SYSTEMATIC REVIEW

Obesity and workplace traumatic injury: does the science support the link?

Keshia M Pollack, Lawrence J Cheskin

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See end of article for authors' affiliations

Correspondence to: Dr K M Pollack, Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, 624 N Broadway, Room 557, Baltimore, MD 21205, USA; kpollack@jhsph.edu

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Objective: To explore whether obesity is associated with non-fatal traumatic occupational injury.
Design: Systematic literature review.
Methods: The peer-reviewed literature was searched from 1 January 1980 to 31 December 2005 for studies on the risk of overweight and obesity on non-fatal traumatic occupational injuries among non-office employees. The search was conducted using Medline, eLCOSH, NIOSHTIC-2, CINAHL, PsycLit, and OSH-ROM. Studies were excluded that focused on military populations, chronic/repetitive workplace injuries, back pain, only height as a risk factor, or were not written in English.
Results: The search identified only 12 studies. The risk of injury for obese versus non-obese employees overall was slightly increased, although many of the estimates were not statistically significant. In studies in which increased risk estimates were shown, there was limited exploration of the mechanism of obesity-related injury, but the influence of chronic disease, fatigue or sleepiness, ergonomics, and physical limitations were most often hypothesized.
Discussion: With the current growing prevalence of obesity worldwide, more research is needed to better establish its impact on workplace injuries and lost work time. Studies are needed that use large diverse samples, advanced statistical methods, and control for potential confounders, and explore issues related to temporality. Gaining a better understanding of how obesity influences workplace injury may foster the development of interventions that address weight, while still emphasizing the important environmental and sociocultural risk factors for injury.

Roughly two-thirds of adults in the US are either overweight or obese.[1] Being obese is notably an independent risk factor for cardiovascular disease, type-2 diabetes, osteoarthritis of the knee and hip, and obstructive sleep apnea.[2–4] Aside from its association with chronic diseases, obesity may also be associated with traumatic injury. The impact of obesity on the risk and distribution of traumatic injuries has received some attention in recently published studies. Results from these studies indicate that obesity is associated, albeit often marginally, with traumatic injuries, especially during participation in sports or motor vehicle crashes.[5–10]

Injuries in the workplace can also be associated with obesity. Obese employees may be at increased risk of occupational injury for a number of reasons, including compromised gait and mobility, fatigue due to sleep apnea, poor ergonomic fit, and the use of potentially sedating medications to treat diseases associated with obesity. Furthermore, obesity may modify the risk of injury because the ability of the body to tolerate hazardous energy exposure is compromised, especially among employees who are already engaged in perilous and/or physically demanding occupations.

With the current prevalence of obesity and recent attention to its impact on injury, we initiated this study to determine if obesity warrants more attention as a risk factor for occupational injury. In this paper, we summarize the findings from a systematic literature review, offer suggestions for future research needs, and discuss the implications of the findings for efforts to prevent workplace injury.

METHODS

A systematic search of the peer-reviewed literature was conducted to identify articles. The following databases were searched: Medline, eLCOSH (Electronic Library of Construction Occupational Safety and Health), NIOSHTIC-2, CINAHL (Cumulative Index to Nursing & Allied Health Literature), PsycLit, and OSH-ROM. The following *a priori* identified Medical Subject Headings (MeSHs) and text words were used: body mass index OR BMI OR body weight OR body size OR body mass OR adiposity OR anthropometrics OR obesity OR overweight OR body habitus AND workplace OR occupation* OR job AND safety AND injur* AND occupational health. The search period covered articles published between 1 January 1980 and 31 December 2005. Articles were not limited to the US, but had to be published in English.

Peer-reviewed articles were included if they met the following criteria: (1) studied adults younger than 65 years; (2) included non-office employees; (3) provided rates, risk, or correlation estimates between non-fatal traumatic injury and obesity; (4) had a clear definition of traumatic injury, defined as damage to the body from an energy transfer with a short latency period between exposure and the health event.[11] In studies that listed ICD-9 codes, the lead author confirmed the injury case classification before deciding to include the study. Articles were excluded if they: (1) did not present data on occupational injuries; (2) examined weight gain after injury; (3) explored mortality; (4) evaluated cumulative injuries, chronic repetitive musculoskeletal disorders, or chronic back pain; (5) focused on office employees; (6) examined military populations; (7) evaluated only height as a risk factor.

Using individual key terms and word strings, the search strategy initially yielded 249 articles. After removal of inadvertently captured studies and stringent application of inclusion criteria, 12 studies remained and form the basis of this review. For a sample (5%) of identified articles, the lead author and a colleague were in 100% agreement with regard to their inclusion or exclusion. Although the methodological quality of the studies varied substantially, we included all identified

Table 1 Findings from 12 studies of body weight and non-fatal traumatic injury

Reference	Study aim and research design	Study population	Definition of body weight*	Definition of occupational injury	Association between body weight and obesity†
Heineman *et al*[12]	To identify risk factors for fireground injuries among professional firefighters; case–control study	1200 fire fighters in the Boston area	Self-reported height and weight from a telephone interview; Quetlet's index: weight (kg)/height (cm^2)	Lost work time injury (due to burns and falls) between 1/1/86 and 31/12/86	OR for BMI and fireground fall-related injury = 3.3 (0.5 to 22.8) when matched on position, size, and type of fire‡
Gauchard *et al*[13]	To determine individual employee characteristics associated with workplace injuries due to imbalance; case-–control study	427 male employees employed for 3 or more years by the French National Society of Railway	Weight and height measured at physical exams; BMI (only assessed risk for BMI ⩾30 kg/m^2)	At least one non-fatal occupational accident with sick leave between 1/3/99 and 29/2/00. Three categories of injuries: slip, trip, collision with a moving vehicle, or bad landing on the floor (when getting out of a vehicle)	OR for BMI ⩾30 and: slips (1.13 (0.53 to 2.44)); trips (1.33 (0.76 to 2.37)); bad landing (1.10 (0.42 to 2.89)). Adjusted OR for BMI ⩾30 and sick leave of ⩾8 days −2.07 (1.03 to 4.16), $p<0.05$
Chau *et al*[14]	To assess the relationships of job, age, and life conditions with the causes and severity of occupational injuries; case–control study	880 male construction workers	Physician measured height and weight; BMI dichotomized into ⩽25 and ⩾26	At least one occupational injury with subsequent sick leave between 1/1/95 and 31/12/96, and seen by an occupational physician; in workers with more than one injury, only the last injury was retained	Bivariate association between BMI and injury, $p<0.10$, and between BMI and hospitalization, $p<0.10$; difference in distribution of BMI for falls to the same level and falls to the lower level both had $p = 0.06$; OR for BMI ⩾26 and falls on same level = 1.85 (1.15 to 3.00), $p<0.01$, and falls to a lower level = 1.68 (1.19 to 2.37), $p<0.01$; stepwise forward procedure OR for BMI ⩾26 and falls on same level = 2.04 (1.30 to 3.21), $p<0.05$, and falls to a lower level = 1.66 (1.20 to 2.29), $p<0.05$; OR for BMI ⩾26 and sick leave >60 days = 1.32 (0.96 to 1.82)‡
Myers *et al*[15]	To examine the effects of anthropometric, ergonomic, and psychosocial factors on the risk of low back injury; case–control study	200 injured case patients and 400 controls of Baltimore City Municipal workers: education, public works, recreation and parks, transportation	Height and weight measured by interviewers within 10 days of an injury; BMI	Workers with incident reported back injury 1/3/90 – 1/4/91 who had been assigned restricted activity or lost work time	Mean BMI (27.9 and 27.0) different between cases and controls ($p<0.05$); OR for case and 1st control: 1.47 (0.99 to 2.19); OR for case and 2nd control: 1.67 (1.11 to 2.52); OR for case and both controls: 1.54 (1.09 to 2.16)
Bigos *et al*[16]	To evaluate the impact of low back injuries in manufacturing employees; cross-sectional study	31 200 hourly employees at the Boeing Company	Height and weight from claims	4645 injury claims (including 900 back injury) filed between 1/7/79 and 28/2/81	No significant differences in the height and weight, by sex, of back versus non-back injury claimants and of high- versus low-cost back injury claimants; data not shown
Kraus *et al*[17]	To determine the effect of back belt use on the incidence of back injury in home attendants; cluster-randomized trial	9 home attendant agencies employing 12 772 home attendants	Height and weight obtained at baseline (May–August 1997); BMI	Number of injury claims filed by each person over a 28-month period, from 1/6/97 to 30/9/99	Crude rate ratio for risk of injury and: underweight/normal (1.03 (0.57 to 1.86)); marginally overweight (1.39 (0.55 to 3.52)); overweight (1.29 (0.74 to 2.25)); severely overweight (1.41 (0.74 to 2.66)). Adjusted rate ratio for increasing BMI and injury (1.21 (0.98 to 1.50)). Adjusted rate ratio for risk of injury and: underweight/normal (1.22 (0.66 to 2.26)); marginally overweight/overweight (1.36 (0.55 to 1.06)); severely overweight (1.22 (0.73 to 2.02))
Ryden *et al*[18]	To examine the relationship between low back injury and individual and workplace risk factors. Case–control study	84 cases of low back injuries and 168 controls of hospital and health center employees	Medical records. Used the 1983 Metropolitan Height and Weight Table to classify employees as normal, overweight, or obese. Up to 30 lb = overweight for height (overweight); more than 30 lb = obese	Low back injury occurring during the work day, regardless of time lost or workers' compensation claim	Two-sample t test found no difference between cases and controls in terms of mean height and weight ($p<0.4$). Risk of injury and: underweight (1.47 (0.70 to 3.10)); normal weight (0.93 (0.30 to 2.82)); overweight (0.90 (0.25 to 3.19)); overweight/obese (0.91 (0.27 to 3.05))
Brown and Thomas[19]	To evaluate a number of risk factors for back injury among medical center employees. Descriptive study	233 medical centre employees	BMI, obtained from medical records. Height and weight taken when a claim was reported	Workers compensation claims that resulted in lost work time	71% of injured workers had a BMI>25; of these, 31% were obese and 11% were extremely obese‡. 67% of workers with a strain injury had a BMI>25‡. Association between increasing BMI and loss of productivity cost (Pearson $\chi^2 = 24.13$; df = 9, $p = 0.004$). Association between increasing BMI and injury site (Pearson $\chi^2 = 36.82$; df = 9, $p = 0.098$)

Table 1 Continued

Reference	Study aim and research design	Study population	Definition of body weight*	Definition of occupational injury	Association between body weight and obesity†
Wohl *et al*[20]	To assess the influence of family-related factors outside of work on a woman's risk of injury. Case–control study	1400 female manufacturing workers at a large aircraft manufacturing company, 1/1/89–31/12/89. 1400/4200 (33%) female manufacturing workers	Height and weight from company health records. BMI	Any woman who reported an acute traumatic work injury during calendar year 1989	Crude odds ratio for injury and: underweight (0.9 (0.3 to 1.7)); normal (referent); overweight (1.6 (1.0 to 2.6)); obese (1.5 (0.9 to 2.6)). χ^2 test for trend, p = 0.03. Adjusted odds ratio for injury and:‡ underweight (0.8 (0.4 to 2.03)); normal (referent); overweight (1.5 (0.9 to 2.6)); obese (1.7 (1.0 to 3.0))
Low *et al*[21]	To assess the incidence, diversity, and personal risk factors for farm injuries. Cross-sectional study	919 surveyed farms in New South Wales	Self-reported height and weight from a telephone interview. BMI	Injury that resulted in suspension of usual farm activities for 1 day, restriction for 5 days, or professional medical care	BMI and injury parameter estimate (on the logit scale) = 0.189, SE = 0.0615.‡ BMI by sleep interaction significant with injury‡
Bhattacherjee *et al*[22]	To assess the relationship of individual level risk factors on occupational injuries. Population based cross- sectional study	2562 employed individuals randomly selected from the population	Self-reported height and weight from a survey administered in 1996. BMI, three groups: $\leqslant$19, 20–24, $\geqslant$25 kg/m^2	Presence of at least one occupational injury in the 2-year period before the survey (1994–96). Occupational injury had to result in sick leave from work and lead to compensation	Distribution of incidence of injuries by BMI: $\leqslant$19 = 2.6%; 20–24 = 4.3%; $\geqslant$25 = 5.4%; p<0.01. Interaction of BMI and injury: partial likelihood ratio χ^2 = − 2.7, df = 2, not statistically significant‡
Froom *et al*[23]	To evaluate body weight as an independent risk factor for injuries in industrial workers. Case–control study	4306 men, 21 industrial plants in Israel: electronics, textiles, and furniture, food, and tire factories, and iron production plants	Weight and height measured at physical exams that occurred 1985–1987. BMI, Categorized as: <22.8, 22.8–25.3, 25.4–27.9, >27.9	On-site injuries with at least one day's loss of work 1986–1987. Injury categories: falls, struck by moving objects, caught in machinery, road accidents, and other. 870 injuries (707/3801 male workers)	OR for BMI and single injury versus no injury = 1.01 (0.92 to 1.09), p = 0.89. OR for BMI and two or more injuries versus no injuries = 1.25 (1.03 to 1.5), p = 0.02

*BMI, body mass index.
†OR, odds ratio; estimates reflect OR for BMI and injury (lower bound CI, upper bound CI).
‡No p value presented.

Key points

- Limited research was found that investigated the impact of obesity on the risk of workplace injury and injury sequelae.
- When an association between obesity and injury was present, most studies were unable to explore the mechanism of obesity-related injury, but the influence of chronic disease, fatigue, or sleepiness, and physical limitations were most often hypothesized.
- Future studies with a primary aim of measuring the risk of BMI and injury need sufficient sample size, should control for potential confounders, and should use appropriate statistical methods to adequately assess the independent contribution of obesity to risk of injury.
- Adding weight control strategies to workplace injury prevention programs can reduce the risk of chronic disease and its associated healthcare and personal costs; its impact on risk of injury remains unclear.

studies to better understand the scope of research on this topic. The publication year, study aims, design, sample, measurement of obesity, definition of workplace injury, and results were extracted for all reviewed studies. All used body mass index (BMI) to measure obesity; unless noted, BMI was calculated as weight (kg) divided by height $(m)^2$. When multiple outcomes were presented, only statistical findings related to the association between obesity and injury were abstracted. However, if an included study presented data on absenteeism or sick leave related to obesity, this finding was also reported. Although a meta-analysis was considered, this method was rejected because of concerns related to uncontrolled confounding in the observational studies included in this review.

RESULTS

Twelve studies were identified that investigated BMI as a risk factor for injury (table 1). Although there was heterogeneity among the industries represented in these studies, many of the studies investigated fall-related injuries (n = 3), back injuries (n = 5), or any occupational injury (n = 4). Studies also varied between the use of self-reported or objectively measured values for BMI calculations.

Two of the three studies of fall-related injuries reported non-significant risk estimates. One of these, a study of 1200 firefighters, showed a positive, although not statistically significant, association between BMI and falls (odds ratio (OR) = 3.3, 95% CI 0.5 to 22.8).[12] The other study that did not report statistically significant risk estimates was of risk factors for work-related slips, trips, or falls that resulted in sick leave among 427 railroad employees.[13] However, the authors did show that BMI was associated with increased odds of slips, trips, or falls that resulted in sick leave of 8 days or more (OR = 2.07, 95% CI 1.03 to 4.16).[13] BMI was significantly associated with falls in a study of workplace injury among 880 male construction workers.[14] In this study, being overweight was significantly associated with falls on the same level (OR = 2.04, 95% CI 1.30 to 3.21) and falls to a lower level (OR = 1.66, 95% CI 1.20 to 2.29).

Of the five studies that investigated back injuries, only one reported a significant association with BMI. Investigators used a case–control (200 cases and 400 controls) design to examine the risk of traumatic low back injury among municipal workers.[15] Weight was ascertained by trained interviewers, within 10 days of the injury, but the means of ascertaining height was not clearly stated. After potential confounders had been controlled for, the risk of traumatic low back injury was found to be increased for the case patient versus both controls (OR = 1.54, 95% CI 1.09 to 2.16). It is worth noting that the mean BMIs were significantly different between the cases and controls ($p<0.05$).

Risk factors for low back injuries were also explored using workers' compensation claims from a cohort of 31 200 employees.[16] Height and weight data were available for only 13% of the total claims filed during the study period. The researchers did not present the data related to BMI, but stated that the mean weights of male and female claimants for back and non-back injuries were not appreciably different. BMI was also explored in an intervention study of back belts and low back injury among 12 772 female home attendants.[17] With the use of self-reported height and weight, the crude and adjusted rate ratios were above 1.0 for the higher BMI groups (1.22–1.36), but none of the confidence intervals excluded the null value. This study relied on self-reported BMI, and despite having non-significant estimates, the authors conclude that BMI is an independent risk factor for injury.

A study of 84 cases of back injury also showed no association between increased body weight and injury among hospital employees.[18] With the use of height and weight obtained during physical examinations, odds ratios indicated a protective effect for all BMI groups, except for the underweight workers, who were at increased risk of injury (OR = 1.47, 95% CI 0.70 to 3.10)), which the authors stated ''approached significance.'' This study was based on a small sample of cases and may have lacked power to conduct comparisons. Height and weight were obtained from records of 233 medical center employees who filed a successful claim for back injury.[19] There was a higher prevalence of obesity and extreme obesity among the injured employees than the non-injured employees. There was also a significant association between increasing BMI and injury-related loss productivity costs ($p = 0.004$), but no significant relationship between BMI and injury site ($p = 0.098$).

Four studies explored risk factors for any occupational injury. Researchers in one of these studies collected height and weight from medical records of 4200 female manufacturing workers.[20] When compared with women with a normal BMI, the workplace injury risk estimates for overweight and obese employees were 1.5 (95% CI 0.9 to 2.6) and 1.7 (95% CI 1.0 to 3.0), but were not statistically significant.

A study using self-reported height and weight explored work-related injuries among 919 farmers. BMI was modeled as a continuous variable and on its own was not significantly associated with injury.[21] The authors also reported that farmers with a BMI less than 29 kg/m^2 had an increased injury rate, as their scores for daytime drowsiness increased. Another study of occupational injuries among 2562 employees included self-reported BMI as a risk factor for injury.[22] The results showed differences in the incidence of experiencing at least one injury across BMI categories ($p<0.01$). However, when the association between BMI and injury was assessed in a saturated log-linear model that included a second-order interaction parameter of BMI and injury, the interaction term was not significant (p value not shown). Despite this, the authors concluded that overweight employees had increased injury risk.

The most comprehensive study that we found of BMI and injury was on a cohort of 4306 men (BMI available on 3801) from 21 industrial plants in Israel.[23] Weight and height were obtained from physical examinations. After control for potential confounders, increasing BMI was associated with multiple injuries (OR = 1.25, 95% CI 1.03 to 1.50), but not single injuries (OR = 1.01. 95% CI 0.92 to 1.09). The authors state that it is unclear if weight reduction would lower injury rates, but that it perhaps could be used as another reason to lose weight.

DISCUSSION

This review was initiated to better understand the evidence on obesity as a risk factor for traumatic workplace injury. The growing national prevalence of obesity is a public health threat; as more research explores its impact on health, and its related costs in the workplace, we felt that a review paper on this topic was needed. We hypothesized that, if there was a strong association between obesity and injury, then efforts to prevent injuries in the workplace could benefit from obesity prevention strategies.

On the basis of our search criteria, we found insufficient evidence in the published literature to support a statistically significant relationship between obesity and traumatic occupational injury. The studies we identified varied substantially in methodological quality in terms of study design, measurement, modeling and classification of BMI, sample size, missing data, and the ability to control for potential confounders. Despite these limitations, conclusions were offered in some of the studies that weight reduction could prevent injuries or that prevention efforts should be targeted to overweight or obese workers.[14 15 22] Only one study clearly stated that it is currently unknown if weight reduction would lower injury rates (but that this perhaps could be another reason to encourage weight loss among obese employees).[23]

On the basis of currently published data, obesity does not clearly emerge as a prominent risk factor for injury. However, as the risk of injury was increased for obese workers in some studies, more studies with sufficient statistical power are needed before decisive conclusions are made. Future studies exploring this association should use a clear definition of injury and consistent and valid categories for BMI, include statistical significance tests, and explore issues related to temporality. Future research would also benefit from the use of company datasets that allow medical records, safety data, and other important risk factors to be merged. Merging these databases would allow the application of statistical methods that isolate the effect of BMI in the presence of additional or confounding risk factors. Workers' compensation files could also be used to retrospectively explore the association between injury claims and BMI, as height and weight are often collected. However, concerns about missing data need to be addressed, especially when workers' compensation data are used. In one study in this review, height and weight were missing in 87% of the workers' compensation claims.[16]

Exploring the potential mechanisms of an association between obesity and traumatic occupational injury may also be helpful in designing future studies. Sleep apnea, sleepiness, and fatigue were potential contributing injury factors. Obstructive sleep apnea is highly prevalent in obese people, and research supports an association between obstructive sleep apnea and fatigue, but also an association between fatigue and occupational injuries.[24–28] Thus, an obese worker would be more likely to have sleep apnea, more likely to be tired, and therefore, more likely to be injured. Another suggested mechanism is the generally poorer health of obese employees. Previous research supports a higher risk of workplace injuries for those who use medication regularly, especially antihistamines, diabetes or cardiac drugs, and antibiotics.[29–32] An obese worker may be at increased risk of injury because of side effects related to prescription drugs for conditions related to obesity.

Gait disturbances and physical limitations could also result in an injury. The few studies that explored adult obesity and biomechanics suggest that excess weight hinders gait and physical functioning.[33–35] Two other mechanisms, not mentioned in the included papers, are ergonomics and personal protective equipment. Required protective equipment may not be available in larger sizes or may be worn less regularly by obese workers because of lack of comfort. Poor ergonomic fit may result if an employee's physical workspace is not designed to adequately fit or sustain workers with larger body circumference. Cognitive and organizational ergonomic concerns may also adversely affect obese employees.

As with any literature review, there were some research limitations. Although we used a number of terms to capture all potential studies related to obesity, we may have missed studies that found a negative association between obesity and injury, but were indexed by terms related to the positive findings for other risk factors. This is a literature review challenge that is not unique to the present paper. The potential omission of studies with negative findings further supports the need for more research before the drawing of firm conclusions and development of weight reduction programs to reduce injury prevalence and risk.

Searching for unpublished studies can reduce publication bias, but this review included only peer-reviewed published studies. A few research studies that were described in conference proceedings looked at the association between obesity and traumatic injury in the workplace, but were not included in this review because it was not clear that they had been subjected to peer review. As we excluded laboratory studies, we may have also missed additional information on the nexus of obesity and injury, especially related to balance. We may have also missed some potential studies that were not published in English.

All of the included studies relied on BMI as a measure of obesity. Arguably, BMI is not the best measure of obesity, and studies have shown that BMI is an uncertain index of obesity, with particular misclassification for adults with BMI below 30 kg/m^2.[36 37] One study published after this review was completed did not find an association between BMI and workplace injury, and cited possible misclassification as a reason.[38] Although the waist-to-hip ratio or waist circumference may have advantages over BMI in predicting risk of obesity-related chronic disease, its association with risk of injury is unknown at this time. Also, in some studies, BMI was self-reported; some research suggests that self-reported weight is often underestimated.[39]

Implications for prevention of workplace injuries

Studying this association was not without concerns related to workplace discrimination. It is possible that an employer might seek to terminate the contract of obese workers because of injury risk concerns. Although the Americans with Disabilities Act (ADA) prohibits an employer from failing to hire extremely obese ($BMI>40\ kg/m^2$) individuals if they are qualified to perform the job, with or without reasonable accommodation, the application of the law to employees not classified as extremely obese is unclear.[40] Regardless, employers should be encouraged to participate in best practices in managing obese employees. However, in those instances where wrongful termination may have occurred, obese employees may seek redress through the courts. One example is the case of a 550-pound trucker in Oregon who was fired because his employer believed that he posed a risk to others on the road because the size of his stomach might impede his ability to turn the steering wheel. The courts cited discrimination and found in favor of the worker.[41]

Known health risks associated with overweight and obesity could certainly affect the work experience because of the large amount of time spent at work.[42] Designers of interventions for workplace injury prevention need to be cautious in assuming that weight reduction is necessary and sufficient to reduce workplace injuries. Reducing obesity may be beneficial for employees simply because of likely improvements in their health and reduction in direct and indirect healthcare costs and in the prevalence of related co-morbidities. It remains to be seen whether prevention of obesity in the workplace will have the added benefit of improving injury rates and reducing lost work time. Efforts to reduce workplace injury should continue to address the most salient and modifiable risk factors, namely those related to job design and tasks, physical environmental, and sociocultural factors.

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Authors' affiliations

Keshia M Pollack, Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA
Lawrence J Cheskin, Department of International Health, Division of Human Nutrition, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

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