | 297.2 | 32,800 | 185.0 | 1,243 | 129.1 | 157,100 | 74.95 |
| 2006 | 354 | 327.8 | 33,900 | 191.5 | 1,297 | 134.7 | 153,200 | 73.09 |
| 2007 | 317 | 293.5 | 25,500 | 143.8 | 1,239 | 128.7 | 135,400 | 64.58 |
| 2008 | 253 | 234.3 | 25,000 | 141.1 | 1,016 | 105.5 | 120,200 | 57.35 |
| 2009 | 222 | 205.6 | 18,000 | 101.6 | 879 | 91.3 | 92,500 | 44.13 |
| 2010 | 182 | 168.5 | 13,000 | 73.38 | 802 | 83.3 | 75,000 | 35.78 |

DAFW, days away from work.
*Source:* U.S. Bureau Labor Statistics, Census of Fatal Occupational Injuries, Survey of Occupational Injuries and Illnesses,http://www.bls.gov/iif/

**APPENDIX II.** Estimated Number of Full-Time Employees (FTEs) in Construction, 2003–2007 (All Employment)

| | Number of FTEs | | | | | Lower 95% CI | | | | | Upper 95% CI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupation** | **2003** | **2004** | **2005** | **2006** | **2007** | **2003** | **2004** | **2005** | **2006** | **2007** | **2003** | **2004** | **2005** | **2006** | **2007** |
| Brickmason | 192,779 | 208,910 | 197,794 | 216,525 | 218,003 | 165,147 | 178,875 | 170,730 | 187,442 | 187,053 | 220,418 | 238,948 | 224,858 | 245,604 | 248,953 |
| Carpenter | 1,332,136 | 1,500,285 | 1,553,681 | 1,570,559 | 1,537,908 | 1,266,449 | 1,429,182 | 1,481,798 | 1,497,711 | 1,465,426 | 1,397,823 | 1,571,383 | 1,625,571 | 1,643,409 | 1,610,389 |
| Manager | 694,542 | 906,036 | 923,676 | 1,041,366 | 1,204,076 | 642,259 | 845,610 | 864,553 | 978,193 | 1,135,987 | 746,819 | 966,460 | 982,796 | 1,104,535 | 1,272,162 |
| Drywall | 204,403 | 202,749 | 230,627 | 281,914 | 226,593 | 175,696 | 174,041 | 201,973 | 249,033 | 196,828 | 233,112 | 231,457 | 259,281 | 314,791 | 256,364 |
| Electrician | 557,945 | 611,089 | 666,521 | 658,716 | 690,673 | 512,690 | 561,944 | 616,285 | 609,511 | 638,493 | 603,201 | 660,227 | 716,764 | 707,919 | 742,859 |
| Foreman | 837,972 | 874,732 | 964,240 | 956,835 | 889,568 | 782,148 | 817,110 | 903,529 | 896,578 | 830,192 | 893,798 | 932,358 | 1,024,951 | 1,017,093 | 948,946 |
| Heating | 218,397 | 276,641 | 270,536 | 310,446 | 325,833 | 189,955 | 243,354 | 237,902 | 275,364 | 289,431 | 246,842 | 309,936 | 303,166 | 345,522 | 362,236 |
| Helper | 103,573 | 101,697 | 117,939 | 113,811 | 98,641 | 83,531 | 81,616 | 95,625 | 92,557 | 78,440 | 123,626 | 121,768 | 140,258 | 135,061 | 118,848 |
| Ironworker | 55,201 | 40,300 | 46,719 | 41,771 | 57,960 | 39,696 | 28,681 | 33,753 | 29,163 | 42,420 | 70,707 | 51,921 | 59,685 | 54,382 | 73,511 |
| Laborer | 995,241 | 1,120,022 | 1,349,282 | 1,534,415 | 1,628,334 | 936,146 | 1,056,196 | 1,279,926 | 1,460,906 | 1,552,100 | 1,054,327 | 1,183,854 | 1,418,643 | 1,607,926 | 1,704,568 |
| Operating engineer | 313,940 | 286,726 | 334,329 | 361,577 | 331,650 | 279,070 | 253,000 | 298,513 | 324,949 | 295,843 | 348,810 | 320,457 | 370,148 | 398,208 | 367,459 |
| Painter | 537,566 | 580,587 | 564,665 | 564,061 | 593,047 | 492,428 | 532,974 | 518,127 | 517,762 | 544,948 | 582,700 | 628,195 | 611,197 | 610,354 | 641,139 |
| Plumber | 449,555 | 482,183 | 481,241 | 552,706 | 578,968 | 408,948 | 438,778 | 437,778 | 506,200 | 531,303 | 490,155 | 525,591 | 524,699 | 599,201 | 626,635 |
| Power installer | 30,804 | 31,919 | 31,562 | 23,026 | 23,889 | 19,514 | 19,900 | 19,605 | 12,955 | 13,858 | 42,089 | 43,940 | 43,517 | 33,095 | 33,926 |
| Roofer | 189,601 | 229,656 | 249,669 | 214,368 | 228,473 | 163,073 | 199,457 | 218,253 | 185,359 | 198,675 | 216,130 | 259,861 | 281,084 | 243,381 | 258,270 |
| Sheet metal worker | 74,290 | 91,206 | 75,035 | 68,369 | 57,532 | 58,383 | 71,501 | 58,134 | 51,726 | 42,572 | 90,201 | 110,906 | 91,932 | 85,020 | 72,487 |
| Truck driver | 203,778 | 210,791 | 186,053 | 203,563 | 203,953 | 175,916 | 182,353 | 159,985 | 176,044 | 175,066 | 231,646 | 239,225 | 212,116 | 231,081 | 232,837 |
| Welder | 86,520 | 112,246 | 110,831 | 91,734 | 92,645 | 68,494 | 87,805 | 89,343 | 71,983 | 71,864 | 104,550 | 136,685 | 132,324 | 111,492 | 113,425 |
| Ethnicity | | | | | | | | | | | | | | | |
| White, non-Hispanic | 7,111,102 | 7,605,268 | 7,716,154 | 7,894,791 | 7,875,657 | 7,017,562 | 7,507,054 | 7,616,019 | 7,791,500 | 7,769,877 | 7,204,646 | 7,703,481 | 7,816,297 | 7,998,076 | 7,981,434 |
| Hispanic | 2,017,211 | 2,194,371 | 2,510,882 | 2,907,366 | 2,911,849 | 1,932,590 | 2,105,841 | 2,419,705 | 2,811,958 | 2,814,110 | 2,101,834 | 2,282,902 | 2,602,051 | 3,002,782 | 3,009,586 |
| All construction | 9,971,414 | 10,670,158 | 11,158,120 | 11,702,692 | 11,763,594 | 9,236,002 | 9,887,299 | 10,370,926 | 10,901,573 | 10,949,283 | 10,706,836 | 11,453,017 | 11,945,303 | 12,503,800 | 12,577,929 |

*Source:* U.S. Bureau Labor Statistics, Current Population Survey, 2003–2007. Calculations by the authors.

**APPENDIX III.** Estimated Number of Full-Time Employees (FTEs) in Construction, 2003–2007 (All Employment)

| | Number of FTEs | | | | | Lower 95% CI | | | | | Upper 95% CI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trades** | **2003** | **2004** | **2005** | **2006** | **2007** | **2003** | **2004** | **2005** | **2006** | **2007** | **2003** | **2004** | **2005** | **2006** | **2007** |
| Brickmason | 145,462 | 152,046 | 158,075 | 172,534 | 158,310 | 121,476 | 126,564 | 133,725 | 146,295 | 131,944 | 169,445 | 177,525 | 182,425 | 198,774 | 184,677 |
| Carpenter | 909,728 | 1,014,226 | 1,072,745 | 1,065,009 | 1,044,793 | 855,329 | 955,490 | 1,012,300 | 1,005,050 | 984,678 | 964,125 | 1,072,968 | 1,133,186 | 1,124,964 | 1,104,907 |
| Manager | 371,762 | 466,436 | 462,858 | 515,052 | 564,647 | 333,223 | 422,545 | 419,815 | 469,707 | 516,627 | 410,302 | 510,326 | 505,903 | 560,393 | 612,663 |
| Drywall | 145,834 | 151,210 | 182,660 | 219,540 | 180,484 | 121,562 | 126,155 | 157,000 | 190,615 | 154,016 | 170,108 | 176,267 | 208,321 | 248,466 | 206,955 |
| Electrician | 475,735 | 521,385 | 555,598 | 566,751 | 572,908 | 434,122 | 476,241 | 510,098 | 521,223 | 525,276 | 517,344 | 566,530 | 601,096 | 612,276 | 620,538 |
| Foreman | 496,964 | 507,957 | 572,911 | 578,183 | 603,882 | 452,975 | 463,904 | 525,274 | 531,011 | 554,236 | 540,951 | 552,011 | 620,548 | 625,355 | 653,535 |
| Heating | 176,941 | 215,445 | 211,947 | 256,448 | 267,646 | 151,590 | 186,716 | 183,561 | 224,626 | 234,987 | 202,296 | 244,171 | 240,336 | 288,267 | 300,311 |
| Helper | 101,502 | 96,841 | 116,108 | 101,363 | 83,095 | 81,704 | 77,149 | 93,968 | 81,222 | 64,705 | 121,298 | 116,539 | 138,253 | 121,509 | 101,489 |
| Ironworker | 44,272 | 28,876 | 41,761 | 36,342 | 52,199 | 30,677 | 19,301 | 29,532 | 24,513 | 37,574 | 57,862 | 38,450 | 53,991 | 48,165 | 66,826 |
| Laborer | 827,621 | 949,554 | 1,157,137 | 1,320,700 | 1,369,003 | 774,095 | 891,215 | 1,093,600 | 1,253,473 | 1,299,770 | 881,145 | 1,007,890 | 1,220,678 | 1,387,934 | 1,438,232 |
| Operatingengineer | 243,672 | 208,209 | 253,218 | 259,960 | 264,798 | 212,453 | 178,722 | 221,354 | 228,804 | 232,334 | 274,891 | 237,692 | 285,084 | 291,115 | 297,262 |
| Painter | 356,345 | 361,842 | 345,892 | 374,519 | 383,140 | 318,669 | 324,693 | 309,162 | 336,568 | 343,931 | 394,022 | 398,993 | 382,622 | 412,470 | 422,344 |
| Plumber | 355,529 | 372,653 | 395,814 | 447,931 | 459,039 | 319,774 | 334,536 | 356,459 | 406,553 | 417,156 | 391,278 | 410,769 | 435,169 | 489,309 | 500,919 |
| Power installer | 28,927 | 29,442 | 26,182 | 23,026 | 19,833 | 17,819 | 17,777 | 15,322 | 12,960 | 11,113 | 40,036 | 41,102 | 37,047 | 33,091 | 28,548 |
| Roofer | 145,264 | 189,461 | 208,293 | 176,199 | 192,164 | 122,481 | 162,111 | 179,812 | 150,132 | 164,855 | 168,048 | 216,808 | 236,773 | 202,262 | 219,477 |
| Sheet metal | 69,825 | 76,801 | 63,810 | 55,406 | 46,717 | 54,384 | 59,433 | 48,303 | 40,824 | 33,143 | 85,268 | 94,169 | 79,319 | 69,984 | 60,291 |
| Truck driver | 157,337 | 169,475 | 145,412 | 176,272 | 171,144 | 132,495 | 143,728 | 122,241 | 150,336 | 144,483 | 182,182 | 195,219 | 168,580 | 202,211 | 197,808 |
| Welder | 77,633 | 106,298 | 106,755 | 83,504 | 83,427 | 60,571 | 82,355 | 85,706 | 64,553 | 64,027 | 94,690 | 130,239 | 127,809 | 102,461 | 102,829 |
| Ethnicity | | | | | | | | | | | | | | | |
| White, non-Hispanic | 4,802,582 | 5,112,532 | 5,288,581 | 5,378,823 | 5,390,886 | 4,721,258 | 5,027,266 | 5,200,785 | 5,288,450 | 5,298,258 | 4,883,911 | 5,197,796 | 5,376,377 | 5,469,199 | 5,483,519 |
| Hispanic | 1,731,228 | 1,824,812 | 2,150,922 | 2,504,520 | 2,476,494 | 1,655,383 | 1,746,390 | 2,069,065 | 2,419,040 | 2,389,252 | 1,807,073 | 1,903,235 | 2,232,775 | 2,590,002 | 2,563,735 |
| Total | | | | | | | | | | | | | | | |
| private wage–and-salary workers in construction | 7,127,622 | 7,577,780 | 8,115,347 | 8,526,333 | 8,588,409 | 6,494,568 | 6,908,844 | 7,434,096 | 7,833,389 | 7,884,812 | 7,760,669 | 8,246,709 | 8,796,606 | 9,219,268 | 9,292,032 |

*Source*: U.S. Bureau Labor Statistics, Current Population Survey, 2003–2007. Calculations by the authors.