Annals of Work Exposures and Health, 2021, Vol. 65, No. 3, 291–306
doi: 10.1093/annweh/wxaa098
Advance Access publication 30 October 2020
Original Article

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Work Characteristics, Body Mass Index, and Risk of Obesity: The National Quality of Work Life Survey

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Submitted 27 November 2019; revised 27 August 2020; editorial decision 1 September 2020; revised version accepted 24 September 2020.

Abstract

Objectives: To examine work characteristics in relation to body mass index (BMI) and risk of obesity.
Methods: We analyzed data from 1150 participants working 20+ h week^{-1} from the 2014 National NIOSH Quality of Work Life Survey, based on a representative sample of US workers. We used multiple linear regression for BMI and multiple logistic regression for obesity to estimate associations with 19 different work characteristics plus one set of occupational categories controlling for age, gender, race/ethnicity, education, marital status, job physical exertion, and television watching.
Results: We found significant positive linear associations between BMI and night shift (versus day shift) schedule ($B = 2.28$, $P = 0.008$) and blue-collar (versus management/professional) work ($B = 1.75$, $P = 0.008$). Night shift schedule [odds ratio (OR) = 2.19, $P = 0.029$], sales/office work (OR = 1.55, $P = 0.040$), and blue-collar work (OR = 2.63, $P = 0.006$) were associated with increased risk of obesity versus 'healthy weight'. No other statistically significant associations between work characteristics and BMI or obesity were observed.
Conclusions: Night shift schedule and blue-collar work were related to increased BMI and obesity risk in US workers in 2014. Identifying risk factors in blue-collar work and redesigning jobs to reduce those risk factors, and reducing night shift work, could play a role in reducing the prevalence of obesity in the USA.

Keywords: BMI; body mass index; obesity; Quality of Work Life survey; work characteristics

What's important about this paper

- This article provides evidence that both night shift schedule and blue-collar work are related to increased BMI and risk of obesity among US workers. This is important because it suggests that the design of shift schedule and other work factors can contribute to controlling the prevalence of obesity in the USA.

Introduction

Approximately 2.8 million people in the world are dying annually as a result of being overweight or obese (WHO, 2017). Obesity is associated with cardiovascular disease (CVD), diabetes, hypertension, and other chronic health conditions for which employers pay a large part of the related medical and productivity costs (Finkelstein *et al.*, 2010). The increasing prevalence of adult obesity, from 1999–2000 (30.5%) to 2013–2014 (37.7%) with a significant linear trend (CDC, 2015b; Ogden *et al.*, 2015) to 2017–2018 (42.4%) (CDC, 2020; Hales *et al.*, 2020) is one of the most alarming health trends in the USA. The overall prevalence of obesity among women was 4% higher than it was among men in 2011–2014 (Ogden *et al.*, 2015), suggesting a gender difference in overall risk of obesity among US adults. The obesity prevalence from combined Behavioral Risk Factor Surveillance System (BRFSS) data (2016–2018) was highest for Blacks (39.1%) and Hispanics (33.3%) compared with Whites (29.3%) (CDC, 2020), suggesting that some race/ethnicity groups are more at risk of obesity than others. The overall prevalence of obesity among US workers from all industries and occupational categories was 27.7%, with highest levels in: public administration (36.3%) and healthcare and social assistance (32%) industries and protective service (40.7%), community and social service (35.6%), and architecture and engineering (34.1%) occupations (Luckhaupt *et al.*, 2014), suggesting that employment in certain industries and occupations may have an effect on the overall risk of obesity among US workers.

Obesity is undoubtably a complex problem with many contributing factors, which may include various work characteristics (Schulte *et al.*, 2007; Pandalai *et al.*, 2013) and socioeconomic status (SES) (Zhang and Wang, 2004). Work characteristics range from work organization factors such as long work hours to psychosocial job stressors. Psychosocial job stressors include psychological job demands, job efforts, job insecurity, lack of job control, job rewards, and workplace social support. The job demand–control (or 'job strain') model (Karasek, 1979) emphasizes that job control buffers the impact of job demands on workers' stress responses and health. Job control, also called job decision latitude, has been operationalized as job decision-making authority and development and use of skills on the job (Hannerz *et al.*, 2004). The effort–reward imbalance (ERI) model (Siegrist, 1996) emphasizes both the effort and the reward structure of work. High ratio of effort spent at work, relative to reward received elicits sustained stress response and poor health. Efforts represent the job demands and/or obligations that are imposed on the worker, such as time pressure and working conditions. Rewards are distributed by the employer and may consist of money, esteem, and career opportunities. The model claims that stressful experience is most likely to result from an imbalance between high extrinsic effort and low extrinsic reward in combination with a high level of over-commitment. Workplace social support (Eisenberger *et al.*, 2002) is the extent to which workers perceive that their well-being is valued by sources within the workplace such as supervisors, coworkers, and the wider organization. Workplace social support has been operationalized as both coworker support and supervisory support. Job insecurity (Yashoglu *et al.*, 2013) is the difference between the level of security an individual experiences and the level they might prefer concerning the preservation of their employment status. Work–family imbalance (Kahn *et al.*, 1964) is a form of interrole conflict that happens when participating in one role interferes with participation in the other. Hostile work environment includes exposure to threats, bullying, or harassment on the job (Luckhaupt *et al.*, 2014). Long work hours (Luckhaupt *et al.*, 2014) is working more than the standard 40 h $week^{-1}$. A large number of these work characteristics have been shown to have associations with various health outcomes, including body mass index (BMI) and obesity in some studies.

Much of the previous work stress and obesity research focused on the demand–control model (Karasek, 1979; Berset *et al.*, 2011; Solovieva *et al.*, 2013) or the ERI model (Siegrist, 1996; Berset *et al.*, 2011; Solovieva *et al.*, 2013). Some authors reported positive associations between psychosocial job stressors and BMI (Kouvonen *et al.*, 2005; Fernandez *et al.*, 2010) and obesity (Kuper and Marmot, 2003; Fernandez *et al.*, 2010) whereas other authors reported no such associations (Landsbergis *et al.*, 1998; Brisson *et al.*, 2000;

Lallukka *et al.*, 2008b; Choi *et al.*, 2010). Several reviews have also been conducted. Solovieva *et al.* included 36 articles that were published between 1995 and 2012 in a systematic review and found weak and inconsistent associations between psychosocial job stressors and obesity, but positive associations between long work hours and obesity. Of the articles used in their review, 34 (94%) examined associations with job demands, job control, or job strain, while 7 examined the ERI model, and only 4 examined job insecurity. None examined work–family imbalance or hostile work environment, and none examined more than five different work exposures. Kivimäki *et al.* (2015) conducted a systematic review and meta-analysis of eight studies and found no associations with obesity, but only examined job strain. Sun *et al.* conducted a systematic review and meta-analysis of 28 studies and found an increased risk of obesity, but only examined shift work. Luckhaupt *et al.* (2014) using data from 2010 National Health Interview Survey (NHIS), reported that US workers employed for more than 40 h week^{-1} and exposed to a hostile work environment were significantly more likely to be obese. These authors examined a variety of work exposures: work schedule, hostile work environment, job insecurity, work–family imbalance, and industries and occupations of employment. They provided more evidence of additional work-related risk factors for obesity, at least in part. However, there are several other important stressful work characteristics that were not captured in their study or have not been well studied previously.

Qualitative studies, among low income US workers (Dobson *et al.*, 2013; Nobrega *et al.*, 2016), used focus group discussions to obtain workers' perspectives on working conditions believed to have an impact on their body weight or contribute to their obesity. Workers in all groups perceived some features of psychosocial job stressors, work organization, work scheduling, or workplace food environment to negatively affect their weight status. Such factors, if they are increasing, may help explain why the US prevalence of obesity is increasing. Greater knowledge of a wider range of occupational risk factors for overweight and obesity may better help target prevention efforts and thus help to reduce the US prevalence of obesity and the global burden of diseases associated with obesity.

In view of the extensive literature studying the effect of work stressors on subsequent obesity, it is remarkable that none to date have examined this topic using the National Institute for Occupational Safety and Health (NIOSH) Quality of Work Life (QWL) survey. The NIOSH QWL survey, unlike any other in the USA, was developed using a wide range of work characteristics to capture changes in work life and experience and to help maintain a baseline for future research. Based on our current knowledge, there is no baseline study to help guide future work stress and obesity research using data from the QWL survey. There is also a need for more national studies in the USA and in other countries on this topic to strengthen similar findings. Marchand *et al.* (2015) investigated various work characteristics in a Canadian national cohort of 3024 men and 2901 women ages 18–64 years. Of the work characteristics evaluated, including job demands, social support, job insecurity, decision authority, work hours, and work schedule, only decision authority was associated with obesity. In an earlier UK based study, Brunner *et al.* (2007) conducted a prospective study that examined dose–response effects on the degree of obesity. Using a representative sample of workers from different employment grades, they found that low work social support is associated with higher odds of waist obesity and greater reports of work stress is associated with higher odds of BMI and waist obesity, all in a dose–response manner.

The present study covers many aspects of the work environment to extend earlier studies. It also adds to the small number of studies that reported on BMI and obesity, simultaneously (Brunner *et al.*, 2007; Fernandez *et al.*, 2010). Additionally, our study examines a wider range of work characteristics than in previous national US studies on this topic, including the MIDUS ll study (Choi *et al.*, 2010) and the NHIS (Luckhaupt *et al.*, 2014). We fill a research gap by expanding the understanding of associations with a wider range of work characteristics than those available in the 2010 or 2015 NHIS, by using the 2014 QWL data and BMI as a continuous variable and obesity as a categorical variable. Our study using this data set provides an important foundation for further evaluation of health outcomes with a wide range of potentially stressful work characteristics.

SES may modify the associations between work characteristics and obesity, as well as being a risk factor for obesity. For example, adults with college degrees had a lower prevalence of obesity when compared with those of less education (CDC, 2020). Therefore, a greater understanding is needed of whether SES inequalities in working conditions are increasing and if working conditions are associated with obesity, thereby helping to explain increases in the overall prevalence of obesity.

We hypothesized that there is an association between psychosocial job stressors (including high job demands, low job control, and low workplace social support), work schedule factors, and both BMI and risk of obesity. We also hypothesized that these associations are stronger:

(i) among low SES workers than high SES workers and (ii) among individuals working long hours compared with those working a standard 40 h week^{-1}. In addition, we hypothesized that the associations are stronger for gender discrimination among women and for race discrimination among Blacks. Fig. 1 represents the hypothesized conceptual framework of the relationships between work characteristics and obesity that guide our study.

Methods

Study population

We used data from the 2014 QWL study, with sample size of 1249 and response rate of 69%. The QWL study was developed and conducted by NIOSH to measure change in work life experience, assess relationships between work characteristics and worker health and safety, assess trends in work characteristics, and identify targets for health and safety preventive interventions [Centers for Disease Control and Prevention (CDC)]. We have described the QWL module in a previous study (Myers *et al.*, 2019). The 2014 QWL module, unlike previous modules, contains height and weight data allowing for the computation of BMI. Occupational and industry codes for the data set were updated to reflect 2010 Census Occupation and 2007 North American Industry Classification System (NAICS) codes.

We restricted the sample for current analysis to QWL participants employed in the civilian labor force for at least 20 h week^{-1}, consistent with other occupational research studies (Dembe *et al.*, 2005; Landsbergis *et al.*, 2015). This restriction excludes workers who may have different job exposures and/or may not experience any significant health impacts of stressful work characteristics because they were working too few h week^{-1}. Of the 1249 US workers who completed the 2014 QWL survey: all military participants (n = 30), participants who worked less than 20 h week^{-1} (n = 68), and participants with missing data on hours worked (n = 1) were excluded. Table 1 summarizes demographic characteristics of the 1150 eligible QWL survey participants for our analysis.

BMI and obesity

We examined two dependent variables: BMI as a continuous outcome variable and obesity as a categorical outcome variable. BMI was calculated by dividing self-reported weight (pounds) by the square of self-reported height (inches) then multiplying by 703 (conversion factor) and categorized according to the CDC guidelines (CDC, 2015a). BMI range and corresponding weight status were: 18.49 kg m^{-2} or less (underweight category), 18.5–24.99 kg m^{-2} (healthy weight category), 25–29.99 kg m^{-2} (overweight category), and 30 kg m^{-2}

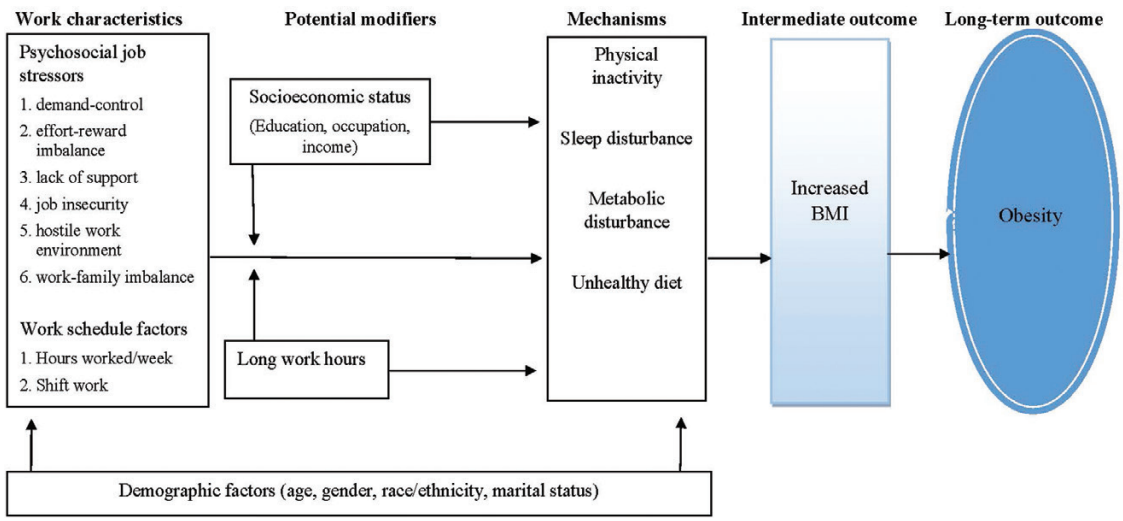

Figure 1. Hypothesized conceptual framework of the relationships between work characteristics and obesity. Work characteristics can be categorized as psychosocial job stressors and work schedule factors, such as long work hours and shift work. According to this model, work characteristics are related to obesity indirectly through behavioral factors as well as sleep and metabolic disturbance. For example, working long hours may limit opportunities for healthy diet, physical activity, and adequate sleep which can result in increased BMI and a progression to obesity. This conceptual framework also recognizes that factors such as low SES may modify the effect of work characteristics on risk of obesity, and that long work hours (in addition to its main effects) may also modify the effects of psychosocial job stressors on risk of obesity.

Table 1. Demographics of 1150 eligible NIOSH QWL survey respondents working at least 20 h week^{-1}: USA, 2014.

	Mean (weighted)	Range	
Age	43.40	18–79	
		N	Weighted %
Gender	Female	584	50.7
	Male	566	49.3
Race/ethnicity	White	736	63.4
	Black	174	13.4
	American Indian-Alaskan-native	14	1.5
	Asian-Pacific Islander	33	3.5
	Hispanic	188	18.2
Education	1–7 years	18	1.8
	8 years	9	0.7
	9–11 years	96	7.7
	HS graduate	286	26.2
	13–15 years	329	29.1
	Bachelor degree	219	18.8
	Postgrad study or degree	188	15.6
Occupation	Management/ professional	431	36.6
	Service	235	21.3
	Sales/office	259	23
	Blue collar	225	19.1
		Mean	**St. deviation**
Other covariates	Job physical exertion (very light to very hard)	2.51	1.196
	Television watching hours (0–24 h)	2.3648	1.29839

Note: Sample size was n = 1150 eligible QWL survey participants. 1249 US workers completed the QWL survey. We excluded the 30 military occupations, 68 participants who were not working at least 20 h week^{-1}, and 1 participant with missing data on hours worked.

or more (obesity category). For the categorial outcome variable, BMI of 30 kg m^{-2} or more were classified as the obesity group ('yes') and BMI less than 30 kg m^{-2} as the reference group ('no') in the binary logistic regression analysis.

Independent variables

A total of 20 work exposures (13 psychosocial job stressors, 6 work schedule factors, and 1 set of occupational categories) were examined: 18 (13 psychosocial job stressors and 5 work schedule factors) from the 2014 QWL survey and 2 (hours worked and 1 set of occupational categories) from the general social survey (GSS). Of the 20 work exposures, 6 psychosocial job stressors were selected as our primary independent variables when testing our hypotheses because of their previous positive associations with BMI and obesity and to reduce the number of multiple comparisons with our hypotheses. All other work exposure variables, including harassment and discrimination, were considered exploratory or 'secondary'. The six primary work characteristics are: high job demand, low job control, low work reward, low work social support, low supervisor support, and work–family conflict. To create these six primary work characteristics, first we selected all items (variable names, in the form of statements or questions) from the QWL survey that screened for each variable (or scale) and grouped them together. Then, we reversed the response codes for categorial items that are in the opposite direction to ensure that each scale is in the direction of increased risk of ill health. Finally, we added the responses for all the QWL items corresponding to that scale. 'Scale' refers to the larger construct (except when variable is an individual item) created by adding all the QWL items in that row (see Supplementary Table S1, available at *Annals of Work Exposures and Health* online) after reverse coding.

We combined QWL psychosocial job stressor items consistent with theory to create scales and assessed internal consistency reliability by Cronbach's alpha for 7 of our 13 psychosocial job stressors: high job demand (6 items, Cronbach's alpha = 0.71), low job control (5 items, Cronbach's alpha = 0.66), low work reward (5 items, Cronbach's alpha = 0.72), low work social support (4 items, Cronbach's alpha = 0.77), low supervisor support (2 items, Cronbach's alpha = 0.71), work–family conflict (2 items, Cronbach's alpha = 0.67), and inadequate resources (2 items, Cronbach's alpha = 0.70). All items had a four-point response option, ranging from either 'not at all true' to 'very true', 'strongly disagree' to 'strongly agree', or 'never' to 'often' (see Supplementary Table S1, available at *Annals of Work Exposures and Health* online edition for a complete list of items and response options). It should be noted that the items used are different from the demand–control and ERI models because the items for our study were taken from the 2014 QWL survey which did not contain all the standard demand–control and effort–reward items. We selected available items and scales believed to most likely be associated with BMI and obesity (some examples include: 'reward/recognition', 'work family conflict', 'work load', 'adequate resources', and 'workplace social support'). We then decided to rename some of our scales such as 'work load' (renamed job demand) as their items and meaning matched well with that of the

more familiar job demand–control model. The questions (or statements) associated with some items were slightly modified to ensure that all scales were in the direction of increased risk of poor health (examples of scales: low reward, work family conflict, low job demand, inadequate resources, and low workplace social support) prior to running statistical analyses for reliability (Cronbach's alpha value).

We created an additional psychosocial job stressor, job strain, by combining high job demand and low job control in two ways: multiplicative (high job demands × low job control) and additive (high job demand + low job control × [6/5]). Multiplying by 6/5 provides equal weight to both job demand (six items) and job control (five items) scales in computing the additive version of job strain. There are a number of ways that job strain has been operationalized in research with no one way superior to any other (Landsbergis *et al.*, 1994). We chose additive and multiplicative because these two methods produce continuous exposure measures and thus have greater statistical power than a dichotomous measure. We were unable to compute an ERI variable because there were few QWL items similar to ERI 'effort' items. The remaining five psychosocial job stressors from the 2014 QWL survey were individual item work characteristics, including sexual harassment ('in the last 12 months, were you sexually harassed by anyone while you were on the job?') and race/ethnicity discrimination ('do you feel in any way discriminated against on your job because of your race or ethnic origin?'). Name and full wording of questions for all individual item work characteristics are contained in Supplementary Table S2 (available at *Annals of Work Exposures and Health* online). Work schedule factors included shift work (day, afternoon, night, split/on-call/irregular, and rotating), ability to vary starting and quitting times (never, rarely, sometimes, often), effort required to take time off during work for family (not at all hard, not too hard, somewhat hard, very hard), days per month working extra hours, and must work extra hours. For complete details see Supplementary Table S1 (available at *Annals of Work Exposures and Health* online).

Two other work exposures analyzed for associations with BMI using multiple linear regression and for associations with obesity using multiple logistic regression were occupational category (management/professional, service, sales/office, and blue-collar) and work hours (40 h, less than 40 h, 41–59 h, and 60 h or more), both obtained from the GSS. We standardized (transformed into *z* scores) all continuous work characteristics variables for the analyses to simplify interpretation of the results.

Other covariates

We adjusted for sociodemographic factors obtained from the GSS, including age, gender, race/ethnicity (White, Black, Hispanic, American Indian/Alaskan Native, and Asian/Pacific Islander), marital status (married, divorced, widowed, separated, and never married), educational level (7 categories), job physical exertion (very light, fairly light, somewhat hard, hard, very hard), and television (TV) watching (0–24 h). We used the following GSS question: 'on the average day, about how many hours do you personally watch television?' to measure TV watching and used it as a proxy variable for sedentary behavior. We truncated the hours for TV watching at 9 h by coding 10 or more hours of TV watching per day as 9. Job physical exertion was measured using responses to the QWL question: 'Please rate the overall physical effort at the job you normally do'.

Statistical analysis

First, we tested for associations between work characteristics and continuous BMI using multiple linear regression for each of our 20 work exposures, separately. Then, we tested for associations between work characteristics and obesity categories using multiple logistic regression models for each of our 20 work exposures, separately. Each of the above steps was conducted twice for each of the 20 work exposures modeled: first, adjusted for age only and then adjusted for age, gender, race/ethnicity, marital status, education level, job physical exertion, and TV watching.

We tested for four different interactions of the relationships between work characteristics, BMI, and risk of obesity. First, to evaluate interactions by SES, we included product terms for the four occupational categories with each work characteristic in separate multiple linear regression models if outcome is BMI and multiple logistic regression models if outcome is risk of obesity. Then, to evaluate interactions by hours worked per week, we included product terms for the 4 work hour categories with each work characteristic in separate multiple linear regression models if outcome is BMI and multiple logistic regression models if outcome is risk of obesity. Finally, we tested for interactions of race discrimination with the 4 race/ethnicity groups and gender discrimination with gender groups using multiple linear regression for BMI and multiple logistic regression for obesity categories. For the tests of interaction, we combined the American Indian/Alaskan Native and Asian/Pacific Islander groups because both groups consisted of a very small number of participants. Each interaction model was adjusted for age, gender (only with

race discrimination interaction models), race/ethnicity (only with gender discrimination models), marital status, education level, job physical exertion, and TV watching.

All statistical analyses were conducted using SPSS v23 Complex Samples with weights to account for the multistage area probability sample of the GSS and produce more precise sample estimates. The weights included: WTSS, to take into account the sub-sampling of non-respondents and the number of adults in the household; VSTRAT, the variance stratum; and VPSU, the variance primary sampling unit. Statistical significance was set at a two-sided alpha value of 0.05. To determine goodness of fit, we used R^2 for multiple linear regression models and Cox and Snell pseudo-R^2 for multiple logistic regression models. PASS (version 15) was used to assess statistical power postanalysis.

Results

Demographic characteristics of the analytic sample are presented in Table 1. The majority (63.4%) of our sample was White, about half (49.3%) male and 63.5% obtained at least some college education. Their age ranged from 18 to 79 years. Of the total sample, 36.6% worked in management/professional, 21.3% worked in service, 23% in sales and office, and 19.1% worked in blue-collar occupations. There were 72 participants out of the 1150 eligible QWL survey participants with missing data (6.26%) on height, weight, or both and thus BMI. Supplementary Table S3 (available at *Annals of Work Exposures and Health* online edition) shows the distribution for continuous BMI and categorical weight status for the 1078 participants with BMI values. 29.1% of the sample had BMI of at least 30.0 kg m^{-2}, 'obesity' status, while 33.9% had BMI range 18.5–24.99 kg m^{-2}, 'healthy weight' status. Due to the very small number of participants in the BMI range of 18.49 kg m^{-2} or less, 'underweight' status (0.9%), they were excluded from the multiple logistic regression analysis.

Work characteristics

Table 2 presents descriptive information on work characteristics for 1150 eligible adults working at least 20 h week^{-1}. The standard error of the mean for each of the 6 main psychosocial job stressor is greater than 0 but less than 1, with smallest of 0.3600 for inadequate resources and largest of 0.08823 for low reward. Supplementary Table S3 (available at *Annals of Work Exposures and Health* online edition) presents data on the 13 psychosocial job stressors (from items in the QWL) and 6 work schedule factors (5 from items in the QWL and hours worked per week from the GSS). The number of participants with missing data for QWL work characteristics varied by QWL variable and ranged from 5 (for

Table 2. Psychosocial job and work schedule characteristics, 1150 eligible QWL survey respondents working at least 20 h week^{-1}: USA, 2014.

Work characteristics		
	Mean	**Std. Error**
Psychosocial job stressors		
Low job control	8.8537	0.07663
High job demand	12.9347	0.08792
Low work social support	6.7877	0.7406
Work family conflict	4.4437	0.04783
Low reward	9.7052	0.08823
Inadequate resources	3.1522	0.03600
Low supervisor support	5.0235	0.05883
Job strain	115.2385	1.36579
Job strain2	23.5628	0.13320
Work schedule factors		
Can't take time off during work for family	2.03	0.030
Ability to vary starting and quitting times	2.44	0.036
Days/month working extra hours	5.67	0.225
	N	Weighted %
Must work extra days (mandatory OT) (yes)	326	28.8
Shift work		
Day shift	815	71.3
Afternoon	58	5.4
Night shift	72	6.3
Split/irregular shift	118	10.1
Rotating shift	82	6.8
Missing	5	
Hours worked/week		
Less than 40 h	278	24.1
40 h	415	37.2
41–59 h	297	25.5
60 h or more	160	13.1
Missing	n/a	
Psychosocial job stressors		
Sexually harassed (yes)	30	2.6
Threatened or harassed on job (yes)	96	8.4
Age discrimination (yes)	71	6.2
Race discrimination (yes)	43	3.8
Gender discrimination (yes)	53	4.6
Census occupational category		
Management/professional	431	36.6
Service	235	21.3
Sales/office	259	23.0
Blue collar	225	19.1

Note: Sample size, n = 1150 eligible QWL survey participants. Missing data ~8% for work characteristics variables.

work–family conflict and discrimination) to 95 (for low reward); 0.43 to 8.26% missing. The prevalence of race/ethnicity discrimination in our sample was 3.8% and varied by race/ethnicity: 6.5% among Blacks, 6.3% among Hispanics, 5.8% among Asian/American Indians and 2.3% among Whites. The prevalence of perception of gender discrimination was 4.8%: 7.6% among women and 2.0% among men. More than 70% of the respondents who reported their work shift, worked the day shift compared with those who worked split/on-call and irregular shift, rotating shift, night shift, and afternoon shift. About 76% of the sample worked at least 40 h week^{-1}.

Outcome measure BMI

Table 3 describes age-adjusted and fully adjusted findings from the multiple linear regression models with continuous BMI and the 20 work exposures examined. After controlling for all potential confounders, positive associations between BMI and night shift work [B = 2.28; 95% confidence interval (CI) = (0.61, 3.96); P = 0.008; R^2 = 0.04] and blue-collar worker [B = 1.75; 95% CI = (0.48, 3.02); P = 0.008, R^2 = 0.05] remained statistically significant. Compared with day shift work, night shift work is associated with 2.28 greater units of BMI (see Supplementary Fig. S1, available at *Annals of Work Exposures and Health* online edition), similarly blue-collar type work is associated with 1.75 greater units of BMI (see Supplementary Fig. S2, available at *Annals of Work Exposures and Health* online edition) when compared with management/professional type work. There were no statistically significant associations between BMI and the 13 psychosocial job stressors and the other 5 work schedule characteristics.

No significant interactions between BMI and work characteristics by SES or by hours worked per week were observed. However, we found a statistically significant interaction between race discrimination and obesity by race/ethnicity (P < 0.0001, R^2 = 0.115). In the BMI interaction analysis with race discrimination by 4 race/ethnic groups, using multiple linear regression (Table 4), the perception of race or ethnic discrimination at work was significantly associated with increased BMI among Blacks [B = 3.05; 95% CI = (0.70, 5.40); P = 0.013; R^2 = 0.085], but not among other race or ethnic groups (see Supplementary Fig. S3, available at *Annals of Work Exposures and Health* online edition). Associations between BMI and the perception of gender discrimination did not differ significantly by gender.

Outcome measure obesity

Adjusted odds ratios (ORs) and 95% CIs for obesity from the multiple logistic regression models are presented in Table 5 for each of the 20 work exposures studied. As compared with day shift workers in the USA, night shift workers had 2.19-fold higher odds of obesity [95% CI = (1.09, 4.39); R^2 = 0.13] in the fully adjusted model (Fig. 2). Statistically significant positive associations with obesity remained for both blue-collar workers [OR = 2.63; 95% CI = (1.34, 5.19); R^2 = 0.13] and sales/office workers [OR = 1.55; 95% CI = (1.02, 2.37); R^2 = 0.13] compared with management/professional workers, after adjusting for all covariates (Fig. 3). There was no statistically significant risk of obesity for any of the 13 psychosocial job stressors and for the other 5 work schedule characteristics.

No significant interactions between risk of obesity and work characteristics by SES or by hours worked per week were observed. However, we found a statistically significant interaction between race/ethnicity and race discrimination (P < 0.0001, R^2 = 0.115). The fully adjusted obesity interaction analysis with race discrimination by 4 race/ethnic groups using multiple logistic regression showed (Table 6) that the perception of race or ethnic discrimination at work had increased odds (6.61) of obesity among Black workers as compared with workers of all other race or ethnic groups [95% CI = (1.43, 30.62); P = 0.018]. In contrast, the risk of obesity due to the perception of gender discrimination at work did not differ significantly by gender.

Discussion

Main findings

This study examined associations of a total of 20 work exposures (13 psychosocial job stressors, 6 work schedule factors, and 1 set of occupational categories) with both continuous BMI and categorical obesity. After controlling for several confounders known to be related to BMI and obesity risk such as age, gender, race/ethnicity, education, job physical exertion, and sedentary behavior (using TV watching as a proxy for this behavior), we did not observe a relationship between any of the 13 psychosocial job stressors (including our 6 primary variables of interest such as high job demand, low job control, and low workplace social support) and risk of obesity or even increased BMI. These findings did not support our hypothesis. Nonetheless, some important statistically significant associations were observed for work schedule factors and occupational category. These results should be interpreted with caution given the low R^2 for work exposure variables showing significant associations with BMI and risk of obesity.

Table 3. Associations between: work characteristics and BMI and occupational category and BMI, among 1150 Americans working at least 20 h week^{-1}: findings from the 2014 National NIOSH Quality of Work Life Survey.

Work characteristics	Estimate (95% CI)	*P*	R^2	Estimate (95% CI)	*P*	R^2
	Model 1, age adjusted			Model 2, fully adjusted		
Psychosocial job stressors						
Low job control	0.160 (−0.269, 0.588)	0.459	0.007	0.160 (−0.295, 0.614)	0.486	0.032
High job demand	0.016 (−0.423, 0.455)	0.943	0.006	0.149 (−0.276, 0.574)	0.485	0.030
Low work social support	0.080 (−0.378, 0.538)	0.728	0.006	0.136 (−0.337, 0.608)	0.568	0.030
Work family conflict	0.010 (−0.355, 0.374)	0.958	0.006	0.127 (−0.268, 0.522)	0.523	0.031
Low reward	0.221 (−0.310, 0.752)	0.408	0.006	0.252 (−0.291, 0.795)	0.358	0.032
Inadequate resources	0.265 (−0.179, 0.709)	0.237	0.009	0.308 (−0.136, 0.752)	0.171	0.034
Low supervisor support	0.133 (−0.309, 0.576)	0.550	0.007	0.149 (−0.299, 0.598)	0.508	0.030
Job strain	0.135 (−0.332, 0.602)	0.566	0.006	0.218 (−0.254, 0.691)	0.443	0.031
Job strain2	0.133 (−0.326, 0.592)	0.565	0.006	0.218 (−0.244, 0.679)	0.349	0.031
Sexually harassed (within last 12 months)	0.796 (−2.006, 3.597)	0.573	0.007	1.193 (−1.646, 4.032)	0.404	0.032
Threatened or harassed on job (within last 12 months)	0.669 (−0.765, 2.102)	0.355	0.007	0.726 (−0.674, 2.127)	0.304	0.032
Age discrimination	0.231 (−1.416, 1.879)	0.780	0.006	0.496 (−1.100, 2.093)	0.537	0.031
Race discrimination	1.720 (−0.445, 3.886)	0.118	0.009	2.069 (−0.110, 4.249)	0.062	0.035
Gender discrimination	0.608 (−1.149, 2.365)	0.492	0.007	0.678 (−1.075, 2.431)	0.443	0.032
Work schedule factors						
Can't take time off during work for family	−0.021 (−0.418, 0.377)	0.917	0.007	0.109 (−0.281, 0.499)	0.579	0.031
Ability to vary starting and quitting times	−0.212 (−0.613, 0.188)	0.293	0.008	−0.228 (−0.633, 0.176)	0.264	0.032
Days/month working extra hours	−0.024 (−0.075, 0.027)	0.349	0.006	−0.020 (−0.070, 0.030)	0.435	0.030
Must work extra days (mandatory OT)	0.243 (−0.448, 0.933)	0.485	0.006	0.374 (−0.326, 1.074)	0.290	0.032
Shift work (day shift = ref.)						
Afternoon shift	1.250 (−0.413, 2.913)	0.138	0.016	1.438 (−0.344, 3.221)	0.112	0.043
***Night shift**	**2.076 (0.402, 3.751)**	**0.016**	**0.016**	**2.280 (0.606, 3.955)**	**0.008**	**0.043**
Split/irregular shift	0.515 (−0.705, 1.736)	0.402	0.016	0.711 (−0.562, 1.985)	0.269	0.043
Rotating shift	0.451 (−0.998, 1.900)	0.536	0.016	0.604 (−0.905, 2.113)	0.427	0.043
Hours worked/week (40 h = ref.)						
Less than 40 h	−0.322 (−1.375, 0.731)	0.543	0.009	−0.326 (−1.364, 0.713)	0.533	0.034
41–59 h	−0.386 (−1.404, 0.631)	0.451	0.009	−0.344 (−1.361, 0.673)	0.502	0.034
60 h or more	0.464 (−0.729, 1.658)	0.440	0.009	0.655 (−0.511, 1.820)	0.266	0.034

Table 3. Continued

Work characteristics	Estimate (95% CI) Model 1, age adjusted	P	R^2	Estimate (95% CI) Model 2, fully adjusted	P	R^2
Census occupational category						
Management/professional (ref.)						
Service	−0.483 (−1.381, 0.415)	0.287	0.021	−0.464 (−1.532, 0.604)	0.389	0.047
Sales/office	0.834 (−0.170, 1.839)	0.102	0.021	0.707 (−0.263, 1.677)	0.150	0.047
*Blue collar	**1.401 (0.480, 2.322)**	**0.003**	**0.021**	**1.749 (0.477, 3.022)**	**0.008**	**0.047**

Note: We conducted analyses by multiple linear regression. Estimate = B-value; R^2 = multiple determination coefficient; Job strain = product of job demand and low control; Job strain2 = sum of job demand and low control (6/5). Sample size was n = 1150 eligible QWL survey participants. 1249 US workers completed the QWL survey. We excluded the 30 military occupations, 68 participants who were not working at least 20 h week^{-1}, and 1 participant with missing data on hours worked. Missing data for job characteristics variables were ~8% and for height and/or weight and thus BMI ~6%. Fully adjusted: We controlled for age, gender, race/ethnicity, marital status, education level, job physical exertion, and TV watching (a proxy for sedentary behavior).

Bold values indicate statistical significance at $P < 0.05$.

*Statistically significant at $P < 0.05$.

Night shift

Our main secondary finding is that both night shift schedule work and blue-collar occupational category are significantly and positively associated with BMI and risk of obesity, after controlling for all confounders. Most earlier studies that investigated the relationship between night shift work and chronic diseases, such as obesity (Miranda *et al.*, 2015; Ramin *et al.*, 2015) and CVD (Vetter *et al.*, 2016) were conducted mainly among women in healthcare settings. Our finding for night shift work, although among a more representative sample of the labor force, is consistent with some of those studies (Buchvold *et al.*, 2015; Ramin *et al.*, 2015). Ramin *et al.* (2015) found that night shift work in American nurses was significantly associated with increased BMI and risk of obesity. A systematic review that included an evaluation of 17 longitudinal studies linking shift work with weight-related outcomes (Proper *et al.*, 2016) found ‘strong evidence’ for a relationship between shift work, mostly night shifts, and increased BMI and risk of obesity.

There are likely multiple mechanisms (Fig. 1) by which working the night shift influence BMI and risk of obesity. Changes in metabolism, insulin sensitivity, and appetite, as well as a reduction in energy for physical activity secondary to disrupted or insufficient sleep (Knutson, 2010) may occur during night shift work. Unhealthy diet may be a key mechanism linking night shift work to weight gain, increased BMI and risk of obesity. Several unhealthy ‘eating behaviors’ that affect night shift workers (including irregular eating patterns, frequent snacks, consumption of more animal fats, proteins, and carbohydrates, and less fiber and green vegetables) were identified in a discussion paper on eating and shift work (Lowden *et al.*, 2010). In our study, we did not control for dietary factors. Consequently, the altered eating behaviors may, at least partially, underlie the associations we observed for night shift work.

Blue-collar category work

Our finding that blue-collar type work (including workers such as machine operators, construction workers, and protective service workers) and sales/office type work (including workers such as office and administrative support workers, retail salespersons, and telemarketers) have higher odds of obesity add support to other studies. For example, in a study of a nationally representative sample of US workers from all industry and occupational categories, Luckhaupt *et al.* (2014) found that protective service workers (e.g. police

Table 4. Associations between racial discrimination and BMI among 1150 Americans working at least 20 h week^{-1}: findings from the 2014 National NIOSH Quality of Work Life Survey.

Race/ethnic groups	Estimate (95% CI), fully adjusted	*P*	R^2	Interaction with race category: fully adjusted *P*	R^2
White	3.657 (–0.575, 7.889)	0.089	0.040	**0.002**	0.039
***Black**	**3.050 (0.698, 5.402)**	**0.013**	**0.085**		
Hispanic	–0.117 (–2.116, 1.882)	0.905	0.039		
***Asian/American Indian**	**–2.800 (–4.712, –0.888)**	**0.010**	**0.350**		

Racial discrimination question: Do you feel in any way discriminated against on your job because of your race or ethnic origin? Asian/American Indian group: We combined American Indian/Alaskan Native and Asian/Pacific Islander due to the small numbers of participants in both groups. Fully adjusted: We controlled for age, gender, marital status, education level, job physical exertion, and TV watching (a proxy for sedentary behavior). Estimate = *B*-value; R^2 = multiple determination coefficient.

Bold values indicate statistical significance at $P < 0.05$.

*Statistically significant at $P < 0.05$.

officers, guards, firefighters, and corrections officers) had the highest prevalence of obesity (40.7%), after controlling for all covariates. They also reported that employment in office and administrative support occupations is associated with increased obesity prevalence. Similarly, Gu *et al.* (2014) reported that the highest age-adjusted prevalence of obesity was among transportation and material moving workers (especially motor vehicle operators), regardless of gender and race/ethnicity. They also reported that the second highest age-adjusted prevalence of obesity was among protective service workers. Conversely, a study involving Hawaiian hotel employees found that the highest prevalence of mean BMI and obesity was among individuals in managerial and facility maintenance occupations (Williams *et al.*, 2007). This study, unlike ours, did not examine a representative sample of US workers, instead it focused on a subset of the service industry known to have a higher prevalence of psychosocial stressors in the workplace than in the general working population and a lower global socioeconomic position than in the US workforce.

Blue-collar type work as a risk factor for obesity may result from a variety of pathways or mechanisms such as low levels of control over working conditions, low access to and participation in wellness programs, and exposure to environmental hazards. However, in our study, levels of job control were not associated with BMI or risk of obesity. Dobson *et al.* (2013) used focus groups to elicit from US firefighters working conditions that they believe have contributed to their obesity. Some working conditions that were reported are fire station eating culture, night calls and sleep interruption, sedentary work and supervisor leadership and physical fitness (Dobson *et al.*, 2013). Exposure to environmental hazards at work such as (i) some pesticides and plastics, which are endocrine disruptors, can increase appetite and insulin sensitivity, leading to increased body fat and (ii) dust and chemical irritants which can produce asthma, leading to decreased leisure-time physical activity (Nobrega, 2013). Future studies should not only examine the relationships between occupational status, work conditions, BMI and risk of obesity to corroborate our results but also explore mechanisms by which blue-collar and sales/office type jobs, specifically, may be linked to higher BMI and risk of obesity.

Interactions

The relationships between work characteristics, BMI, and risk of obesity did not significantly differ by either SES or hours worked per week. The perception of race/ethnicity discrimination at work was significantly associated with increased BMI and risk of obesity among Black workers, but not among Hispanic workers. Unexpected findings were a 'protective' effect of race/ethnicity discrimination on BMI and risk of obesity in the small sample of Asian/American Indian workers, and a borderline significant ($P < 0.10$) association between race/ethnicity discrimination and BMI and risk of obesity among White workers. Since the race/ethnicity distribution in QWL respondents was designed to be similar to that of the US workforce in 2014 (BLS, 2015), our results support the importance of addressing racial discrimination in the workplace among Black workers, making up 13.4% of our sample and 12% of the US workforce in 2014, as a means of reducing the overall prevalence of obesity in the USA. In addition, further research is needed to better understand the unexpected findings among Asian/American Indian workers and White workers.

Null results

Our null result for all 13 psychosocial job stressors (especially the 6 primary psychosocial job stressors of interest) is contrary to what we hypothesized. The majority of

Table 5. Associations between work characteristics and risk of obesity among 1150 Americans working at least 20 h week^{-1}: findings from the 2014 National NIOSH Quality of Work Life (QWL) Survey.

Work characteristics	OR (95% CI) Model 1, age adjusted	*P*	R^2	OR (95% CI) Model 2, fully adjusted	*P*	R^2
Psychosocial job stressors						
Low job control	1.124 (0.932, 1.356)	0.218	0.052	1.115 (0.913, 1.362)	0.281	0.120
High Job demand	1.013 (0.826, 1.244)	0.897	0.045	1.066 (0.870, 1.307)	0.531	0.116
Low work social support	1.002 (0.809, 1.241)	0.984	0.053	0.995 (0.792, 1.249)	0.964	0.125
Work family conflict	1.033 (0.881, 1.210)	0.687	0.049	1.086 (0.909, 1.298)	0.358	0.117
Low reward	1.076 (0.858, 1.349)	0.522	0.041	1.078 (0.849, 1.369)	0.531	0.108
Inadequate resources	1.123 (0.923, 1.366)	0.241	0.049	1.138 (0.928, 1.396)	0.210	0.119
Low supervisor support	1.033 (0.849, 1.258)	0.740	0.050	1.027 (0.837, 1.260)	0.798	0.121
Job strain	1.101 (0.911, 1.330)	0.315	0.047	1.131 (0.927, 1.380)	0.222	0.119
Job strain2	1.102 (0.908, 1.336)	0.321	0.046	1.130 (0.925, 1.380)	0.229	0.118
Sexually harassed (within last 12 months)	1.108 (0.312, 3.942)	0.872	0.046	1.457 (0.403, 5.271)	0.561	0.117
Threatened or harassed on job (within last 12 months)	1.437 (0.838, 2.465)	0.184	0.049	1.487 (0.853, 2.593)	0.159	0.119
Age discrimination	0.862 (0.461, 1.615)	0.639	0.047	0.906 (0.486, 1.689)	0.753	0.118
Race discrimination	2.148 (0.820, 5.631)	0.118	0.053	2.445 (0.882, 6.772)	0.084	0.125
Gender discrimination	1.470 (0.685, 3.154)	0.317	0.049	1.684 (0.775, 3.660)	0.185	0.119
Work schedule factors						
Can't take time off during work for family	1.013 (0.843, 1.216)	0.892	0.048	1.067 (0.882, 1.290)	0.500	0.119
Ability to vary starting and quitting times	0.928 (0.771, 1.117)	0.423	0.047	0.941 (0.785, 1.129)	0.510	0.116
Days/month working extra hours	0.991 (0.962, 1.020)	0.531	0.043	0.992 (0.964, 1.020)	0.548	0.116
Must work extra days (mandatory OT)	1.332 (0.916, 1.936)	0.131	0.047	1.379 (0.949, 2.005)	0.091	0.120
Shift work (day shift = ref.)						
Afternoon shift	1.518 (0.715, 3.223)	0.273	0.059	1.786 (0.805, 3.963)	0.151	0.130
***Night shift**	1.933 (0.963, 3.881)	0.063	0.059	**2.186 (1.088, 4.390)**	**0.029**	**0.130**
Split/irregular shift	1.381 (0.786, 2.426)	0.257	0.059	1.473 (0.843, 2.573)	0.171	0.130
Rotating shift	1.171 (0.552, 2.484)	0.676	0.059	1.277 (0.580, 2.808)	0.538	0.130
Hours worked/week (40 h = ref.)						
Less than 40 h	0.826 (0.546, 1.250)	0.360	0.064	0.847 (0.555, 1.293)	0.437	0.126
41–59 h	0.893 (0.548, 1.457)	0.647	0.064	0.944 (0.573, 1.555)	0.818	0.126
60 h or more	1.257 (0.655, 2.414)	0.486	0.064	1.414 (0.736, 2.717)	0.294	0.126
Census occupational category						
Management/professional (ref.)						
Service	0.927 (0.564, 1.523)	0.762	0.068	1.057 (0.581, 1.921)	0.854	0.132
***Sales/office**	**1.527 (1.002, 2.328)**	**0.049**	**0.068**	**1.553 (1.020, 2.365)**	**0.040**	**0.132**
***Blue collar**	**2.414 (1.471, 3.963)**	**0.001**	**0.068**	**2.633 (1.336, 5.189)**	**0.006**	**0.132**

Note: Analyses were conducted by logistic regression. R^2 = Cox and Snell pseudo-*R* square; Job strain = product of job demand and low control; Job strain2 = sum of job demand and low control (6/5). Sample size was n = 1150 eligible QWL survey participants. 1249 US workers completed the QWL survey. We excluded the 30 military occupations, 68 participants who were not working at least 20 h week^{-1}, and 1 participant with missing data on hours worked. Missing data: Job characteristics variables ~8 %, height and/or weight ~6%. Fully adjusted: We controlled for age, gender, race/ethnicity, marital status, education level, job physical exertion, and TV watching (a proxy for sedentary behavior).

Bold values indicate statistical significance at $P < 0.05$.

*Statistically significant at $P < 0.05$.

previous US cross-sectional (Fernandez *et al.*, 2010) and longitudinal (Block *et al.*, 2009) studies and non-US cross-sectional (Kouvonen *et al.*, 2005) and longitudinal (Kuper and Marmot, 2003; Brunner *et al.*, 2007) studies with similar populations of working adults found at least one positive association between psychosocial job stressors, BMI, and/or risk of obesity in the expected direction. Fernandez *et al.* (2010) found that high job strain in US workers was associated with BMI and overweight/obesity. On the other hand, several studies (mostly cross-sectional) of either US or non-US workers found no positive associations between BMI and (i) job demand and job control (Brisson *et al.*, 2000), (ii) job strain (Brisson *et al.*, 2000); and no positive associations between obesity and (i) job strain (Lallukka *et al.*, 2008a), (ii) low supervisor support (Choi *et al.*, 2010), and (iii) work–family imbalance (Luckhaupt *et al.*, 2014).

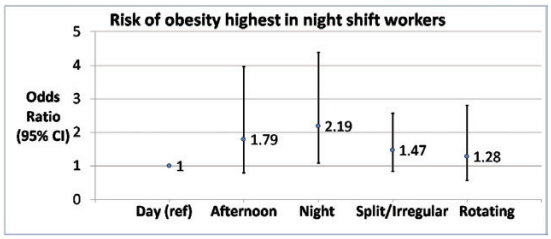

Figure 2. Association between obesity and shift work schedule; NIOSH QWL survey, 2014. *Note*: ORs derived from multiple logistic regression, adjusted for age, gender, race/ethnicity, education, marital status, job physical exertion, and TV watching.

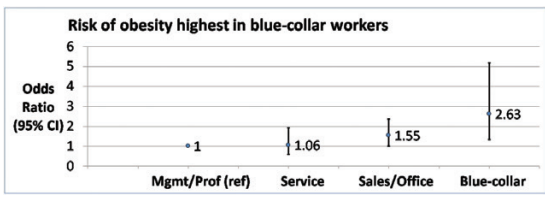

Figure 3. Association between obesity and occupational categories; NIOSH QWL survey, 2014. *Note*: ORs derived from multiple logistic regression, adjusted for age, gender, race/ethnicity, education, marital status, job physical exertion, and TV watching.

We also found no association between hours worked per week and increased BMI or risk of obesity. A finding consistent with a US study (Choi *et al.*, 2010) showing that hours of work per week was not associated with obesity among men and women from diverse occupations and industries. Luckhaupt *et al.* (2014), on the other hand, reported an association between working more than 40 h week^{-1} and obesity among US workers in unadjusted analysis. Shields showed that men who worked long hours (>35 h week^{-1}) had increased odds (1.4) of being overweight. For women, however, long hours of work were not associated with overweight (Shields, 1999).

In partial support of our overall null findings for psychosocial job stressors and hours of work, a longitudinal study, using data representative of the Canadian workforce, found that work characteristics (including psychological demands, social support, and hours worked per week) were unrelated to an increased risk of obesity in men and women when controlling for non-work-related and individual factors (Marchand *et al.*, 2015). Similarly, a longitudinal study of employed men in the USA reported that change in overweight was not associated with job characteristics (Landsbergis *et al.*, 1998).

There are many potential reasons for our primarily null findings. The 2014 QWL is a cross-sectional survey, thus, information and selection biases resulting from the

Table 6. Associations between racial discrimination and obesity among 1150 Americans working at least 20 h week^{-1}: findings from the 2014 National NIOSH Quality of Work Life (QWL) Survey.

Race/ethnic groups	OR (95% CI), fully adjusted	*P*	R^2	Interaction with race category: fully adjusted *P*	R^2
White	4.794 (0.847, 27.119)	0.075	0.105	**<0.001**	0.115
*Black	**6.606 (1.425, 30.622)**	**0.018**	0.177		
Hispanic	0.54 (0.133, 2.204)	0.376	0.194		
Asian/American Indian	0[a]				

Racial discrimination:
1.Question = Do you feel in any way discriminated against on your job because of your race or ethnic origin?
2.Prevalence = 0% among Asian/American Indian with obesity.
Asian/American Indian group: We combined American Indian/Alaskan Native and Asian/Pacific Islander due to the small numbers of participants in both groups.
Fully adjusted: We controlled for age, marital status, education level, job physical exertion, and TV watching (a proxy for sedentary behavior). R^2 = Cox and Snell pseudo-*R* square.
Bold values indicate statistical significance at $P < 0.05$.
[a]Among the 47 participants in this race/ethnic group, only two reported racial discrimination, and, of those two, none were obese.
*Statistically significant at $P < 0.05$.

study design could lead to either an over or underestimation of the true associations. Likewise, the cross-sectional studies that reported different findings are also subject to this study design limitation which may partially explain their inconsistent results too. The inability to determine exposure duration in cross-sectional studies, especially as it is believed that most people gain weight gradually, also increases the likelihood of underestimation of true associations. The 'healthy worker effect', where workers with most adverse health problems and/or health behaviors may have left the workforce for health or other reasons could lead to underestimation of the true associations.

Limitations and strengths

Our study has several limitations. First, even though we observed findings that are consistent with some previous studies, we cannot make definitive causal inferences about the effect of the 13 psychosocial job stressors, 6 work schedule factors, and 1 set of occupational categories on BMI and obesity in US workers because of the cross-sectional study design. Second, the QWL sample response rate of 69% indicates the possibility of selection bias, however, the amount of bias due to a response rate that high is likely to be small (Gerrits *et al.*, 2001; Rindfuss *et al.*, 2015). Third, the QWL data set had missing information for less than 10% of both exposure and outcome variables. About 6% of participants had missing data on height and/or weight, and thus BMI which resulted in loss of some information. In addition, the incomplete QWL scales to measure psychosocial job stressors, likely resulted in the somewhat reduced scale internal consistency reliability and thus random measurement error. Further, variables for health-related behaviors, such as exercise, diet, smoking, and alcohol use, were not available in the GSS, therefore we could not account for their potential contribution to BMI and obesity. Moreover, sedentary behavior is a potential mediator of the relationships between psychosocial and work schedule factors and both BMI and obesity and adjustment for the potential mediator, 'physical inactivity', may have represented overadjustment. Mediation analysis was beyond the scope of this study.

Even more, because of the high prevalence of obesity (29.1%) in the sample, our choice for measure of association (ORs), overestimated the magnitude of the true prevalence ratios (Tamhane *et al.*, 2016). Although the statistical significance of our results would not change, interpreting prevalence ORs as if they are prevalence ratios may incorrectly imply that the magnitude of associations is greater than they, in fact, are. Finally, the study was based on self-reported data and thus subject to self-report bias. For example, individuals (especially the obese) tend to underestimate their weight and overestimate their height (Krul *et al.*, 2011). As a result, BMI (and therefore obesity prevalence) may be underestimated. If such misclassification in non-differential (unrelated to the reporting of work stressors), then associations between work stressors and BMI and risk of obesity would be underestimated. If individuals who underestimate BMI also overestimate or underestimate the frequency or intensity of work stressors, then associations could be biased in either direction.

The problem of multiple comparisons occurs when a statistical analysis involves multiple statistical tests and, if not adjusted for, some observed associations are only statistically significant by chance. Our study examined a large number of statistical tests: 20 work exposures by 2 outcomes and all the tests of interaction which would have meant that some of these two-sided tests would have been spurious observed associations that would have been statistically significant at an alpha of 0.05 by chance alone. To address the problem of multiple comparisons, we specified six psychosocial job stressors as our primary variables of interest when testing our hypotheses. The remaining tests were considered exploratory. Therefore, the two significant main effects we observed (blue-collar work and night shift work) and the one significant interaction (for race discrimination), all part of the exploratory analyses, should be interpreted with caution.

The main strengths of our study are that it was based on a large nationally representative sample of US working adults and the QWL survey, unlike the NHIS, National Health and Nutrition Examination Survey (NHANES), and Multi-Ethnic Study of Atherosclerosis (MESA), includes detailed measures of a large group of psychosocial job stressors and work schedule characteristics. Thus, the 2014 QWL survey is an important source of data for occupational safety and health research and provides a unique opportunity to assess relationships between a large group of work characteristics and weight status.

Public health implications

To effectively reduce obesity in working populations, public health practitioners and organization leaders should consider workplace interventions that manage occupational level risk factors, such as job types and duties (especially those characteristic of blue-collar work), organizational level risk factors, such as work schedules (including night shift work), and individual level risk factors, such as diet and physical activity. One means of achieving this is by incorporating the NIOSH-developed and funded Total Worker Health approach which is the

integration of occupational health and safety protection with health promotion to prevent worker injury and illness and advance their health and wellness (CDC).

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

Funding

Funding for this study was provided by the Pilot Projects Research Training Program of New York/New Jersey Education and Research Center, National Institute for Occupational Safety and Health (grant number: T42 OH 008422).

Acknowledgements

We are grateful to Dr Naomi Swanson and Robin Dunkin of NIOSH for their advice on these analyses.

Conflict of interest

The authors declare no conflict of interest related to the material presented in this article.

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