



## Risk Factors for Back Injury in 31,076 Retail Merchandise Store Workers

Lytt I. Gardner, Douglas P. Landsittel, and Nancy A. Nelson

Risk factors for work-associated strain or sprain back injuries were investigated in a cohort of 31,076 material handlers from 260 retail merchandise stores in the United States. The workers studied were those with significant material-handling responsibilities—daily lifting and movement of merchandise. Workers in jobs with the greatest physical work requirements had an injury rate of 3.64 per 100 person-years versus 1.82 in workers with lesser work requirements. The unadjusted injury rate for males was 3.67 per 100 person-years compared with 2.34 per 100 person-years for females, but the excess for males was confounded by higher physical work requirements for men in the stocker/receiver job category. The injury rate ratio for short versus long duration of employment was 3.53 (95% confidence interval: 2.90, 4.30); for medium versus long duration of employment, it was 1.38 (95% confidence interval: 1.18, 1.62). The elevated rate ratios were maintained when the data were stratified by subsets with different rates of turnover. The results suggest that workers with the greatest physical work requirements and those with the shortest duration of employment are at the highest risk of back injuries. However, selection forces causing worker turnover within this cohort of active workers are not well characterized and have the potential to bias the measures for time-related factors such as duration of employment. *Am J Epidemiol* 1999;150:825–33.

incidence; low back pain; musculoskeletal system; occupational exposure; wounds and injuries

Progress in reducing back injury morbidity to workers overall has not been evident despite noteworthy successes in reducing the highest risk activities in certain industries (1, 2). Back injuries at work in the United States constitute about 20 percent of all workers' compensation claims, but an even larger share of the costs (3–5). Current data from the Bureau of Labor Statistics indicate that large retail merchandise stores employ approximately 2.4 million workers in the United States, and this number has grown by 350,000 workers per year since 1993 (6). Consequently, retail merchandise store workers contribute a growing fraction of occupationally associated back problems in American workers in spite of relatively modest back injury rates of 2 to 3 percent per year.

The epidemiologic literature has been consistent in showing that workers in jobs that require more lifting or movement of heavy loads are at higher risk of back injuries (7). This relation has been noted using a variety of study designs (cross-sectional, case-control, and prospective) and a variety of definitions of back problems, i.e., questionnaire reports of low back pain, state

workers' compensation records, and studies based on individual company claims records for injuries. Lifting and movement of heavy loads also have strong biologic plausibility because of the inherent biomechanical relation of those activities to the load-bearing structures of the back. Thus, lifting and movement of heavy loads are generally regarded as factors for which the evidence of causality according to any criteria is very strong.

However, for the individual characteristics of age, sex, and duration of employment, less consensus has been reached. Worker age and duration of employment are important because an exposure-response relation with duration and intensity of job activities should be demonstrable, given that physical requirements of work are causally related to injuries. Definition of the relations of age and duration of employment to back injuries also leads to a better understanding of chronic (long-term) versus acute (short-term) work exposures as causes. The lack of consensus is exemplified by the disparity within literature reviews concerning duration of employment. One literature review cited evidence supporting a negative association between duration of employment and back pain, i.e., higher injury rates in workers with the shortest lengths of employment (8). However, a later review concluded from the literature that epidemiologic data do not support a negative association with duration of employment (9). Disparities within the existing literature are also numerous con-

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From the Division of Safety Research, National Institute for Occupational Safety and Health, Morgantown, WV.

Reprint requests to Dr. Lytt I. Gardner, Centers for Disease Control and Prevention, Mailstop E-45, Atlanta, GA 30333.

cerning the effect of age on work-related back injuries, with prospective studies tending to show a negative association (10–13) and cross-sectional studies tending to show a positive or null association (14–22).

Few prospective studies of material handlers in the retail merchandise industry have been published, and the individual factors, as contrasted with the lifting hazards, have not been treated in detail. The objective of this study was to examine the associations of job-related lifting and material handling, age, sex, and duration of employment with the incidence of work-related back injuries and to examine the evidence for acute versus chronic causal models for back injuries in this population.

## MATERIALS AND METHODS

### Study population

The data collected for this study were generated to provide background data to be used in the design of a longitudinal investigation of the effect of back belts in the retail merchandise stores of a single company. The design of our study is a dynamic historical cohort, with workers entering and leaving the cohort in accordance with their payroll records. The company provided payroll and injury records for the period January 1, 1994, to September 30, 1995. These data contained the records of 31,076 material-handling workers in 260 stores located in nine states (Vermont, Rhode Island, Massachusetts, Michigan, North Carolina, Kentucky, Delaware, New Jersey, and Pennsylvania).

### Data sources

The payroll data records that were used to assemble the cohort were provided in electronic form by the company. The social security number, job title, sex, date of birth, date of hire, and hours worked (per quarter) were determined from quarterly payroll files covering seven consecutive calendar quarters from January 1, 1994, through September 30, 1995. These files were linked with the company's injury claim records for the same period. The injury claim records contained name, social security number, external cause of injury, body part, date of injury, days lost, and indemnity payment, if any. Injury reports were related by telephone to a claims processing center for the company.

### Injury definition

Diagnosis of a work-related back injury is generally based on nonspecific back pain symptoms (1). Physical examinations and radiographs, which are fre-

quently used for other musculoskeletal disorders, have proven to be of little use in improving the specificity of a diagnosis of low back pain or strain (23). Back injuries included in the study were only those specifically related to material handling. All back injuries coded with an external cause code containing "strain" followed by "lifting," "pushing," "pulling," "reaching," "holding," or "carrying" were included. This external cause code combined the "nature of injury or illness" with the "source of injury or illness," using the Z16.2 standard terminology (24). Back injuries listed in any non-material-handling or bodily motion category, for example: fall, caught by, caught between, struck by, slip, or trip without fall were excluded. The company offers light duty to workers with a back injury. In 71 percent of the cases, workers with a back injury continued their employment without filing an indemnity claim, i.e., a claim for payment of lost work time.

### Back Injury risk factors

**Age.** Age was calculated as the difference between date of birth and January 1, 1994 (or date of hire if after January 1994) and was divided into tertiles in the analysis.

**Sex.** The sex of the injured worker was provided in the payroll data.

**Job title.** The study included workers with significant manual material-handling responsibilities: receivers, stockers, and department managers. Job titles were provided in the payroll data; stockers and receivers were combined into a single code in the payroll data. For the purpose of the analysis, workers were assigned the job title of the job in which they had spent the most hours over the seven calendar quarters. The frequency and weight of lifts for the three jobs in the study were evaluated by directly observing 134 workers in 15-minute intervals in a pilot in-store survey (25). Workers were classified into lifting categories based on how often they were observed to lift weights in a category: not observed to lift ("very light lifters"); lifted less than 1 pound (less than 0.454 kg) ("light lifters"); lifted 1–25 pounds (0.454–11.35 kg) ("moderate lifters"); lifted 25–50 pounds (11.35–22.7 kg), or lifted more than 50 pounds (more than 22.7 kg) ("heavy lifters"). For receivers, 19.6 percent were classified as "heavy lifters," a significantly greater proportion than stockers (0 percent) or department managers (4.2 percent). The percentage of very light lifters was also significantly higher in stockers and department managers compared with unloaders. Items lifted varied from clothing and paper goods, household cleaning supplies, fabrics and toys to paint, hardware, pet supplies, lawn and garden supplies, and automotive merchandise.

Receivers move freight in boxes from trucks on the loading dock to wooden pallets in the back of the store. From the pilot survey, 63 percent of receivers performed more than 60 lifts per hour (mean, 137 lifts per hour). Stockers are responsible for moving freight to the front part of the store, removing stock from cartons, and unloading some or all of it onto the shelves in departments. From the pilot survey, 23 percent of stockers performed more than 60 lifts per hour (mean, 49 lifts per hour). Receivers also become stockers after unloading the trucks on their shift.

Department managers work alongside stockers (if a stocker is assigned to their department), placing freight on shelves, building and breaking down displays, and conducting other departmental duties. These workers also must manage inventory and direct other workers in their department, and thus, the job title has less material handling than do the other two titles. From the pilot survey, 19 percent of the department managers performed more than 60 lifts per hour (mean, 36 lifts per hour).

From the pilot survey, the ratio of males to females in receiver jobs (19:1) was significantly higher than that in stocker jobs (0.75:1), and therefore, the lifting requirements for men and women were quite different. Because the company payroll job codes combined stockers with receivers into a "stocker/receiver" job code, the job code remains confounded by sex differences in lifting requirements.

**Duration of employment.** Duration of employment is the amount of time from hire date until the worker left the payroll system. This risk factor creates difficulties because of the potential for job turnover and job change (toward lighter work), which could lead to a biased low estimate of the risk in workers with longer duration of employment. Injury data covered the entire duration of employment for workers hired on or after January 1, 1994. Workers with earlier hire dates did not have injury data prior to January 1, 1994. Rather than introduce assumptions about the effect of missing injury data and missing worker turnover data prior to January 1, 1994,

the relative rate measures of duration of employment were stratified by the subsets shown in table 1 (worker job titles and dates of hire). Date of termination of a worker was estimated as the first day of the quarter for which the worker was off the payroll data.

### Statistical and analytical methods

Simple descriptive injury rates were calculated as injuries per 100 workers per year (i.e., percent injured) using the formula  $\text{rate} = \text{number of injured} / \text{worker hours} \times 200,000$ ; this assumes that typical employees work 2,000 hours per year. Descriptive univariate rates and stratified rate ratios are presented for the risk factors. Person-hours of work over seven quarters were summed separately for each subset of the population presented in each strata of the stratified analyses. Multivariable estimates of rate ratios for risk factors were calculated by using a Poisson model of the multiplicative form  $\exp^{X\beta}$  with categorical risk factors. Rate ratio (incidence density ratio) estimates and standard errors were calculated by using the GENMOD Procedure of the Statistical Analysis System (26).

Twelve-month turnover rate was calculated as the percentage of workers who had left employment during a 12-month period beginning with the first quarter of 1994. Job change toward lighter work was calculated by counting the number of workers who switched to department manager from an initial stocker/receiver job title. Duration of employment was categorized into tertiles, and rate ratios compared the shortest and middle tertiles with the longest tertile. Workers hired after January 1, 1994, contributed no data to the longest tertile.

## RESULTS

For the 21-month study period, 1,085 total back injuries were reported from the accident reporting system. Of these, 180 were trauma-related back injuries, and 905 were material handling-related back injuries.

TABLE 1. Characteristics of the worker population in 260 retail stores, United States, 1994–1995

Characteristic	No.	Mean age (years)	% male	Median duration of employment (years)	Median weekly hours*	Job changes†		12-month turnover rate (%)
						No.	%	
<b>Job title</b>								
Stocker/receiver	20,863	31.6	54.4	1.3	30.8	1,542/20,863		7.4
Department manager	10,213	35.3	24.8	3.0	38.1			16.1
<b>Date of hire</b>								
On or after January 1, 1994	14,150	30.1	58.3	0.6	28.7	421/14,150		3.0
Before January 1, 1994	16,926	35.2	33.3	3.0	36.7	1,121/16,926		6.6

\* Based on workers with one or more complete quarters of work.

† Job changes to lighter work of department manager.

Of the 905 injuries, 138 were dropped for individuals with payroll job categories that were not those for department manager or stocker/receiver, leaving 767 total injuries. The 31,076 workers contributed 54,845,247 working hours during the period of follow-up. The overall incidence of back injuries was 2.80 per 100 person-years.

### Worker characteristics

Mean and median values for important characteristics are presented in table 1. Stocker/receivers had a shorter median duration of employment—1.3 years compared with 3.0 years for department managers. On average, stocker/receivers worked fewer hours per week (median = 30.8) than did department managers (median = 38.1). The difference was due to higher turnover rather than to being scheduled to work fewer hours per week. There was no difference for workers who had been employed for at least 21 months, but for those who had been employed for 6 months or less, the average number of hours worked per week were significantly shorter for stocker/receivers. Twelve-month turnover rates were considerably higher for stocker/receivers compared with department managers, and for workers with a hire date after January 1, 1994, compared with those hired before that date. Rates of job change toward the lighter work of department manager were low. Workers hired before January 1, 1994, had lower job

turnover rates and made slightly more changes toward lighter work than did those hired after January 1, 1994.

Workers ranged in age from 16 to 83 years, and the female workers were slightly older on average than were the male workers. Thirty-eight percent of the workers were between ages 21 and 30 years (males, 44 percent; females, 33 percent), and an additional 25 percent were between ages 31 and 40 years (males, 19 percent; females, 30 percent). Only 1 percent of workers were aged 61 years or older.

### Risk factor-specific incidence rates

Table 2 presents univariate risk factor-specific incidence rates. The incidence rate of back injuries was significantly higher in males compared with females, in stocker/receivers compared with department managers, in younger compared with older workers, and in workers with the shortest durations of employment. The Poisson model-adjusted rate ratios in table 2 were lower compared with the crude rate ratios. The reduction in ratios from the crude analysis was more pronounced for the effects of sex and young age, which were reduced by 24 and 22 percent, respectively. Rate ratios for sex are presented in more detail in table 3.

**Age.** The effect of age, which indicated younger workers (less than age 25 years) were at 1.54 times the risk of older (more than age 36 years) workers, was reduced to a borderline significant relative rate of 1.19

**TABLE 2. Risk factor-specific incidence rates of back injuries with rate ratios and 95% confidence intervals, 260 retail stores, United States, 1994–1995**

Risk factor	No. of Injuries	Working hours	Incidence rate per 200,000 hours	Crude RR*	95% CI*	Poisson model-adjusted RR†	95% CI
Total	767	54,845,247	2.80				
Sex							
Males	345	18,783,500	3.67	1.57	1.36, 1.81	1.19	1.03, 1.39
Females	422	36,061,747	2.34	1.00		1.00	
Job							
Stocker/receiver	537	29,508,190	3.64	2.00	1.72, 2.34	1.62	1.38, 1.91
Department manager	230	25,337,057	1.82	1.00		1.00	
Age (years)							
≤25	254	14,600,844	3.48	1.54	1.29, 1.83	1.19	0.99, 1.42
26–36	255	17,413,936	2.93	1.30	1.09, 1.54	1.21	1.02, 1.44
>36	258	22,830,467	2.26	1.00		1.00	
Duration of employment							
<8 months	147	3,974,245	7.40	3.53	2.90, 4.30	2.60	2.10, 3.22
8 months–2.3 years	313	21,582,922	2.90	1.38	1.18, 1.62	1.18	1.00, 1.39
>2.3 years	307	29,288,080	2.10	1.00		1.00	

\* RR, rate ratio; CI, confidence interval.

† Adjusted for all other risk factors.

**TABLE 3. Back Injury incidence rates and rate ratios for males and females, controlling for job and duration of employment, 260 retail stores, United States, 1994–1995**

Duration of employment tertiles and job category	Sex	No. of Injuries	Working hours	Incidence rate per 200,000 hours	Male/female rate ratio	95% CI*	
<8 months (short) Stocker/receiver	Female	42	1,263,746	6.65	1.00		
	Male	92	2,213,217	8.31	1.25	0.87, 1.80	
	Department manager	Female	9	322,193	5.59	1.00	
		Male	4	175,089	4.57	0.82	0.25, 2.66
8 months to 2.3 years (middle) Stocker/receiver	Female	101	6,896,129	2.93	1.00		
	Male	137	6,736,778	4.07	1.39	1.07, 1.80	
	Department manager	Female	52	5,574,853	1.87	1.00	
		Male	23	2,375,163	1.94	1.04	0.64, 1.70
>2.3 years (long) Stocker/receiver	Female	95	8,306,570	2.29	1.00		
	Male	70	4,091,750	3.42	1.50	1.10, 2.04	
	Department manager	Female	123	13,698,257	1.79	1.00	
		Male	19	3,191,503	1.19	0.66	0.41, 1.08
Department manager summary rate ratio† (males/females)					0.68	0.44, 1.06	
Stocker/receiver summary rate ratio† (males/females)					1.39	1.17, 1.65	

\* CI, confidence interval.

† Mantel-Haenszel summary rate ratio.

in the Poisson regression analysis in table 2. With a continuous term for duration of employment, the effect of age diminished further in size and significance (data not shown).

**Sex.** Table 3 shows a stratified analysis of incidence rates and male/female rate ratios. Controlling for duration of employment, a consistent pattern of higher rates for males than for females is evident for stocker/receivers (summary rate ratio, 1.39). On the other hand, the opposite pattern of lower rates for males versus females was apparent for department managers (summary rate ratio, 0.68).

**Duration of employment.** Figure 1 shows that the incidence rate for back injuries is strongly and negatively associated with duration of employment. The incidence rates and rate ratios by tertiles of duration of employment, controlling for other risk factors in a Poisson model, are given in table 2. Job- and sex-specific incidence rates and rate ratios for duration of employment are shown in table 4. Table 4 indicates that the individuals with a short or middle duration of employment had consistently higher back injury incidence rates compared with workers with more than 2.3 years of employment, independent of the effects of the job title and sex of the worker. Because as workers quit or change jobs they may leave behind a healthier group of "survivors" as duration of employment increases,

we examined in table 5 the association between back injury incidence rates and duration of employment within subgroups with less turnover and less job changing (hire date before January 1, 1994, and department managers). Table 5 shows that when the data are stratified by date of hire and job title and are additionally controlled for the balance of the risk factors in a Poisson model, the relative rate for short versus medium duration of employment varied only from 2.06 to 2.78.

**Job titles.** Table 2 shows that individuals working in stocker/receiver jobs were at 2.0 times the risk of back injuries versus those with department manager job title. When all other factors were controlled in the Poisson model, the stocker/receiver workers remained at 1.6 times the risk of back injury as the workers in the department manager job. The category stocker/receivers, which had the highest turnover rate and, hence, the shortest duration of employment, was somewhat confounded with the risk factor for duration of employment. Nevertheless, substantial excess risk for stocker/receivers remained after accounting for the effects of duration of employment. Because of the combined stocker/receiver job title, the excess risk for receivers, which is the job with the highest lifting requirement, is not distinguishable from that for stockers in this analysis.

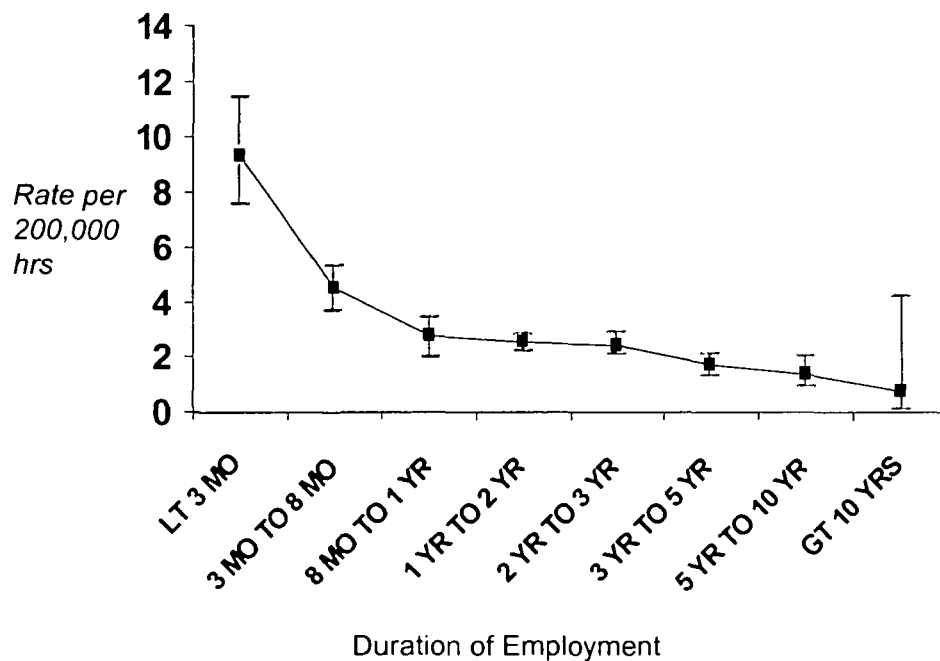


FIGURE 1. Back injury rates by duration of employment, with 95% confidence intervals.

## DISCUSSION

Much has been written about risk factors for work-related back injuries, and a few factors associated with work have been consistently identified as conferring excess risks, i.e., heavy lifting (27–29), extremely awkward postures (28), and whole-body vibration (30,

31). Workers in the stocker/receiver job title in this study had a 62 percent higher rate of back injuries than did department managers after other risk factors were controlled for. This finding is consistent with higher physical work requirements for the stocker/receiver job. However, for the basic epidemiologic factors of age, sex, and duration of employment, the lack of con-

TABLE 4. Back Injury incidence rates and relative rates by duration of employment, controlling for sex and job category, 260 retail stores, United States, 1994–1995

Job category and sex	Duration of employment tertiles	No. of injuries	Working hours	Incidence rate per 200,000 hours	RR*	95% CI*
Stocker/receiver Female	<8 months	42	1,263,746	6.65	2.91	2.02, 4.18
	8 months–2.3 years	101	6,896,129	2.93	1.28	0.97, 1.70
	>2.3 years	95	8,306,570	2.29	1.00	
Male	<8 months	92	2,213,217	8.31	2.43	1.78, 3.32
	8 months–2.3 years	137	6,736,778	4.07	1.19	0.89, 1.59
	>2.3 years	70	4,091,750	3.42	1.00	
Department manager Female	<8 months	9	322,193	5.59	3.11	1.58, 6.12
	8 months–2.3 years	52	5,574,853	1.87	1.04	0.75, 1.44
	>2.3 years	123	13,698,257	1.80	1.00	
Male	<8 months	4	175,089	4.57	3.84	1.31, 11.28
	8 months–2.3 years	23	2,375,163	1.94	1.63	0.89, 2.99
	>2.3 years	19	3,191,503	1.19	1.00	

\* RR, rate ratio; CI, confidence interval.

TABLE 5. Poisson models of rate ratios for duration of employment, 260 retail stores, United States, 1994–1995

Duration of employment tertiles	Total population (n = 31,076)		Date of hire before January 1, 1994 (n = 16,926)		Date of hire after January 1, 1994 (n = 14,149)		Stocker/receiver (n = 20,882)		Department manager (n = 10,213)	
	Adjusted RR*,†	95% CI*	Adjusted RR†	95% CI	Adjusted RR†	95% CI	Adjusted RR‡	95% CI	Adjusted RR‡	95% CI
<8 months (vs. 8 months–2.3 years)	2.20	1.80, 2.68	2.42	1.31, 4.47	2.18	1.71, 2.78	2.06	1.66, 2.55	2.78	1.55, 5.03
8 months–2.3 years (referent)	1.00		1.00		1.00		1.00		1.00	
>2.3 years (vs. 8 months–2.3 years)	0.84	0.72, 1.00	0.82	0.68, 1.00			0.85	0.69, 1.04	0.83	0.63, 1.11

\* RR, rate ratio; CI, confidence interval.

† Adjusted for sex, age, and job title.

‡ Adjusted for sex and age

sensus on these risk factors has led to opposite conclusions from literature reviews on occupational back injuries. It is possible to say that while few truly prospective studies of workplace back disorders have been carried out, several have reported consistent findings on age, sex, and duration of employment (10–13). The positive and null studies concerning duration of employment (16, 19, 21, 32–36) are mainly cross-sectional studies, which have the least ability to sort out temporal relations.

Our study found a strong association between shorter duration of employment and higher risk of back injury. A causal interpretation of this association is supported by two lines of evidence. First, workers may become more physically fit after a few weeks of heavy lifting. The military medical literature has examples of the highest rates of lower-extremity injury occurring among basic trainees during the initial 3 weeks of physical training, before muscles and bones have adapted to the intensity of physical training (37). Second, the moderate average physical work requirements of these workers (25) argue for the importance of peak loads and brief high-energy exposures rather than for a chronic disease process associated with consistently heavy workloads. Competing noncausal explanations are possible. First, the effect of duration of employment may be confounded by physical work requirements being greater in the workers with the least seniority. While this was not likely to be an issue in this population, it is more of an issue in populations with long durations of employment, greater job switching, and union seniority rules. Second, the healthy worker selection effect might reduce the rate ratio for the most heavily exposed workers and distort the risk associated with duration of employment. No simple adjustment for selection after hire is possible, unlike control for time since hire, which eliminates bias from the healthy hire effect (38). Four reports have proposed a selective process or high turnover rates as reasons why the most heavily exposed work-

ers in some worksites may have injury rates that are underestimated (39–42). Reasons for turnover may vary across industries and are likely to involve health-related reasons and non-health-related (pay or work pace) reasons. When we stratified the data on factors including varying 12-month turnover rates, we found that the negative association of duration of employment with back injuries was maintained. Clearly, additional work on populations with high rates of worker turnover is warranted, since high turnover and job switching are characteristics of jobs with elevated rates of musculoskeletal injuries (41–43).

Age had a weak negative association with injury in this study. No consensus on the effect of age has emerged from the vast epidemiologic literature on work-related back pain. One literature review stated that the relation of back problems to age is not yet fully understood (9). Another review said that age has a different effect on worker's compensation reports than on symptom surveys, in an attempt to explain increasing prevalence rates of back symptoms with increasing age in cross-sectional surveys, but decreasing rates of worker's compensation reports with older age in an historical cohort study (44). There is substantial evidence that the spine deteriorates with age and, in particular, that the load-bearing capacity of the spine diminishes with age (45). Age may operate in occupational cohorts as sex does; aging workers may be less well matched to the strength requirements of the job and, hence, less able to make dynamic adjustments as required. However, we saw no evidence of a positive age effect in this retail worker cohort, and this may have been due to the strong negative association of the short duration of employment with risk of injury in young workers. Because older workers may be placed in less physically demanding jobs within the same job title, a positive association between the incidence of back injuries and worker age may be difficult to observe in occupational cohorts that have not analyzed physical work requirements at the level of tasks rather than jobs.

The prevalence or incidence of symptoms of low back pain have been reported to be the same for men and women (8, 44), while data from state workers' compensation claims have shown a consistent twofold excess rate for men (3). The latter results are attributable to the fact that men and women perform different tasks within the same job titles, so that exposure differences have not actually been accounted for (46). Most studies reporting sex ratios have been cross-sectional by design (14, 18, 19); apparently, very few studies have had both sufficient men and women included and a prospective design permitting calculation of incidence rate ratios for the sexes.

Back injury rates for males appeared to be higher than those for females in the overall analysis of the data, but the overall rate ratio was biased due to confounding of the physical job requirements with sex in the stocker/receiver job category. When stratified analyses were carried out separately by job title, female department managers were found to have higher rates than did male department managers. A number of other occupational cohorts or case-control studies have shown a moderate excess back injury rate for female workers, when job titles contained adequate information. In a large historical cohort of home improvement store workers, females were found to have a 20 percent excess risk after controlling for age, length of employment, and job title-based lifting intensity (10). A large case-control study of postal workers reported an odds ratio of 2.0 for females versus males after controlling for age, job lifting requirements, history of back injury, duration of employment, and job change (11). A large cohort study of aerospace workers found that women had fewer injuries than did men, although it was not apparent that denominators or person-time were included in the analysis (12).

The lower rates observed for males are consistent with those for other cohort studies and with the fact that, on average, men are better matched to the strength requirements of job tasks. Confounding of results by unmeasured differences in physical work requirements may be quite common and unrecognized in occupational studies that rely heavily on job titles to present accurate information on work exposure. This type of bias when using job titles is clearly a problem when making comparisons between injury rates for males and females. In future occupational cohorts concerned with back injuries, investigators should ensure that if physical work requirements are assessed by job titles rather than by questionnaires, the job titles must have homogeneous lifting or physical load requirements for men and women.

This study, despite its advantages of a historical prospective study design, does present some limita-

tions. Reporting of injuries to the employer may not be consistent over time and may involve some type of selection process compared with reports from independent symptom surveys. This study had a limited range of exposures. The lowest exposure group, department managers, did not represent a group unexposed to manual material handling. To estimate the effect of lifting or heavy work with precision would require estimates of duration and frequency of specific tasks rather than of job titles. This population had a limited duration of employment compared with many other occupational cohorts; the median was less than 3 years. However, short job tenure and high turnover are characteristic of this industry. Gender effects were estimable only in the lowest exposure group in this study, another limitation due to the reliance on job titles as the basis for lifting exposures. Some different types of analyses might shed more light on the acute versus the chronic model of injury or pain causality. One alternative would be to establish more precisely the relation of job status to injury by using time-to-event models that update exposure status. In this study, the job assigned was the most frequent job held. Because information on jobs was available only for the job reported at the end of the calendar quarter, the detail for alternative analyses in this data set was inadequate. Height, weight, smoking history, and history of previous injury, which have been included in past studies, were not assessed in this study. A prospective study design that includes information on transient exposures contributing to acute or instantaneous risk would also be of use in sorting out the effects of time-related factors (47).

The most important result of this study concerning causal models of back injury was a strong association of increasing duration of employment with declining injury rates independent of physical work exposures, sex, and age. This result suggests that most of the injuries in these workers have a very short induction time, days or weeks, which is contrary to the theories of cumulative trauma and aging of the spine as a source of occupational back problems. However, there is still a need to model more comprehensively the effects of worker turnover and job switching, since the selection forces that contribute to turnover are unmeasured and may bias estimates of both work exposure and time-related factors.

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