

Obesity and Workers' Compensation

Results From the Duke Health and Safety Surveillance System

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Background: Obese individuals have increased morbidity and use of health services. Less is known about the effect of obesity on workers' compensation. The objective of this study was to determine the relationship between body mass index (BMI) (calculated as weight in kilograms divided by height in meters squared) and number and types of workers' compensation claims, associated costs, and lost workdays.

Methods: Retrospective cohort study. Participants included 11 728 health care and university employees (34 858 full-time equivalents [FTEs]) with at least 1 health risk appraisal between January 1, 1997, and December 31, 2004. The main outcome measures were stratified rates of workers' compensation claims, associated costs, and lost workdays, calculated by BMI, sex, age, race/ethnicity, smoking status, employment duration, and occupational group. The body part affected, nature of the illness or injury, and cause of the illness or injury were also investigated. Multivariate Poisson regression models examined the effects of BMI, controlling for demographic and work-related variables.

Results: There was a clear linear relationship between BMI and rate of claims. Employees in obesity class III (BMI ≥ 40) had 11.65 claims per 100 FTEs, while recommended-weight employees had 5.80; the effect on lost workdays (183.63 vs 14.19 lost workdays per 100 FTEs), medical claims costs (\$51 091 vs \$7503 per 100 FTEs), and indemnity claims costs (\$59 178 vs \$5396 per 100 FTEs) was even stronger. The claims most strongly affected by BMI were related to the following: lower extremity, wrist or hand, and back (body part affected); pain or inflammation, sprain or strain, and contusion or bruise (nature of the illness or injury); and falls or slips, lifting, and exertion (cause of the illness or injury). The combination of obesity and high-risk occupation was particularly detrimental.

Conclusions: Maintaining healthy weight not only is important to workers but should also be a high priority for their employers given the strong effect of BMI on workers' injuries. Complementing general interventions to make all workplaces safer, work-based programs targeting healthy eating and physical activity should be developed and evaluated.

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OBESITY REPRESENTS A LARGE and increasing public health problem,¹ being a risk factor for overall mortality² and for most chronic diseases, including cancer, diabetes mellitus, cardiovascular disease, and musculoskeletal disorders.³⁻⁵ The economic costs related to obesity are also substantial and affect both the obese individuals and society as a whole.^{6,7}

See also pages 750 and 774

Because many Americans receive health insurance through their workplaces, the health care costs of obesity are a significant concern for employers of working-age adults.⁸ Increasing body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, is associated with greater costs to employee health plans,^{9,10} with obese workers having up to 21% higher health care costs compared with

those of recommended weight.¹¹ In 1994, the estimated cost of obesity to US businesses was \$12.7 billion, including \$7.7 billion in health care costs alone.¹²

Less is known about more direct costs of obesity to employers, such as work-related illness and injury. While some studies have assessed the effect of indirect costs such as absenteeism^{13,14} and presenteeism,^{15,16} workers' compensation is not often included in such analyses but represents real health-related costs. In California in 2000, workers' compensation accounted for almost one quarter of all direct and indirect employer health care costs attributable to obesity.¹⁷ Little is known about the effect of body mass on workers' compensation claims, despite evidence that health risk factors in general are associated with increased claims¹⁸ and that obesity raises the likelihood of unintentional injury.¹⁹

Certain kinds or causes of injuries may be related to increased weight. Obesity is as-

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sociated with musculoskeletal problems, especially in the lower back,²⁰⁻²² knee,^{23,24} hip,^{25,26} and wrist.^{27,28} Therefore, it is of interest to consider which illnesses and injuries occur most frequently in the workplace for employees of differing weights.

Using an integrated surveillance system based on administrative data from a large health care system and university, the objectives of the present study were as follows: (1) to longitudinally investigate the relationships between BMI and workers' compensation claims, associated costs, and lost workdays; (2) to determine whether these relationships are confounded by demographic, work-related, and other health risk factors; and (3) to investigate the primary drivers (body part affected, nature of the illness or injury, and cause of the illness or injury) of any relationships found.

METHODS

DUKE HEALTH AND SAFETY SURVEILLANCE SYSTEM

The Duke Health and Safety Surveillance System is a comprehensive data repository for all Duke University Health System and Duke University employees. The Duke Health and Safety Surveillance System was developed around several ongoing programs and existing data sets, including human resources, health benefits, industrial hygiene, occupational medicine, workers' compensation, and employee health promotion.²⁹ A key feature is the ability to link data from multiple sources to define the population of employees and their demographics, occupations, work locations, potential exposures, and health outcomes. The system enables comprehensive surveillance of occupational exposure hazards, occupational injuries, and occupational diseases and, while protecting confidentiality, permits individual-level analyses. All data are deidentified per the requirements of the Health Insurance Portability and Accountability Act of 1996 using an external independent contractor.

COHORT DEFINITION AND FOLLOW-UP

The Duke Health and Safety Surveillance System includes data from a health risk assessment (HRA) (Insight questionnaire; Johnson & Johnson, New Brunswick, NJ), available annually to all employees eligible for health benefits. Participation is voluntary. The HRA includes questions about physical activity, nutrition, tobacco use, height (using a portable stadiometer [SECA Corp, Hanover, Germany]), and weight (using a standardized scale [Tanita BWB 800S; Tanita Corporation of America, Inc, Arlington Heights, Ill]). Blood pressure, total cholesterol, and nonfasting glucose levels are measured.

The study cohort was defined as all employees with at least 1 HRA between January 1, 1997, and December 31, 2004. The first available HRA was used to define the start date of follow-up for each cohort member, and time at risk was accumulated until employee termination, disability, or the study end date (December 31, 2004). The first HRA was used to determine obesity classification and cigarette smoking status (fixed covariates). Individual demographic and job characteristics (sex, age, race/ethnicity, employment duration, and occupational group) were updated for each year of follow-up (time-varying covariates). Employment dates and work schedules were used to estimate full-time equivalents (FTEs) for each cohort member by follow-up year (each employee contributes 1 FTE per year of full-time employment).

To assess selection bias and generalizability of the study results, we compared the study cohort to the population of all Duke University Health System and Duke University employees in the study period (1997-2004). For that population, follow-up began on January 1, 1997, or the first date of employment if later than that date.

WORKERS' COMPENSATION CLAIMS

Workers' compensation claims were the primary outcome measure. The workers' compensation benefit program provides medical care, income replacement (indemnity), and rehabilitation services to all full-time or part-time employees who are injured or contract occupational diseases during the course of employment. Workers' compensation is a state-legislated program administered by the North Carolina Industrial Commission. Duke self-insures employees for workers' compensation.

For each claim, the body part affected, nature of the illness or injury, and cause of the illness or injury are recorded, as is the number of days off work (lost workdays). Routine medical services associated with the claims are provided by Duke University's occupational health service, and these costs are not itemized. Medical claims costs are recorded in aggregate per workers' compensation claim and are only recorded for referrals for more serious illness and injury. Referrals represent approximately 25% of the claims, although being the more serious and expensive cases, they represent more than 25% of the total medical costs. Although recorded costs in our claims represent an underestimate of the total medical costs, these data are useful for comparisons of relative costs within the cohort. All indemnity costs are recorded.

All workers' compensation medical and indemnity claims in the study period were analyzed. "Report only" and first-aid only cases (including most blood or body fluid exposures [previously reported³⁰]) were excluded. Only claims on or after each individual's follow-up start date were included.

DATA ANALYSIS

Body mass index was categorized as follows: less than 18.5 (underweight), 18.5 to 24.9 (recommended weight), 25 to 29.9 (overweight), 30 to 34.9 (obesity class I), 35 to 39.9 (obesity class II), or 40 or higher (obesity class III).³¹ Smoking status was categorized as nonsmoking or as smoking 1 to 3, 4 to 9, or 10 or more cigarettes daily. Covariates included sex, occupational group, age group (15-34, 35-54, or ≥ 55 years), race/ethnicity (white, black, or other), and employment duration (ie, years with the current employer [< 1 , 1-4, 5-9, or ≥ 10 years]) (**Table 1**).

Overall rates of medical and indemnity claims (per 100 FTEs) were calculated by BMI and by each covariate. Lost workday rates (days per 100 FTEs) were calculated by multiplying these stratum-specific claims rates by their corresponding mean number of lost workdays per claim. Similarly, multiplying the claims rate by the stratum-specific mean costs (including the amount already paid and the amount reserved) allowed calculation of cost rates (dollars per 100 FTEs) separately for medical and indemnity claims costs. Confidence intervals were calculated assuming that the number of events followed a Poisson distribution.

Claims per 100 FTEs by BMI category were also broken down by body part affected, nature of the illness or injury, and cause of the illness or injury. Given the limited number of claims for underweight employees, they were grouped with recommended-weight employees in these analyses. For each body part affected, nature of the illness or injury, and cause of the illness or injury, a χ^2 test for trend (Mantel extension test)³² was used to determine whether there was a BMI effect.

Table 1. Baseline Characteristics of the Study Cohort Compared With All Employees, 1997-2004*

Characteristic	Study Cohort (n = 11 728)	All Employees (N = 74 060)†
Follow-up, mean, y	2.97	2.44
Body mass index category‡		Not available
<18.5 (Underweight)	2.0	...
18.5-24.9 (Recommended weight)	42.3	...
25-29.9 (Overweight)	29.9	...
30-34.9 (Obesity class I)	14.2	...
35-39.9 (Obesity class II)	6.8	...
≥40 (Obesity class III)	4.9	...
Sex		
Male	30.5	40.2
Female	69.5	59.8
Age group, y		
15-34	44.5	63.1
35-54	48.1	31.4
≥55	7.5	5.5
Race/ethnicity		
White	65.1	67.3
Black	27.1	21.5
Other	7.7	11.2
Smoking status (No. of cigarettes per day)		Not available
None	82.9	...
Occasional (1-3)	2.1	...
Light (4-9)	3.5	...
Heavy (≥10)	6.5	...
Unknown	5.0	...
Employment duration, y		
<1	24.1	50.6
1-4	41.7	30.5
5-9	12.7	7.7
≥10	21.5	11.3
Occupational group		
Laundry staff	0.3	0.1
All secretarial staff	21.2	10.2
Dietary service	1.1	0.8
Housekeeper	2.8	1.6
Inpatient nurse	9.9	7.3
Laboratory animal technician	0.4	0.1
Medical supply assembly	0.3	0.1
Nurses' aide	2.6	2.3
Odd job	2.2	13.5
Other clinical technicians	6.9	4.5
Outpatient nurse	3.1	1.4
Skilled craft worker	1.9	0.9
Other high-risk occupations	4.4	2.5
Low-risk referent group	43.2	54.8
Missing job information	<0.1	<0.1

*Data are given as percentages unless otherwise indicated. Because of rounding, percentages may not total 100.
 † χ^2 Test for differences between study cohort and all employees found significant differences ($P < .05$) for all characteristics.
 ‡Calculated as weight in kilograms divided by height in meters squared.

Multivariate Poisson regression models were developed to assess the relative effect of BMI category on claim rates, controlling for the other covariates. Similar models were developed for relative rates of lost workdays, medical claims costs, and indemnity claims costs. These latter models were overdispersed (ie, the variance was greater than predicted by the Poisson distribution); therefore, confidence intervals for the rate ratio (RR) estimates were adjusted using a scaling factor (square root of the model deviance divided by degrees of freedom).

Table 2. Workers' Compensation Claims*

Variable	Study Cohort	All Employees
Workers' compensation claims		
1997-2004	2539	11 452
Per 100 FTEs	7.28 (7.00-7.56)	5.47 (5.37-5.57)
Lost workdays		
1997-2004	19 828	146 159
Per 100 FTEs	54.00 (53.23-54.78)	69.82 (69.46-70.18)
Medical claims costs‡		
1997-2004, \$ million	5.1	32.0
Per 100 FTEs, \$ thousand	14.46 (14.44-14.46)	15.26 (15.25-15.27)
Indemnity claims costs		
1997-2004, \$ million	5.4	38.0
Per 100 FTEs, \$ thousand	15.41 (15.39-15.43)	18.17 (18.16-18.18)

*Data per 100 full-time equivalents (FTEs) are given as value (95% confidence interval).
 †For referrals to outside providers (ie, generally serious and nonroutine medical services).

An additional multivariate Poisson regression model interacting BMI (<25, 25-29.9, or ≥30) with occupational group (low risk, middle risk, or high risk) was developed. This model used fewer categories for BMI and occupational group to achieve convergence of the Poisson regression model and to assure greater model stability.

To evaluate potential selection bias, we performed several additional analyses. First, we compared the demographic characteristics of the study cohort with those of all Duke University Health System and Duke University employees. Second, we compared workers' compensation claim rates, lost workday rates, and cost rates between the 2 cohorts, stratified by BMI category, smoking status, and the demographic covariates. Third, we developed Poisson regression models for both cohorts using those variables available for both cohorts from human resources data (ie, all variables except BMI category and smoking status). This allowed comparison of RRs after adjustment for differences in the distribution of demographic characteristics. The Duke University Medical Center Institutional Review Board approved this study.

RESULTS

The study cohort included 11 728 employees (34 858 FTEs during the study period). Table 1 gives their characteristics at inception and compares them with the population of all employees (74 060 individuals with 152 796 FTEs). There were higher proportions of female, black, and older employees in the study cohort. The distribution by occupational group reflected the higher proportion of women in the study cohort, with more employees in jobs with higher female representation (ie, secretarial and nursing staff).

Crude rates of workers' compensation claims, lost workdays, and associated medical and indemnity claims costs for the study cohort and for all employees are given in **Table 2**. Overall, employees who completed an HRA were significantly more likely to submit a claim but had fewer lost workdays and somewhat lower claims costs.

There was a clear linear relationship between BMI category and claims rates (**Table 3**), with the rate for the

Table 3. Bivariate Models of Rates of Workers' Compensation Claims, Lost Workdays, and Claims Costs

Variable	Per 100 Full-time Equivalents			
	Claims	Lost Workdays	Medical Claims Costs, \$*	Indemnity Claims Costs, \$
Body mass index category†				
<18.5 (Underweight)	5.53	40.97	7109	3924
18.5-24.9 (Recommended weight)	5.80	14.19	7503	5396
25-29.9 (Overweight)	7.05	60.17	13 338	13 569
30-34.9 (Obesity class I)	8.81	75.21	19 661	23 633
35-39.9 (Obesity class II)	10.80	117.61	23 373	34 293
≥40 (Obesity class III)	11.65	183.63	51 091	59 178
Sex				
Male	6.99	64.78	18 626	21 064
Female	7.41	49.30	12 629	12 945
Age group, y				
15-34	7.36	35.32	9810	7820
35-54	7.30	53.74	15 578	17 517
≥55	7.02	100.46	20 443	23 991
Race/ethnicity				
White	5.47	43.43	12 353	12 571
Black	11.61	86.33	20 417	23 303
Other	5.95	12.59	8339	8018
Smoking status (No. of cigarettes per day)				
None	6.65	51.22	13 826	14 709
Occasional (1-3)	11.99	182.75	28 676	46 808
Light (4-9)	10.81	36.25	18 418	15 703
Heavy (≥10)	11.53	60.63	15 778	14 854
Employment duration, y				
<1	9.82	78.59	19 404	19 222
1-4	7.67	38.02	11 360	9748
5-9	6.82	30.52	10 797	8509
≥10	6.92	81.00	19 118	24 636
Occupational group				
Laundry staff	27.72	129.90	41 982	89 457
All secretarial staff	4.88	56.31	12 869	14 107
Dietary service	21.14	64.53	13 401	9361
Housekeeper	25.33	137.02	29 807	27 893
Inpatient nurse	12.27	123.12	30 633	41 515
Laboratory animal technician	62.91	62.91	26 483	13 482
Medical supply assembly	35.83	375.64	56 714	25 619
Nurses' aide	19.60	287.44	36 377	46 999
Odd job	17.97	184.81	29 310	15 303
Other clinical technicians	9.62	14.01	11 234	9038
Outpatient nurse	7.30	20.44	17 465	7940
Skilled craft worker	17.16	296.83	75 009	92 121
Other high-risk occupations	12.07	103.53	26 960	38 247
Low-risk referent group	2.97	8.68	5084	3907
Overall	7.28	54.00	14 451	15 412

*For referrals to outside providers (ie, generally serious and nonroutine medical services).

†Calculated as weight in kilograms divided by height in meters squared.

heaviest employees being twice that of recommended-weight employees. Because the number of lost workdays and the costs per claim also increase rapidly with BMI (**Figure 1**), the effects of BMI on lost workdays and costs were even stronger. The number of lost workdays was almost 13 times higher, medical claims costs were 7 times higher, and indemnity claims costs were 11 times higher among the heaviest employees compared with those of recommended weight.

Large differences in claims rates were also observed by occupational group. Jobs in the low-risk referent group included faculty, house staff, and scientific and administrative personnel. Much higher rates of claims were ob-

served for physically demanding jobs involving lifting or other ergonomic stress. High rates were observed among laundry staff, housekeepers, laboratory animal technicians, and medical supply assembly employees. Inpatient nurses and nurses' aides also had higher claim rates, reflecting tasks such as patient lifting and repositioning. Higher rates were also found among skilled craft employees involved with facility maintenance activities. The heterogeneous category of "other high-risk occupations" included employees involved with hospital sterilization, patient services, clinical supplies, and parking and traffic operations. Employees in several of the high-risk occupations were heavier than average (data not

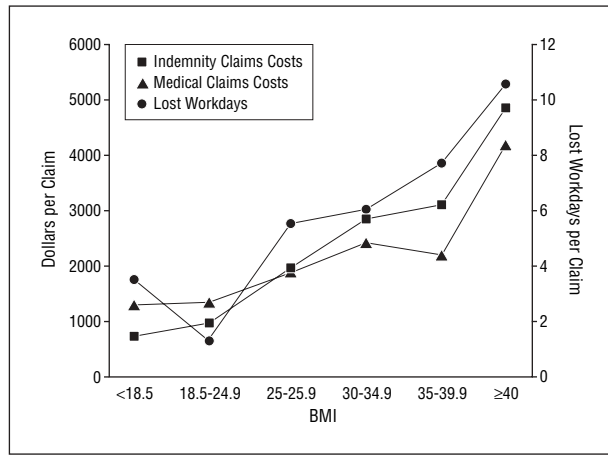


Figure 1. Mean indemnity claims costs, medical claims costs, and number of lost workdays per claim by body mass index (BMI) category. Body mass index is calculated as weight in kilograms divided by height in meters squared.

shown), emphasizing caution in the interpretation of the bivariate relationships.

Table 4 summarizes the relationship between BMI category and the claims RR, adjusted for covariates. Similar multivariate models are shown for lost workdays, medical claims costs, and indemnity claims costs. These models show a strong effect of BMI category on claims and an even stronger effect on lost workdays and costs. Women have a significantly lower RR for lost workdays and costs. The RRs for lost workdays and costs, but not for claims, were significantly elevated for employees 55 years or older. Black subjects were found to be at increased risk, possibly reflecting greater concentration in higher-risk jobs. Employment duration had a protective effect on all outcomes. The multivariate analyses substantiated the much higher risks for workers' compensation claims in selected occupational groups, including laundry staff, housekeepers, nurses' aides, inpatient nurses, skilled craft workers, and medical supply assembly employees. The effects of smoking status are mixed and are difficult to interpret. In the model interacting BMI category with occupational group (data not shown), employees with BMIs of 30 or higher and employed in high-risk occupations had a claims RR of 7.04 (95% confidence interval, 5.95-8.33) compared with employees with normal BMIs and low-risk jobs.

Figure 2A shows that the BMI effect is present for work injury or illness involving most parts of the body, but claims relating to the back, wrist or arm, neck or shoulder, and lower extremity (knee, foot, and hip) are common and are significantly associated with BMI category. Finger injuries, although common, were not significantly associated with BMI category. In terms of the nature of the work injury or illness (Figure 2B), sprain or strain, contusion or bruise, and pain or inflammation were the strongest drivers of the BMI effect (blood or body fluid exposure was significantly inversely related to BMI category). Claims caused by lifting, falls or slips, and exertion (a heterogeneous category) were most significantly affected by BMI (Figure 2C).

There were differences in the demographic characteristics of the study cohort compared with those of all

employees; these differences would be expected to affect overall crude rates but should have less effect on stratified rates and RRs observed in the Poisson regression models, which simultaneously adjust for demographic covariates. Poisson regression models were also developed for the study cohort and for the population of all employees. These models (data not shown) resulted in comparable parameter estimates and RRs, providing additional assurance that the study results are valid for the population as a whole.

COMMENT

Our results show that the effect of excess body mass on health care use extends into the workplace, with a strong effect of BMI on work illness and injury as reflected in rates of workers' compensation claims. Because the number of lost workdays and the costs associated with each claim also increase rapidly with BMI, the adverse effects on these outcomes are even stronger.

Obesity is associated with low back pain in general²⁰⁻²² and with disability and health insurance claims for back pain on the job.^{33,34} This association is confirmed in our data, with the back being a common body site of injury and with pain or inflammation being a common nature of injury in obese workers. Obesity also adversely affects the lower extremities (knee,^{23,24} hip,^{25,26} and ankle³⁵), wrists,^{27,28} and shoulder,³⁶ all of which are reflected in our study.

Our analyses also identified several occupational groups at greatly increased risk for workers' compensation claims, pointing to the need to identify causal factors and to develop appropriate interventions to reduce risks. Most high-risk jobs were associated with lifting and other ergonomic hazards. Newly hired subjects had higher injury rates. This could be due to "selective survival" but is more likely related to lack of training and experience.^{37,38}

To further reduce the rates of work illness and injury, a 2-pronged approach is needed comprising (1) continued general interventions to make all jobs as safe as financially and practically possible and (2) increased focus on improving workers' health. It is increasingly common for employers to support healthy lifestyle interventions such as healthy cafeteria food, on-site fitness facilities, and encouragement of physical activity during work breaks.³⁹⁻⁴¹ Our study lends support to the notion that such programs may not only improve the health of employees but also be financially beneficial.⁴² Increased workers' compensation costs are only part of the health-related costs to employers⁴³; the overall magnitude of benefits from healthy lifestyle interventions should be confirmed in intervention studies.

The economic benefits of reduced obesity should extend to employees as well. Employers are increasingly transferring health care costs to their employees through higher premiums, copayments, and deductibles. Although most of these costs likely fall on the obese workers, some are carried by normal-weight employees who are cost sharing.

Based on our findings of an adverse synergistic effect between obesity and certain job types and job situations, work-based health promotion and weight

Table 4. Multivariate Models of Rate Ratios of Workers' Compensation Claims, Lost Workdays, and Claims Costs

Variable	Rate Ratio (95% Confidence Interval)			
	Claims	Lost Workdays	Medical Claims Costs*	Indemnity Claims Costs
Body mass index category†				
<18.5 (Underweight)	0.81 (0.57-1.16)	3.21 (1.90-5.43)	1.02 (0.58-1.77)	0.78 (0.34-1.80)
25-29.9 (Overweight)	1.09 (0.98-1.21)	3.43 (2.81-4.17)	1.46 (1.26-1.68)	1.94 (1.63-2.32)
30-34.9 (Obesity class I)	1.21 (1.08-1.37)	3.39 (2.74-4.20)	1.95 (1.67-2.29)	2.95 (2.45-3.55)
35-39.9 (Obesity class II)	1.33 (1.15-1.53)	5.43 (4.34-6.80)	2.44 (2.03-2.94)	4.55 (3.72-5.56)
≥40 (Obesity class III)	1.45 (1.23-1.70)	8.04 (6.42-10.07)	5.36 (4.54-6.34)	7.71 (6.33-9.39)
Female sex‡	1.02 (0.93-1.13)	0.68 (0.59-0.79)	0.59 (0.53-0.67)	0.50 (0.44-0.57)
Age group, y§				
35-54	1.04 (0.94-1.14)	1.05 (0.90-1.24)	1.63 (1.36-1.96)	1.48 (1.25-1.76)
≥55	1.08 (0.93-1.25)	1.81 (1.49-2.20)	1.28 (1.11-1.47)	1.12 (0.82-1.53)
Race/ethnicity				
Black	1.28 (1.16-1.41)	0.91 (0.80-1.04)	0.98 (0.87-1.10)	1.04 (0.91-1.17)
Other	1.22 (1.01-1.47)	0.50 (0.31-0.81)	0.99 (0.76-1.30)	1.12 (0.82-1.53)
Smoking status (No. of cigarettes per day)¶				
Occasional (1-3)	1.14 (0.92-1.43)	2.56 (2.04-3.21)	1.58 (1.23-2.03)	2.32 (1.84-2.91)
Light (4-9)	1.10 (0.93-1.30)	0.56 (0.39-0.79)	1.15 (0.92-1.45)	1.01 (0.76-1.33)
Heavy (≥10)	1.27 (1.12-1.44)	0.76 (0.62-0.94)	0.85 (0.70-1.02)	0.74 (0.60-0.91)
Employment duration, y#				
1-4	0.88 (0.73-1.05)	0.57 (0.44-0.74)	0.65 (0.51-0.82)	0.55 (0.42-0.72)
5-9	0.76 (0.62-0.92)	0.43 (0.32-0.57)	0.57 (0.44-0.73)	0.43 (0.32-0.58)
≥10	0.64 (0.53-0.78)	0.82 (0.64-1.07)	0.74 (0.58-0.93)	0.88 (0.67-1.14)
Occupational group**				
Laundry staff	7.35 (5.14-10.50)	8.80 (4.62-16.77)	5.80 (3.50-9.64)	12.15 (7.97-18.53)
All secretarial staff	1.44 (1.24-1.66)	5.37 (4.19-6.88)	2.31 (1.93-2.75)	3.12 (2.53-3.85)
Dietary service	5.58 (4.41-7.07)	4.69 (2.83-7.77)	1.90 (1.18-3.05)	1.40 (0.74-2.63)
Housekeeper	6.44 (5.42-7.64)	10.19 (7.47-13.89)	4.21 (3.27-5.41)	4.17 (3.09-5.63)
Inpatient nurse	4.01 (3.46-4.64)	15.01 (11.65-19.35)	6.70 (5.59-8.03)	12.04 (9.79-14.81)
Laboratory animal technician	17.36 (13.74-21.93)	6.94 (2.97-16.23)	4.74 (2.62-8.57)	3.07 (1.21-7.78)
Medical supply assembly	9.18 (6.39-13.18)	22.34 (13.91-35.87)	6.18 (3.72-10.26)	2.63 (1.15-6.04)
Nurses' aide	4.98 (4.03-6.15)	26.94 (20.12-36.06)	5.82 (4.42-7.67)	9.06 (6.75-12.16)
Odd job	4.54 (3.59-5.75)	14.90 (10.64-20.86)	4.05 (2.93-5.61)	2.55 (1.56-4.18)
Other clinical technicians	3.13 (2.66-3.69)	1.39 (0.86-2.25)	2.07 (1.60-2.67)	1.97 (1.43-2.72)
Outpatient nurse	2.53 (2.01-3.18)	2.17 (1.28-3.66)	3.63 (2.76-4.77)	2.02 (1.31-3.11)
Skilled craft worker	5.43 (4.46-6.60)	20.24 (15.49-26.44)	9.37 (7.70-11.41)	11.96 (9.57-14.95)
Other high-risk occupations	3.65 (3.07-4.35)	9.25 (6.95-12.30)	4.47 (3.61-5.54)	7.27 (5.76-9.17)

*For referrals to outside providers (ie, generally serious and nonroutine medical services).

†Calculated as weight in kilograms divided by height in meters squared. Reference is 18.5 to 24.9.

‡Reference is male sex.

§Reference is 15 to 34 years.

||Reference is white race/ethnicity.

¶Reference is nonsmoking.

#Reference is less than 1 year.

**Reference is low-risk referent group.

control programs should not only target physical activity and healthy eating but also address the types of injuries obese individuals are more likely to sustain compared with their colleagues of recommended weight. Programs could also focus explicitly on preventing injuries to the body parts for which obese workers are at particularly high risk, namely, the back, wrist or hand, and lower extremity.

LIMITATIONS

Body mass index was only available for employees who had completed an HRA. However, in separate multivariate models that included employees not undergoing HRAs, risk estimates for the common variables were similar, suggesting that there were no major systematic dif-

ferences between the employees who did and did not undergo HRAs.

Because the employers' occupational health service provides care for minor occupational illnesses and injuries without itemized billing, the total medical costs are underestimated in our analyses. However, we found no differential referral to outside providers by BMI category (data not shown), providing support for the validity of our RR analyses of medical claims costs.

Shift work has been shown to be associated with injuries and related work absences.⁴⁴ Although information about shift work was unavailable in the database, there would need to be a relationship between shift work and obesity for this factor to confound the associations reported.

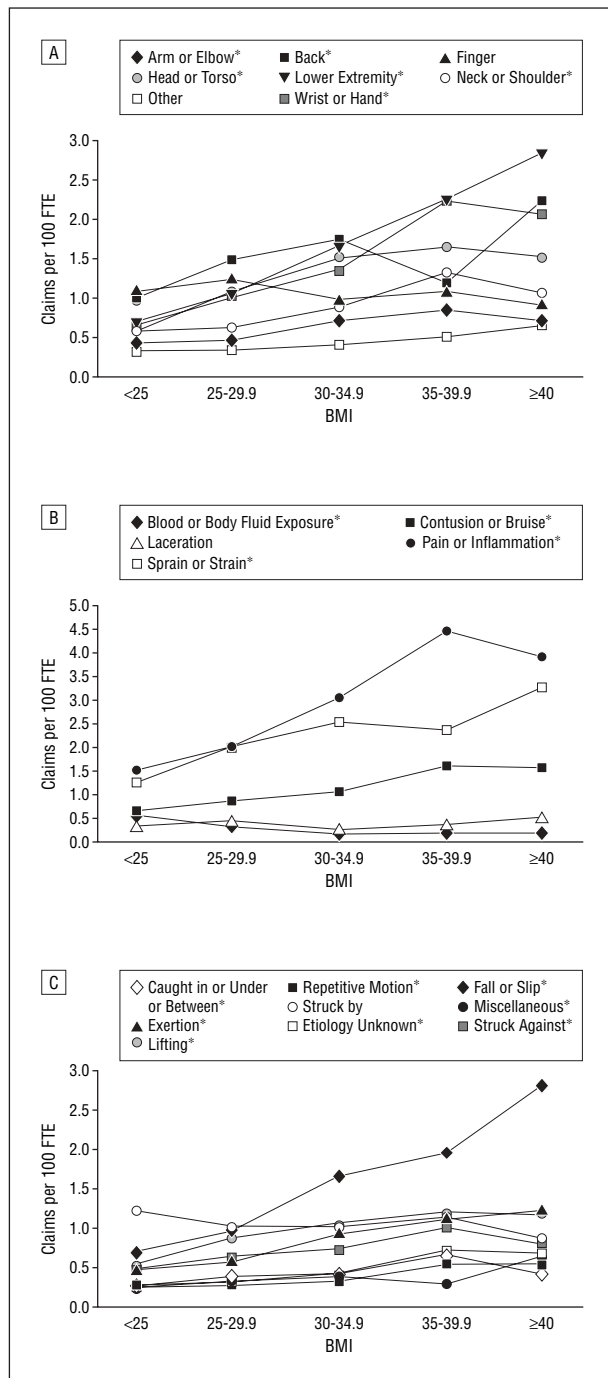


Figure 2. Claims per 100 full-time equivalents (FTEs). A, Body part affected, by body mass index (BMI) category. B, Nature of the injury or illness, by BMI category (includes only categories with ≥ 100 claims in total). C, Cause of the illness or injury, by BMI category (includes only categories with ≥ 100 claims in total). Body mass index is calculated as weight in kilograms divided by height in meters squared. * $P < .01$ (χ^2 test for trend).

Within each occupational group, it is possible that obese employees are at higher risk of adverse outcomes than those of normal weight. For example, if obese nurses (because of discrimination or for some other reason) are less likely to get promoted, they may be doing more of the heavy lifting. It is also possible that obese workers, given the same illness or injury, may be more or less likely to submit a workers' com-

pensation claim than a colleague of recommended weight; we cannot assess this possibility based on our data. Furthermore, there are potential underlying unobservable factors that might make obese individuals more likely to get injured independent of their weight. Education may be such a factor, although educational differences are, at least to some extent, adjusted for through occupational category.

Finally, there may be false-positive claims (ie, claims based on injuries primarily taking place outside of the workplace) and false-negative claims (ie, claims denied that truly should have been covered). In practice, the underlying cause of injury is likely to be multifactorial due to the environment outside of work and the worker's mental and physical health, as well as the job and work environment. This is an inherent problem in the study of work-related illness and injury, although it may be particularly relevant for our analysis, which involves individuals at high risk for health problems unrelated to their workplace.

STRENGTHS

These analyses are based on a comprehensive data set from a large employer, resulting in a large population for study. Although all data are from the Duke University Health System and Duke University, this employer is the second largest in North Carolina, and the results should be generalizable given the breadth and diversity of the study sample in terms of sex, income, race/ethnicity (27% black), and occupational group (ranging from low-risk university jobs to more "dangerous" hospital jobs²⁹). Our multivariate analyses of claims rates using the entire employee population provide additional support for internal validity and generalizability.

The primary predictor variable, BMI, is based on actual rather than self-reported height and weight, and the comprehensiveness of the data set allows for consideration of key confounding variables. The study cohort has high rates of overweight and obesity, lending itself well to answering the study questions. The longitudinal design of the study also strengthens the findings.

CONCLUSIONS

The National Institute for Occupational Safety and Health has traditionally targeted occupational safety issues. This focus has recently been complemented by increased attention to the overall health of workers, namely, health protection combined with health promotion.⁴⁵ Several ongoing initiatives target lifestyle issues, including tobacco control, alcohol and substance use, prevention of chronic disease, and (most relevant from the point of view of our study) obesity reduction through improved nutrition and increased physical activity. Maintaining healthy weight should be of strong interest not only to workers but also to their employers and to the workers' compensation system.

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