Injuries and Illnesses From Wood Framing in Residential Construction, Washington State, 1993–1999

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The construction industry is associated with high rates of work-related injury. We used workers compensation data to describe the injuries and illnesses, claim rates, and claim costs associated with wood framing activities in construction. From 1993 to 1999, there were 33,021 accepted state fund workers compensation claims with direct costs of over $197 million. The average annual claim rate was 45 per 100 full-time equivalent. Statistically significant downward trends were noted in claim rates for all injuries and illnesses, compensable time loss claims, eye and fall injuries. However, these trends were not statistically significantly different from those observed in all other construction risk classes combined. The information in this report can be used to guide prevention efforts and to evaluate the effectiveness of Washington state initiatives to reduce injury and illness rates in wood frame construction. (J Occup Environ Med. *2003;45:1171–1182*)

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Construction is one of the largest industries in the United States with annual employment of over 6.3 million workers.[1] Construction is also one of the most dangerous industries. In 1999, construction, when compared with other major industry divisions, had the third highest fatality rate, 14 per 100,000 workers,[2] and the highest nonfatal injury rate, 8.4 injuries per 100 full-time equivalent employees (100 FTEs).[1] In addition to the high morbidity and mortality, the injuries sustained by workers have significant economic implications; construction laborers and carpenters rank in the top 3% of all occupations for total annual cost of injury and illness.[3]

The injury rate for the construction industry varies by state and by the industry subsector.[1] The 1999 Washington Bureau of Labor Statistics (BLS) nonfatal injury rate in the construction industry division was 14.5 injuries per 100 FTEs and is nearly double the national average.[4] Within general building contractors (Standard Industrial Classification [SIC] 15), the Washington state nonfatal injury rate for "residential building construction" (SIC 152) was 18.1 injuries per 100 FTEs, which far exceeds the nonfatal injury rate in "nonresidential construction" (SIC 154) at 12.8 injuries per 100 FTEs.[4]

Within the Washington state construction industry, workers involved in wood frame construction have been identified as having a high fatality rate and a large number of

TABLE 1
Prevention Index Ranking, State Fund Compensable* Claim Counts and Claim Incidence Rates for All Construction Risk Classes, Washington State, 1993–1999

WIC DESCRIPTION	Hours	Claim	Claims/100 FTE	L 95% CI	U 95% CI	C	R R	PI
0507 Roof work	26,074,382	3267	25.1	24.2	25.9	3	2	2.5
0510 Wood framing	143,132,647	9349	13.1	12.8	13.3	1	6	3.5
0518 Non-wood frame building	70,687,518	3460	9.8	9.5	10.1	2	15	8.5
0301 Landscape construction	35,872,863	1933	10.8	10.3	11.3	8	12	10.0
0502 Floor covering installation	16,325,020	941	11.5	10.8	12.3	14	7	10.5
0302 Masonry construction	16,696,543	954	11.4	10.7	12.2	13	8	10.5
0512 Insulation installation	19,305,270	1097	11.4	10.7	12.1	12	9	10.5
0504 Painting: building exterior	54,088,807	2640	9.8	9.4	10.1	6	16	11.0
0306 Plumbing	76,050,594	2903	7.6	7.4	7.9	5	17	11.0
0516 Carpentry	36,035,426	1878	10.4	10.0	10.9	9	14	11.5
0519 Sheet metal siding	5,896,092	423	14.3	13.0	15.8	19	4	11.5
0307 Heating, ventilating, air condition	69,821,016	2485	7.1	6.8	7.4	7	18	12.5
0521 Painting: building: interior	4,327,868	291	13.4	11.9	15.1	21	5	13.0
0601 Electrical wiring: building	121,429,117	3104	5.1	4.9	4.7	4	22	13.0
0506 Building raising, moving	636,969	115	36.1	29.8	43.3	26	1	13.5
0517 Factory built home	2,067,852	164	15.9	13.5	18.5	25	3	14.0
0511 Glass installation	11,865,367	626	10.6	9.7	11.4	16	13	14.5
0513 Interior finish carpentry	51,543,974	1699	6.6	6.3	6.9	10	20	15.0
0308 Lawn care maintenance	33,800,877	1133	6.7	6.3	7.1	11	19	15.0
0514 Garage door installation	4,162,995	234	11.2	9.8	12.8	22	10	16.0
0303 Plastering, stuccoing	3,654,158	200	10.9	9.5	12.6	23	11	17.0
0603 Machinery installation	33,965,040	746	4.4	4.1	4.7	15	24	19.5
0607 Household appliance installation.	31,610,520	581	3.7	3.4	4.0	17	25	21.0
0606 Vending machine installation	14,040,015	335	4.8	4.3	5.3	20	23	21.5
0608 Telephone & electric	34,044,992	506	3.0	2.7	3.2	18	26	22.0
0602 Elevator installation	5,855,896	166	5.7	4.8	6.6	24	21	22.5

* Compensable claims involve 4 or more lost workdays, result in total permanent disability, loss of earning power or a fatality.
C = count rank; RR = rate rank; PI = Prevention index.

nonfatal severe injuries.[5] In this study, we used the Washington state workers compensation claims databases to characterize work-related injuries and illnesses in wood frame construction. Washington State Department of Labor and Industries claims data have been used successfully in a number of similar studies.[6–8] We also compared the claims rate in wood frame construction to claims rates in other sectors of construction.

Materials and Methods

In Washington state, all employers (except the self-employed and the Federal government) are required to obtain workers compensation insurance through the Washington State Department of Labor and Industries (L&I) industrial insurance system, the State Fund, unless they are able to self-insure. The L&I State Fund covers approximately two thirds of the workers in Washington state (the remainder work chiefly for the 400 largest employers in Washington state and are covered by their self-insured employers). Most of the Federal workers are not included in the Washington state industrial insurance system. As a result of inconsistencies in data reported by self-insured employers to the Washington State Department of Labor and Industries, this analysis was restricted to State Fund employers.

The L&I claims management database consists of 2 major data processing systems. The Medical Information and Payment System (MIPS) receives all billing information generated by provider medical bills. All State Fund claims are entered into the Labor and Industries Industrial Insurance System (LINIIS). The employer's industry is identified using the Standard Industrial Classification (SIC) coding system. Washington state also uses the Washington Industrial Classification (WIC) system that combines industry and occupation to group workplaces by similar risk of injury for insurance purposes.

From LINIIS we obtained all accepted State Fund workers compensation claim data for all the risk classes (WIC) in building construction and trades filed between January 1, 1993, and December 31, 1999. Washington state construction WIC codes and descriptions are in Table 1. We also obtained all accepted State Fund workers compensation claim data in all construction (SIC 15, 16, and 17) and in "residential building construction" (SIC 152) for the same study period. The claim status for accepted claims can be divided into 2 categories: compensable (4 or more days of time lost) and noncompensable (payments of medical bills only). Claims that involve a fatality, an employee kept on salary

(by the employer), a claimant's loss of earning power, or resulting in total permanent disability or death are considered compensable. We obtained further information on each claim in the "'Wood Frame Building; Construction or Alterations, Not Otherwise Classified" (WIC 0510) risk class.[9] WIC code 0510 includes all building framing activities done in connection with wood frame building construction, including the placement of roof trusses, sheathing roofs, installation of exterior building siding, and the installation of exterior doors and door frames.[9] Most wood framing activities associated with construction occur in residential construction. We extracted information on claimants' gender, age, details of the injury and illness as coded using the American Standard Method of Measuring and Recording Injury Experience of the American National Standard Institute (ANSI).[10] The ANSI codes describe the injury or illness by: 1) the body part involved (eg, code 330 = hand, 130 = eye, 530 = foot), 2) the "source" of the event (eg, code 2355 = power saw, 2245 = nonpower knife), 3) its "nature" (eg, code 170 = cut, 210 = fracture), and 4) its "type" (eg, code 31 = fall from scaffold, 32 = fall from ladder, 34 = fall from vehicle, 35 = fall on stairs, 36 = fall into openings, 37 = fall from roof, 39 = fall to lower level, 50 = fall on same level, 52 = fall against objects).

We used a text word search of the workers compensation report of accident form for specific injury sources not coded by ANSI. For injuries related to the use of pneumatic nail guns, we used the words "nailgun," "nail gun," "nailer," or a combination of the words "pneumatic" and "nail."[11] Work-related musculoskeletal disorder claims were identified and categorized by body region and specific diagnosis using methods described elsewhere.[6] Claim costs reported here reflect actual totals for closed claims. For claims that were not closed, costs reflect actual totals of the study period and the total future estimated costs as calculated by Washington State Department of Labor and Industries actuarial staff. We identified claims associated with inpatient hospitalization from MIPS. Employment information is reported to Labor and Industries by State Fund employers as the number of hours worked by employees for each quarter of the year. These hours are reported by the employers' account. The number of FTE employees working per year was calculated assuming that each full-time employee works 2000 hours per year (40 hours per week for 50 weeks per year).

Statistical Analysis

Descriptive analyses included a frequency of claims by year of injury, occupation, nature of injury, body part injured, source and types of injury or illness for all accepted claims in wood frame construction. We calculated compensable claim rates in all construction WIC classes and SIC codes. Claim rates per 100 FTEs were determined by dividing the number of identified claims by the number of hours reported multiplied by 200,000. Payroll data reported to the workers compensation system were used to extract the number of hours worked. Number of hours was aggregated to the WIC and SIC levels and reported separately by year. Claim rates were calculated by year and expressed as number of claims per 100 FTE employee-years. Ninety-five percent confidence intervals (95% CI) for average annual rates per 100 FTE over the study period were calculated from the 95% CI around the total count of injury divided by the total FTE (Table 1). We compared the compensable claims rate in wood frame construction (WIC 0510) to compensable claims rates calculated from the combination of all construction risk classes, excluding wood frame construction. We also compared the compensable claim rate in "residential building construction" (SIC 152) to all construction (SIC 15, 16, 17) other than SIC 152. We used a Poisson regression model to test for evidence of a trend in claims rates as a function of calendar year. The GENMOD procedure, with a Poisson distribution, was used to evaluate trends over time (using SAS release 8.2). We used the following regression model:

$$Ln(\lambda_{year}) = \beta_0 + \beta_1(\text{Year})$$

Here the λ_{year} is the injury rate for each year and the natural log transformation ensures that the model-based predictions of rates are constrained to be greater than or equal to zero. We estimated the annual percent decrease in injury rate by exponentiating the coefficients from the fitted model. For example, the estimated coefficient of the compensable claim rate for wood frame construction (WIC 0510) was -0.0424 with a standard error of 0.0036 (Table 2). The $e^{(-0.0424)} = 0.9585$, which translates into an annual change of -4.15% [$(1-0.9585) \times 100$] in the compensable claims incidence rate over the study period.

To prioritize industries for intervention purposes, the claim frequency and claims incidence rate are important considerations. We combined the rank orders of both frequency and incidence rate to create a "Prevention Index" (PI). PI = (Frequency Rank + Incidence Rank) / 2.[6]

Results

A total of 35,267 workers compensation State Fund claims were filed for work-related injuries and illnesses in wood frame construction (WIC 0510) from January 1, 1993, to December 31, 1999. Of these, 33,021 (93.6%) were accepted claims. The majority of the accepted claims (98.8%) were closed. Approximately 28% of the accepted claims were compensable. Male workers filed 98% of the claims. The mean age of claimants was 32 ($\pm$ 11 standard deviation) years.

TABLE 2
Poisson Regression to Estimate Trend of State Fund Compensable Claims in Washington State, 1993–1999

WIC Description	*% Rate Change per Year (95% CI)*
Univariate analysis	
Wood frame construction	−4.15% (−4.84%; −3.47%)
All construction risk classes combined, except wood framing	−3.99% (−4.47%; −3.53%)
Falls in wood framing	−4.72% (−6.50%; −2.93%)
Falls in all other construction risk classes combined	−3.62% (−6.08%; −1.10%)
Eye injuries in wood framing	−6.47% (−7.83%; −5.09%)
Eye injuries in all other construction risk classes combined	−5.78% (−7.45%; −4.08%)
Multivariate analysis	***Difference in % Rate Change***
Wood frame construction compared to all other construction risk classes combined except wood framing	−0.16% (−1.08%; +0.76%)
Fall injuries in wood frame construction compared to fall injuries in all other construction risk classes combined	−1.14% (−4.35%; +2.16%)
Eye injuries in wood frame construction compared to eye injuries in all other construction risk classes combined	−0.73% (−3.26%; +1.86%)

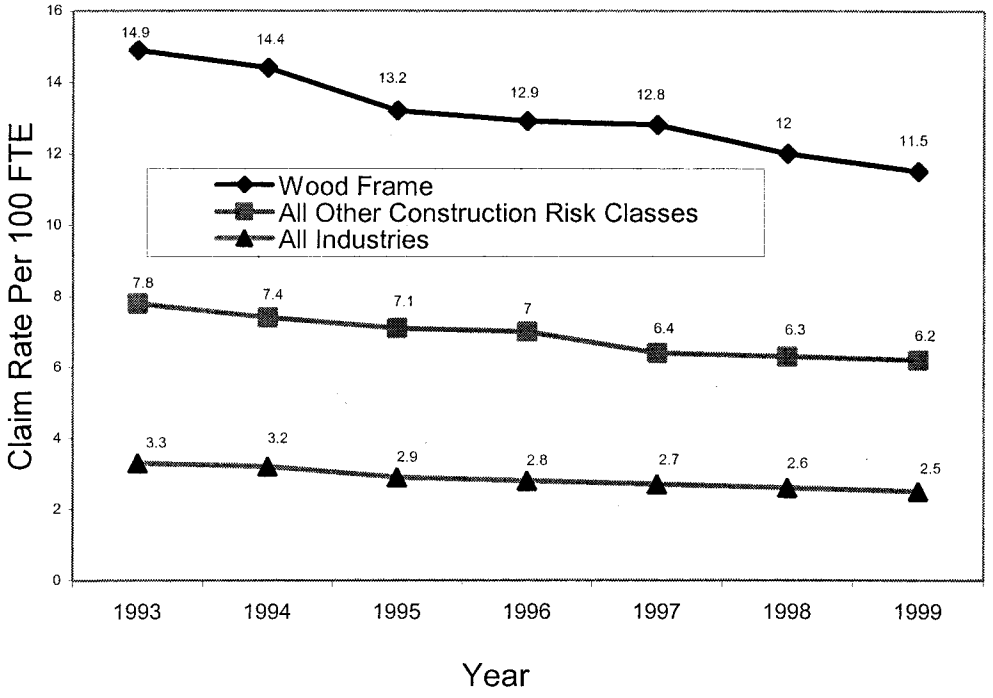

Fig. 1. State Fund, compensable claims incidence rate in wood framing (WIC 0510) compared with all construction risk classes and all industries, Washington state, 1993–1999. Compensable claims involve 4 or more lost workdays, result in total permanent disability, loss of earning potential, or a fatality.

Wood frame construction workers included in this study experienced an overall average workers compensation claim rate of 45 claims per 100 FTEs per year, with the rate decreasing from 52 claims per 100 FTEs in 1993 to 41 claims per 100 FTEs in 1999. Trend analysis showed an annual average change of −3.69% (95% CI = −4.88%, −2.26%). We noted a similar average annual change of −4.68% (95% CI = −5.29%, −4.05%) in all construction (WIC) except wood framing. The rates of decrease over the study period were not statistically different between wood frame construction and all other construction risk classes combined.

In WIC 0510, temporal trends in compensable claims rates, those involving 4 or more days of lost time from work, decreased over the study period (Fig. 1); however, the trend

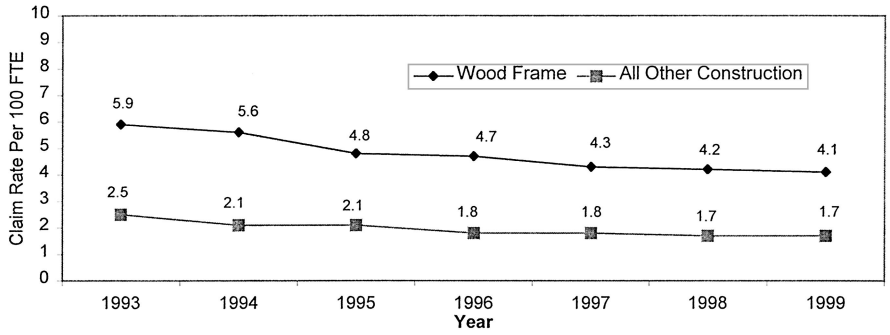

Fig. 2. State Fund claims rate for eye injuries in wood framing (WIC 0510) and in all other construction risk classes combined, Washington state, 1993–1999.

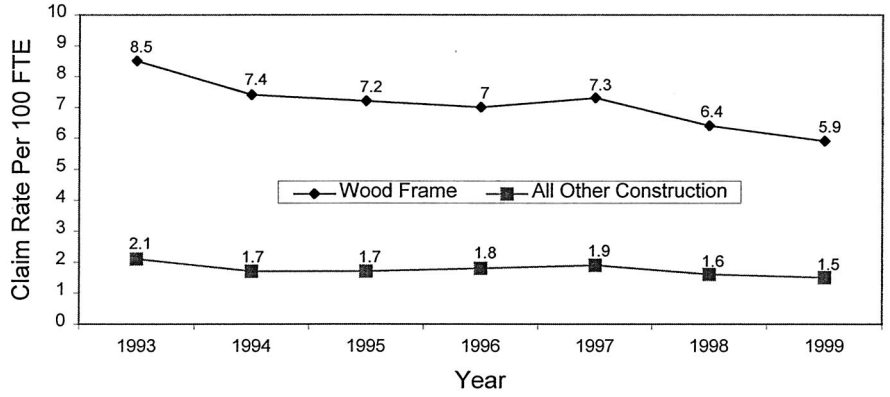

Fig. 3. State Fund claims rate for "falls" in wood framing (WIC 0510) and in all other construction risk classes combined, Washington state, 1993–1999.

when compared with compensable claim rates in all other construction risk classes combined except wood frame construction were not significantly different (Table 2). Trends in fall and eye injury claim rates in wood frame construction (Figs. 2 and 3, respectively) did not differ from their respective rates when compared with all other construction risk classes combined, excluding wood frame construction as well (Table 2).

The number of compensable claims and the corresponding claims rate in each of the construction risk classes are presented in Table 1. The number of compensable claims in wood frame construction was the highest of all construction risk classes. According to the prevention index, the wood frame construction risk class had the second highest ranking.

We also calculated the claims rate in construction using the SIC code. The overall average annual claims rate for State Fund construction (SIC 15, 16, 17) was 25.7 per 100 FTEs, with the rate decreasing from 30.8 in 1993 to 23.1 in 1999. The average annual compensable claims rate was 6.5 per 100 FTEs in all construction (SIC 15, 16, and 17) except SIC 152, with rates decreasing from 7.6 to 5.9 per 100 FTEs. The overall claims rate for State Fund "residential building construction" (SIC 152) was 29.1 claims per 100 FTEs, with the rate decreasing from 34.9 in 1993 to 25.0 in 1999. The average compensable claims rate in State Fund "residential building construction" (SIC 152) was 7.9 claims per 100 FTEs, with rates decreasing from 9.5 per 100 FTEs in 1993 to 6.8 in 1999. We noted a significant decline in the compensable claims rate both in "residential construction," SIC 152 (−6.00% annual change; 95% CI = −7.55%, −4.42%) and all construction, SIC 15 through 17 (−3.77% annual change; 95% CI = −5.15%, −2.35%) over the study period, but there was no statistically significant difference in slopes between these 2 groups.

We identified claims in LINIIS that were coded with SIC 152 or WIC 0510. Of the 49,555 claims identified, 16,541 (33.4%) were unique to SIC code 152, 13,231 (26.7%) were unique to WIC code 0510, and 19,783 (39.9%) were coded with both SIC 152 and WIC 0510. Only injuries and illness associated with WIC 0510 are described further.

There were 11 fatalities reported during the study period in wood frame construction. The majority of these fatalities (64%) occurred as a result of multiple injuries. Five of the fatalities were the result of falls from roofs, 2 were the result of inhalation of asbestos (both were carpenters with malignant mesothelioma from exposures occurring greater than 30 years before claim filing), 2 were the

TABLE 3
Falls in Wood Frame Construction by Cost, and Associated Source in Washington State, 1993–1999

Nature of fall	*N* (%)	Cost total	Cost median	Hospitalized N (%)	Associated source of injury	*N* (%)
Fall to lower level	1,771 (35.1)	$22,975,726	$ 534.7	121 (27.7)	Work-surface Unsound	724 (40.9)
					Timber/wood not secured	185 (10.4)
					Work-surface slippery/wet	171 (09.7)
					All others	691 (39.0)
Fall from ladder	1,273 (25.3)	$16,555,157	$ 797.8	114 (26.1)	Moveable ladder	859 (67.5)
					Ladder broke/collapsed	270 (21.2)
					Work-surface slippery/wet	68 (05.3)
					All others	76 (06.0)
Fall against objects	546 (10.8)	$ 3,066,721	$ 283.8	19 (4.3)	Ladder/timber slab unstable	184 (33.7)
					Work-surface slippery/wet	102 (18.7)
					Fasteners/metal items unsound	81 (14.8)
					All others	179 (32.8)
Fall from roof	421 (08.4)	$13,076,423	$2215.4	88 (20.1)	Roof weak/unsound	368 (87.4)
					Openings in the roof	32 (07.6)
					Roof surface slippery	7 (01.7)
					All others	14 (03.3)
Fall from scaffold	414 (08.2)	$11,394,086	$1093.6	58 (13.3)	Scaffold/un-sound platform	146 (35.3)
					Work-surface Unsound	89 (21.5)
					Work-surface rough	28 (06.8)
					All others	151 (36.5)
Fall into openings	233 (04.6)	$ 3,250,878	$ 362.2	16 (3.7)	Openings in roof/floor	78 (33.5)
					Work-surface Unsound	64 (27.5)
					Un-sound platform	27 (11.6)
					All others	64 (27.5)
Fall on stairs	191 (03.8)	$ 2,323,707	$ 447.3	13 (3.0)	Stairway/steps unsound	139 (72.8)
					Ladder/steps unsound	20 (10.5)
					Surface slippery	10 (05.2)
					All others	22 (11.5)
Fall from Vehicles	106 (02.1)	$ 1,377,546	$ 471.3	5 (1.1)	Highway Vehicle unsound	80 (75.5)
					Powered carrier unsound	10 (09.4)
					Slippery surface/shoes	5 (04.7)
					All others	11 (10.4)
Fall on same level	85 (01.7)	$ 626,920	$ 443.0	3 (0.7)	Work-surface Unsound	32 (37.6)
					Slippery surface	20 (23.5)
					Roof-unsound	11 (12.9)
					All others	22 (25.9)
Total	5,040 (100.0)	$74,647,164		437 (100.0)		

result of motor vehicle accidents, 1 was the result of a crash of a private plane (worker commuting to job site on employer's plane), and 1 was the result of being struck by a falling object. Twenty people received total permanent disability as a result of their injuries. The majority of these injuries (13 of 20) were caused by falls; 8 of these 13 cases involved fracture of multiple body parts.

The total cost incurred by the State Fund over the study period resulting from injuries and illnesses in wood frame construction (WIC 0510) was $197,318,444. The mean and median costs of all work-related injury and illness claims were $6082 and $244, respectively. The median cost for a compensable claim was $3620. The median cost for a noncompensable claim (medical only claims) was $191. Of all claims, a significant proportion (38.8%) of the total cost was associated with fall-related injuries (Table 3). We examined the types of fall injuries, the total and median cost incurred for each type of fall, and the number of people admitted to the hospital (Table 3). There were 1070 hospital admissions. Of all hospital admissions in wood frame construction, 40.8% (n = 437) were related to an injury sustained from a fall.

There were 6562 State Fund accepted claims for work-related musculoskeletal disorders (WMSDs) in WIC 0510 over the 7-year study period. The average annual claims incidence rate for all WMSDs was 9.2 per 100 FTEs. Back WMSDs accounted for 3831 claims or an average annual claims incidence rate of 5.4 claims per 100 FTEs. There were 622 WMSDs of the neck for an average annual claims incidence rate of 0.9 per 10,000 FTEs and 2016 WMSDs of the upper extremity or an average annual claims incidence rate of 2.8 per 100 FTEs. For WMSDs with specific diagnosis, there were

119 claims with sciatica, (0.2 per 100 FTEs per year), 290 claims with rotator cuff syndrome, (0.4 per 100 FTEs per year), 285 claims with epicondylitis, (0.4 per 100 FTEs per year), 351 claims with carpal tunnel syndrome (0.5 per 100 FTEs per year), and 261 claims with hand-wrist tendonitis (0.4 per 100 FTEs per year). Claims could contain more than one MSD.

"Carpenters and apprentices" and construction laborers sustained most of the injuries and illnesses, accounting for 74% of the total cases. Counts by nature of injury were highest for cuts (32%), sprains (27%), contusions (9%), and scratches (9%); these accounted for the majority (77%) of all claims. Fingers were the most common body parts injured (17.5%), followed by the back (14%), eye (10.4%), hand (7.4%), knee (5.4%), and wrist (4.3%). "Fasteners" were involved in a large percentage of the injuries (13.5%), followed by "timber/slab" (10%) and "particles" (6.9%). Of injuries in which fasteners were listed as the source, 39% were associated with pneumatic nail gun use. The highest counts by mechanism (type of injury) were observed for being struck by an object (41.5%), overexertion (20.8%), falls (14.8%), and being abraded by an object (7.5%). These 4 types accounted for almost 85% of the reported claims.

We grouped body parts into general body regions (eg, arm, forearm, elbow, wrist, hand, and fingers constituted the "upper limbs"), and examined the nature of injury and leading sources of injury using ANSI codes for body part (Table 4A–D). There were 84 amputation cases (ANSI Z 16.2 Nature Code = 100 "Amputation"). Of all the body parts, finger(s) amputation was the most common and accounted for 82 of the 84 cases; amputation of the hand was involved in 1 case and the toe in another. A power saw (68.6%) or a nonpower saw (27%) was the source of injury in most of the amputation cases. The total cost of amputation injuries was $1,847,532. Of all the injury nature codes, "amputation" had the highest median claim cost, $12,297.

Discussion

Workers doing wood framing in building construction (WIC 0510) in Washington state have one of the highest injury rates in the construction industry. During the study period, the overall annual average accepted workers compensation claim rate was 45 claims per 100 FTEs. One of every 4 workers compensation claims in WIC 0510 resulted in a compensable claim. By prevention index, wood frame construction was one of the highest-priority construction risk classes for intervention. Clearly, there are indications for intervention to reduce and prevent further injuries associated with wood framing activities.

In an effort to reduce injuries and to improve compliance with Washington workplace regulations, the Washington State Department of Labor and Industries, in 2001, developed the Residential Wood Framing Initiative.[12] This initiative focuses on reducing fall injuries and eye injuries in wood framing workers through improved compliance with workplace safety regulation. A previous Washington state study demonstrated an association between workplace safety and health regulatory enforcement and decreasing fall injury rates in construction.[13,14] Furthermore, the Residential Wood Framing Initiative aims to increase both employer compliance with the reporting of the number of employee work-hours and the registration of wood framing contractors.

One of the major priorities of the Residential Framing Initiative is to decrease fall and eye injuries. Workers compensation claim costs associated with wood frame construction totaled $197 million over a 7-year period; 38% of the cost was associated with fall injuries. There were 11 work-related fatalities during the 7-year study period, 5 of which were the result of falls. Twenty of the 31 permanent partial disability cases were the result of a fall. A number of studies have shown that work-related falls from roofs constitute a major problem for workers in the construction industry.[15,16] Falls, along with cave-ins, and electrocutions were leading causes of fatal injuries in the construction industry, accounting for 45% of construction deaths in Washington state.[17] "Fall to a lower level" followed by "fall from ladders" were the most frequent fall related injuries in our study. The "fall to a lower level" classification was associated with the greatest proportion (11.9%) of all fall-related construction fatalities in 1999 followed by "fall from roof" (2.5%) and "fall from ladder" (1.6%).[18] We noted a decline in the fall injury rates over the study period, but there was no significant difference in the rate of decline when compared with the decline in fall injury rates in all other construction risk classes. The Residential Framing Initiative intends to increase compliance to the fall protection standard and reduce fall injury rates associated with wood frame construction.[13]

Eye injuries are common in construction, accounting for 11% of work-related emergency room visits by construction workers[19] and 12% of workers compensation claims for union carpenters.[20] Eye injuries accounted for 10.4% of all claims in wood framers. Scratches associated with particles were the most common eye injuries in our study (59%) as well as others.[19,20] The use and type of eye protection as well as the circumstances of the eye injury are unknown in our study. Interviews with 62 construction workers presenting to an emergency room with an eye injury found that only 55% were wearing eye protection at the time of injury.[19] Of those injured while wearing eye protection, 94% had the agent circumvent the eye protection.[19] To reduce eye injuries, the intervention must include com-

TABLE 4A
Body Part Injured by Nature and Sources of Injury in the Wood Frame Construction, Washington State, 1993–1999.

Nature	*n* (%)	Source*	*n* (%)
Upper limb (fingers, hand, wrist, forearm, arm)			
Cuts	6865 (61.7)	Fasteners	2177 (31.7)
		Power saw	742 (10.8)
		Non-power knife	724 (10.5)
		Sliver/splinter	450 (06.6)
		All other	2772 (40.4)
Fracture	1150 (10.3)	Fasteners	192 (22.2)
		Non-power hammer	160 (13.9)
		Power saw	127 (11.0)
		Work-surface	108 (09.4)
		All other	563 (49.0)
Contusion	968 (08.7)	Non-power hammer	226 (23.3)
		Timber/slab	165 (17.0)
		Wall/Fence	43 (04.4)
		Work-surface	43 (04.4)
		All other	491 (50.7)
Sprains	963 (08.7)	Timber/slab	124 (12.9)
		Non-power hammer	105 (10.9)
		Work-surface	65 (06.7)
		Ground-outdoor	55 (05.7)
All others	1175 (10.6)	All other	614 (63.8)
Lower limb (Toe, foot, ankle, knee, leg, thigh)			
Cuts	2251 (37.0)	Fasteners	1,530 (68.0)
		Power saw	211 (09.4)
		Nonpower knife	79 (03.5)
		Structural metals	44 (02.0)
		All other	387 (17.2)
Sprains	1768 (29.1)	Bodily motion	591 (33.4)
		Work-surface	247 (14.0)
		Ground-outdoor	209 (11.8)
		Timber/slab	114 (06.4)
		All other	607 (34.3)
Contusion	798 (13.1)	Timber/slab	168 (21.1)
		Work-surface unsound	75 (09.4)
		Non-power hammer	64 (08.0)
		Ground-outdoor	55 (06.9)
		All other	436 (54.6)
Fractures	576 (09.5)	Work-surface unsound	114 (19.8)
		Ground-outdoor	87 (15.1)
		Timber/slab	82 (14.2)
		Fasteners	64 (11.1)
		All other	229 (39.8)

* Four most frequent sources for each nature of injury

pliance with the use of eye protection, the use of appropriate eye protection to prevent particles from circumventing the protection, and engineering controls to limit dust and particle exposures.[19,20]

Fasteners were found to be the most common source of injuries in this study. The use of pneumatic nail guns accounted for over 39% of these claims. There have been reports of fatal and life-threatening injuries associated with the use of pneumatic nail guns.[21,22] Between 1990 and 1998, there were 3616 accepted Washington State Fund claims associated with nail gun injuries, costing $692,488 per year.[11] Potentially significant reductions in injuries associated with pneumatic nail gun use can be accomplished from previously published safety recommendations.[11]

We identified 6562 State Fund accepted work-related musculoskeletal disorder (WMSD) claims in wood frame construction between 1993 and 1999. In Washington state, WMSDs resulted in $2.6 billion in direct costs and 20.5 million lost workdays over the period between 1990 and 1998.[6] Silverstein et al.[6] used Washington state workers compensation state fund data from 1990 to 1998 to identify high-risk WIC, by prevention index, for WMSDs. Of 281 WIC classifications ranked by prevention index, wood frame building construction ranked third for

TABLE 4B
Body Part Injured by Nature and Source of Injury in the Wood Frame Construction, Washington State, 1993–1999

Nature	*n* (%)	Source	*n* (%)
Head/face/neck/shoulder			
Sprains	1654 (57.0)	Timber/Slab	375 (22.7)
		Work Surface Uns.	123 (07.4)
		Ground outdoor	99 (06.0)
		Misc	85 (05.1)
		All other	972 (58.8)
Cuts	570 (19.6)	Timber/slab	147 (25.8)
		Non-power hammer	72 (12.6)
		Fasteners	30 (05.3)
		Power hammer	22 (03.9)
		All other	299 (52.5)
III-defined Symptoms	216 (07.4)	Timber/Slab	38 (17.6)
		Misc	16 (07.4)
		Ground outdoor	12 (05.6)
		Wall/fence	11 (05.1)
		All other	139 (64.4)
Contusion	186 (06.4)	Timber/Slab	34 (18.3)
		Ground-outdoor	15 (08.1)
		Wall/fence	13 (07.0)
		Floor	12 (06.5)
		All other	112 (60.2)
Chest, Abdomen, Back			
Sprains	4295 (71.7)	Timber/Slab	1001 (23.3)
		Bodily Motion.	314 (07.3)
		Misc NEC	246 (05.7)
		Unknown	198 (04.6)
		All other	2536 (59.1)
Contusion	526 (08.8)	Work surface	76 (14.4)
		Timber/slab	74 (14.1)
		Ground-outdoor	70 (13.3)
		Floor	44 (08.4)
		All other	262 (49.8)
III_Def. Symptoms	438 (07.3)	Timber/Slab	88 (20.1)
		Unknown	29 (06.6)
		Ground-outdoor	26 (05.9)
		Wood Items	26 (05.9)
		All other	269 (61.4)
Inguinal	228 (03.8)	Timber/Slab	52 (22.8)
		Unknown	25 (11.0)
		Misc NEC	20 (08.8)
		Wall/fence	14 (06.1)
All other (n = 18)	501 (18.4%)	All other	117 (51.3)

compensable WMSDs of neck, back, and upper extremity; second for WMSDs of the back; fifth for WMSDs of the upper extremity; third for sciatica; 11th for rotator cuff syndrome; first for epicondylitis; and eighth for carpal tunnel syndrome.[6] Although not a focus of the Residential Framing Initiative, the importance of interventions to reduce musculoskeletal disorders in this WIC appears paramount. Hazard reduction through implementation of Washington state's ergonomics rule could lead to a reduction of WMSD claims in wood frame construction.[23]

The WIC system provides the opportunity to assess injury and illness rates based on industry and occupation (workplace exposure). The SIC coding system is based solely on commerce (eg, clerical workers for a construction company have a different WIC than workers performing wood framing activities). Comparing WIC data with the SIC-based data presented in the Bureau of Labor Statistics Annual Survey of Occupational Injury and Illness is inappropriate. Workers engaged in framing activities in construction partly overlap with that of the "residential construction" SIC code 152. The 1999 Washington state workers compensation State Fund claims rates for accepted injuries and illnesses in SIC 152 was 25.0 per 100 FTEs. The 1999 Washington State BLS rate estimate was 18.2 per 100 FTEs.[5] The 1999 Washington state workers compensation compensable claims rate was 6.8 per 100 FTEs, whereas the

TABLE 4C
Body Part Injured by Nature and Source of Injury in the Wood Frame Construction, Washington State, 1993–1999

Body part nature	*n* (%)	Source	*n* (%)
Eye			
Scratches	2780 (81.1)	Particles	2021 (72.7)
		Metal Chips	287 (10.3)
		Wood Dust	113 (04.1)
		Fasteners	59 (02.1)
		All others	300 (10.8)
Conjunctivitis	201 (05.9)	Particles	127 (63.2)
		Wood Dust	12 (06.0)
		Chemicals	8 (04.0)
		Calcium hydroxide	7 (03.5)
		All other	47 (23.3)
Cuts	188 (05.5)	Fasteners	58 (30.9)
		Particles	47 (25.0)
		Metal chips	28 (14.8)
		Timber/slab	8 (04.3)
		All other	47 (25.0
III-def. Symptoms	112 (03.3)	Particles	55 (49.1)
		Fasteners	16 (14.3)
		Wood Items	5 (04.5)
		Misc. NEC	5 (04.5)
All other (n = 13)	144 (04.2)	All other	31 (27.6)
Ear, nose, mouth			
Hearing Loss	427 (48.4)	Noise	427 (100.0)
Cuts	181 (20.5)	Timber/Slab	45 (24.9)
		Non-power hammer	21 (11.6)
		Misc NEC	11 (06.1)
		Power hammer	10 (05.5)
		All other	94 (51.9)
Teeth	179 (20.3)	Non-power hammer	30 (16.8)
		Timber/slab	25 (14.0)
		Fasteners	15 (08.4)
		Power hammer	11 (06.1)
		All other	98 (54.7)
Fracture	33 (03.7)	Timber/slab	11 (33.3)
		Nonpower hammer	4 (12.1)
		Misc NEC	3 (09.1)
		Wood item	3 (09.1)
All other (n = 12)	63 (07.1)	All other	21 (36.4)

1999 Washington BLS SIC 152 injury and illness rate for cases resulting in "days away from work" was 6.9 injuries per 100 FTEs. The BLS rates for nonfatal injuries and illnesses that involve "days away from work" are calculated based on 1 or more workdays lost, whereas the Washington state workers compensation compensable claims require 4 or more lost workdays. In 1999, 32.2% of BLS cases in SIC 152 involving "days away from work" had only 1 or 2 lost workdays.[4] Given the much higher threshold for the workers compensation compensable injury and illness rate, BLS survey data significantly underestimates the injury and illness rates in "residential building construction" in Washington state. Additional reasons for the rate disparity between the 2 systems include different reporting requirements, sampling error associated with BLS survey estimates of the number of cases and number of hours worked, and the absence of data for Washington state self-insured employers. Self-insured employers usually have more developed safety programs.

Complete reporting of work-related injuries from the construction of the Denver International Airport (DIA) document a "true" injury rate more than twice that of national BLS injury rate estimates for construction.[24] Differences between the true injury rate from DIA and national BLS estimates were primarily non-lost work time injuries. The injuries associated with construction of DIA were also underreported to the workers compensation system.[24] Overall, workers compensation adjusted payment rates per $100 of payroll exceeded the overall Colorado-specific National Council on Compensation Insurance expected loss rates by 11%. The DIA study suggests that both workers compensation and BLS

TABLE 4D
Multiple Body Parts Injured By Nature and Source in the Wood Frame Construction, Washington State, 1993–1999

Nature	*n* (%)	Source	*n* (%)
Multiple body parts			
Multiple injuries	624 (23.8)	Ground outdoor	146 (23.4)
		Work surface	143 (22.9)
		Timber/slab	50 (08.0)
		Floor	30 (04.8)
		All other	255 (40.9)
Sprains	404 (15.4)	Ground outdoor	66 (16.3)
		Timber/slab	55 (13.6)
		Work surface	46 (11.4)
		Bodily motion	27 (06.7)
		All other	210 (52.0)
Contusion	339 (12.9)	Work surface	66 (19.5)
		Ground-outdoor	48 (14.2)
		Timber/slab	38 (11.2)
		Floor	28 (08.3)
		All other	159 (46.9)
Cut	338 (12.9)	Fasteners	46 (13.6)
		Nonpower hammer	35 (10.4)
		Timber/slab	27 (08.0)
		Power saw	21 (06.2)
All other ($n = 12$)	917 (35.0)	All other	209 (61.8)

underestimate injury and illness rates in construction. Given the difference in injury and illness rate estimates between Washington State BLS and Washington state workers compensation data, workers compensation rates more accurately reflect the true injury rate.

The residential construction industry presents a number of unique challenges for the goal of reducing workplace injury/illness burden. This industry has a strong underground economy in which some contractors might not be licensed in Washington state. Some work "under the table" with respect to reporting hours worked, on which premiums are paid for workers compensation insurance. Workers in this industry often have not completed an apprenticeship program, are often transient, and work part-time for multiple employers over the year. The transient nature of the worksites of both the contractor and the worker makes for a moving target in terms of industry regulatory initiatives. The Residential Framing Initiative, launched in 2001 in Washington state, seeks to improve the reporting of hours by encouraging contractors to comply with reporting requirements.

There are several potential limitations to using workers compensation data to describe the injury and illness rate within a particular industry or risk class. Workers compensation data could underreport the true number of injuries in this industry because both a worker and physician must recognize his or her condition as work-related and file a claim with the Washington State Department of Labor and Industries. The worker must also satisfy the state criteria for eligibility to have an injury accepted by the Washington workers compensation system.[25] We describe the injury rate as a measure of incidence with claims as the numerator and hours of work as the denominator. If significant numbers of work-related injuries or illness were not reported to the workers compensation system (eg, on-site medical care, failure to report), the injury rate presented here would be underestimated. Because WIC injury rates are based on employer-reported hours, potential bias in rate estimates could occur if employers overreport or underreport the number of hours worked by their employees. Similarly, employers within "high-risk" and consequently more expensive risk classes could either intentionally or unintentionally misallocate the hours worked by their employees to alternative risk classes. If the workers compensation claim is allocated to the appropriate risk class and the employee hours are allocated to a different risk class, the injury rates presented here would be overestimated. Determining whether this misclassification and underreporting of hours occurs is one of the objectives of the Washington State Residential Framing Initiative.

The State Fund, from 1993 to 1999, incurred a total of $197,318,444 in direct costs as a result of workers compensation claims in wood framing. A single indicator such as direct cost does not capture all the dimensions of injury burden. Burden also includes indirect costs (often borne by worker and worker's family as well as employer and community) such as lost productivity, increased absenteeism, higher employee turnover, and recruitment of replacement workers.

There is a need for additional research to explore the circumstances of injury occurrence. There were 84 amputation cases over the study period and amputation injuries had the highest median claim cost. Most of

the amputations occurred as a result of a manual saw or a power saw, but we do not know the root cause of the injury: Were the workers trained in the operation of the saw(s)? Was the saw guarded? Did the power saw have a kickback device? The answers to these questions and many more will more fully indicate appropriate methods for effective intervention.

In summary, workers in the wood framing industry experience a large number of injuries with significant morbidity and mortality. The Department of Labor and Industries has launched a Washington State Residential Framing Initiative to bring all wood framers in compliance with regulations regarding workplace safety and workers compensation insurance. The goal is to reduce injuries to framers and to bring premiums, now among the highest in the industry, in line with other trades. Understanding the occurrence of injuries in the target population is critical to implementing and evaluating effective intervention programs. By using the Washington state workers compensation databases, we will be able to monitor the success of this initiative.

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