Occupational Injury Costs and Alternative Employment in Construction Trades

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Objective: *To present the costs of fatal and non-fatal days-away-from-work injuries in 50 construction occupations. Our results also provide indirect evidence on the cost exposure of alternative construction workers such as independent contractors, on-call or day labor, contract workers, and temporary workers.* ***Methods:*** *We combine data from the Bureau of Labor Statistics on average annual incidence from 2000 to 2002 with updated per-case costs from an existing cost model for occupational injuries. The Current Population Survey provides data on the percentage of alternative construction workers.* ***Results:*** *Construction laborers and carpenters were the two costliest occupations, with 40% of the industry's injury costs. The 10 costliest construction occupations also have a high percentage of alternative workers.* ***Conclusions:*** *The construction industry has both a high rate of alternative employment and high costs of work injury. Alternative workers, often lacking workers' compensation, are especially exposed to injury costs.* (J Occup Environ Med. *2007;49:1218–1227*)

In spite of the high risk of fatal and non-fatal workplace injuries in the construction industry, there are few national estimates of occupational injury costs in the industry. Cost estimates would combine the frequency and severity of injuries into one measure that can be used to highlight problem areas and define the case for safety interventions. Prior studies of construction injuries also ignore the growing numbers of construction workers employed in alternative employment arrangements such as independent contractors, on-call or day labor, contract workers, and temporary workers.[1]* Such workers are often not covered by workers' compensation insurance, leaving them without any income replacement benefits or coverage for medical expenses associated with on-the-job injuries. There is little data on the injury costs faced by such non-traditional workers in construction.

In this paper, we present estimates of the costs of fatal and non-fatal days-away-from-work injuries (DFW) for detailed construction occupations using incidence data from the Bureau of Labor Statistics (BLS) and cost estimates based on an existing cost model for occupational injuries.[2–6] We combine these cost estimates with occupation-specific data from the Current Population Survey (CPS) on the percentage of construction

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*Alternative workers refer to those whose employment is arranged by an intermediary or whose place, time, and quantity of work is potentially unpredictable.[1] Independent contractors form the largest group of alternative workers, and are often self-employed consultants or free-lancers.

workers in alternative employment arrangements. Our results will provide indirect evidence on the cost exposure of these construction workers.

Background

Studies across industries suggest that injury rates and costs are higher than average in the construction industry. A study using workers' compensation data from Washington State estimated that workers' compensation costs for medical treatment and indemnity in construction were four times higher than for most industries.[7] Using national survey data, the Center to Protect Workers' Rights estimated that the average level of injury compensation payment (of all types) for a construction worker was nearly double the level for a worker in other industries—$7542 compared with $3943 per year, respectively (CPWR, 2002). Leigh and Miller[8] reported that construction laborer and carpenter were two occupations with high costs of occupational injury and illness.

Most studies on costs of construction injuries and illnesses focus only on a specific construction sector or a particular geographic area. A recent study based on data from the construction of the Denver International Airport reported that slips and trips accounted for 25% of workers' compensation payments or more than $10 million.[9] Using more than 20,000 workers' compensation claims by Oregon construction employees between 1990 and 1997, Horwitz and McCall[10] estimated that the average claim cost was $10,084, and structural metal workers had the highest average costs per claim ($16,472). Reviewing more than 30,000 workers' compensation claims among North Carolina Homebuilders Association members and their subcontractors for the period 1986 to 1994, Dement and Lipscomb[11] found roofers and carpenters had higher medical costs than the average. Lipscomb et al[12] report that falls resulted in the highest costs per workers' compensation claim for residential carpenters, and 14% of claims resulted in 83% of the costs. Shah et al[13] estimated that the direct costs of injuries and illnesses from wood framing in residential construction were over $197 million in Washington State based on workers' compensation claims data from 1993 to 1997.

Most studies on the costs of fatal and non-fatal injuries rely on data from workers' compensation. However, the details and eligibilities of the workers' compensation system vary from state to state. This has made it difficult to provide a national cost estimate for the entire range of construction occupations. Also, all workers do not access the workers' compensation system for their work-related injuries. In a cross-sectional study, Rosenman et al[14] estimated that only 25% of 1598 individuals with work-related musculoskeletal disorders filed for workers' compensation. These problems are heightened for construction workers, a large proportion of who are employed in alternative work arrangements with questionable benefit eligibility. According to the BLS, 22% of independent contractors work in construction compared to only 6% of regular employees.[15] In addition, more than 2 million (24%) of construction workers are self-employed,[16] and they are not covered by workers' compensation systems.

At the same time, research on alternative workers suggests that they may experience a higher level of injury risk than traditional workers do. Collinson[17] finds less favorable working conditions and more severe injuries for contract workers on US oil rigs. Alternative workers may receive less safety training[18] because firms have little incentive to train workers who have no long-term relationship with them. Mehta et al[19] found that workers supplied by temporary staffing agencies to building contractors in the Atlanta metropolitan area reported a limited access to safety equipment with 12% receiving no equipment from the temp agencies. These studies are particularly relevant for the construction industry, which is a significant employer of alternative workers, yet surprisingly little attention has been paid to describing and measuring their injury costs. This paper will highlight the injury costs of occupations that are largely staffed via alternative workers.

Data and Methods

Our cost estimates rely on estimates of per-case costs by detailed occupations from an existing 1993 cost model.[2–6] In the 1993 model, information on days away from work from the 1993 Survey of Occupational Injuries and Illnesses (hence–forth Annual Survey) collected by the BLS was combined with permanent disability probabilities from Detailed Claims Information (DCI) data and wage data from the 1993 monthly CPS data to calculate productivity losses for each DFW case. Medical costs for each case were calculated using data from nine different datasets and a survey of jury verdicts related to occupational injury or illness was used to predict pain and suffering costs. Occupation-specific average costs per DFW case were calculated as a weighted average of these per-case costs (see Leigh et al[4] for a discussion on the costs of occupational injuries using the 1993 cost model).

We inflate these 1993 costs to 2002 dollars and apply them to average annual incidence using data from the Annual Survey for a 3-year period from 2000 to 2002. The Annual Survey is a federal/state program that has collected non-fatal occupational injury and illness data on an annual basis since 1972, from logs that employers maintain according to Occupational Safety and Health Administration (OSHA) guidelines. It excludes injuries to the self-employed; to workers on farms with fewer than 11 employees; to private household workers; and to employees in federal, state, and local governments. In 2002, em-

ployer reports of worker injuries were collected from about 183,000 private industry establishments. Information on worker occupation is only collected in detailed case and demographic data on DFW cases, therefore our cost estimates do not account for non-fatal injuries with no lost work or only restricted work. Data on fatal injury incidence is taken from the 2000 to 2002 Census of Fatal Occupational Injuries (CFOI), which is also collected by the BLS.†

To account for self-employed construction workers, we inflate the incidence estimates in the Annual Survey using the average 23% self-employment rate (both incorporated and unincorporated) in construction.[16] Data on the proportion of alternative workers in construction occupations are drawn from the February 2001 Contingent Worker Supplement of the CPS. Because it is possible that some temp agency construction workers may be reported under the temporary services industry code, our tabulations include both workers in the construction industry and those in construction trade occupations (1990 census occupation codes 553 to 599) in the temporary services industry.

To inflate 1993 medical costs, we use data on personal consumption expenditures for medical care services from the Bureau of Economic Analysis' Economic Report of the President (The White House,[20] Table B-16, last column). We divide this by the population of the United States including Armed Forces overseas, as estimated by BEA and the Bureau of the Census (The White House,[20] Table B-31, last column). Work-loss and quality-of-life losses are inflated by an index of total compensation in private industry (The White House,[20] Table B-48, first column). This index, estimated by BLS, measures the total cost of employing workers, including wages and fringe benefits. Note that our use of the 1993 cost model for 2000 to 2002 injuries assumes that the composition and type of construction injuries are similar between the two periods.

Below, we present a brief description of the methods employed in our 1993 cost model. Thorough descriptions are available from the authors upon request.

Direct Costs

For non-fatal DFW injuries, direct costs were estimated separately for hospitalized and non-hospitalized victims, by diagnosis. The same procedure is used by the US Consumer Product Safety Commission in its regulatory impact analyses.[21] The direct costs for hospitalized victims are the product of five diagnosis-specific factors involving length of stay; hospital cost per day; ratio of professional fee payments to hospital payments; ratio of cost in the first 6 months to costs during the initial admission; and ratio of the present value of lifetime medical payments to payments in the first 6 months. The direct costs for non-hospitalized victims are the product of diagnosis-specific factors involving the probability that an injury or illness will require medical treatment; the number of visits to physicians' offices or emergency departments; payments per non-hospitalized visits; ratio of payments including pharmaceutical and ancillary expenses to payments for medical visits; and ratio of the present value of lifetime medical payments per non-hospitalized case to payments in the first 6 months.

Medical costs for an average victim are calculated as a weighted average of the admitted and non-admitted cases using probabilities of hospital admission for lost-work injuries by injury diagnosis group and age group. Medical costs were estimated for International Classification of Diseases, 9th Edition, Clinical Modification diagnoses, then mapped to the nature of injury codes used in BLS data.‡

For non-fatal DFW illnesses, direct costs were computed in a simpler manner because less information was available. The annual medical spending for hospitalizations, for example, was computed as the product of length of stay, cost per day, and the ratio of hospital plus professional fee payments to hospital payments. We attribute a constant medical cost of $777 (in 2002 dollars) to medically treated cases without any work loss and $618 for cases with restricted work activities. These $777 and $618 were estimated using data from the National Health Interview Survey. For fatalities, we follow Miller and Galbraith[22] and attribute a constant medical cost of $18,300 to each fatality.

Indirect Costs

Indirect or productivity losses for non-fatal cases can be divided into short-term and long-term wage losses and household productivity losses. For short-term wage losses, we multiplied the estimated days away from work (adjusted for censoring via a survival model) by the predicted daily wage rate received by a worker of the same age group, race, gender, industry, and occupation as the injury victim. The predicted wage rates are based on linear regression of hourly wages on these characteristics using the monthly files of the 1993 Current Population Survey. Finally, to account for the total compensation due a worker, we adjusted for fringe benefits attributable to different occupation groups using data from the BLS' Employment Cost Index.[23]

The Annual Survey lacks information on the permanent disability status of injured workers. Therefore, our cost model applies average probabilities of permanent disability by

†CFOI data for 2001 exclude deaths from the September 11, 2001 attacks. However, nonfatal injuries due to the attacks may be included because the survey design of the Annual Survey does not permit BLS to separate these workers.

‡A crosswalk between International Classification of Diseases, 9th Edition, Clinical Modification and BLS nature of injury codes can be provided upon request.

diagnosis from the Detailed Claims Information sample of 452,000 workers' compensation claims from 1979 to 1988. Long-term wage losses resulting from permanent total disability were based on estimates of lifetime wage loss calculated using a 2.5% discount rate and a standard age-earnings model for different age (5-year age groups) and gender categories.[24] To reflect the worker's current industry and occupation more accurately, the long-term wage losses for all permanent disabilities were multiplied by the ratio of hourly wages by age, race, sex, industry, and occupation to the hourly wages for different age and sex categories.

Following Miller et al,[21] we estimated household work loss duration by the number of days away from work times 365/243 times 0.9. These adjustments account for the fact that household work may be lost on days when wage work is not and also reflects results showing that 90% of the time lost to wage work is also lost to household work.[25]

For fatalities, we calculated lifetime wage losses using a 2.5% discount rate and a standard age-earnings model[24] for different 5-year age groups and sex categories. Age-gender lifetime wage losses were adjusted for industry and occupation where possible, using average wages by age, gender, industry, and occupation based on 1993 CPS data. Using the specialist cost approach outlined in Douglass et al,[25] lifetime household work losses were also calculated for different age and sex groups.

Quality of life costs for non-fatal injuries were estimated using jury verdicts in tort liability lawsuits.[26,27,21] The method assumes that the quality-of-life costs of an injury survivor can be approximated by the difference between the amount of compensatory damages awarded by a jury and the out-of-pocket costs claimed by the victim. Punitive damages were excluded.

The quality-of-life costs due to a fatality can be calculated as the difference between the willingness to pay to avoid the injury and the victim wage and household work loss costs associated with it. Miller[28] surveyed 30 such studies and computed an average willingness-to-pay of approximately $2.7 million in after-tax compensation (1993 dollars) per workplace fatality. After subtracting the indirect costs, the quality of life costs were estimated for the average worker at $1.9 million per workplace fatality. This estimate was adjusted for different age groups using average life expectancies for each group.

Results

According to the BLS, on average between 2000 and 2002, there were over 1000 fatalities per year and 159,000 non-fatal injuries involving days away from work in the construction industry. Construction injuries resulted in an average annual cost of $12.7 billion from 2000 to 2002. On average, a construction fatality results in losses valued at $4 million while a non-fatal injury involving days away from work costs approximately $42,000. The construction industry is disproportionately costly, accounting for 15% of all private industry injury costs[29] but only 5.2% of all private industry employment in 2002.[30]

Table 1 presents the average annual number of cases between 2000 and 2002 and the per-case costs (in 2002 dollars) for fatal and non-fatal DFW injuries in 50 construction occupations. Construction laborers recorded the most fatalities (299) resulting in the highest average annual fatality costs at $1200 million. They were followed by carpenters (average annual fatality costs of $376 million), roofers ($308 million), and electricians ($260 million), who recorded a combined average of 232 fatalities per year over the 3-year period. The cost per fatality was highest for electrician apprentices and plumbers, pipefitters, and steamfitter apprentices at $5.3 million. Mining machine operators and earth drillers faced the highest costs per DFW, of $145,000 and $76,000, respectively.

Table 2 presents the 10 occupations with the highest combined costs from fatal and DFW injuries, together with the percentage of alternative workers in these occupations. Together, these occupations account for approximately three-quarters of the industries full-time equivalent employees. The costliest occupation was construction laborers at $3.3 billion; followed by carpenters at $1.9 billion; electricians with just under $1 billion; plumbers, pipefitters, and steamfitters at $600 million; and roofers following closely behind. These five occupations accounted for over half of the total industry costs during the 3-year period. They experienced a high burden from both fatalities and DFW injuries, and four of the five occupations were ranked in the top 10 for both types of costs.

Notably, workers in these costly occupations are also likely to be alternative workers. Approximately one in five carpenters were employed as an independent contractor, as were 40% of supervisors, and 30% of painters. Almost 1 in 10 construction laborers were employed in day labor or on-call arrangements. Overall, the CPS data indicate that 24% of construction workers are employed in alternative arrangements, with the majority as independent contractors (19%) followed by on-call or day laborers (4.5%).

Table 3 presents the injury cost per full-time equivalent employee (FTE). Brickmason and stonemason apprentices bore the highest injury burden per FTE at approximately $200,000. However, given that this occupation reported zero fatalities between 2000 and 2002 and was ranked 43rd among 50 occupations in the total costs of fatal and DFW injuries, this ranking appears driven by its low level of employment.

The next highest costs per worker were recorded in miscellaneous material moving equipment operators ($84,000 per FTE), followed by helpers, mechanics, and repairers;

TABLE 1
Total Costs of DFW and Fatal Occupational Injuries in the Construction Trades Occupations

Occupation Code	Detailed Occupation	Average Annual Number of Fatal Injuries	Cost/Fatal Injury	Average Annual DFW Cases Including Self-Employed*	Cost/DFW	Total Fatal Cost (Millions)	Ranked by Total Fatal Cost	Total DFW Cost (Millions)	Ranked by Total DFW Cost	Total Fatal + DFW (Millions)	Ranked by Total DFW + Fatal Cost
553	Supervisors, brickmasons, stonemasons, tile setters	PC	$4,041,457	175	$50,444	3	42	$9	43	$13	45
554	Supervisors, carpenters, related workers	8	$3,141,057	1,158	$44,707	$24	22	$52	26	$76	25
555	Supervisors, electricians, power transmission installers	6	$3,600,470	658	$48,682	$20	26	$32	32	$52	31
556	Supervisors, painters, paperhangers, plasterers	PC	$4,041,457	319	$52,853	PC	29	$17	38	$32	38
557	Supervisors, plumbers, pipefitters, steamfitters	PC	$3,605,382	561	$33,494	PC	28	$19	37	$37	36
558	Supervisors, n.e.c.	74	$3,520,815	6,415	$41,187	$261	5	$264	9	$525	6
563	Brickmasons and stonemasons	16	$3,756,208	3,893	$52,311	$59	15	$204	12	$262	13
564	Brickmason and stonemason apprentices	0	—	388	$40,568	$0	48	$16	39	$16	43
565	Tile setters, hard and soft†	PC	$3,756,208	1,039	$37,491	PC	30	$39	30	$50	33
566	Carpet installers	PC	$5,242,967	1,000	$54,840	PC	34	$55	25	$64	28
567	Carpenters	94	$3,999,029	34,625	$45,330	$376	2	$1,570	2	$1,945	2
569	Carpenter apprentices	PC	$5,242,967	1,562	$47,122	PC	39	$74	20	$81	23
573	Drywall installers	11	$4,281,993	5,619	$46,683	$46	17	$262	10	$308	11
575	Electricians	63	$4,115,215	14,486	$49,021	$261	4	$710	3	$971	3
576	Electrician apprentices	6	$5,323,544	2,863	$32,840	$30	20	$94	18	$124	18
577	Electrical power installers, repairers	15	$4,470,520	477	$54,977	$67	13	$26	35	$93	22
579	Painters, construction, and maintenance	40	$3,681,941	5,869	$45,296	$146	8	$266	8	$412	8
583	Paperhangers‡	0	—	134	$45,343	$0	49	$6	44	$6	48
584	Plasterers	PC	$4,281,993	1,355	$40,534	PC	36	$55	24	$62	29
585	Plumbers, pipefitters, and steamfitters	28	$4,115,215	12,216	$39,934	$114	11	$488	4	$602	4
587	Plumber, pipefitter, and steamfitter apprentices	PC	$5,323,544	1,694	$30,247	PC	38	$51	27	$58	30
588	Concrete and terrazzo finishers	8	$4,470,520	2,156	$43,778	$36	18	$94	16	$130	17
589	Glaziers	PC	$3,681,941	1,635	$44,401	PC	41	$73	21	$79	24
593	Insulation workers	6	$3,210,855	2,341	$40,311	$18	27	$94	17	$113	20

(Continued)

TABLE 1
(Continued)

Occupation Code	Detailed Occupation	Average Annual Number of Fatal Injuries	Cost/Fatal Injury	Average Annual DFW Cases Including Self-Employed*	Cost/DFW	Total Fatal Cost (Millions)	Ranked by Total Fatal Cost	Total DFW Cost (Millions)	Ranked by Total DFW Cost	Total Fatal + DFW (Millions)	Ranked by Total DFW + Fatal Cost
594	Paving, surfacing, tamping equipment operators	PC	$3,667,448	164	$29,389	PC	31	$5	47	$16	42
595	Roofers	75	$4,100,743	6,231	$46,610	$308	3	$290	6	$598	5
596	Sheetmetal duct installers	PC	$3,563,283	3,972	$40,039	PC	37	$159	13	$166	16
597	Structural metal workers	42	$3,796,550	4,754	$50,387	$161	6	$240	11	$400	9
598	Drillers, earth	7	$3,439,563	591	$76,387	$23	24	$45	29	$68	27
599	Construction trades, n.e.c.	24	$4,095,104	3,639	$41,564	$97	12	$151	14	$248	14
616	Mining machine operators‡	PC	$4,574,831	336	$145,140	PC	46	$49	28	$50	32
643	Boilermakers	PC	$3,700,434	105	$41,556	PC	32	$4	48	$14	44
653	Sheet metal workers	6	$4,045,979	1,569	$43,440	$26	21	$68	22	$94	21
779	Machine operators, not specified	PC	$3,943,474	639	$39,119	PC	43	$25	36	$29	40
783	Welders and cutters	30	$3,919,634	2,101	$36,228	$116	10	$76	19	$192	15
785	Assemblers	PC	$3,862,477	778	$39,792	PC	40	$31	33	$37	35
796	Production inspectors, checkers, and examiners‡	PC	$3,505,385	174	$34,378	PC	44	$6	45	$9	47
804	Truck drivers	40	$3,860,590	7,010	$39,401	$154	7	$276	7	$431	7
843	Supervisors-material moving equipment operators‡	PC	$4,030,886	102	$30,360	PC	33	$3	49	$13	46
844	Operating engineers	30	$3,981,648	3,366	$44,396	$119	9	$149	15	$269	12
849	Crane and tower operators	6	$3,656,980	284	$43,040	$22	25	$12	41	$34	37
853	Excavating and loading machine operators	16	$3,652,643	1,042	$57,479	$58	16	$60	23	$118	19
855	Grader, dozer, scraper operators	10	$3,392,832	675	$55,738	$33	19	$38	31	$70	26
856	Industrial truck operators	6	$3,958,823	378	$37,918	$24	23	$14	40	$38	34
859	Miscellaneous material moving equipment operators	PC	$3,740,896	183	$56,854	PC	35	$10	42	$19	41
865	Helpers, mechanics, and repairers	PC	—	825	$36,375	PC	47	$30	34	$31	39
866	Helpers, construction trades	13	$4,707,308	8,589	$37,103	$61	14	$319	5	$380	10
867	Helpers, surveyors‡	PC	—	136	$16,780	PC	45	$2	50	$4	50
868	Helpers, extractive occupations‡	0	—	75	$76,028	$0	50	$6	46	$6	49
869	Construction laborers	299	$4,034,180	55,998	$37,186	$1,208	1	$2,082	1	$3,290	1

*The number of DFW cases is inflated to incorporate the 24% self-employed workers who are excluded from the scope of the Annual Survey.

†Attributed fatal costs of brickmasons and stonemasons to tile setters, since the latter group recorded zero fatalities in 1993. Similarly, ascribed fatal costs of supervisors, plasterers, painters, and paperhangers (556) to supervisors of brickmasons and stonemasons (553).

‡Average DFW was calculated using fewer than 3 yrs of data due to confidentiality restrictions.

PC indicates cell counts and per-case costs are not shown to preserve confidentiality; n.e.c. indicates not elsewhere classified.

TABLE 2
Construction Trades Occupations With the Ten Highest Total Costs of DFW and Fatal Occupational Injuries

Occupation Code	Detailed Occupation	Total Cost of Fatal + DFW (Millions)	Ranked by Total DFW + Fatal Cost	% Independent Contractor	% On-Call/Day Labor	% Temp Agency	% Contract	% of Industry Cost
869	Construction laborers	$3,290	1	3	9	1	0	25.9
567	Carpenters	$1,945	2	22	4	0	1	15.3
575	Electricians	$971	3	9	6	1	2	7.6
585	Plumbers, pipefitters, and steamfitters	$602	4	14	3	1	0	4.7
595	Roofers	$598	5	10	6	2	0	4.7
558	Supervisors, n.e.c.	$525	6	41	0	1	1	4.1
804	Truck drivers	$431	7	8	1	3	0	3.4
579	Painters, construction and maintenance	$412	8	29	8	2	0	3.2
597	Structural metal workers	$400	9	5	9	0	4	3.2
866	Helpers, construction trades	$380	10	6	4	0	0	3.0

TABLE 3
Construction Trades Occupations With the Ten Highest Costs per Full-Time Equivalent Worker of DFW and Fatal Occupational Injuries

Occupation Code	Detailed Occupation	Number of FTEs*	Average DFW + Fatal Cost/FTE	Ranked by Average Cost/FTE	% of Industry Cost	% of Industry FTEs
564	Brickmason and stonemason apprentices	78	$201,471	1	0.1	0.0
859	Miscellaneous material moving equipment operators	228	$83,983	2	0.2	0.0
865	Helpers, mechanics, and repairers	2,767	$11,378	3	0.2	0.0
785	Assemblers	3,834	$9,758	4	0.3	0.1
569	Carpenter apprentices	9,030	$8,925	5	0.6	0.1
779	Machine operators, not specified	3,529	$8,205	6	0.2	0.1
843	Supervisors-material moving equipment operators†	1,629	$7,672	7	0.1	0.0
597	Structural metal workers	57,642	$6,944	8	3.2	0.9
554	Supervisors, carpenters	14,488	$5,235	9	0.6	0.2
596	Sheetmetal duct installers	34,961	$4,753	10	1.3	0.5

*Author calculations from the 2002 Current Population Survey. Each FTE = 2000 hr worked.
†Average DFW was calculated using fewer than 3 yrs of data due to confidentiality restrictions.

assemblers; and carpenter apprentices, each with approximately $9000 to $11,000 per FTE. These occupations' rankings also appeared to be primarily due to the small denominator in the cost per FTE ratio. Among the 50 construction occupations examined, only seven occupations (roofers; sheetmetal duct installers; structural metal workers; welders and cutters; helpers, construction trades; electrician apprentices; construction laborers) were ranked among the top 20 occupations for both the total costs of fatal and DFW injuries and the cost per FTE.

Table 4 presents the per-case and per-worker injury costs for the 10 construction occupations with the highest share of alternative workers. Paperhangers were the most likely to have non-traditional work arrangements, with almost 60% working as independent contractors. However, because there was an average of zero fatalities for these workers from 2000 to 2002, they were exposed to a modest injury burden of $480 per worker. Over half of the supervisors of painters, paperhangers, and plasterers were independent contractors facing an injury burden of $1600. Painters and supervisors, not elsewhere classified had a high rate of alternative work (40%) and as shown in Table 2, also ranked highly in their total costs of fatal and DFW injuries. Injured workers in these jobs can expect losses valued at an average of over $3.5 million per fatality and over $40,000 per DFW case. One of three carpenter apprentices was an on-call worker.

Discussion

Earlier work by this research team shows that in 2002, construction injuries cost $11.5 billion, with approximately $4 billion in fatalities

TABLE 4
Total Costs of DFW and Fatal Occupational Injuries in the Construction Trades Occupations With the Highest Rate of Alternative Work

Occupation Code	Detailed Occupation	Cost/Fatal Injuries	Cost/DFW	Average DFW + Fatal Cost/FTE	% Independent Contractor	% On-Call/ Day Labor	% Temp Agency	% Contract	% Alternative	Ranked by % Alternative	Number of FTEs
583	Paperhangers*	—	$45,343	$482	58	0	0	0	58	1	12,576
556	Supervisors, painters, paperhangers, plasterers	$4,041,457	$52,853	$1,612	52	0	0	0	52	2	19,654
855	Grader, dozer, scraper operators	$3,392,832	$55,738	$1,735	29	18	0	0	47	3	40,598
553	Supervisors, brickmasons, stonemasons, tile setters	$4,041,457	$50,444	$2,449	46	0	0	0	46	4	5,253
577	Electrical power installers, repairers	$4,470,520	$54,977	$2,936	13	32	0	0	44	5	31,771
558	Supervisors, n.e.c.	$3,520,815	$41,187	$634	41	0	1	1	43	6	827,203
566	Carpet installers	$5,242,967	$54,840	$805	40	2	0	0	42	7	78,909
579	Painters, construction and maintenance	$3,681,941	$45,296	$817	29	8	2	0	39	8	503,971
569	Carpenter apprentices	$5,242,967	$47,122	$8,925	0	35	0	0	35	9	9,030
584	Plasterers	$4,281,993	$40,534	$1,336	28	6	0	0	34	10	46,463

*Average DFW was calculated using fewer than 3 yrs of data due to confidentiality restrictions.

(40%) and $6.9 billion in non-fatal DFW injuries.[29] The average construction fatality was estimated to cost $4 million. Non-fatal–days-away injuries in construction were more costly than average, at $42,000 per case compared to $37,000 in all private industry. In the current study, construction laborers and carpenters were the two costliest occupations, with $5 billion in fatal and non-fatal DFW costs, approximately 41% of the industry's average annual burden of $12.7 billion.

The costs presented here are incidence-based representing the costs of injuries over victims' lifetimes. Preventing the injuries would avert all of these costs. Incidence-based costs, thus, are the appropriate costs to use to estimate cost savings in an evaluative or resource allocation context. They do not, however, describe the total burden during 2000 to 2002 on victims of occupational injury, including those being treated for injuries from prior years. The estimates presented in this paper rely on Annual Survey estimates of nonfatal injury incidence using a scientifically selected probability sample rather than a census of the entire population. Thus, the incidence estimates presented here are subject to sampling error. If the estimated number of injuries was two standard errors from the reported average annual DFW incidence, the average annual costs of DFW cases would vary by 4.6% and the total cost of fatal and DFW cases would vary by 3.1%.§

Because of the comprehensive accounting of costs in our model including estimates of household costs and pain and suffering costs, the cost estimates presented here are higher than those based on workers' compensation data. Thus, Horwitz and McCall[31] estimated an average claim cost for structural metal workers $16,472, much lower than our esti-

§We use the 3-year average of the relative standard error reported by the BLS for the construction industry.

mate of approximately $50,000 for this group of workers. The estimated per-fatality cost of $4 million in construction is also higher than the recent National Institute for Occupational Safety and Health estimate of $864,000.[32] However, subtracting quality of life costs from our estimate results in a more similar cost per fatality of approximately $1 million.

We rank occupations using combined costs of fatal and DFW injuries as well as the total cost per FTE. This latter measure represents the average injury burden for workers in different occupations. However, as our rankings show, the cost per FTE can be misleading for occupations with very low employment. On the other hand, the total costs of injury are likely to be higher for high-employment occupations, such as carpenters and construction laborers. Seven occupations including roofers, construction laborers, and structural metal workers ranked high both for total costs of injury as well as for per-worker costs, suggesting that safety training and enforcement activities should be prioritized in these occupations. Many of the workers in these three occupations are in alternative employment arrangements, unlikely to be covered by workers' compensation for their medical care or receive income replacement benefits.

A comparison of the costs per FTE of supervisors, regular workers, and apprentice workers shows that in general, apprentice workers appear to bear the highest burden of injury per worker. For example, the cost per worker for apprentice carpenters was 35% higher than for supervisors, and almost five times that of regular carpenters. At the same time, note that the per-fatality cost for apprentices is also higher than for regular workers, possibly reflecting their relative youth and higher lifetime earnings losses.

As stated earlier, our cost estimates for construction occupations combine average annual estimates of injury incidence from 2000 to 2002 with 1993 per-case costs that are inflated to 2002 dollars. Thus, we assume that the composition of construction injuries within each occupation remains stable between the two periods. A simple comparison of the injury distribution between 1993 and 2002 reveals that this is a reasonable assumption. Sprains and strains, fractures, cuts, and bruises accounted for approximately 68% of days-away injuries in 1993 and 70% in 2002. Back sprains and other injuries to the muscles, tendons, or ligaments accounted for 38% and 36%, respectively, of the construction days-away cases in 1993 and 2002. Similarly fractures and dislocations account for a stable 10% of these cases for both years.

This study ignores the large demographic shift in the construction industry toward workers of Hispanic ethnicity over the past decade and the associated rise in their injuries. From 1994 to 2001, the number of Hispanic hourly construction workers rose from 9% to 17% of hourly workers in construction.[33] In 2002, Hispanic workers accounted for 18% of days-away injuries in the 10 costliest construction occupations, up from 9% in 1993 while white workers accounted for a smaller share of injuries (66% in 1993, 58% in 2002). To the extent that these minority workers earn lower wages than white workers do, our extrapolation of 1993 per-case costs to 2002 will overstate the wage losses.

Our cost model relies on Annual Survey data, which has some drawbacks.[34] The data is limited in scope, excluding federal, state, and local government workers, workers on farms with fewer than 11 employees, and the self-employed. However, as stated earlier, we adjust for the self-employed in our estimate of DFW injury incidence. The Survey lacks information on the actual long-term disability status of each injured worker requiring the adjustments to our calculation of long-term losses described earlier. Occupational diseases, many of which are not apparent until years after exposure, are also likely to be underestimated in our data. Finally, we lack data by occupation on more minor injuries involving no lost work or restricted work activities, thus, we cannot provide costs for all non-fatal injuries by occupation. Still, the Annual Survey is the best and largest establishment-based survey of non-fatal occupational morbidity currently available in the United States.

Our data on the distribution of alternative workers uses the February supplement to the CPS data, the only source of data on such employment. Since February is traditionally a slow month for construction, we may underestimate the percentage of alternative construction workers (especially temp workers and day workers) because they may be employed in other industries in the absence of construction employment. Yet, the data on alternative workers shows that such employment arrangements are relatively common in the construction industry.

Our study provides interesting information on the cost exposure of non-traditional construction workers in alternative employment arrangements. These workers' eligibility for benefits such as workers' compensation hinges on how the employer or employee is defined. The employee status of independent contractors is not always clear and can vary by state or by specific law or regulation. While most states require that leasing or temporary-help companies purchase workers' compensation insurance to protect their workers from the financial consequences of work injury, they often exempt domestic, farm, and "casual" workers as well as self-employed independent contractors. Such workers would need to purchase insurance coverage themselves in order to receive workers' compensation benefits.

In addition, Park and Butler[35] point out that the worker may be more exposed to work hazards if the temp agency or contract company that is responsible for providing workers' compensation coverage is unable to monitor safety behavior at

the client workplace, which is responsible for compliance with safety regulations. This lack of accountability alters the incentives for enhancing workplace safety by shielding clients from higher workers' compensation costs. Thus, construction workers in alternative work arrangements may be particularly exposed to the costs of injury since these jobs may allow employers to legally avoid benefit costs and at the same time, reduce incentives for providing safe workplaces. Further research is needed on the injury exposure and access to safety training for these workers.

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