There is increasing evidence that obesity and overweight may be related, in part, to adverse work conditions. In particular, the risk of obesity may increase in high-demand, low-control work environments, and for those who work long hours. In addition, obesity may modify the risk for vibration-induced injury and certain occupational musculoskeletal disorders.

We hypothesized that obesity may also be a co-risk factor for the development of occupational asthma and cardiovascular disease that and it may modify the worker’s response to occupational stress, immune response to chemical exposures, and risk of disease from occupational neurotoxins. We developed 5 conceptual models of the interrelationship of work, obesity, and occupational safety and health and highlighted the ethical, legal, and social issues related to fuller consideration of obesity’s role in occupational health and safety. (Am J Public Health. 2007;97:428–436. doi:10.2105/AJPH.2006.086900)

ASSOCIATION OF WORK AND WORK CONDITIONS WITH OBESITY AND BODY WEIGHT

Little research has examined the effects of occupational status and work conditions (including organizational factors) on BMI. BMI is assumed to represent the degree of body fat, but other measures may be better. Nonetheless, BMI has been widely used in studies of the impact of work on obesity.21

Twelve studies (mostly cross-sectional) were identified that have used some measure of job stress to test for associations with BMI.22–33 The demand–control model was used in 8 of these studies,22,24,26,28–30,33 and other measures of job stress were used in the remaining 4 studies, although none of these included the effort–reward imbalance model.34

Four of the studies with the demand–control model (high demands and low control) showed a positive statistically significant relationship with BMI,24,28–30 but the remaining 4 showed no association.22,26,31,33 Two of the remaining 4 studies that used other measures of job strain showed positive and statistically significant relationships with BMI.23,32 These studies did not fully control for physical activity, long hours spent at work, or shift work (all variables that have been associated with obesity in other studies).30

The relationship of nonpsychosocial work conditions to BMI has also been investigated. Using data from the National Population...
Health Survey in Canada, Shields demonstrated that, after statistical adjustment, men who worked more than 35 hours a week had an odds ratio of 1.4 for being overweight (BMI > 25 kg/m²). Long hours of work were not associated with overweight in women. Additionally, increased body weight has been reported among shift workers in developed countries, and shift work has been associated with BMI among Dutch men and women and among middle-aged Swedish women.

In a large, population-based Finnish cohort, unemployment was positively associated with BMI for men and women although the association was particularly strong for women with long histories of unemployment. Unemployment was also associated with greater BMI among a cohort of Swedish women. In a cohort of 14,799 Australian women aged 18 to 23 years, overweight and obesity were associated with unemployed status and low occupational and educational status. In addition, increased body weight has been reported over a 12-year period among shift workers in developed countries.

Yamada et al. hypothesized 3 ways that work could facilitate weight gain: (1) job stress could impact behaviors such as alcohol consumption and sedentary leisure activities that are related to weight gain, (2) psychological strain could lead to modification of endocrine factors related to weight gain, and (3) long work hours, shift work, and overtime could result in fatigue and inhibit behaviors that prevent weight gain and abdominal fat accumulation.

ASSOCIATION OF OBESITY WITH WORK PERFORMANCE AND HEALTH CARE COSTS

Obesity appears to have a significant positive association with absenteeism (measured as work loss days). Body fat distribution has been found to be associated with high annual sick leave incidence and long spells of absence in a Belgian workforce. In a banking company, workers with high BMI had additional health risks, short-term absences because of disability and illness, and higher health care costs than workers who were not overweight (no elevated BMI).

Obese workers were found to be 1.7-times more likely to experience a high level of absenteeism (defined as 7 or more absences because of illness during the past 6 months) and were 1.6-times more likely to report moderate absenteeism (3 to 6 absences because of illness during the past 6 months). Burton and Conti reported that obese workers also tended to incur greater productivity losses than nonobese workers.

Other studies have shown that a worker’s BMI classification predicts assignment to high health care cost and high-absence groups. The Insurance Information Institute anticipated higher costs for overweight workers:

Because overweight and obese people suffer from a higher incidence of chronic disease, including musculoskeletal disorders, recovery from any given injury or illness—including those that occur in the workplace or as a result of occupational exposures—is likely to be more difficult and more expensive than for normal-weight individuals.

In one analysis, obesity was shown to be associated with higher health care costs than were smoking, drinking, and poverty. It is important, however, to realize that there is not a simple causal link between obesity and these characteristics. Rather, the relationships are complex and not easily explained.

POTENTIAL IMPACT OF OBESITY ON WORK-RELATED DISEASE

Few studies have examined the role of obesity or excess body weight in the modification of risk of occupational diseases and conditions. Henschel reviewed the role of obesity in alteration of the intensity of response to the following 7 occupational hazards—heat exhaustion and heat stroke in hot environments, physiological strain during performance of hard physical work, respiratory strain and disorders during hard physical work, accidents involving equipment operators and other duties, decompression sickness, high altitude tolerance, and pesticide exposures—and concluded that obesity should be considered a significant occupational hazard. However, the cited literature in that paper was quite limited.

Evidence of varying strength suggests that obesity increases the risk of certain occupational diseases or conditions such as musculoskeletal disorders, cardiovascular disease, asthma, and vibration-induced injury. Obesity may also modify physiological responses to neurotoxins and immune responses to chemical challenges, many of which are found at work. Obesity may interact with occupational stress. The effectiveness or availability of personal protective equipment may be limited for obese workers. Also, although the role intake plays in the risk of certain cancers is generally well documented in animals, it is not known the extent to which an interaction occurs with occupational cancers. In the following subsections we review what is known about the effects of obesity or excessive body weight on various occupational diseases or conditions. We also offer hypotheses about potential interactions.

Vibration-Induced Injury

In the United States, approximately 1.5 million workers perform tasks in which they are exposed to upper-limb vibration. Depending on their occupation, 6% to 95% (average, 46%) of the workers exposed to upper-limb vibration will develop hand–arm vibration syndrome (HAVS). This syndrome can be characterized by vasospasms of the peripheral vasculature that result in blanching of the digits (white finger), reductions in thermal and tactile sensitivity, upper-limb weakness, pain, and reductions in fine-motor coordination.

Occupational factors such as exposure duration and amplitude of the vibration exposure serve as risk factors for developing HAVS. In addition, a number of personal health factors such as hypertension and diabetes are correlated with the presence of HAVS-related symptoms. Epidemiological studies that assess body mass demonstrate that the incidence of obesity and diabetes is increased in people with HAVS and other upper-limb musculoskeletal disorders. Damage resulting from obesity or obesity-related changes in physiology may compromise muscular, neural, and vascular tissues, making them more susceptible to vibration-induced injury.

Work-Related Asthma

Asthma occurs in 10% to 15% of the adult population and is more common in industrialized settings; it has been estimated that up to...
15% of all cases are associated with workplace exposure. No studies have addressed obesity as a risk factor in the development of work-related asthma; however, substantial attention has been devoted to obesity as a risk factor for asthma because of the observation of dyspnea in obese individuals. In general, excess fat tissue impairs ventilatory functions, although this is thought to be relatively mild except in cases of severe obesity.

Cross-sectional and prospective cohort studies have shown associations between obesity and asthma in children and in women. Associations between obesity and asthma in men are less clear; several prospective studies showed a limited association or showed a stronger association in women than in men. However, a recent study indicated that although women show a monotonic association between asthma and BMI, men show a U-shaped relationship, indicating that both extremes of weight are associated with a higher prevalence of asthma. Animal studies are more limited. One study indicated that immune mediators involved in asthma in mice are modulated in mice fed high-fat diets. In other studies, ozone-induced airway responses were increased in obese mice compared with controls.

Chemical Immunomodulation

No reported epidemiological studies have specifically indicated that obesity is a risk factor for microbial infections in adults, but several studies show increased infections in obese adolescents, which suggests that the immune system is affected by obesity. Evidence also indicates that wound healing is adversely affected in obese adults. Bhati et al. concluded from their studies that obesity, uncontrolled diabetes mellitus, and female gender are associated with higher infection rates. Chemical exposure in the workplace may lead to altered immune function, including both allergy and immune suppression. Immune suppression can lead to increased susceptibility to infectious agents.

Laboratory experiments support the biological plausibility of this relationship. Most experimental studies of the effects of obesity on the immune system have focused on the use of ob/ob leptin-deficient animal models. These animals show pleiotropic effects on a number of systems in the body, including altered states of immunity. Leptin-deficient mice demonstrate thymus atrophy with the thymic cortex being particularly sensitive. As leptin plays a role in protecting CD4+CD8+ cells from glucocorticoid-induced apoptosis, it may play an important role in chemical-induced immune suppression. Likewise, leptin may play a significant role in the development of allergy and the balance between Th1 and Th2 responses. Increased levels of leptin have been shown to support a Th1 response leading to T cell–mediated disease, whereas low leptin levels are more supportive of Th2 responses, increased levels of interleukin 4, and potentially immunoglobulin E–mediated disease. Obesity in workers that is not related to mutation of the ob gene may be correlated with increased levels of leptin.

Musculoskeletal Disorders

Musculoskeletal disorders are defined as structural damage, inflammation, or pain that results from injuries to nerves, tendons, muscles, blood vessels, or other supportive tissues associated with the musculoskeletal system. Certain workplace exposures are correlated with an increased risk for acquiring a work-related musculoskeletal disorders. These include exposures to repetitive movements, excessive loading, muscle overuse, and vibration. A worker’s health status may also affect the risk of acquiring a work-related musculoskeletal disorder. Only a few epidemiological studies have explicitly studied the joint effects of work, obesity, and musculoskeletal disorders. Various musculoskeletal disorders such as carpal tunnel syndrome and osteoarthritis have been associated with increased BMI or obesity in studies that control for work and nonwork risk factors. Obesity is also associated with type 2 diabetes. This condition has been linked to physiological changes in the cardiovascular, nervous, and skeletal muscle systems. It could be hypothesized that the pathophysiological parameters associated with obesity will increase the risk of acquiring a musculoskeletal disorder and impair the recovery mechanisms.

Neurotoxicity

Although no epidemiological studies have investigated the risk of neurotoxicity in workers as a function of BMI, recent studies provide evidence to show that low calorie intake decreases the risk of Parkinson’s disease and Alzheimer’s disease, whereas increased midlife adiposity serves as a risk factor for developing Parkinson’s disease. Together, these data suggest that the nervous system, like other organ systems, is vulnerable to the adverse consequences of obesity. Indeed, over the past decade, anecdotal and experimental data obtained with animals often suggest that rats and mice with increased body mass show exaggerated neurotoxic responses to diverse classes of known neurotoxic chemicals (e.g., organometals, substituted pyridines, substituted amphetamines). Thus, given the linkage between obesity and factors known or suspected to damage the nervous system, it could be hypothesized that obesity may enhance the susceptibility of the nervous system to toxic chemicals found in the work environment.
conditions such as depression. Furthermore, magnetic resonance imaging studies of the human brain suggest that excessive exposure to stress chemicals such as cortisol in Cushing disease or to extremely traumatic events is associated with shrinkage of brain areas important for cognition.92

Experimental work indicates that stress is linked to maladaptive remodeling of the brain, including atrophy of neurons and shrinkage of the areas and elements of the neuron responsible for communication. Remodeling is believed to play a role in links between stress and diseases such as addiction and dementia.93 Aberrant remodeling is also hypothesized to play a role in depression. It is also known that chemicals associated with the stress response (e.g., glucocorticoids, catecholamines) compromise the activation of pathways responsible for maintaining the structure and function of these same cellular elements. It is not known whether the brain of the obese or overweight person is more susceptible to the impact of stress. An important research question is whether obesity (especially intraabdominal deposition of fat) increases the susceptibility of the brain to stress-induced remodeling. It could be hypothesized that obese persons, especially those with intraabdominal fat, will show elevated stress signaling in the brain and will be more susceptible to stress-induced brain remodeling.

Cardiovascular Disease

The interplay between psychosocial stress at work and cardiovascular disease has been investigated.34,94,95 Despite various methodological issues, several reviewers and investigators have supported the hypothesis that the psychosocial aspects of work are related to the risk of developing cardiovascular disease.34,96 Obesity also is a known risk factor for cardiovascular disease, and the question is whether obesity modifies the association between workplace stress and cardiovascular disease.

Another hypothesis of cardiovascular disease development involves occupational risk factors (including carbon disulfide, arsenic, ultrafine dusts, or fumes) that modify atherosclerosis progression through induction of vascular oxidative and inflammatory effects.97–100 Adipose tissue mass, especially visceral fat, in addition to the endocrine and metabolic dysfunction, is also linked with increased production of proinflammatory mediators.101 Thus, inflammatory responses mediated by obesity and occupational exposure to chemicals or dusts may interact synergistically to increase the risk of atherosclerosis-related cardiovascular diseases.

Cancer

Energy restriction has long been known to impact the development of various cancers in animals that were administered chemical carcinogens.92–94 However, no studies have been specifically identified that explore the relationship of BMI to the development of work-related cancers in occupational cohorts. Despite associations of high energy intake with various cancers such as breast, colon, rectum, kidney, thyroid, and prostate, the more traditional occupational cancers such as lung and bladder cancer were found to be inversely associated with body weight. However, these analyses did not generally account for cigarette smoking or competing causes of death.103

Occupational Safety

Limited research has been done on the impact of obesity on worker safety. A few studies of work-related injuries have identified notable characteristics among injured workers, including increased BMI.105–108 Sleep-disordered breathing and obesity have been found to be risk factors in traffic accidents among commercial long-haul truck drivers.109 Various other transportation studies (particularly those that focused on seat belt use) have included BMI as a potential risk factor; however, the studies did not specifically address workers.103–102

Utility of Personal Protective Equipment

Although anthropometric characteristics have been shown to vary among occupations and should be considered in designing personal protective equipment, little information exists on the impact of obesity on personal protective equipment effectiveness or availability.111 Human physiological variables, including body weight, can affect respiratory performance during respirator tests and use.112 Body weight has also been a variable in research on fall protection, impact restraints,113 and the effectiveness of protective clothing.114,115 Because obesity has been shown to be a risk factor for soldiers training in hot and humid environments, it may also be assumed that this result pertains to workers, especially workers in protective equipment.117,118

CONCEPTUAL MODELS OF INTERRELATIONSHIPS OF WORK, OBESITY, AND DISEASE

On the basis of the literature described, it is possible to suggest various ways to view the interrelationship of work, obesity, and disease. Some are shown in testable conceptual models pictured in Figure 1. Although the models focus primarily on these 3 elements, each is subject to various cultural and social influences. Work is also depicted as a risk factor because of its organization or nature and because of exposures that might occur during work.

In model A, a workplace exposure leads to an occupational disease. This relationship may be modified by obesity or weight gain, so that the risk will be greater (or lesser) in the obese workers. Model B depicts 2 independent and possibly additive pathways to disease. Obesity may serve as an independent risk factor in one pathway, and workplace exposure in another. Model C shows a combination of models A and B, with work as the source of adverse environmental exposures as well as a contributor to obesity and the combination or each factor independently resulting in modified disease risk. Model D illustrates that workplace exposure may be an effect modifier of an obesity–disease relationship. Model E illustrates how obesity may cause a particular disease and workplace exposure may cause another disease and there may be some interaction between the 2 diseases. That is, having 1 disease may put a worker at increased risk of the other. These models are presented for heuristic purposes, but they still require testing and validation. Additional modification of these models could occur as preliminary data are corroborated with regard to the hypothesis that in utero or neonatal exposures to environmental chemicals (notably endocrine disruptors) play a role in the etiology of obesity.120

INTERVENTION

If work, obesity, and occupational health and safety are considered to have some
relationship, it may be useful to consider interventions that address them simultaneously. Some evidence exists that workers adhere better to health promotion guidance in a workplace setting when it addresses both workplace and personal risk factors, rather than just personal risk factors. Within the workplace, there is an opportunity to focus on interventions that realistically address the work organization and environmental factors that increase the risk for obesity.

However, there is a need for further work on strategies that merge traditional workplace health protection with workplace health promotion that relates to weight gain and obesity. This logically includes a focus both on the work environment and on individual options, choices, and behaviors. It is also useful to emphasize the role employers and workers could play in advocacy of not only social policy changes that affect workplace hazards, but also those that treat weight control as a national priority supported by environmental, economic, and social initiatives.

**ETHICAL, LEGAL, AND SOCIAL ISSUES**

To protect all workers, employers are responsible for providing workplaces that are free of recognized hazards. To the extent that obesity increases the risk of adverse health effects from certain occupational exposures, decisionmakers may have to consider strategies for effective protection of these more vulnerable workers. A major challenge will be to determine how to consider health consequences of obesity without using approaches that are prejudicial, discriminatory, stigmatizing, or punitive. Work-related areas where such considerations are likely to arise include worker privacy and autonomy, employment discrimination, risk communication, and workers’ compensation and tort liability.

**Worker Privacy and Autonomy**

Although work may convey other benefits, most people work to provide economically for themselves and their families and to obtain access to other work-associated benefits such as health insurance. People do not generally work to have their behavior changed or their health improved. As a result of the Health Insurance Portability and Accountability Act of 1996, workers have a reasonable expectation for personal privacy with regard to health information. This privacy expectation is reinforced by certain legal protections, especially with regard to confidentiality of health-related information.

Work-based programs that focus on individual behaviors may be perceived accurately as intrusive and insensitive to the privacy and autonomy expectations of workers. Obesity is a particularly sensitive personal issue, and workers may be appropriately resistant to interventions that appear to single out obese persons. Alternatively, these issues may be addressed by worksite interventions that benefit all workers, for example, by diversifying food choices in cafeterias and in snack and soda machines, increasing opportunities for exercise, or reducing work-related stress for all workers.

**Employment Discrimination**

Extensive evidence exists that shows bias against and stigmatization of overweight persons. This may lead to discrimination in employment practices that result in limited job choices and lower wages. Thus far, Michigan is the only state that prohibits employment discrimination on the basis of weight. Various misconceptions may lead to discriminatory action. For example, there is the possibility that findings of associations between obesity and work attendance such as described earlier in this article may be taken as causal when that has not been established or when other uncontrollable risk factors, such as age and genetics, confound the association.

One major concern is that attention to obesity in workers will devolve to “blaming the victim.” That is, only a worker’s behavior and attributes may be considered factors for intervention. This approach negates the knowledge that obesity is affected by environmental and organizational as well as genetic, societal, cultural, and economic factors. Obesity may be a bona fide consideration in job placement after a hiring decision is made (as are other health-related considerations), but it generally should not be a determinant in the hiring decision itself.

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**FIGURE 1—Models of the interrelationships of work, obesity, and disease.**

*Note. Adapted from Ottman.*
Whether obesity should be considered a disease, a disability, or a lifestyle condition will influence how it is treated in the workplace.\textsuperscript{5,138} No consistent record indicates whether obesity is considered a disability under the Americans With Disabilities Act.\textsuperscript{5,139} Similarly, the Centers for Medicaid and Medicare Services (formerly the Health Care Financing Administration) historically did not consider obesity an illness and did not make payments for obesity treatments, except in some cases when obesity was a consequence of another disease or was a direct cause of another serious condition.\textsuperscript{14} However, a ruling in 2004\textsuperscript{141} removed the language that “obesity itself cannot be considered an illness.” This step allows members of the public to request a review of their own medical evidence to determine whether treatments related to obesity would be covered by Medicare.

In addition, the Social Security Administration provides disability benefits for people who meet requirements and requires claim adjudicators to examine the effect of obesity on the ability to do basic work.\textsuperscript{142} Increased awareness of the health consequences of obesity may prompt some employers to consider obesity and weight gain when dealing with insurance, hiring, placement, and promotion, regardless of whether obesity is a disease or disability. Data on increased absenteeism, illness, mortality, and cost of obese workers are likely to be part of this consideration.\textsuperscript{40,43,44,143} Future research that identifies obesity as an effect modifier of occupational exposure—disease associations may be included in employer decisionmaking, raising significant social, ethical, and potential legal issues about how society deals with the concept of susceptibility.

Risk Communication

Sound scientific information that relates to modifiers of health risk from occupational exposures has been the focus of risk communication. For example, construction workers who smoked and were exposed to asbestos at work have been informed about the health risks of both hazards and the added risk to workers exposed to both.\textsuperscript{143,146} When sufficient information exists to include consideration of the role of obesity in worksite health communication, such communications will need to be fact-based and directed toward reinforcement of proven health-protective strategies. Because obesity can be a consequence of workplace exposures, an effect modifier, an independent risk factor, a co-factor, or a confounding factor, communications will need to be circumstance-specific and based on the best-available information. Group risk communication may have a different focus than individual risk communication. For the group, population concepts such as prevalence and variability might predominate. For the individual worker, clinical interpretation and individual risk are important.

In ordinary language, “obesity” may be considered a pejorative term despite the intention in its use. Furthermore, many obese persons may not recognize themselves as such. Moreover, a person’s overweight status does not automatically imply ill health.\textsuperscript{147} The range of opinions and perceptions about the relationship of obesity to personal responsibility, genetic determinism, and environmental pressures should be considered in risk communications.

If obesity is known to modify the effect of an occupational exposure, how should an employer portray the risks without inappropriately shifting responsibility to the worker? To answer this question, it may be useful to consider how employers and workers have handled other personal factors (such as smoking) that are known to modify occupational exposures (such as to asbestos).\textsuperscript{142}

Workers’ Compensation and Tort Liability

Workers’ compensation is supposed to provide partial or complete wage replacement and health care payments for people who experience a disease or injury caused by (or, in some instances, significantly exacerbated by) workplace exposures and conditions. Efforts have grown to limit the costs of workers’ compensation benefits provision in many jurisdictions. In some compensation systems, there are requirements to “apportion” the cause of a disease or injury among various work-related and nonwork factors and to compensate only for work-related causes.\textsuperscript{148} However, the ability to accurately determine the extent to which a worker’s disability pertains to work or nonwork factors is not a precise science. To the extent that effect modifiers such as obesity or genetic factors are involved, apportionment of causation to work-related factors may be reduced. The issue is further complicated by the fact that state workers’ compensation laws vary in terms of designation of obesity as an underlying medical condition related to specific injuries and illnesses.

CONCLUSIONS

Work and obesity both contribute to population morbidity and mortality as well as to attendant health care and societal costs, but each exists in a separate domain. Employers have traditionally been responsible for the prevention of work-related morbidity and mortality, but workers have been held responsible for the prevention of overweight and obesity. The 2 risks are likely to be interrelated, but the extent, nature, and temporality of these relationships have not been well studied. Research is warranted to explore how the work environment and work practices promote or discourage the development of obesity (and overweight in general) and to define the extent to which obesity acts to modify the risk of occupational diseases and injuries. This research can serve as the basis to determine the extent to which resources should be committed to this area and whether worksite alterations and programs are needed to reduce exposures or risks. In the meantime, it may be useful to consider selective strategies that address both work-related risk factors and obesity together. Such strategies will have to be sensitive to issues of language, prejudice, inappropriate apportionment of causality, and the various perceptions of employers and workers. Occupational morbidity and mortality and obesity are important, highly prevalent national problems. If it is more efficient to consider them together, the use of resources and health outcomes may improve.

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