Work-Related Injuries Among Union Drywall Carpenters in Washington State, 1989–2008

Ashley L. Schoenfisch, PhD,[1,2]* Hester Lipscomb, PhD,[1] Steve Marshall, PhD,[2,3] Wilfred Cameron, MS, CIH,[4] David Richardson, PhD,[2,3] and Carri Casteel, PhD[2,3]

Background *Drywall installers are at high-risk of work-related injury. Comprehensive descriptive epidemiology of injuries among drywall installers, particularly over time, is lacking.*

Methods *We identified worker-hours and reported and accepted workers' compensation (WC) claims for a 20-year (1989–2008) cohort of 24,830 Washington State union carpenters. Stratified by predominant type of work (drywall installation, other carpentry), work-related injury rates were examined over calendar time and by worker characteristics. Expert interviews provided contextual details.*

Results *Drywall installers' injury rates, higher than those of other carpenters, declined substantially over this period by 73.6%. Common injury mechanisms were struck by/against, overexertion and falls. Drywall material was considered a contributing factor in 19.7% of injuries. One-third of these drywall material-related injuries resulted in paid lost time, compared to 19.4% of injuries from other sources. Rates of injury were particularly high among workers with 2 to <4 years in the union. Notable declines over time in rates of overexertion injury in which drywall material was a contributing factor were still observed after controlling for secular temporal trends. Experts highlighted changes over the past 20 years that improved both work safety and, in some cases, production.*

Conclusions *Declines in drywall installers' injury rates over time likely reflect, in part, enhanced workplace safety, including efforts to reduce overexertion hazards associated with handling drywall. Continued injury prevention efforts are needed, particularly for less tenured workers. Given the potential for under-reporting to WC, additional sources of health outcomes data may provide a more complete picture of workers' health.* Am. J. Ind. Med. 56:1137–1148, 2013. *© 2013 Wiley Periodicals, Inc.*

KEY WORDS: drywall carpenters; occupational injury; workers' compensation; construction industry; longitudinal analyses

[1]Division of Occupational and Environmental Medicine, Department of Community and Family Medicine, Duke University Medical Center, Durham, North Carolina
[2]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
[3]UNC Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
[4]Strategic Solutions for Safety, Health & Environment, Seattle, Washington
Contract grant sponsor: National Institute for Occupational Safety and Health; Contract grant number: 1 U60OH009761.
Disclosure Statement: The authors report no conflicts of interests.
*Correspondence to: Ashley L. Schoenfisch, PhD, Department of Community and Family Medicine, Division of Occupational and Environmental Medicine, Duke University Medical Center, 2200 West Main Street, Suite 400, Durham, North Carolina 27705. Email: ashley.schoenfisch@duke.edu

Accepted 27 March 2013
DOI 10.1002/ajim.22198. Published online 16 July 2013 in Wiley Online Library (wileyonlinelibrary.com).

INTRODUCTION

In the 1940s prefabricated gypsum wallboard, or drywall (commercially manufactured in the US under the trade name "sheetrock"), began to replace lath and plaster for finishing building interiors, facilitating more rapid building completion. Comprised of a layer of gypsum material between two layers of paper, drywall now holds nearly the entire market share for interior finishing materials in North America [Ferguson, 2002]. Drywall sheets were initially manufactured as 4′ wide, 8′ long and 3/8″ thick, but a variety of sizes and types exist today. Standard sheet lengths of 8′, 10′, 12′, and 16′ and thicknesses of 3/8″, 1/2″, and 5/8″ are available, some with a lighter weight counterpart. Materials resistant to dents, mold and sound provide additional building options. Larger sheet dimensions reflect the desire to minimize finishing time and to satisfy building design trends. For example, when the number of homes built with 9′ ceilings increased in the 1990s, 4.5′ wide sheets became available to avoid two horizontal seams on walls.

Drywall installers have high rates of work-related injury [Chiou et al., 1997; Lipscomb et al., 2000], including back injuries [The Center for Construction Research and Training, 2007; Lipscomb et al., 2008], relative to their construction counterparts. Their injury incidence is typically attributed to the lifting, carrying and cutting of large sheets of drywall and fastening them in place [Chiou et al., 1997, 2000; Dement and Lipscomb, 1999; Lipscomb et al., 2000, 2003].

Pan and Chiou [1999] estimated considerable biomechanical stresses on workers' shoulders, torsos and hips for four common drywall lifting methods; lifts involving a 100 lb drywall sheet were predicted to have low back disc compression forces in excess of the Back Compression Design Limit recommended by the National Institute for Occupational Safety and Health (NIOSH) [National Institute for Occupational Safety and Health, 1981]. Additional research (based on drywall sheet sizes of 4′ by 8′, as well as partial sheets) estimated drywall installers' low back disc compression forces in excess of NIOSH-recommended limits for 8.5% of the time of a typical 8 hr workday [Yuan et al., 2007]. Musculoskeletal stressors associated with lifting drywall sheets place workers at risk for overexertion injuries. Additionally, fall-related and struck-by injuries reflect drywall installation work tasks, which include carrying drywall sheets on a work site, up stairs or through narrow openings; measuring and cutting drywall to accommodate doorways, windows and other openings or fixtures; and lifting, securing and hanging drywall sheets into place. Work at elevation is common, and some work is performed on surfaces with limited space which may compromise worker posture, coordination and balance. Fastening drywall sheets requires both work overhead and below the knees, invoking awkward work postures. In a questionnaire survey of perceived hazards during drywall installation, ceiling installation work was rated by drywall hangers as the most hazardous task in respect of physical stress, potential for falling and being struck by/against an object [Pan et al., 1999].

Despite the widespread use of drywall in modern construction, comprehensive descriptive epidemiology of the injuries associated with drywall installation is lacking. In particular, there remains a gap in the understanding of drywall installers' injury experiences over a period when changes in the industry have occurred. Using data from a well-defined retrospective cohort of unionized carpenters in Washington State, the purpose of this study was to describe the work-related injury experience among construction industry workers engaged in drywall installation over a 20-year period, from 1989 through 2008, with an emphasis on identifying injury patterns over time and high risk subgroups of workers.

METHODS

Cohort Data

Previous research has used union membership and health insurance eligibility files provided by the Carpenters Trusts of Western Washington (CTWW) to define a dynamic, historical cohort of active union carpenters who were members of the United Brotherhood of Carpenters and Joiners of Western Washington between January 1, 1989 and December 31, 2008 [McCoy et al., 2013]. Earliest follow-up for this cohort began March 1, 1989, as carpenters had to work at least three months of union hours to enter the study cohort, with observation beginning the month they met this criterion. Data available for each carpenter included date of birth, gender, date of union initiation, union local affiliation and hours of union work per month.

In these data, the predominant type of work performed is assigned at the level of the local union affiliate, rather than at the level of the individual carpenter. Affiliates perform a range of carpentry work, including drywall installation, heavy commercial, light commercial, millwrighting, pile-driving, cabinet/fixture work and residential building. The focus of these analyses was the sub-cohort formed by union carpenters in the local predominantly installing drywall. Drywall installation is performed on residential and commercial work sites, and in Washington State, this work does not include drywall finishing tasks such as taping or sanding.

Time at Risk and Covariates

Individual worker-hours as a union carpenter were used as the measure of time at risk for an injury. All hours worked during a given month were considered time at risk for any injury occurring during that month. The main exposures of interest were the predominant type of work performed (drywall installation versus other types of carpentry) and calendar time. Other covariates of interest included worker gender, age and time in the union. Carpenters typically spend four years in apprenticeship training prior to receiving journeyman status, and time in the union was categorized to explore rates of injury by periods of time within workers' apprenticeship (<4 years in the union) and journeyman years (≥4 years in the union) of experience separately.

Injury and Illness Data

Workers' compensation (WC) claims for the cohort were linked to the union eligibility and membership files at the individual level using an encrypted identifier. A more thorough description of these methods is available [Lipscomb et al., 1997]. Claims data were available from 1989 through 2008 from the Washington State Department of Labor and Industries. Of note, Washington is one of a handful of US states that relies on a state run WC program. As such, WC claims data are centralized and available from the Washington State Department of Labor and Industries. These data include first aid, medical-only and paid lost work time (occurring after the third lost day after injury in Washington State) injury and illness claims. Data elements available for each work-related injury or illness (hereafter referred to as "injury") include: event date, number of paid lost days from work, body part affected, nature, type of event or exposure (i.e., mechanism) and source. These last four variables utilized an American National Standards Institute (ANSI) based coding scheme prior to July 2005, and Occupational Injury and Illness Classification System (OIICS) codes were used in later years. Of note, claims from companies in Washington State that self-insure for WC coverage are included in this study. However, the Washington State Department of Labor and Industries only assigns ANSI/OIICS codes to such claims if they resulted in paid lost time. All reported and accepted WC claims for events occurring during months in which the carpenter worked union hours were considered outcomes of interest. Individual workers were allowed to contribute more than one injury per month.

Injury event text descriptions, available for approximately 90% of drywall installers' WC claims, were reviewed systematically to (a) confirm whether drywall material was a contributing factor in the 733 injuries assigned an ANSI/OIICS code for drywall material and (b) identify injuries in which drywall material was a contributing factor that were *not* captured based on ANSI/OIICS source of injury codes. Through manual review, 1.8% (n = 12) of ANSI/OIICS code defined drywall material related injuries were determined to be related to material other than drywall (e.g., cement board, plywood) and were not considered drywall material related for analyses. Next, an index list of commonly used words in the injury narratives of ANSI/OIICS code defined drywall material-related injuries was created ("drywall," "sheetrock," "gypsum," "wallboard," "coreboard," "plasterboard," "DW," "GWB"). Narratives available for 4,634 (86.9%) of the 5,333 injuries not assigned an ANSI/OIICS source code for drywall were flagged if they contained a word on the index list. After manual review, an additional 472 injuries were identified in which drywall material was a contributing factor, for a total of 1,193 drywall material-related injuries among drywall installers over the 20-year study period.

Small group interviews with five industry and trade experts in Washington State were conducted to gather information on industry- and trade-specific trends over time and work-related exposures, providing a context within which the injury rate data arose. Potential participants were contacted through union local leaders and business agents. The interviewees, a purposive sample, had a range of experience from 20 to more than 40 years in the trade. They included former drywall installers currently serving in supervisory, job assignment or training roles. Interviews followed primarily a structured guide; additional questions were asked to clarify aspects of drywall installation work observed during visits to several Washington State construction sites over a 3-day period. Results from these interviews were summarized.

Statistical Methods

The study cohort was described in terms of the distribution of worker gender, age and time in the union. Stratified by the predominant type of work performed (i.e., drywall installation versus other types of carpentry), the frequency and proportion of work-related injuries and worker-hours at risk were calculated overall, by worker demographic characteristics and over calendar time. Among drywall installers only, the frequency and proportion of injuries by mechanism, nature and body part affected were described, stratified by whether drywall material was considered a contributing factor in the injury event.

Poisson regression, which can incorporate both the time at risk contributed by each subject and changes in covariate values over time [Checkoway et al., 1989], was used to calculate injury rates, crude and adjusted rate ratios and 95% confidence intervals by year and characteristics of workers (age, gender, time in the union). Injury rates were expressed as the number of injuries per 200,000 worker-hours (or 100 full-time equivalents). Stratified analyses were performed by characteristics of the injury (mechanism, source, paid lost time). Multivariate models were used to examine the effect of predominant type of work performed while controlling for worker gender, age and time in the union. For analyses restricted to carpenters belonging to the union local whose predominant type of work was drywall installation, models controlled for age and time in the union. Within all models, worker age and time in the union were allowed to vary over time so that time at risk was correctly allocated to the appropriate strata over the 20-year study period.

Given increases in the size (and weight) of drywall sheets handled by these union carpenters over time, but with exact timing of changes not known, we were interested in understanding patterns over the 20 year study period in the rates of work-related injury in which drywall material was a contributing factor. In so doing, we sought to control for secular trends that could affect rates of all work-related injuries over the same time period (e.g., work practices aimed at enhancing overall workplace safety, increased barriers to reporting injuries through the workers' compensation system) using an internal group of injuries as a standard. Poisson models were constructed separately for each of the three common mechanisms of injury (i.e., struck by/against, overexertion, falls):

Log (rate of drywall material-related injuries/rate of injuries not related to drywall material) $= \beta_0 + \beta_i X_i$,

where β_i and X_i represent coefficients and values of indicator variables for calendar time, respectively. The offset for the model was specified as natural log (worker-hours $\times$ rate of injuries not related to drywall material), or simply natural log (number of injuries not related to drywall material) [Breslow and Day, 1987]. In the absence of a change over time that would affect the rate of drywall material-related injuries only (e.g., increasing drywall sheet size, weight) or the rate of injuries related to other sources only, the ratio of (a) the rate of drywall material-related injuries to (b) the rate of injuries resulting from other sources is expected to be constant over time. Analyses were performed in SAS version 9.1 [2002–2004].

Study procedures were approved by the Institutional Review Boards at Duke University Medical Center, the Washington State Department of Health and Human Services and the University of North Carolina at Chapel Hill.

RESULTS

Description of the Study Cohort

The main cohort was comprised of 24,830 carpenters who worked a total of 192,371,021 union hours from 1989 through 2008. Characteristics of this cohort, including worker demographic characteristics, hours worked and injury patterns have been described [McCoy et al., 2013]. Union local was missing for 1,895 carpenters who contributed 1,875,485 worker-hours; these workers were not included in the current analyses. One fifth of the workers (n = 5,073) belonged to a union local whose predominant type of work was drywall installation. At entry into the study cohort, drywall installers averaged 3.2 years in the union (range 0–43) and had a mean age of 31.0 years. Compared to carpenters in other types of work, drywall installers were, on average, 3.9 years younger and had 2.5 years less time in the union. Drywall installers also averaged fewer hours worked per month (142.3) compared to their carpentry counterparts (149.1) ($t = 63.93$, $P < 0.0001$), and they had a higher proportion of male workers (99.2% vs. 97.2%; $\chi^2 = 71.87$, $P < 0.0001$).

Work-Related Injury Claims Among Drywall Installers

Among drywall installers, 6,066 workers' compensation claims were reported and accepted between 1989 and 2008 for 42% (n = 2,127) of the cohort with an overall rate of 33.1 (95%CI 32.3, 33.9) work-related injuries per 200,000 worker-hours. Injury rates among drywall installers declined over time, from a high of 59.1 per 200,000 worker-hours in 1999 to a low of 15.6 per 200,000 worker-hours in 2008 (Fig. 1a). Twenty-two percent (n = 1,337) of the work-related injuries among drywall installers resulted in paid lost time for an overall rate of 7.3 events per 200,000 worker-hours (95% CI 6.9, 7.7). Paid lost time claims were filed by 18% (n = 895) of the drywall cohort. Overall paid lost time injury rates among these workers declined over time, from a high of 15.1 per 200,000 worker-hours in 1999 to a low of 2.3 per 200,000 worker-hours in 2007 (Fig. 1b).

Compared to carpenters in other predominant types of work, drywall installers had higher rates of overall injuries (Adjusted IRR 1.19, 95% CI 1.16, 1.23) and paid lost time injuries (Adjusted IRR 1.59 95% CI 1.49, 1.70), controlling for worker gender, age and time in the union. These patterns held across all categories of age and time in the union and among male workers. Female drywall installers had lower rates of overall injury than female workers in other types of carpentry work (Adjusted IRR 0.47 95% CI 0.29, 0.78). Although drywall installers exhibited higher rates of injury than carpenters in other types of work across most years of observation (Fig. 1a,b), declines in overall injury rates from 1990 (when the highest rates were observed) to 2008 were greater among drywall carpenters (73.6%) than their carpentry counterparts (62.0%). There was no difference

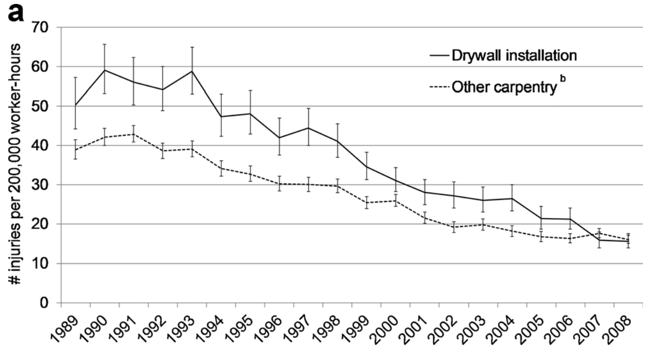
a


FIGURE 1a. Crude rates of work-related injuries overall and 95% confidence intervals over calendar time, stratified by predominant type of work performed[a], Washington State union carpenters, 1989–2008.

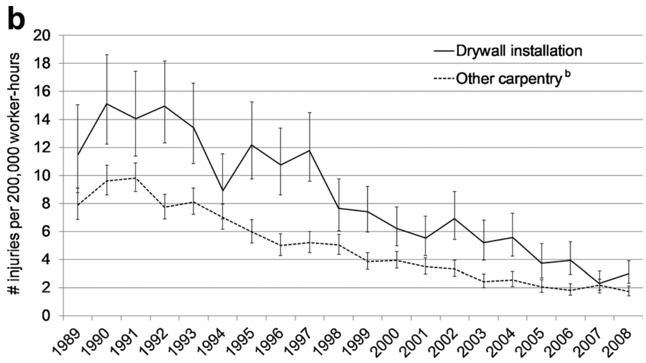


FIGURE 1b. Crude rates of work-related injuries with paid lost time and 95% confidence intervals over calendar time, stratified by predominant type of work performed[a], Washington State union carpenters, 1989–2008.

[a]Predominant type of work is based on the union local to which the worker belongs.

[b]Other includes residential building, roadway and bridge construction, pile-driving, and light and heavy commercial building.

by predominant type of work performed in the decline in rates of paid lost time injuries over this time (80.3% and 81.8%, respectively).

ANSI/OIICS-Based Characteristics of Work-Related Injuries Among Drywall Installers

Common mechanisms of injury among drywall installers, regardless of whether drywall material was a contributing factor, included struck by/against (n = 2,118, 34.9%), overexertion (n = 1,637, 27.0%) and falls (n = 727, 12.0%) (Table I). Falls from elevation and overexertion events had the highest proportion of injuries with paid lost time (40.5% and 38.2%, respectively), and struck by/against events resulted in paid lost time in 9.3% of the injuries. One-third of injuries overall and half of paid lost time injuries were coded as sprains, strains, or tears. Cuts and abrasions made up nearly 40% of injuries; overall, 4.2% of cuts and abrasions resulted in paid lost time. Although fractures and dislocations represented a small proportion of injuries (3.2% and 1.5%, respectively), 53.1% of fractures and 47.7% of dislocations resulted in paid lost time. Commonly affected body parts included hand(s)/finger(s) (n = 1,414, 23.3%), back/trunk (n = 1,340, 22.1%) and eye(s) (n = 737, 12.1%). The proportion of injuries with paid lost time was high for injuries to the knees (41.6%), shoulder (41.1%), back/trunk (36.3%), wrists (32.5%), ankles (32.1%), neck (31.6%) and elbow (31.0%).

Common sources of injury based on ANSI/OIICS primary source of injury codes included chips, particles, splinters (11.0%), floors, walkways, ground surfaces (10.6%), drywall material (11.3%), tools, instruments, equipment (9.9%), structural metal (6.5%) and bodily motion (6.3%). Scaffolds were coded in 1.6% of injuries overall; however, one in four of scaffold-related injuries resulted in paid lost time. Injuries attributed to carts, dollies and hand trucks represented a small proportion of injuries overall (0.9%), yet 20.8% had paid lost time.

Based on the combination of ANSI/OIICS codes and review of injury narratives, drywall material was identified as a contributing factor in 19.7% (n = 1,193/6,066) of work-related injury events among drywall installers. One-third (32.8%; n = 391/1,193) of drywall material-related injuries resulted in paid lost time, compared to 19.4% (n = 946/4,873) of injuries from other sources. The highest overall rates of injury in which drywall material was a contributing factor were for overexertion events (often while lifting or carrying drywall, sometimes with concurrent twisting, turning or reaching), events with a nature of sprain, strain or tear, and injuries to the back. Struck by/against events were common as well; among those in which drywall material was considered a contributing factor, cutting hand tools and fasteners were common primary or secondary sources of injury. For injuries in which drywall material was not a contributing factor, struck by/against injuries (often from structural metal and fasteners), cuts/lacerations and injuries to the fingers were common.

Drywall Installers' Injury Rates by Gender, Age and Time in the Union

Drywall installers' rates of injury overall and with paid lost time were examined by gender, age and time in the union. By gender, female drywall installers had a lower rate of injury than their male counterparts (crude IRR 0.64, 95% CI 0.39, 1.04). Adjusted analyses by age suggest injury rate patterns differed depending on whether drywall material was considered to be a contributing factor (Table II). For drywall material-related injuries, rates were highest among workers 25 to <45 years of age compared to their younger and older working counterparts. For injuries in which drywall material was not considered to be a contributing factor, workers <35 years old had the highest rates of injury. Rates of drywall material-related injuries with paid lost time were highest for workers 35 to <45 years old; paid lost time injury rates increased with increasing age for injuries in which drywall material was not considered to be a contributing factor. By time in the union, patterns in rates of injury overall and with paid lost time were highest among workers in their latter apprenticeship years (2 to <4 years in the union), regardless of whether drywall material was a contributing factor. The proportion of injuries with paid lost time increased with increasing age and time in the union.

Stratified by common injury mechanisms and by whether drywall material was considered to be a contributing factor, drywall installers' rates of injury across categories of worker age and time in the union are presented in Table III. Regardless of whether drywall material was considered a

TABLE I. Among drywall installers, frequencies (n)[a], rates[b] and 95% confidence intervals (CI) of work-related injuries, and proportion with paid lost time (PLT), stratified by whether drywall material was considered a contributing factor[c] in the injury event and by mechanism, nature and body part affected, Washington State, 1989–2008

	Total number of injuries	Drywall material considered to be a contributing factor to the injury event				Drywall material not considered to be a contributing factor to the injury event		
			All injuries		PLT injuries	All injuries		PLT injuries
	All injuries	PLT injuries	n	Rate (95% CI)	n (%)[d]	n	Rate (95% CI)	n (%)[d]
Mechanism								
Struck against	920	81	83	0.45 (0.37–0.56)	15 (18.1)	837	4.56 (4.27–4.88)	66 (7.9)
Struck by	1,198	115	195	1.06 (0.92–1.22)	26 (13.3)	1,003	5.47 (5.14–5.82)	89 (8.9)
Rubbed, abraded, jarred	631	16	54	0.29 (0.23–0.38)	1 (1.9)	577	3.15 (2.90–3.41)	15 (2.6)
Fall on same level	273	94	34	0.19 (0.13–0.26)	17 (50.0)	239	1.30 (1.15–1.48)	77 (32.2)
Fall from elevation	454	184	41	0.22 (0.16–0.30)	20 (48.8)	413	2.25 (2.05–2.48)	164 (39.7)
Bodily reaction	348	113	35	0.19 (0.14–0.27)	9 (25.7)	313	1.71 (1.53–1.91)	104 (33.2)
Overexertion	1,637	626	704	3.84 (3.57–4.13)	294 (41.8)	933	5.09 (4.77–5.43)	332 (35.6)
Other mechanisms[e]	293	36	28	0.15 (0.11–0.22)	3 (10.7)	265	1.45 (1.28–1.63)	32 (12.1)
NEC/Unknown[f]	312	72						
Nature of injury[a]								
Sprain, strain, tear	2,005	688	652	3.56 (3.29–3.84)	250 (38.3)	1,353	7.38 (7.00–7.78)	438 (32.4)
Cut, laceration	1,636	86	167	0.91 (0.78–1.06)	10 (6.0)	1,469	8.01 (7.61–8.43)	76 (5.2)
Bruise, contusion	459	76	74	0.40 (0.32–0.51)	15 (20.3)	385	2.10 (1.90–2.32)	61 (15.8)
Fracture	194	103	22	0.12 (0.08–0.18)	15 (68.2)	172	0.94 (0.81–1.09)	88 (51.2)
Abrasion, scratch	668	11	54	0.29 (0.23–0.38)	2 (3.7)	614	3.35 (3.09–3.62)	9 (1.5)
Ill-defined	298	119	74	0.40 (0.32–0.51)	29 (39.2)	224	1.22 (1.07–1.39)	90 (40.2)
Musculoskeletal disorders	129	38	24	0.13 (0.09–0.20)	7 (29.2)	105	0.57 (0.47–0.69)	31 (29.5)
Multiple	134	39	28	0.15 (0.11–0.22)	12 (42.9)	106	0.58 (0.48–0.70)	27 (25.5)
Other nature[g]	297	143	73	0.40 (0.32–0.50)	45 (61.6)	224	1.22 (1.07–1.39)	98 (43.8)
NEC/Unknown[f]	303	43						
Body part affected[a]								
Eye(s)	737	9	54	0.29 (0.23–0.38)	1 (1.9)	683	3.72 (3.46–4.01)	8 (1.2)
Neck	256	81	91	0.50 (0.40–0.61)	33 (36.3)	165	0.90 (0.77–1.05)	48 (29.1)
Shoulder	353	145	127	0.69 (0.58–0.82)	55 (43.3)	226	1.23 (1.08–1.40)	90 (39.8)
Back	1,123	421	412	2.25 (2.04–2.47)	155 (37.6)	711	3.88 (3.60–4.17)	268 (37.7)
Other trunk	217	65	53	0.29 (0.22–0.38)	19 (35.8)	164	0.89 (0.77–1.04)	46 (28.0)
Elbow(s)	171	53	50	0.27 (0.21–0.36)	20 (40.0)	121	0.66 (0.55–0.79)	33 (27.3)
Wrist(s)	311	101	54	0.29 (0.23–0.38)	24 (44.4)	257	1.40 (1.24–1.58)	77 (30.0)
Finger(s)	969	66	141	0.77 (0.65–0.91)	15 (10.6)	828	4.52 (4.22–4.83)	51 (6.2)
Hand(s)	445	51	53	0.29 (0.22–0.38)	11 (20.8)	392	2.14 (1.94–2.36)	40 (10.2)
Other arm(s)	231	29	37	0.20 (0.15–0.28)	10 (27.0)	194	1.06 (0.92–1.22)	19 (9.8)
Knee(s)	344	143	47	0.26 (0.19–0.34)	25 (53.2)	297	1.62 (1.45–1.81)	118 (39.7)
Ankle(s)	134	43	12	0.07 (0.04–0.12)	3 (25.0)	122	0.67 (0.56–0.79)	40 (32.8)
Foot (feet)	165	31	18	0.10 (0.06–0.16)	7 (38.9)	147	0.80 (0.68–0.94)	24 (16.3)
Multiple body parts	375	133	106	0.58 (0.48–0.70)	49 (46.2)	269	1.47 (1.30–1.65)	84 (31.2)
Other[h]	466	59	44	0.24 (0.18–0.32)	8 (18.2)	422	2.30 (2.09–2.53)	51 (12.1)
NEC/Unknown[f]	75	2						

[a] Injuries with multiple natures or body parts affected were allowed up to three codes for these categories, with one being "multiple".
[b] Rates are per 200,000 worker-hours.
[c] Defined using ANSI/OIICS source of injury codes and review of injury narrative text.
[d] Paid lost time injuries as a proportion of all injuries in the subgroup defined by whether drywall material was considered to be a contributing factor.
[e] Includes mechanisms of injury making up less than 2% of injuries overall: caught in/crushed/compressed, contact with electric current, contact with temperature extremes, contact with toxin, transportation accidents and noise.
[f] NEC = Not elsewhere classified.
[g] Includes natures of injury making up less than 2% of injuries overall: dislocation, burn, hearing loss, hernia, concussion, nervous system disorders.
[h] Includes body parts affected in less than 2% of injuries overall: ear(s), face, other head, other upper extremities, other leg, other lower extremities, body systems.

TABLE II. Among drywall installers, number of worker-hours and work-related injuries, with proportion with paid lost time, crude injury rates[a], adjusted incidence rate ratios (IRR) and 95% confidence intervals (CI), workers' compensation claims data, Washington State union carpenters, 1989–2008

		Drywall material considered to be a contributing factor[b]						Drywall material not considered to be a contributing factor[b]					
				All injuries (n = 1,193)		Paid lost time injuries[c] (n = 391)				All injuries (n = 4,873)		Paid lost time injuries[c] (n = 946)	
	Hours worked	# Injuries	% With paid lost time	Crude rate[a]	Adjusted IRR (95% CI)[d]	Crude rate[a]	Adjusted IRR (95% CI)[d]	# Injuries	% With paid lost time	Crude rate[a]	Adjusted IRR (95% CI)[d,e]	Crude rate[a]	Adjusted IRR (95% CI)[d]
Gender													
Male	36,507,212	1,191	32.8	6.5	–	2.1	–	4,857	19.4	26.6	–	5.2	–
Female	151,378	2	0.0	2.6	–	0.0	–	14	7.1	18.5	–	1.3	–
Age in years													
<25	3,350,814	97	15.5	5.8	0.72 (0.57–0.92)	0.9	0.29 (0.17–0.51)	533	11.3	31.8	1.15 (0.99–1.34)	3.6	0.58 (0.43–0.79)
25 to <35	12,136,436	447	28.9	7.4	0.94 (0.82–1.08)	2.1	0.71 (0.56–0.92)	1,764	16.3	29.1	1.09 (0.99–1.20)	4.7	0.77 (0.65–0.91)
35 to <45	13,030,821	465	37.6	7.1	1.00	2.7	1.00	1,705	22.1	26.2	1.00	5.8	1.00
45 to <55	6,889,499	161	37.3	4.7	0.73 (0.60–0.88)	1.7	0.72 (0.53–1.00)	702	25.4	20.4	0.83 (0.73–0.94)	5.2	1.00 (0.82–1.22)
55+	1,250,018	23	52.2	3.7	0.61 (0.39–0.94)	1.9	0.85 (0.45–1.58)	167	25.7	26.7	1.12 (0.89–1.41)	6.9	1.42 (1.01–2.00)
Years in union													
up to 2	5,696,882	179	26.8	6.3	1.25 (0.96–1.63)	1.7	1.26 (0.80–1.97)	821	15.3	28.8	1.15 (0.97–1.36)	4.4	1.26 (0.94–1.67)
2 to <4	4,031,688	168	32.1	8.3	1.61 (1.24–2.10)	2.7	1.83 (1.19–2.83)	655	17.1	32.5	1.31 (1.10–1.56)	5.6	1.54 (1.16–2.05)
4 to <6	3,510,588	142	27.5	8.1	1.53 (1.17–1.99)	2.2	1.40 (0.88–2.22)	509	17.7	29.0	1.19 (0.99–1.42)	5.1	1.36 (1.01–1.83)
6 to <8	3,352,459	110	36.4	6.6	1.22 (0.92–1.61)	2.4	1.40 (0.89–2.20)	417	18.7	24.9	1.03 (0.86–1.24)	4.7	1.18 (0.87–1.60)
8 to <10	3,079,128	116	29.3	7.5	1.39 (1.06–1.83)	2.2	1.25 (0.78–1.99)	381	24.7	24.7	1.04 (0.87–1.25)	6.1	1.51 (1.13–2.00)
10 to <20	10,483,684	331	36.0	6.3	1.17 (0.94–1.46)	2.3	1.19 (0.84–1.70)	1,400	20.6	26.7	1.17 (1.02–1.34)	5.5	1.26 (1.01–1.57)
20+	6,518,826	147	38.8	4.5	1.00	1.7	1.00	690	22.9	21.2	1.00	4.8	1.00

[a]Injuries per 200,000 worker-hours.
[b]Defined through analyses of ANSI/OIICS codes and injury narrative text.
[c]Paid lost time occurs after the third lost day of work in Washington State.
[d]Poisson regression model, adjusted for age and years in the union.
[e]Scaled to set Pearson chi-square/degrees of freedom = 1.

TABLE III. Among drywall installers, crude rates, adjusted[a] incidence rate ratios (IRR) and 95% confidence intervals (CI) of work-related injuries by worker age and time in the union, stratified by the source of injury, Washington State union carpenters, 1989–2008

	Struck by/against		Fall		Overexertion	
	Crude rate	Adjusted IRR (95% CI)	Crude rate	Adjusted IRR (95% CI)	Crude rate	Adjusted IRR (95% CI)
Drywall material considered to be a contributing factor[b]						
Age in years						
<35	1.9	1.02 (0.77–1.36)	0.43	0.68 (0.40–1.17)	3.8	0.86 (0.72–1.04)
35 to <45	1.5	1.00	0.48	1.00	4.4	1.00
45+	0.81	0.59 (0.39–0.88)	0.27	0.67 (0.33–1.35)	2.9	0.68 (0.54–0.84)
Years in union						
<4	2.2	1.72 (1.24–2.41)	0.51	1.95 (1.02–3.72)	3.6	0.95 (0.76–1.18)
4 to <10	1.6	1.24 (0.89–1.73)	0.50	1.80 (0.98–3.31)	4.4	1.14 (0.94–1.38)
10+	1.1	1.00	0.29	1.00	3.7	1.00
Drywall material not considered to be a contributing factor[b,c]						
Age in years						
<35	12.8	1.29 (1.15–1.44)	3.5	1.03 (0.73–1.45)	4.7	0.82 (0.65–1.05)
35 to <45	9.1	1.00	3.4	1.00	5.9	1.00
45+	6.1	0.69 (0.59–0.80)	3.8	1.11 (0.78–1.59)	4.5	0.73 (0.56–0.96)
Years in union						
<4	13.2	1.27 (1.11–1.44)	3.3	0.94 (0.63–1.39)	5.3	1.01 (0.77–1.32)
4 to <10	10.6	1.07 (0.94–1.21)	3.8	1.07 (0.75–1.53)	4.3	0.79 (0.61–1.03)
10+	7.9	1.00	3.6	1.00	5.4	1.00

[a]Poisson regression models, adjusted for worker age and time in the union.
[b]Defined through analyses of ANSI/OIICS codes and injury narrative text.
[c]Models of fall and overexertion injury events scaled to set Pearson chi-square/degrees of freedom = 1.

contributing factor, rates of struck by/against injuries were higher among workers <45 years old than their older counterparts, as well as among workers with <4 years in the union. Rates of injuries from falls related to drywall material were higher among workers with less than 10 years in the union than their more experienced counterparts, yet no difference was observed in rates by time in the union for fall injuries in which drywall material was not considered a contributing factor. Overexertion injury rates were higher among workers age 35 to <45 for injuries related to drywall material and for injuries from other sources, compared to their younger and older working counterparts. Compared to workers with <4 or 10+ years in the union, workers with 4 to <10 years of in the union had modestly higher rates of overexertion injuries in which drywall material was considered a contributing factor but lower rates of overexertion injuries in which drywall material was not a contributing factor.

Drywall Installers' Injury Rates Over Time, by Mechanism

Declines in crude rates of overexertion, fall and struck by/against injuries were observed over the 20-year study period among drywall installers [Schoenfisch and Lipscomb, 2012] in line with patterns observed overall (Fig. 1a,b). However, when controlling for secular temporal trends, patterns in rates of injury over time in which drywall material was a contributing factor varied by injury mechanism (Fig. 2). The decline over time in rates of overexertion

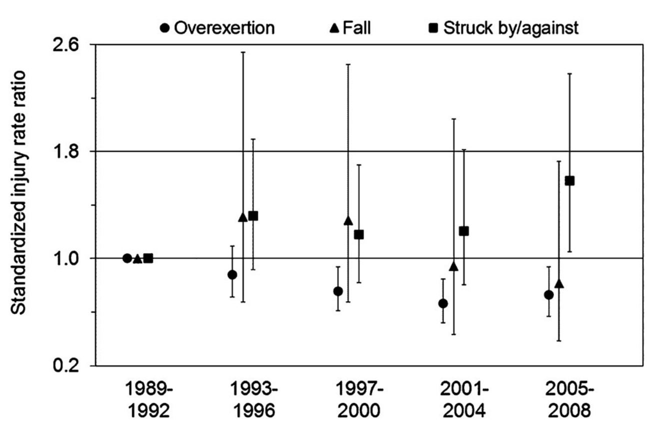


FIGURE 2. Among drywall carpenters, standardized injury rate ratios and 95% confidence intervals of injuries over time in which drywall material was a contributing factor, Washington State union carpenters, 1989–2008, Poisson regression models, created separately for each mechanism, employed an offset natural log (worker-hours × rate of injuries not related to drywall material) as a way to directly control for trends over calendar time affecting all injuries of a similar mechanism. The reference time period is 1989–1992.

injury in which drywall material was a contributing factor exceeded the expected decline based on our internal standard group of injuries in which drywall material was not a contributing factor. For falls, trend-adjusted rates of injury in which drywall material was a contributing factor appear to have declined since the mid-/late-1990s, although data here are rather sparse to make meaningful interpretations. Contrasting patterns were observed for rates of injury from struck by/against events in which drywall material was a contributing factor, which were higher than expected in the latter years of observation.

Small Group Interviews

Interviewees were clear that work safety—both in respect of the technological advances in safety equipment and in how safety is addressed by managers—has improved over the past 20 years. Keeping workers safe was described as making "financial sense," in part because "if workgroups have a lot of injuries, they cannot bid well." Interviewees highlighted an increased availability and use of personal fall arrest systems, the use of gloves to prevent cuts/lacerations (since the early 2000s, with framers using gloves with a higher level of cut-resistance than drywall installers), and an increased focus on workers taking safety-training classes. Many of the well-implemented changes to which improved workplace safety was attributed were described as increasing building production as well. For larger companies, use of custom made material cart systems and ordering pre-cut materials in custom sizes (e.g., metal studs, drywall sheets) were described as eliminating much of the worker exposure to moving, measuring and cutting materials—as well as decreasing production time and amount of wasted material. Emphasis was also placed on good housekeeping; "not only does it prevent injuries," it "enhances productivity, and companies like it." Interviewees described limited use of drywall lifts (perceived by workers to "slow them down"), cord trees and cordless screw guns.

DISCUSSION

Among this cohort of union carpenters in Washington State, rates of work-related injuries accepted through the state-run workers' compensation system were higher among drywall installers than among workers in other types of carpentry in nearly all years of observation, among male workers and within certain categories of worker age and time in the union. Declines in rates of overall injury claims over the 20-year period were likely the result, to some extent, of changes in the late 1980s that placed an enhanced focus on workplace safety, injury management and return-to-work programs [Welch et al., 2007]. Notably, large construction owners began to pre-qualify bidders based in part on safety and health performance. In addition, WC costs began to rise dramatically. However, the extent to which the observed decline in injury rates over time represents a true reduction, both among drywall installers and carpenters in other types of work, is unclear. Efforts aimed at enhancing safety may have also encouraged under-reporting—particularly of less severe injuries—by employers and by employees, through incentives to not report and fear of potential consequences of reporting (e.g., reduced hours, job loss) [Pransky et al., 1999; Azaroff et al., 2002; Shannon and Lowe, 2002].

In line with the work tasks performed by drywall installers, as well as the literature on work-related injuries among drywall installers and construction workers overall, the more common mechanisms of injury were overexertion, struck by/against and falls. Drywall material was a contributing factor in a significant proportion of overexertion events as noted by other researchers [Lipscomb et al., 1996; Chiou et al., 2000; Lipscomb et al., 2000], as well as in injuries from struck by/against and fall events. Falls from elevation and on the same level made up a small proportion of injuries overall, yet they were more likely to result in paid lost time than other mechanisms of injury, particularly for fall events involving drywall material. Decreasing rates of struck by/against injuries with increasing age and time in the union have been observed previously among drywall carpenters [Lipscomb et al., 2000]. For injuries resulting from overexertion or a fall, the oldest and most tenured workers may be more effective at controlling fall and overexertion hazards, or they may be performing tasks with less exposure such as measuring, cutting or supervisory roles.

The lower rates of injury observed among female drywall installers than their male counterparts is in contrast to patterns observed in the source cohort for injuries overall but in line with patterns for falls to a lower level [McCoy et al., 2013]. Experts we interviewed suggested women drywall installers might have lower exposure to more hazardous job tasks than men and be more willing to recruit assistance. We caution, however, that women make up less than 1% of all drywall installers in this cohort, and their estimates are based on very few injury events.

Over time, patterns observed in rates of injuries in which drywall material was a contributing factor were different for overexertion injury events from those of more acute injury events including falls and struck by/against events, when controlling for secular trends over time. Sheets of drywall have increased in size and weight over the 20-year study period. The observed decline in the rate of overexertion injuries attributed to drywall material suggests that supervisors and drywall installers may be taking action to reduce their risk of overexertion injury from handling these increasingly heavy sheets. Trade experts described requesting stockers to place materials closer to the location of hanging, teaching apprentices to use partners for heavy tasks, and (to a lesser extent) provision of assistive devices on some projects.

Patterns observed for fall-related injuries suggest increased control of fall risks associated with handling drywall material since the late 1990s. Falls prevention received regulatory attention during the study period that likely contributed to substantial declines in fall-related injuries among drywall installers and other carpenters [McCoy et al., 2013], including a vertical fall protection standard for the construction industry in 1991 in Washington State and a national revised Safety Standard for Fall Protection by the Occupational Safety and Health Administration (OSHA) promulgated in 1994 [US Department of Labor Occupational Safety and Health Administration, 1926]. Trade experts also highlighted an enhanced focus on housekeeping over time. Because carrying drywall sheets can limit a worker's visibility, it is plausible that such attention could have a more pronounced effect on fall injuries in which drywall material was a contributing factor.

In contrast to patterns in rates of overexertion and fall injuries, rates of struck by/against injuries related to drywall material have increasingly exceeded that which would be expected over the 20-year period, controlling for overall struck by/against injury trends. Several explanations may exist for this pattern. An increase in the size/weight of drywall may increase the risk of a struck by injury during fastening, particularly from sheets falling from overhead. Also, scoring and cutting drywall of longer lengths may increase the risk of a cut/laceration. However, for this mechanism in particular, the internal group of injuries used to control for secular trends that could affect rates of all struck by/against injuries over time may not have been ideal; framing tasks were performed by some cohort members, and some prevention efforts over time—notably, ordering of pre-cut/pre-drilled metal framing and more recent use of highly-cut-resistant gloves during framing—may only affect rates of those injuries in which drywall material was *not* a contributing factor.

Various assistive devices and new materials have been developed to reduce the hazardous physical demands involved in transporting, lifting and screwing drywall [Schneider and Susi, 1994; Hess et al., 2010]. Work practice recommendations have been made as well, including two-worker lifting of drywall sheets, task rotation and rest breaks [National Institute for Occupational Safety and Health, 2006]. The prevalence of use of these efforts on commercial and residential worksites in the US has not yet been fully described, although barriers to use—such as the perception of decreased productivity with use, the inability to use devices in certain areas (e.g., panel lift in stairwells), and the limitations of device use (e.g., carrier handles getting in the way of drywall installation)—have been suggested [Schneider and Susi, 1994; Hess et al., 2010]. There may be associated hazards as well. For example, coupling tools may place considerable physical demands on the shoulders and/or wrists during use, and two-worker carrying of drywall sheets may increase shear loads from asymmetric handling [Marras et al., 1999; Hess et al., 2010].

Nearly one quarter of the carpenters in this cohort joined the union prior to 1989. These workers may represent a healthy subset of all workers who joined the union before the beginning of the study follow-up; if so, their inclusion could introduce bias and influence injury rate patterns we observed [Applebaum et al., 2007].

Limitations

No direct measures of job tasks or individual work-related exposures were available on workers in this cohort. Interviews with business agents for each union local were conducted by an industrial hygienist as part of the assembly of the source cohort to guide assignment of predominant type of work performed. Such assignment is subject to misclassification. The local used to define drywall carpenters in this study has consistently performed drywall installation tasks over time. Other locals are not as well classified, particularly with economic changes in more recent years, guiding our decision to compare drywall carpenters to carpenters in all other categories of work combined.

We lacked information on the non-union work experience of these workers, including number of hours worked or type of work performed. In terms of our analysis, we excluded injuries occurring during months in which no union hours were worked. Also, we recognize that our measure of time in the union provided a crude classification of apprentice versus journeymen; carpenters with non-union work experience may have entered the union as a journeyman.

The cohort data do not allow assignment of hours of work to a type of work site (i.e., commercial, residential), a type of project (i.e., new construction, renovation, demolition) or the size of the establishment in which the worker is employed—factors which may influence work exposures and injury risk among drywall installers and construction industry workers in general [The Center for Construction Research and Training, 2007]. The cohort data also do not include worker race or ethnicity information. Through the 1990s, this carpenter cohort was nearly all white. Trade experts highlighted an increase in the proportion of Hispanic and Spanish-speaking workers in the union, particularly since the early 2000s. This increase may be differential by predominant type of work performed, with Hispanic workers likely engaged in more hazardous, lower skilled trades, such as drywall installation. An examination of injury rates by ethnicity in this cohort, both between and within predominant types of work, would be enlightening and strengthened by an understanding of differences by ethnicity in the proportion of true work-related injuries captured through the WC system.

Finally, our study outcomes of interest were based on injuries that were *reported* and *accepted* through the workers' compensation system. The extent to which these events reflect the true work-related injury experience of these union carpenters, both overall and over time, is unknown.

Strengths

Access to data specific to drywall workers for epidemiologic research is difficult. In this study, the particular local specializing in drywall installation was robust and well classified over the 20-year study period for the analyses performed, and data were available on time at risk. Other surveillance data capturing nonfatal occupational injuries and illnesses in the construction industry do not contain consistent or reliable information on type of work performed or the population at risk [The Center for Construction Research and Training, 2007], limiting researchers' abilities to understand patterns of risk by occupation and subsequently inform development of targeted injury prevention strategies.

Analyses of linked, brief injury event narratives allowed us to identify a considerable proportion (40%) of drywall material related injuries other than those found though ANSI/OIICS source codes alone. Narrative text data have been recognized as a useful supplement to coded data in construction industry injury research [Dement et al., 2003; Shah et al., 2003; Lipscomb et al., 2004; Bondy et al., 2005; Lombardi et al., 2005], both for identifying particular outcomes and providing information on circumstantial factors surrounding injury events [Sorock et al., 1997; McKenzie et al., 2010].

Finally, qualitative data gathered through expert interviews enhanced our understanding of the context from which the injury rate data arose.

CONCLUSIONS

Drywall installers have high rates of work-related injury compared to construction workers engaged in other types of work, and there is a particular need for efforts focused on preventing injuries among young drywall installers as well as those in their latter apprenticeship years and first few years as a journeyman. Reductions in work-related injury rates among drywall installers over the 20-year study period are encouraging. However, the use of workers' compensation claims data as the sole source of outcome data may fail to provide a complete picture of workers' injury experiences.

Efforts to understand circumstances related to drywall material injuries over time, including the prevalence of and barriers to the use of assistive devices and recommended work practices, are warranted. Furthermore, an understanding of the influence of broad trade and industry characteristics on work exposures, injury risk and injury event reporting is important, as is an understanding of the challenges these varying characteristics pose to the incorporation of any standard, recommendation or related training into drywall installers' work practices. It is noteworthy that this cohort of union carpenters has access to private health insurance through the union. Future work incorporating these data or additional sources of health outcome measures may be useful in capturing a more complete picture of workers' health [Koehoorn et al., 2006; Lipscomb et al., 2009].

ACKNOWLEDGEMENTS

We thank Lin Conley and Larry McNutt at the Carpenters Trusts of Western Washington for their continued support in making the union carpenter data available for research purposes. We thank Barbara Silverstein and Darrin Adams at the Safety and Health Assessment and Research Prevention (SHARP) Program in the Washington State Department of Labor and Industries for helpful comments and provision of the workers' compensation claims files for linkage to the carpenter cohort. We thank Amanda McCoy at the Duke University School of Medicine and the Gillings School of Global Public Health at the University of North Carolina at Chapel Hill (UNC-CH), as well as Alan Brookhart at the Gillings School of Global Public Health at UNC-CH for comments in early stages of this study. Finally, we thank the Pacific Northwest Regional Council of Carpenters as well as many representatives, instructors and construction superintendents and foremen who allowed us to visit their worksites and spent time talking with us about the drywall trade and the construction industry as a whole. Contract grant sponsor: National Institute for Occupational Safety and Health; Contract grant number: 1 U600H009761.

REFERENCES

Applebaum KM, Malloy EJ, Eisen EA. 2007. Reducing healthy worker survivor bias by restricting date of hire in a cohort study of Vermont granite workers. Occup Environ Med 64:681–687.

Azaroff LS, Levenstein C, Wegman DH. 2002. Occupational injury and illness surveillance: Conceptual filters explain underreporting. Am J Public Health 92:1421–1429.

Bondy J, Lipscomb H, Guarini K, Glazner JE. 2005. Methods for using narrative text from injury reports to identify factors contributing to construction injury. Am J Ind Med 48:373–380.

Breslow NE, Day NE. 1987. Statistical Methods in Cancer Research. Volume II: The design and analysis of cohort studies. World Health Organization International Agency on Research for Cancer New York: Oxford University Press.

Checkoway H, Pearce N, Crawford-Brown D. 1989. Cohort studies. In: Checkoway, Pearce and Crawford-Brown, editors. Research methods in occupational epidemiology. New York: Oxford University Press. pp. 103–169.

Chiou SS, Pan CS, Fosbroke DE. 1997. Identification of risk factors associated with traumatic injury among drywall installers. Adv Occup Ergon Saf 377–380.

Chiou SS, Pan CS, Keane P. 2000. Traumatic injury among drywall installers 1992–1995. JOEM 42:1101–1108.

Dement JM, Lipscomb H. 1999. Workers' compensation experience of North Carolina residential construction workers, 1986–1994. AOEH 14:97–106.

Dement JM, Lipscomb H, Li L, Epling C, Desai T. 2003. Nail gun injuries among construction workers. AOEH 18:374–383.

Ferguson MR. 2002. Drywall: Professional techniques for great results. Newtown, CT: The Taunton Press, Inc.

Hess JA, Kincl LD, Davis K. 2010. The impact of drywall handling tools on the low back. Appl Ergon 41:305–312.

Koehoorn M, Cole DC, Hertzman C, Lee H. 2006. Health care use associated with work-related musculoskeletal disorders among hospital workers J Occup Rehabil 16:411–424.

Lipscomb HJ, Cameron W, Silverstein B. 2008. Back injuries among union carpenters in Washington State, 1989–2003. Am J Ind Med 51:463–474.

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D. 2003. Work-related injuries in residential and drywall carpentry. AOEH 18:479–488.

Lipscomb HJ, Dement JM, Gaal JS, Cameron W. 2000. Work-related injuries in drywall installation. Appl Occup Environ Hyg 15:794–802.

Lipscomb HJ, Dement JM, Loomis DP, Silverstein B, Kalat J. 1997. Surveillance of work-related musculoskeletal injuries among union carpenters. Am J Indust Med 32:629–640.

Lipscomb HJ, Dement JM, Silverstein B, Kucera KL, Cameron W. 2009. Health care utilization for musculoskeletal back disorders, Washington State Union Carpenters, 1989–2003. J Occup Environ Med 51:604–611.

Lipscomb HJ, Glazner J, Bondy J, Lezotte D, Guarini K. 2004. Analysis of text from injury reports improves understanding of construction falls. J Occup Environ Med 46:1166–1173.

Lipscomb HJ, Kalat J, Dement JM. 1996. Workers' compensation claims of union carpenters 1989–1992: Washington State. Appl Occup Environ Hyg 11:56–63.

Lombardi DA, Pannala R, Sorock GS, Wellman H, Courtney TK, Verma S, Smith GS. 2005. Welding related occupational eye injuries: A narrative analysis. Inj Prev 11:174–179.

Marras WS, Davis KG, Kirking BC, KP G. 1999. Spine loading and trunk kinematics during team lifting. Ergonomics 42:1258–1273.

McKenzie K, Scott DA, Campbell MA, McClure RJ. 2010. The use of narrative text for injury surveillance research: A systematic review. Accid Anal Prev 42:354–363.

McCoy AJ, Kucera KL, Schoenfisch AL, Silverstein BA, Lipscomb HJ. 2013. Twenty years of work-related injury and illness among union carpenters in Washington State. Am J Indust Med 56:381–388.

National Institute for Occupational Safety and Health. 1981. Work practices guide for manual lifting. National Institute for Occupational Safety and Health Technical Report No. 81–122. US Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, OH.

National Institute for Occupational Safety and Health. 2006. Preventing injuries from installing drywall. DHSSS (NIOSH) Publication No. 2006-147.

Pan CS, Chiou SS. 1999. Analysis of biomechanical stresses during drywall lifting. Int J Ind Ergon 23:505–511.

Pan CS, Chiou SS, Hsiao H, Wassell JT, Keane PR. 1999. Assessment of perceived traumatic injury hazards during drywall hanging. Int J Ind Ergon 25:29–37.

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.

SAS Institute Inc. 2002–2004. SAS online doc, 9.1.3. Cary, NC: SAS Institute Inc.

Schneider S, Susi P. 1994. Ergonomics and construction: A review of potential hazards in new construction. Am Ind Hyg Assoc J 55:635–649.

Schoenfisch AL, Lipscomb HJ. 2012. 20-year injury trends in drywall injury rates: How much do these changes reflect real progress in work-related injury prevention? 30th International Congress on Occupational Health. March 18–23, 2012. Cancun, Mexico.

Shah S, Bonauto D, Silverstein B, Foley M, Kalat J. 2003. Injuries and illnesses from wood framing in residential construction, Washington State 1993–1999. JOEM 45:1171–1182.

Shannon HS, Lowe GS. 2002. How many injured workers do not file claims for workers' compensation benefits? Am J Ind Med 42:467–473.

Sorock GS, Smith GS, Reeve GR, Dement J, Stout N, Layne L, Pastula ST. 1997. Three perspectives on work-related injury surveillance systems. Am J Ind Med 32:116–128.

The Center for Construction Research and Training. 2007. The Construction Chart Book: The US Construction Industry and its Workers (Fourth Edition), www.cpwr.com.

US Department of Labor, Occupational Safety and Health Administration. Safety and Health Regulations for Construction (29 CFR Part 1926). Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_-document?p_table=STANDARDS&p_id=10593.

Welch LS, Dong X, Carre F, Ringen K. 2007. Is the apparent decrease in injury and illness rates in construction the result of changes in reporting? Int J Occup Environ Health 13:39–45.

Yuan L, Buchholz B, Punnett L, Kriebel D. 2007. Estimation of muscle contraction forces and joint reaction forces at the low back and shoulder during drywall installation. Proc Human Factors Ergon Soc 51st Annual Meeting 51:952–956.