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Impact of Musculoskeletal and Medical Conditions on Disability Retirement—A Longitudinal Study Among Construction Roofers

Laura S. Welch, MD,[1]* Elizabeth Haile, MS,[1]
Leslie I. Boden, PhD,[2] and Katherine L. Hunting, PhD, MPH[3]

Background *To assess the intersection of work demands, chronic medical and musculoskeletal conditions, aging, and disability, we initiated a longitudinal study of construction roofers who were current union members between the ages of 40 and 59.*
Methods *Participants were asked about the presence of medical conditions and musculoskeletal disorders; the Work Limitations Questionnaire, the SF-12, and other validated assessments of social and economic impact of injury were included.*
Results *Factors at baseline that predicted leaving for a health-related reason were older age, lower physical functioning, work limitations, and having missed work. Those who left roofing for a health-related reason were much more likely to have a lower economic score at the 1 year interview.*
Conclusions *Medical and musculoskeletal conditions are strongly associated with work limitation, missed work, and reduced physical functioning; these factors are also associated with premature departure from the workforce.* Am. J. Ind. Med. 53:552–560, 2010. © *2010 Wiley-Liss, Inc.*

KEY WORDS: injury; job accommodation; low back pain; occupation; work ability; work

INTRODUCTION

The average worker in the United States, and the average construction worker, is getting older; the number of workers over age 55 is increasing at an annual rate of 2.5% [Pransky et al., 2000]. Construction workers are typically younger than the national labor force but are also aging [CPWR, 2007]. As we learn more about the characteristics of older workers, and their ability to maintain health and productivity on the job, the evidence suggests that work demands need to be changed in order to accommodate the work limitations of an older workforce [Wegman and McGee, 2004; Ilmarinen, 2006]. Job accommodation is particularly difficult in the construction industry; a construction worker may have several employers in a single year, and both his work and his workplace are constantly changing as a construction job proceeds [Ringen et al., 1995]. Yet there is a projected shortage of skilled construction workers [Goodrum, 2004], and keeping skilled workers from leaving the industry is a high priority in the United States.

To investigate the intersection of work demands, chronic medical and musculoskeletal conditions, aging, and disability, we initiated a longitudinal study of construction roofers. Roofers have a high rate of injury even compared with other construction workers [Sorock et al., 1993; Dement and Lipscomb, 1999; Jackson and Loomis, 2002], and 15% of the members of the Roofers International Union leave the

[1]CPWR—The Center for Construction Research and Training, Silver Spring, Maryland
[2]Boston University School of Public Health, Boston, Massachusetts
[3]Department of Environmental and Occupational Health, George Washington University School of Public Health and Health Services, Washington, District Columbia
Contract grant sponsor: NIOSH; Contract grant number: RO1OH00369.
*Correspondence to: Laura S. Welch, CPWR—The Center for Construction Research and Training, 8484 Georgia Ave, Suite 1000, Silver Spring, MD 20910. E-mail: lwelch@cpwr.com

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union each year. Here we describe the characteristics of roofers who left their trade within 1 year of a baseline interview, and the subset who left their trade due to a health condition.

METHODS

We enrolled 979 roofers in a longitudinal study; the methods are described in detail in a prior publication [Welch et al., 2008]. In brief, working with the Roofers International Union, we enrolled a random sample of union members who: (1) were between the ages of 40 and 59; (2) were regular dues paying current members; (3) had maintained continuous union membership during the previous 2 years; and (4) were working as a roofer or roofing supervisor (either full- or part-time) or expected to be so employed in the next 3 months (information on current work was determined in the interview). Roughly equal numbers of subjects were selected from the age sub-groups 40–44, 45–49, 50–54, and 55–59. The project was approved by the institutional review boards of the CPWR and George Washington University. Informed consent was obtained over the telephone prior to the start of the interview. Interviews were conducted in both English and Spanish.

The baseline interview included questions on: (1) medical and musculoskeletal (MSD) conditions experienced by the respondent in the past 2 years, (2) missed work and job accommodations related to these conditions, (3) frequency and duration of MSD symptoms, (4) the respondent's functional status, and (5) the respondent's economic status. We classified one condition for each worker as his most serious condition. Respondents whose most serious condition was a musculoskeletal problem were also asked a series of questions regarding the frequency and duration of symptom episodes in the year prior to the interview, using a series of questions validated in prior studies [Hunting et al., 1994; Welch et al., 2000].

To assess the impact of health problems on respondents' functional status and work performance, we used previously validated instruments: the SF-12 [Ware et al., 1995; Ware et al., 2002], 8 items from the Work Limitations Questionnaire (WLQ) [Lerner et al., 2001], and a series of questions developed and validated by Pransky et al. [2000] to assess social and economic changes in the past 12 months. The SF-12 is a subset of questions from a 36-item questionnaire (SF-36); the SF-36 was created to measure eight health concepts included in the Medical Outcomes Study (MOS) [Stewart et al., 1989; Ware and Sherbourne, 1992]. The SF-36 was judged to be the most widely evaluated generic patient-assessed health outcome measure in a bibliographic study of the growth of ''quality of life'' measures [Garratt et al., 2002]. The questionnaire items represent behavioral function and dysfunction, distress and well-being, objective reports and subjective ratings, and both favorable and unfavorable self-evaluations of general health status. Twelve items from the SF-36 were then found to reproduce at least 90% of the variance and reproduce the profile of eight SF-36 health concepts sufficiently for large sample studies, allowing the creation of the short version SF-12. We used the SF-12 to calculate a score for physical function, general health, vitality, and bodily pain.

The full WLQ includes 25 items, which can generate 4 scale scores. We included the subset for physical demands; the other subsets focus on time management, mental and interpersonal demands, and output commands related to work quantity quality and timeliness. This instrument has been validated in a range of different employee and patient populations and for a variety of different health conditions [Lerner et al., 2003]. Using the WLQ, we classified each participant as having none, 1–2, and 3 or more limitations among the eight questions.

There were seven questions that measured economic impact: dipped into savings, borrowed money, had problems paying bills, applied for food stamps, moved to a less expensive house, lost health insurance coverage, or spouse had to take a job. We used factor analysis to determine the appropriate weighting of the answers to these questions; the overall results suggested that a sum of the items formed the most reliable scale based on Cronbach's alpha ($\alpha = 0.540$). We created four categories using the sum of positive answers to these seven questions: no economic impact (0), mild economic impact (1–2), moderate economic impact (3), and severe economic impact (4–7).

In addition to repeating the baseline set of questions, the 1-year interview asked each participant if he was still working as a roofer. We asked each individual who had stopped work as a roofer whether he was working in another job and his reason for leaving roofing.

Statistical Methods

Comparisons for continuous variables were performed using the Student's *t*-test for normally distributed data or the Wilcoxon rank sum test for non-parametric data. Dichotomous variables were compared using the chi-square test of general association. Ordinal data were compared using the Cochran–Armitage test for trends. Of the 12 items in the SF-12 measure of health status, 5 items were used to create four subscales. The physical functioning (PF) health concept was estimated using two items, which included health limitations due to moderate activities and problems such as climbing several flights of stairs. Bodily pain (BP) consisted of one item about pain interference with normal work, and general health (GH) consisted of one item about general health, and vitality (VT) from one item about energy. The SF-12 version 2 manual provided formulas to transform each raw score to a scale of 0–100, as well as formulas to standardize the scores to a Norm-Based Score (NBS) system

[Ware et al., 2002]. The NBS is a linear transformation of the scores to achieve a mean of 50 and a standard deviation of 10 in the general U.S. population, and this system makes interpretations and comparisons more meaningful across scales. Lower SF-12 scores indicate a less favorable health status.

Separate logistic regression models were used to determine predictors for leaving roofing, leaving roofing due to health-related reasons, and leaving roofing due to non-health-related reasons—each in comparison with current roofers. Predictors with *P*-values less than 0.20 while model building using a forward selection method were included in the final logistic models. Model fit analysis was evaluated by using the Hosmer–Lemeshow goodness-of-fit statistical analysis. The *C*-statistic is reported as a measure of predictive power.

All statistical analyses were performed with SAS for Windows Version 9.1 [SAS Institute, Inc., 2003].

RESULTS

We completed a second interview with 773 of the 979 roofers enrolled at baseline, for a follow-up rate of 79%. The roofers lost to follow-up were younger, with a mean age of 48.9 years compared with 49.8 for those roofers who completed an interview. There was no significant difference between these two groups in baseline characteristics of physical functioning, bodily pain, general health, vitality, type of condition, having missed work in the 2 years prior to baseline, work limitations, or economic impact score.

Table I describes the baseline characteristics of the 695 roofers who continued to work in roofing and the 78 (10%) who left the trade; 4 subjects missing physical functioning data were excluded from the analysis of physical functioning and 5 subjects missing work limitations data were excluded from the analysis of work limitations. The roofers who left were older, had significantly lower physical functioning and general health scores, more bodily pain, had marginally lower vitality scores, had more diagnosed MSD and/or medical conditions, were more likely to have missed work in the 2 years prior to baseline, and reported more work limitations at baseline. Even though the median (25th–75th percentile) comparisons between the groups are identical in some cases, the distributions are different between the groups. Where there are more current roofers with higher SF-12 scores the *P*-values are significant in some of the comparisons, although the medians are the same.

The four subscale scores from the SF-12 measure of health status were highly correlated. Each subscale was assessed in a bivariable model as a predictor of leaving roofing. Physical functioning was the strongest predictor and was chosen for inclusion in subsequent multivariate models.

Using multivariate logistic regression (Table II), each year increase in age at the baseline interview was associated with a 16% increase in the likelihood of leaving roofing in the year following the baseline interview. Each point decrease in the physical functioning score at baseline was associated with a 6% increase in the likelihood of leaving roofing. After accounting for these factors, there was no

TABLE I. Baseline Characteristics of Current Roofers Versus Former Roofers (n = 773)

	Current roofers (n = 695)	Former roofers (n = 78)	*P*-value
Age (mean ± std)	49.4 ± 5.4	53.6 ± 5.1	<0.01*
Physical functioning [median (25th–75th percentile)]	56.5 (47.9–56.5)	47.9 (39.3–56.5)	<0.01**
Bodily pain [median (25th–75th percentile)]	47.3 (37.1–57.4)	47.3 (26.9–57.4)	<0.01**
General health [median (10th–90th percentile)]	44.7 (29.6–62.0)	44.7 (29.6–55.5)	0.02**
Vitality [median (10th–90th percentile)]	57.8 (47.7–67.9)	57.8 (37.7–67.9)	0.06**
Type of condition			0.05***
Musculoskeletal disorder (MSD)	26.8%	35.9%	
Medical	14.1%	16.7%	
Both MSD and medical	27.6%	30.8%	
None	31.5%	16.7%	
Any missed work (vs. no missed work) in 2 years prior to baseline	29.8%	42.3%	0.02***
Work limitations			0.01****
None	52.2%	42.1%	
1–2	38.4%	38.2%	
3+	9.4%	19.7%	

*Student's *t*-test.
**Wilcoxon rank sum test.
***Chi-square test.
****Cochran–Armitage trend test.

TABLE II. Baseline Characteristics Associated With Leaving Roofing (n = 769)

	OR	95% CI
Type of condition		
Musculoskeletal disorder only vs. none	1.59	(0.74, 3.45)
Medical only vs. none	1.01	(0.42, 2.48)
Both medical and musculoskeletal disorder vs. none	0.76	(0.32, 1.83)
Age	1.16	(1.10, 1.23)
Physical functioning	0.94	(0.92, 0.97)
Any missed work (vs. no missed work) in 2 years prior to baseline	1.57	(0.87, 2.85)

Four subjects excluded due to missing physical functioning data.
Hosmer and Lemeshow goodness-of-fit test: chi-square = 5.84, df = 8, $P = 0.67$, C-statistic = 0.77.

significant association between type of condition or missed work and the likelihood of leaving roofing.

Among the 78 roofers who left roofing, 47 (60%) reported they did so for health-related reasons. Table III compares this subset of former roofers with the still-current roofers. For many, the health condition that led to retirement from roofing was not present at baseline, but the presence of a baseline condition was significantly associated with leaving roofing for a health-related reason; only one person who left for a health-related reason had no conditions at baseline. The mean age of the roofers who left for a health-related reason is very similar to the age of all former roofers, but there are stronger associations between leaving roofing and both missed work and work limitation among the group that left for health-related reasons. One-third of the roofers who left for health-related reasons had three or more work limitations, compared with 9% of those who stayed at work.

We used multivariate logistic regression (Table IV) to measure the strength of association between these factors and leaving work because of health-related reasons. Results showed that each year increase in age at the baseline interview was associated with an 18% increase in likelihood of leaving roofing, and each point decrease in physical functioning at baseline was associated with a 9% increase in the likelihood of leaving roofing for health-related reasons. The odds of leaving roofing were eight times as high for roofers who had an MSD only compared with those roofers with no conditions; the sample size was small (N = 17) and this difference was only marginally statistically significant (95% CI, 0.98–64.3). The odds of leaving were almost seven times as high for roofers with a medical condition only (N = 19), and the odds were over four times as high for roofers with both an MSD and a medical condition (N = 10) (95% CI, 0.80–58.1 and 95% CI, 0.54–39.15, respectively).

There were 31 roofers who left roofing for reasons other than health. Of these, 21 (67.7%) left due to retirement, 3 (9.7%) left due to lack of regular work, 3 (9.7%) left due to roofing being seasonal, 7 (22.6%) left because roofing was too dirty and physically demanding, 3 (9.7%) left because roofing was too dangerous, and 6 (19.4%) had opportunities

TABLE III. Baseline Characteristics of Current Roofers Compared to the Roofers Who Left Roofing for Health-Related Reasons (n = 742)

	Current roofers (n = 695)	Former roofers who left roofing for health-related reasons (n = 47)	*P*-value
Age (mean ± std)	49.4 ± 5.4	54.0 ± 5.0	<0.01*
Physical functioning [median (25th–75th percentile)]	56.5 (47.9–56.5)	39.3 (30.7–47.9)	<0.01**
Bodily pain [median (25th–75th percentile)]	47.3 (37.1–57.4)	37.1 (26.9–47.3)	<0.01**
General health [median (25th–75th percentile)]	44.7 (44.7–55.5)	44.7 (29.6–55.5)	<0.01**
Vitality [median (25th–75th percentile)]	57.8 (47.7–57.8)	47.7 (37.7–57.8)	<0.01**
Type of baseline condition			<0.01***
Musculoskeletal disorder	26.8%	36.2%	
Medical	14.1%	21.3%	
Both musculoskeletal disorder and medical	27.6%	40.4%	
None	31.5%	2.1%	
Any missed work (vs. no missed work) in 2 years prior to baseline	29.8%	57.5%	<0.01***
Work limitations			0.01****
None	52.2%	24.4%	
1–2	38.4%	42.2%	
3+	9.4%	33.3%	

*Student's *t*-test.
**Wilcoxon rank sum test.
***Chi-square test.
****Cochran–Armitage trend test.

TABLE IV. Baseline Characteristics Associated With Leaving Roofing for Health-Related Reasons (n = 742)

	OR	95% CI
Type of condition		
Musculoskeletal disorder only vs. none	7.92	(0.98, 64.29)
Medical only vs. none	6.83	(0.80, 58.09)
Both medical and musculoskeletal disorder vs. none	4.63	(0.55, 39.15)
Age	1.18	(1.09, 1.27)
Physical functioning	0.91	(0.88, 0.94)
Any missed work (vs. no missed work) in 2 years prior to baseline	1.97	(0.95, 4.10)

Three subjects excluded due to missing physical functioning data.
Hosmer and Lemeshow goodness-of-fit test: chi-square = 5.53, df = 8, $P = 0.70$, C-statistic = 0.88.

to make money doing other things. Because respondents could give more than one reason, there is some overlap between the categories presented above. Table V compares these 31 roofers with the 695 current roofers. This group of former workers was comparable in age with the group who left for health-related reasons, and therefore older than the group that stayed at work, but was less likely to have work limitations at baseline than the roofers who stayed at work.

For the multivariable analysis comparing baseline characteristics between roofers who left due to non-health-related reasons with current roofers, only age and work limitations met the criteria to be included in the model, while physical functioning, missed work, and type of condition all dropped out. The estimates showed that each year increase in age at baseline interview was associated with a 14% increase in likelihood of leaving roofing. Workers who left were 1.88 times more likely to have had at least one work limitation at baseline; however, this association was not statistically significant ($P = 0.11$).

Table VI presents multinomial logistic regression estimates of factors associated with the economic impact score at the 1 year interview, divided into mild, moderate, or severe impact, compared with no impact. Table VI includes all roofers who participated in the study. Younger workers were more likely to report an economic impact. Higher SF-12 subscores for physical functioning at baseline

TABLE V. Baseline Characteristics of Current Roofers and of Roofers Who Left Roofing DueTo Non-Health-Related Reasons (n = 726)

	Current roofers (n = 695)	Former roofers who left roofing due to non-health-related reasons (n = 31)	*P*-value
Age (mean ± std)	49.4 ± 5.4	53.1 ±5.3	<0.01*
Physical functioning [median (minimum–maximum)]	56.5 (22.1–56.5)	56.5 (30.7–56.5)	0.34**
Bodily pain [median (25th–75th percentile)]	47.3 (37.1–57.4)	57.4 (47.3–57.4)	0.06**
General health [median (25th–75th percentile)]	44.7 (44.7–55.5)	55.5 (44.7–55.5)	0.14**
Vitality [median (minimum–maximum)]	57.8 (27.6–67.9)	57.8 (37.7–67.9)	0.11**
Type of baseline condition			0.37***
Musculoskeletal disorder	26.8%	35.5%	
Medical	14.1%	9.7%	
Both musculoskeletal disorder and medical	27.6%	16.1%	
None	31.5%	38.7%	
Any missed work (vs. no missed work) in 2 years prior to baseline	29.8%	19.4%	0.21***
Work limitations			0.04****
None	52.2%	67.7%	
1–2	38.4%	32.3%	
3+	9.4%	0.0%	

*Student's *t*-test.
**Wilcoxon rank sum test.
***Chi-square test.
****Cochran–Armitage trend test.

TABLE VI. Economic Impact Score at 1 Year Follow-Up (n = 738)

	Mild economic impact (n = 385), OR (95% CI)	Moderate economic impact (n = 26), OR (95% CI)	Severe economic impact (n = 20), OR (95% CI)
Age	0.92 (0.89–0.95)	0.87 (0.80–0.95)	0.91 (0.83–1.00)
Physical functioning	0.97 (0.95–0.99)	0.93 (0.89–0.97)	0.95 (0.91–1.00)
Any missed work (vs. no missed work)	1.69 (1.19–2.41)	2.80 (1.15–6.81)	3.33 (1.29–8.62)
Former roofers who left due to health-related reasons (vs. current roofers)	3.91 (1.52–10.05)	19.04 (4.96–73.06)	6.49 (1.25–33.83)

OR, odds ratio; 95% CI, 95% confidence intervals.
Reference category is no economic impact (n = 307).

were associated with modest but significant decreases in the likelihood of reporting economic impacts at 1 year. Roofers who had missed work in the 2 years previous to baseline were significantly more likely to have mild, moderate, and severe economic impacts 1 year later (ORs = 1.69, 2.80, and 3.33, respectively).

The odds of adverse economic impact at 1 year were increased 4- to 19-fold among former roofers who had left due to health-related reasons, compared with active workers. Work limitations and type of conditions did not meet the criteria of $P < 0.20$ to stay in the model.

DISCUSSION

In this article we describe the characteristics of roofers who left their trade within 1 year of a baseline interview, and the subset of those who left their trade due to a health condition. Factors at baseline that predicted leaving for a health-related reason were older age, lower physical functioning, work limitations, and having missed work. Those who left roofing for a health-related reason were much more likely to have an economic impact after leaving. Predictive factors were distinctly different between roofers who left the trade for health-related reasons compared with those who left for other reasons.

Ten percent of our baseline sample left roofing within a year of enrollment in the study, and among this group 60% left because of poor health. Prior studies reported annual rates of disability retirement of 5.3 per 1,000 among construction workers in Ireland [Brenner and Ahern, 2000], rates between 2 and 8.7 per 1,000 person/years for specific construction trades, and 7.4 per 1,000 for roofers specifically, in Sweden [Stattin and Jarvholm, 2005], and rates between 4 and 7 per 1,000 in Switzerland [Guberan et al., 1989]. Our classification ''leaving for health related reasons'' is less restrictive than disability retirement, since it includes those leaving because of health even if the roofer did not take a disability retirement. Since our study was restricted to roofers over the age of 40 and the three studies mentioned were from European countries with differing disability retirement and social security systems, we cannot use these reported rates for a direct comparison.

We believe the roofers enrolled in this study are representative of our target population of union roofers in age, ethnicity, and race. At baseline there was no significant difference in participation by age group. Ten percent of our study group was Hispanic, and 11% were from a racial minority. Although the Roofers International Union does not keep data on race and ethnicity for its members, we estimate using a combination of national data on the proportion of all roofers who are Hispanic and the proportion of all union construction workers who are Hispanic that 16% of union roofers are Hispanic [Welch et al., 2008]. Nationwide, 12% of roofers are from a racial minority, again quite comparable to the 11% among our participants [Center to Protect Workers' Rights, 2002; Welch et al., 2008]. In addition, our study includes only union construction workers, so it is not representative of all roofers. Our findings may therefore underestimate the social and economic impact of injuries and diseases of aging in this industry, as union construction workers have better wages as well as a retirement and disability pension system available to them.

Like older working populations, this study population has surely been subject to selection, since it includes the workers with MSD and medical conditions who managed to return to work and thus be eligible for entering this study. In the Netherlands, construction workers over the age of 55 had a decreased risk of disability retirement compared with the workers aged 45–54, suggesting a healthy worker effect [Burdorf et al., 2005]. As we follow this group of roofers forward in time we will have a better estimate of the effect of MSDs as a determining factor in leaving the workforce.

Obtaining a measure of the rate of work disability in the United States to which we can compare our findings is difficult. There are data about the likelihood of disability for specific injuries such as work-related low back injury, spinal cord injury, or traumatic brain injury, but no incidence data are available for the general population or for construction workers specifically. Several national surveys provide prevalence data, with the definition used by the Current

Population Survey (CPS) most useful for comparison here. CPS tracks the prevalence of work disability on an annual basis; people are categorized as ''work disabled'' if they are receiving disability benefits or if the person has a problem working (or is not working) because of illness or disability. According to the CPS data, the percentage of the working-age population (16–64) reporting a work disability has been fairly stable at around 10% from 1993 until 2003; state-specific prevalence using the National Health Interview Survey from 1990 ranged from 6.4% to 12.6% [Centers for Disease Control, 1993].

Construction workers are less likely to return to work after an injury than workers in other occupations [Rossignol et al., 1988; Oleinick et al., 1996; McIntosh et al., 2000; Turner et al., 2000]. Studies have shown that 10% of construction workers do not return to work after an acute MSD injury [Gillen, 1999; Welch et al., 1999]. Among all occupations, the presence of an MSD increases the likelihood of a disability retirement among those doing heavy or moderate work [Karpansalo et al., 2002; Nordlund and Ekberg, 2004], and MSDs increase the risk for retirement among construction workers [Vingard et al., 1992; Burdorf et al., 2005]. MSDs are responsible for over 75% of disability retirements among sheet metal workers [Welch and Hunting, 1992]. A recent study from Germany [Arndt et al., 2005] looked at the causes for early retirement due to disability among 14,474 construction workers. When compared with the general workforce, construction workers had a higher standardized incidence ratio for retirement secondary to cancer, injuries, respiratory diseases, musculoskeletal diseases, and all causes combined. Almost two-thirds of German construction workers retire due to permanent disability, compared with 44% for all industries [Siebert et al., 2001]. In a study from Ireland, the median age at retirement among a large cohort of construction workers was 58 years [Brenner and Ahern, 2000]. Construction workers with respiratory disease in general [Rothenbacher et al., 1998] and asthma in particular [Sauni et al., 2001] had twice the rate of disability retirement as a comparison population.

Prior research has identified specific risk factors for disability retirement [Krause et al., 1997; Burkhauser and Butler, 1999; Borg et al., 2001; Karpansalo et al., 2002; Salonen et al., 2003; Nordlund and Ekberg, 2004; Pransky et al., 2005; Steenstra et al., 2005; Seland et al., 2006]. These factors include: age, having a musculoskeletal disorder, the severity of injury, greater pain and functional disability, a low score on the Work Ability Index (WAI) [Ilmarinen et al., 1997], missing more than 7 days of work, physically demanding work, lack of job accommodation, psychosocial factors related to coworker support, and expectations of recovery. Working in construction was specifically identified as a risk factor. Our findings are similar, with age, functional impairment, and missed work all associated with an increased OR for leaving work.

Construction is clearly physically demanding, and so this industry may be less able to accommodate workers with MSD or medical conditions. In a prospective population-based study of almost 35,000 men and women [Hagen et al., 2002], workers with back pain engaged in physically demanding work were four times more likely to retire early compared with workers with less physically demanding work. The age-adjusted odds of retirement were also increased if the worker assessed his general health as not good or bad (OR 3.7), described himself as tired or very tired (OR 1.7), or had diabetes or angina (3.2 and 2.0, respectively). If all these risk factors were present, the OR increased 25-fold. Krause et al. [1997] found that age and physically demanding work were the most important predictors of disability retirement. Others have reported that perceived health or fatigue is a strong predictor of disability retirement [Karpansalo et al., 2004]. Physically demanding work also predicted early retirement, without specific mention of disability, in one study.

In some European studies work limitations are assessed using the WAI [Ilmarinen et al., 1997]. Among construction workers, Burdorf et al. [2005] used existing studies to estimate that a low WAI carried an odds ratio of 10 for disability retirement, that an age of 45–54 versus age 30 conferred a risk of 6.6, and that severe back pain had an OR of 3. The four risk factors combined predicted a 40-fold increase in the probability of disability retirement. Using a decision model, these researchers predict that a 50-year-old construction worker with an MSD and poor workability has a probability of 0.65 of retiring due to a disability in the subsequent 4 years. These estimates are in keeping with our calculated ORs (see Table IV); additional years of follow-up will allow us to develop more precise predictions.

In this analysis we also looked at the economic well-being of those leaving the roofing profession. Among all the roofers, including those who continued to work, older age and better physical function were associated with better economic status at 1 year. Those who left roofing for a health-related reason were much more likely to feel an economic impact after leaving, even when other factors were accounted for in the analysis.

Identification of risk factors for leaving the roofing trade are important if the knowledge leads to work modification, a change in work organization, or some modification of the risk factors to prevent disability and the attendant economic impact. Burdorf proposes that specific intervention programs be developed for construction workers with a 4-year probability of disability retirement between 20% and 38%, while those with a probability over 38% be offered a less strenuous job. A randomized prospective study, among manufacturing workers over 50 who reported they would not be able to work up to retirement found that an individually designed intervention program maintained workability and improved quality of life [de Boer et al., 2004], and a

systematic review concluded that work disability duration is significantly reduced by work accommodation [Franche et al., 2005]. A similar program has not been reported for the construction industry. Given the demographic changes anticipated, and a potential shortage of experienced construction workers, such an intervention program is clearly needed.

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REFERENCES

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

Borg K, Hensing G, Alexanderson K. 2001. Predictive factors for disability pension—An 11-year follow up of young persons on sick leave due to neck, shoulder, or back diagnoses. Scand J Public Health 29:104–112.

Brenner H, Ahern W. 2000. Sickness absence and early retirement on health grounds in the construction industry in Ireland. Occup Environ Med 57:615–620.

Burdorf A, Frings-Dresen MH, van Duivenbooden C, Elders LA. 2005. Development of a decision model to identify workers at risk of long-term disability in the construction industry. Scand J Work Environ Health 31:31–36.

Burkhauser RV, Butler JS. 1999. The importance of accommodation on the timing of disability insurance applications. J Hum Resour 34:589–611.

Center to Protect Workers' Rights. 2002. The Construction Chart Book: The US Construction Industry and Its Workers. D1-02. Silver Spring, MD: CPWR. p. 1–120.

Centers for Disease Control. 1993. Prevalence of work disability—United States, 1990. Morb Mortal Wkly Rep 42(39):757–759.

CPWR. 2007. The Construction Chart Book: The US Construction Industry and Its Workers. Silver Spring, MD: CPWR—The Center for Construction Research and Training. p. 1–120.

de Boer AG, van Beek JC, Durinck J, Verbeek JH, van Dijk FJ. 2004. An occupational health intervention programme for workers at risk for early retirement; a randomised controlled trial. Occup Environ Med 61:924–929.

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

Franche RL, Cullen K, Clarke J, Irvin E, Sinclair S, Frank J. 2005. Workplace-based return-to-work interventions: A systematic review of the quantitative literature. J Occup Rehabil 15:607–631.

Garratt A, Schmidt L, Mackintosh A, Fitzpatrick R. 2002. Quality of life measurement: Bibliographic study of patient assessed health outcome measures. Br Med J 324:1417.

Gillen M. 1999. Injuries from construction falls. Functional limitations and return to work. AAOHN J 47:65–73.

Goodrum PM. 2004. Hispanic and non-Hispanic wage differentials: Implications for United States Construction Industry. J Constr Eng Manage 130:552–559.

Guberan E, Usel M, Raymond L, Tissot R, Sweetnam PM. 1989. Disability, mortality, and incidence of cancer among Geneva painters and electricians: A historical prospective study. Br J Ind Med 46:16–23.

Hagen KB, Tambs K, Bjerkedal T. 2002. A prospective cohort study of risk factors for disability retirement because of back pain in the general working population. Spine 27:1790–1796.

Hunting KL, Welch LS, Cuccherini BA, Seiger LA. 1994. Musculoskeletal symptoms among electricians. Am J Ind Med 25:149–163.

Ilmarinen J. 2006. Towards a longer and better working life: A challenge of work force ageing. Med Lav 97:143–147.

Ilmarinen J, Tuomi K, Klockars M. 1997. Changes in the work ability of active employees over an 11-year period. Scand J Work Environ Health 23(Suppl 1):49–57.

Jackson SA, Loomis D. 2002. Fatal occupational injuries in the North Carolina Construction Industry, 1978–1994. Appl Occup Environ Hyg 17:27–33.

Karpansalo M, Manninen P, Lakka TA, Kauhanen J, Rauramaa R, Salonen JT. 2002. Physical workload and risk of early retirement: Prospective population-based study among middle-aged men. J Occup Environ Med 44:930–939.

Karpansalo M, Manninen P, Kauhanen J, Lakka TA. 2004. Perceived health as a predictor of early retirement. Scand J Work Environ Health 30:287–292.

Krause N, Lynch J, Kaplan GA, Cohen RD, Goldberg DE, Salonen JT. 1997. Predictors of disability retirement. Scand J Work Environ Health 23:403–413.

Lerner D, Amick BC III, Rogers WH, Malspeis S, Bungay K, Cynn D. 2001. The Work Limitations Questionnaire. Med Care 39:72–85.

Lerner D, Amick BC III, Lee JC, Rooney T, Rogers WH, Chang H, Berndt ER. 2003. Relationship of employee-reported work limitations to work productivity. Med Care 41:649–659.

McIntosh G, Frank J, Hogg-Johnson S, Bombardier C, Hall H. 2000. Prognostic factors for time receiving workers' compensation benefits in a cohort of patients with low back pain. Spine 25:147–157.

Nordlund A, Ekberg K. 2004. Self reported musculoskeletal symptoms in the neck/shoulders and/or arms and general health (SF-36): Eight year follow up of a case–control study. Occup Environ Med 61:e11.

Oleinick A, Gluck JV, Guire K. 1996. Factors affecting first return to work following a compensable occupational back injury. Am J Ind Med 30:540–555.

Pransky G, Benjamin K, Hill-Fotouhi C, Himmelstein J, Fletcher KE, Katz JN, Johnson WG. 2000. Outcomes in work-related upper extremity and low back injuries: Results of a retrospective study. Am J Ind Med 37:400–409.

Pransky G, Benjamin K, Savageau JA, Currivan D, Fletcher K. 2005. Outcomes in work-related injuries: A comparison of older and younger workers. Am J Ind Med 47:104–112.

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

Rossignol M, Suissa S, Abenhaim L. 1988. Working disability due to occupational back pain: Three-year follow-up of 2,300 compensated workers in Quebec. J Occup Med 30:502–505.

Rothenbacher D, Arndt V, Fraisse E, Zschenderlein B, Fliedner TM, Brenner H. 1998. Early retirement due to permanent disability in relation to smoking in workers of the construction industry. J Occup Environ Med 40:63–68.

Salonen P, Arola H, Nygard CH, Huhtala H, Koivisto AM. 2003. Factors associated with premature departure from working life among ageing food industry employees. Occup Med (Lond) 53:65–68.

SAS Institute, Inc. 2003. SAS for Windows, Release 9.1. Cary, NC: SAS Institute, Inc.

Sauni R, Oksa P, Vattulainen K, Uitti J, Palmroos P, Roto P. 2001. The effects of asthma on the quality of life and employment of construction workers. Occup Med (Lond) 51:163–167.

Seland K, Cherry N, Beach J. 2006. A study of factors influencing return to work after wrist or ankle fractures. Am J Ind Med 49:197–203.

Siebert U, Rothenbacher D, Daniel U, Brenner H. 2001. Demonstration of the healthy worker survivor effect in a cohort of workers in the construction industry. Occup Environ Med 58:774–779.

Sorock GS, Smith EO, Goldoft M. 1993. Fatal occupational injuries in the New Jersey construction industry, 1983 to 1989. J Occup Med 35: 916–921.

Stattin M, Jarvholm B. 2005. Occupation, work environment, and disability pension: A prospective study of construction workers. Scand J Public Health 33:84–90.

Steenstra IA, Verbeek JH, Heymans MW, Bongers PM. 2005. Prognostic factors for duration of sick leave in patients sick listed with acute low back pain: A systematic review of the literature. Occup Environ Med 62:851–860.

Stewart AL, Greenfield S, Hays RD, Wells K, Rogers WH, Berry SD, McGlynn EA, Ware JE, Jr. 1989. Functional status and well-being of patients with chronic conditions. Results from the Medical Outcomes Study. J Am Med Assoc 262:907–913.

Turner JA, Franklin G, Turk DC. 2000. Predictors of chronic disability in injured workers: A systematic literature synthesis. Am J Ind Med 38: 707–722.

Vingard E, Alfredsson L, Fellenius E, Hogstedt C. 1992. Disability pensions due to musculo-skeletal disorders among men in heavy occupations: A case–control study. Scand J Soc Med 20:31–36.

Ware JE Jr, Sherbourne CD. 1992. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 30:473–483.

Ware JE, Jr., Kosinski M, Keller SD. 1995. SF-12: How to score the SF-12 physical and mental health summary scales. 2nd edition. Boston: Health Institute, New England Medical Center.

Ware JE, Kominsky JR, Turner-Bowker DM, Gandek B. 2002. How to Score Version 2 of the SF-12 Health Survey (with a Supplement Documenting Version 1). Lincoln, RI: QualityMetric Incorporated.

Wegman D, McGee J, editors. 2004. Health and safety needs of older workers. Washington, DC: National Research Council.

Welch LS, Hunting KL. 1992. Analysis of disability applications to the Sheet Metal Workers National Pension Fund. Sheet Metal Workers National Pension Fund.

Welch LS, Hunting KL, Nessel-Stephens L. 1999. Chronic symptoms in construction workers treated for musculoskeletal injuries. Am J Ind Med 36:532–540.

Welch LS, Goldenhar LM, Hunting KL. 2000. Women in construction: Occupational health and working conditions. J Am Med Women's Assoc 55:89–92.

Welch LS, Hunting KL, Haile E, Boden L. 2008. Musculoskeletal and medical conditions among construction roofers. Work 31:377–386.