MATERNAL WORKPLACE EMOTIONAL STRESSORS AND PHYSICAL ACTIVITY AND ADVERSE BIRTH OUTCOMES

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DEDICATION

To my parents

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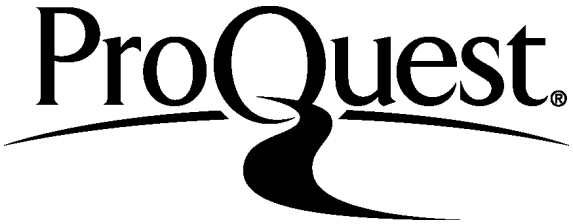

PREFACE

This doctoral dissertation is presented as two separate manuscripts for publication. Chapter I provides an introduction to the project with background information to support the hypothesis that maternal occupational physical activity and emotional stressors are associated with selected adverse birth outcomes, specifically preterm birth and small-for-gestational age. Additionally, Chapter I includes the research methods for the dissertation. Chapters II and III of the dissertation were written in manuscript form for publication in *American Journal of Industrial Medicine* and *Occupational and Environmental Medicine*, respectively. Chapter IV is a summary of important findings from the two manuscripts.

This doctoral dissertation uses data from the National Birth Defects Prevention Study (NBDPS) and the Occupational Information Network (O*NET). While completing this work, I was funded as an Occupational Epidemiology Trainee as part of the National Institute for Occupational Safety and Health (NIOSH) Southwest Center for Occupational and Environmental Health Training Grant 5T42OH008421.

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Preterm birth (PTB) and being born small-for-gestational age (SGA) are major contributors to infant mortality and morbidity in the U.S. Several risk factors for PTB and SGA have been identified, but the identification of additional risk factors is important for identifying future prevention targets. Maternal occupational exposures such as heavy lifting have been suggested as potential risk factors for PTB and SGA. Despite increasing epidemiological literature on certain work activities and adverse birth outcomes, the role of many domains of occupational physical activities (e.g., bending) and emotional stressors (e.g., dealing with unpleasant or angry people) on adverse birth outcomes remain unknown.

Using data from the National Birth Defects Prevention Study (NBDPS), specifically infants born with no major birth defects, we 1) described estimated maternal occupational physical activities, sedentary behaviors, and emotional stressors during pregnancy and 2) examined the role of a wide range of maternal occupational physical activities and emotional stressors in each trimester of pregnancy on PTB and SGA. Information on multiple domains of occupational exposures was gathered by linking mother's self-reported jobs to the U.S. Department of Labor's Occupation Information Network (O*NET). Additionally, factor analysis was utilized to address the issue of correlated individual occupational activities.

Regarding maternal occupational exposures during pregnancy, this study suggested that the most frequent estimated physical activity associated with jobs during pregnancy was standing. Of 6,337 mothers, 31% reported jobs associated with standing for ≥75% of their time. The most common source of emotional stressors was dealing with unpleasant or angry people, estimated to occur ≥75% of the time in jobs reported by 10.3% of mothers. There was significant variability in estimated occupational exposures by maternal age, race/ethnicity, and educational level. For the main study question on the role of maternal occupational physical activity and emotional stressors on PTB and SGA, mothers who reported jobs in the highest quartile of occupational physical activity were 36% more likely to have a child being born SGA than mothers who reported jobs in the lowest quartile (95% confidence interval 1.02, 1.82; *P* for trend = 0.001). No other significant associations were observed.

These studies expand our understanding about the associations between work exposures and certain adverse birth outcomes relative to previous studies of more limited scope and our findings may ultimately 1) help women of reproductive age in various occupations to decrease their risk of adverse birth outcomes and 2) inform employers to better accommodate pregnant workers from potentially hazardous occupational activities.

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CHAPTER I: MATERNAL OCCUPATIONAL EXPOSURES AND ADVERSE BIRTH OUTCOMES

Introduction and Specific Aims

Preterm birth (PTB) and being born small-for-gestational age (SGA) are major contributors to infant mortality in the U.S. (Saigal and Doyle 2008, Swamy, Ostbye et al. 2008, MacDorman and Mathews 2009, Crump, Sundquist et al. 2011, Martin, Hamilton et al. 2012, 2013). Infants born early and/or small for their gestational age are at an increased risk of significant short- and long-term disabilities such as cerebral palsy, language disorders, and hypertension (Kramer 2003, Institute of Medicine 2006, Moster, Lie et al. 2008, Saigal and Doyle 2008); have reduced survival rates into adulthood (Swamy, Ostbye et al. 2008, Crump, Sundquist et al. 2011); and account for half of infant and pediatric hospitalization costs (Russell, Green et al. 2007). PTB occurs in about 12% of live births and low birth weight (less than 2,500 grams, a proxy for SGA) accounts for about 8% of live births (Martin, Hamilton et al. 2015). Despite the prevalence and clinical importance of PTB and SGA, there are relatively few established modifiable risk factors for these adverse birth outcomes and effective prevention strategies to reduce the public health burden of these adverse birth outcomes are lacking.

Maternal occupational exposures such as heavy lifting have been suggested as potential risk factors for PTB and SGA (Croteau, Marcoux et al. 2006, Bonzini, Coggon et al. 2007, Croteau, Marcoux et al. 2007, Bonzini, Coggon et al. 2009). Occupational exposures are of particular importance as there has been a dramatic increase (>20%) in the prevalence of employed pregnant women during the last four decades, and the majority (~90%) of

pregnant women remain employed throughout pregnancy (Laughlin 2011). Additionally, women are now largely represented in certain occupational sectors (e.g., service) that include jobs that are 1) physically demanding or sedentary and/or are 2) highly stressful (Landsbergis 2003, Church, Thomas et al. 2011). Studies have shown that certain occupational exposures (e.g., heavy lifting) may increase the risk of PTB and SGA (Croteau, Marcoux et al. 2006, Bonzini, Coggon et al. 2007, Croteau, Marcoux et al. 2007), although such associations are not seen all studies (Pompeii, Savitz et al. 2005, Bonzini, Coggon et al. 2009). Further, there are many domains of occupational physical activity and emotional stressor for which little or no research has been conducted regarding their possible associations with adverse birth outcomes.

The underlying hypothesis of this study is that maternal exposure to physically demanding activities and emotional stressors are independently associated with PTB and SGA in offspring. This hypothesis was tested using data from the control infants (i.e., live born with no known major birth defects) in the National Birth Defects Prevention Study (NBDPS), the largest, population-based case-control study of birth defects, funded by the U.S. Centers for Disease Control and Prevention (CDC). Information on a wide range of maternal occupational physical activities and emotional stressors was obtained by linking the NBDPS data to the Occupational Information Network (O*NET) using mother's primary job title during different periods of pregnancy, coded in the Standard Occupational Classification (SOC) system. As some of the variables may be correlated, factor analysis was first used to identify underlying latent factors and unconditional logistic regression was then used to assess their associations with PTB and SGA, adjusting for information on potential

confounders collected during the NBDPS interview. Specifically, the three aims of this study were:

Specific Aim 1. Characterize occupational physical activity, sedentary behaviors, and occupational emotional stressors among NBDPS control mothers who were employed during pregnancy.

Sub-Aim 1. Examine the variation in estimated occupational exposures to physical activity, sedentary behaviors, and emotional stressors by maternal age, race/ethnicity, and education.

Specific Aim 2. Examine the role of maternal occupational physical activity during each trimester of pregnancy on PTB and SGA among NBDPS controls. This study utilized resources provided by the NBDPS and O*NET and addressed several important limitations from previous studies including a large sample size (~6,850 infants), extensive covariate data, a comprehensive array of occupational exposures, and exposure assessment during each trimester of pregnancy.

Specific Aim 3. Examine the role of maternal occupational emotional stressors during each trimester pregnancy on PTB and SGA among NBDPS controls.

Background and Significance

PTB and SGA

PTB, deliveries before 37 completed weeks of gestation (1977), occurs in approximately 1 of every 8 births (~12%) in the U.S. (Martin, Hamilton et al. 2015). PTB is the leading cause of infant mortality (Callaghan, MacDorman et al. 2006, Liu, Johnson et al. 2012), and its prevalence increased by more than 30% from 1981 to 2006 (Martin, Hamilton

et al. 2015, Osterman, Kochanek et al. 2015). Despite a recent reduction in the rate of PTB, it remains higher than the rates from previous decades and has had a significant impact on the U.S. infant mortality rate (Martin, Hamilton et al. 2015, Osterman, Kochanek et al. 2015). SGA is an important proxy measure for intrauterine growth restriction, and it distinguishes infants who are small due to growth restriction from those who are small due to PTB (Kramer 2003). SGA is typically defined as infants whose birth weight is less than the 10th percentile for their gestational age, gender, and race/ethnicity (Ananth, Balasubramanian et al. 2004).

Infants born early (i.e., PTB) and/or small (i.e., SGA) for their gestational age are at an increased risk of neonatal and infant mortality (Kramer 2003, Callaghan, MacDorman et al. 2006, Liu, Johnson et al. 2012), and affected individuals who survive often experience neurodevelopmental (e.g., cerebral palsy, visual and hearing impairments), cognitive (e.g., language disorders, learning disabilities), and health problems (e.g., hypertension, type-2 diabetes) (Kramer 2003, Institute of Medicine 2006, Moster, Lie et al. 2008, Saigal and Doyle 2008); have reduced survival rates into adulthood (Swamy, Ostbye et al. 2008, Crump, Sundquist et al. 2011); and account for half of infant and pediatric hospitalization costs (Russell, Green et al. 2007). While several risk factors for PTB and SGA have been identified, they do not explain a majority of cases and effective prevention strategies are lacking (Goldenberg and Culhane 2007, Goldenberg, Culhane et al. 2008).

Women in the Workplace

Women comprised approximately half of the total U.S. work force in 2010 (U.S. Department of Labor Bureau of Labor Statistics 2010). The largest proportion of women

(41%) worked in management and professional occupations; 32% worked in sales and office occupations; 21% worked in service occupations; 5% in production and transportation occupations; and less than 1% worked in construction and maintenance occupations (U.S. Department of Labor 2010). Among those employed, women differed in demographics based on the types of occupations they held. For example, large proportions of employed Asian (47%), non-Hispanic White (41%), and Black (34%) women worked in the management and professional occupations, while a smaller proportion (25%) of employed Hispanic women held these occupations (U.S. Department of Labor 2010). Employed Hispanic (32%) and Black (28%) women were more likely to hold service occupations compared to non-Hispanic White or Asian women (20%) (U.S. Department of Labor 2010).

Given changes in the workforce, more women are now employed in certain occupational sectors (e.g., service) that may lead to physically demanding (e.g., heavy lifting) or sedentary (e.g., prolonged sitting) activities (Landsbergis 2003, Church, Thomas et al. 2011). Furthermore, changes in the types of jobs help by women has led to greater job stress (Landsbergis 2003). Job stressors include factors related to physical exertion (e.g., heavy lifting, prolonged standing, climbing stairs) and work organization (e.g., prolonged work hours, alternative work shifts, machine-paced work) (Landsbergis 2003). These issues are of growing importance as women are more likely than ever to work during pregnancy and the effects of these exposures on pregnancy are unclear. During 2006-2008, more than 65% of first-time pregnant women (aged 15-44 years) in the U.S. were employed, which was a dramatic increase from 44% of women who worked while pregnant in 1961-1965 (Laughlin 2011). Additionally, more women are working later into pregnancy. Among first-time

mothers who worked while pregnant, 88% worked into their last trimester, while 65% worked into their last month of pregnancy (Laughlin 2011).

Women who work during pregnancy are different from those who do not work in terms of several demographics. During 2006-2008, non-Hispanic White women had the highest proportion of women working (75%) during pregnancy, followed by Asian (61%), Black (52%), and Hispanic (42%) women (Laughlin 2011). Within age groups, the majority (80%) of women aged 30 years and older were employed during pregnancy and less than 15% of women under 18 worked while pregnant (Laughlin 2011). The proportion of women working while pregnant increased as women became pregnant later in life (Laughlin 2011). Additionally, those with a bachelor's degree or higher were more likely to have worked during pregnancy (87%) compared to women with lower level of education (i.e., less than high school to some college; 28 to 71%) (Laughlin 2011). Further, more women with a bachelor's degree or higher were employed into their last trimester of pregnancy (93%), compared with 80% of women with less than a high school education (Laughlin 2011).

As stated, with more women continuing to work throughout pregnancy, there is a concern that those who engage in certain activities at work may be at risk for adverse birth outcomes. For example, based on a study published in 2007, the prevalence of occupational activities, relating to physical activity and emotional stressors were common among pregnant workers: working more than 40 hours a week (10%), having an irregular work schedule (15%), standing for at least 7 hours a day (21%), and sitting for more than 3 hours a day (56%) (Croteau, Marcoux et al. 2007). There are limited studies evaluating differences in the

level of occupational physical activity or emotional stressors on the basis of maternal demographic factors.

Occupational Physical Activity and Selected Adverse Birth Outcomes

There is a considerable epidemiological literature on the association of certain domains of occupational physical activity (i.e., prolonged standing, heavy lifting, and high physical workload) and adverse birth outcomes, including PTB and SGA (Mozurkewich, Luke et al. 2000, Bonzini, Coggon et al. 2007, Palmer, Bonzini et al. 2013). In some studies, occupational activities that are physically demanding have been shown to increase the risk of PTB and SGA (Croteau, Marcoux et al. 2006, Bonzini, Coggon et al. 2007, Croteau, Marcoux et al. 2007), although null associations were observed in others (Pompeii, Savitz et al. 2005, Bonzini, Coggon et al. 2007). According to a recent meta-analysis, which systematically reviewed studies published from 1966 to 2011, prolonged standing (i.e., > 4 hours/day), for instance, was modestly associated with the risk of PTB (summary relative risk [RR] 1.22; 95% confidence interval [CI] 1.12, 1.33; number of studies 12) (Palmer, Bonzini et al. 2013). For SGA, the effects of prolonged standing at work were closer to the null (RR 1.07; 95% CI 0.94, 1.22; number of studies 7) (Palmer, Bonzini et al. 2013).

Epidemiological studies of occupational physical activity and PTB and SGA had significant methodological challenges such as differences in how occupational physical activity has been defined and measured. For example, prolonged standing may be defined as "yes" or "no," standing at least 3 hours per day, and standing at least 40 hours a week (Bonzini, Coggon et al. 2007, Croteau, Marcoux et al. 2007). Additionally, some studies were insufficiently powered and others failed to control for potential confounders

(Mozurkewich, Luke et al. 2000, Bonzini, Coggon et al. 2007, Palmer, Bonzini et al. 2013). Further, several studies did not consider the timing of exposures during pregnancy, although the same occupational activity may carry different risks depending on timing during pregnancy (Mozurkewich, Luke et al. 2000, Bonzini, Coggon et al. 2007, Palmer, Bonzini et al. 2013).

Additionally, with a substantial increase in the prevalence of service occupations (represented 43% of U.S. occupations in 2008), which mainly consist of light and sedentary activities (Church, Thomas et al. 2011), daily occupation-related energy expenditure has decreased by more than 100 calories over the last five decades (Church, Thomas et al. 2011). According to a study by Church et al., this reduction in daily energy expenditure at work had a significant contribution to the increased mean body weights for U.S. men and women (Church, Thomas et al. 2011). Physical activity at work accounts for a large proportion of total physical activity for pregnant workers (Chasan-Taber, Schmidt et al. 2004). The effects of sedentary activities (e.g., prolonged sitting) in the workplace on birth outcomes remain largely unknown. However, prolonged sitting at work (uninterrupted, for at least 3 hours a day) has been shown to be positively associated with PTB (odds ratio [OR] = 1.4), although not statistically significant (Croteau, Marcoux et al. 2007) and may adversely affect birth outcomes.

Occupational Emotional Stressors and Selected Adverse Birth Outcomes

There is evidence in support of an association between adverse birth outcomes and maternal emotional stressors during pregnancy (Dole, Savitz et al. 2003, Bell, Zimmerman et al. 2008). However, specific sources of stress operating as risk factors remain unclear due to

differences in how maternal emotional stressors has been measured and defined (Mamelle, Laumon et al. 1984, Dole, Savitz et al. 2003, Bell, Zimmerman et al. 2008, Lee, Ha et al. 2011). Previous studies have mainly focused on emotional stressors from experiencing certain life events (e.g., job loss, divorce), and effects of emotional stressors from other domains (i.e., occupational) are relatively unknown. Given the current prevalence of pregnant workers, stress experienced during the course of employment may be an important component in the overall stress women experience during pregnancy.

Previous studies on several health outcomes (e.g., cardiovascular disease) have measured occupational emotional stressors with the Job Content Questionnaire (JCQ) (Karasek, Brisson et al. 1998) to obtain information about job demands and job control, two main components of the demand-control model (Karasek, Baker et al. 1981). This questionnaire is based on the concept that job stress (i.e., high job strain) results from high level of job demands in combination of low level of control over those demands (Karasek 1979, Karasek, Baker et al. 1981). Job demands represent a job's pace and pressure (e.g., 'my job requires working very hard') (Karasek 1979, Karasek, Baker et al. 1981). Job control represents potential control and decision latitude over the demands at work (e.g., 'my job allows me to make a lot of decisions on my own') (Karasek 1979, Karasek, Baker et al. 1981). Occupations such as nurse's aide and waitress, traditionally occupied by women, are found in the high job strain category (Karasek, Brisson et al. 1998).

Epidemiological literature on the effects of occupational emotional stressors on birth outcomes is limited, yet findings from the studies of occupational emotional stressors on birth outcomes based on the demand-control model were generally consistent, showing

modest associations. In Canada, there were positive associations for PTB (OR = 1.2) and SGA (OR = 1.3) in mothers exposed to high job strain with low social support compared to low strain (Croteau, Marcoux et al. 2006, Croteau, Marcoux et al. 2007). Among U.S. women with full-time jobs (≥35 hours/week), high-strain job was positively associated with PTB (OR = 1.4), although the association was not statistically significant (Brett, Strogatz et al. 1997). In Mexico, high job strain (RR = 1.23) and conflicts at work (RR = 1.54) were independently associated with PTB (Ceron-Mireles, Harlow et al. 1996). Additionally, other occupational factors such as irregular or shift work was positively associated with SGA (OR = 1.2) (Croteau, Marcoux et al. 2006), although no association was found with PTB (OR = 1.0) (Croteau, Marcoux et al. 2007).

Mechanisms

The biological mechanisms by which maternal workplace exposures, relating to physical activity or emotional stressors during pregnancy might result in PTB or SGA remain unclear (Goldenberg, Culhane et al. 2008). Possible mechanisms include increased catecholamine levels in response to physical or emotional stressors such as heavy lifting, repetitive work, and prolonged standing (Mozurkewich, Luke et al. 2000). Catecholamines have been shown to increase the blood pressure, uterine contractibility, and decrease placental function in humans (Mozurkewich, Luke et al. 2000, Bell, Zimmerman et al. 2008). Additionally, disrupted circadian rhythms from shift work could lead to neuroendocrine changes that affect fetal growth and timing of birth, while increased noradrenaline levels from physically demanding work could lead to uterine contractibility and PTB (Palmer, Bonzini et al. 2013). Further, emotional stressors at work has been shown to increase the

level of stressors hormones (e.g., corticosteroids) and lead to negative health behaviors (e.g., smoking) (Green and Johnson 1990), indirectly affecting development (Carmichael and Shaw 2000).

*O*NET as a Job Exposure Matrix*

The O*NET has been used in several areas of health research (Cifuentes, Boyer et al. 2007, Alterman, Grosch et al. 2008, Fujishiro, Diez-Roux et al. 2013, Dale, Zeringue et al. 2015), including the study of adverse birth outcomes such as PTB and low birth weight (Meyer, Warren et al. 2007, Bell, Zimmerman et al. 2008, Meyer, Warren et al. 2010). While the use of the O*NET to assign occupational exposures is yet to be validated, it has been used to construct job exposure matrices in previous studies (Cifuentes, Boyer et al. 2010). A 2007 study examined the associations between two maternal occupational factors (i.e., job control and physical demands) and PTB using the information from a state birth registry and the O*NET and found the results to be comparable between the two sources (Meyer, Warren et al. 2007). Additionally, physically demanding work was found to be modestly associated with both PTB and low birth weight using the O*NET data (Meyer, Warren et al. 2007, Bell, Zimmerman et al. 2008, Meyer, Warren et al. 2010).

Methods

Study Population

The study population included NBDPS control infants (i.e., live born with no known major birth defects) with an estimated date of delivery between October 1, 1997 and December 31, 2009. The details of the NBDPS have been published elsewhere (Cogswell,

Bitsko et al. 2009, Reefhuis, Gilboa et al. 2015). Briefly, the NBDPS is an on-going, population-based case-control study of birth defects. It includes data collected by birth defects surveillance in 10 U.S. states: Arkansas, California, Georgia/Centers for Disease Control and Prevention, Iowa, Massachusetts, New Jersey, New York, North Carolina, Texas, and Utah. Cases in the NBDPS have at least one of over 30 eligible birth defects and were live born, stillborn, or electively terminated. Control subjects are randomly selected from birth certificates or medical records of unaffected live births from the same surveillance regions that gave rise to the cases.

For this study, we used data from NBDPS control infants whose mothers 1) have completed the computer-assisted telephone interview (CATI), 2) were employed during pregnancy, and 3) had an estimated date of delivery from October 1, 1997 through December 31, 2009. We excluded infants whose mothers had multiple gestations, a strong and well-established risk factor for PTB and SGA (Goldenberg, Culhane et al. 2008, Martin, Hamilton et al. 2015).

Exposure Assessment

NBDPS. The CATI was conducted by trained interviewers in either English or Spanish with mothers of cases and controls. During the interview, each mother was asked about her work experiences (i.e., paid, volunteer, or military service) at home or outside the home, including part-time jobs that lasted at least one month in duration from three months before pregnancy to the date her child was born. If a mother reported working, she was asked about work information including the job title, name of company or organization, service or product provided by the company, the mother's main activities or duties, and

machines used. Additionally, each mother was asked to report the start and stop date (month and year) as well as the days per week and hours per day worked for each job. Each job was coded for occupation and industry using the 2000 Standard Occupational Classification (SOC) system and the North American Industry Classification System (NAICS) (U.S. Department of Labor Bureau of Labor Statistics 2001, U.S. Department of Labor Bureau of Labor Statistics 2009).

For our study, employment for each mother was defined as any work experience (i.e., paid, volunteer, military service) at home or outside the home including part-time that lasted at least one month in duration anytime from the estimated date of conception to the date her child was born. For this study period (i.e., 1997 to 2009), approximately 99.9% of the mothers of singleton control infants who completed the CATI responded to either working or not working during pregnancy. Less than 0.1% of the mothers refused, did not know, or missed the main employment question (i.e., "from three months before you became pregnant to the end of pregnancy, did you have a job?"). Mothers who refused, did not know, or missed the main employment question as well as mothers who reported not working (e.g., unemployed, homemakers/parents, students, disabled) during pregnancy were not included in the study. However, mothers who reported working as students or working at home (e.g., childcare/nannies) and were assigned SOC codes for their work were included in the study.

For each working mother in the NBDPS, her job title, coded in the 2000 SOC taxonomy, was abstracted. For any woman who held multiple jobs, the primary job with the most hours worked was selected for each trimester of pregnancy. For this study period, of those mothers employed anytime during pregnancy, most (84%) held one job during

pregnancy, while 13.5% had two jobs, 1.9% had three jobs, 0.3% had four jobs, and less than 0.1% had five or six jobs.

NBDPS-O*NET Linkage. Developed by the U.S. Department of Labor, the O*NET is a publicly available database that includes detailed occupational information on over 900 U.S. job titles (O*NET Resource Center 2015). Details of the O*NET are available online (http://www.onetonline.org). Briefly, the O*NET collects key job attributes (e.g., generalized work activities, tasks, work context) and worker characteristics (e.g., abilities, work values, skills, education) by surveying randomly selected workers and experts in each occupation (O*NET Resource Center 2015). The O*NET database is updated on a regular basis, mainly to provide the most up-to-date information on occupations as they evolve over time (O*NET Resource Center 2015). The current version of the Version 19.0 (as of April 2015).

For our study, we selected the appropriate version of O*NET (i.e., version 9.0), based on our study period (1997 to 2009). The version 9.0 of the O*NET database was updated in December 2005 and includes occupations coded in the 2000 SOC taxonomy. We then linked the NBDPS with O*NET using the SOC groups to assign occupational physical activity and occupational emotional stress measures to each mother based on her primary job during each trimester of pregnancy. There were 1167 occupations represented in the version 9.0 of the O*NET database.

The NBDPS contains a mix of major, minor, broad, and detailed SOC codes, based on the level of detail provided by the mother regarding her job during pregnancy. The structure of the SOC codes is described in Appendix A. The O*NET uses the O*NET-SOC

codes, which are based on the SOC taxonomy; however, if the O*NET-SOC codes are more detailed than the original SOC codes, two-digit extensions (e.g., 11-1011.01) are assigned to the original six-digit SOC codes (e.g., 11-1011). Because of this, in order to merge the NBDPS and the O*NET, the O*NET subgroup data (e.g., 11-1011.01) was aggregated to the SOC group level (e.g., 11-1011).

Occupational Physical Activity. Assessment of occupational physical activity using the O*NET is not well described in the literature. Therefore, commonly studied occupational physical activity exposures and/or exposures that have been shown to be associated with adverse birth outcomes in previous studies have been selected *a priori* from the O*NET. These elements include: time spent sitting, standing, walking and running, and climbing (i.e., climbing ladders, scaffolds, or poles). For elements time spent sitting, standing, walking and running, and climbing, survey respondents are asked to report the frequency (1=never, 2=less than half the time; 3=about half the time, 4=more than half the time; 5=continually or almost continually) of the exposure (e.g., "how much does this job require sitting?") to each element. The O*NET database includes exposure estimate, standard error, and survey sample size for each SOC group. For example, 20% of the surveyed accountants (O*NET-SOC code: 13-2011.01) responded sitting half the time (raw value of 3), 6% sitting more than half the time (raw value of 4), and 74% sitting continually (raw value of 5); therefore, accountants have a raw mean value of 4.54 for sitting. Additionally, accountants have a mean value of 2 for standing, 1.71 for walking and running, and 1.03 for climbing. If the mean value is closer to 5, most workers in that job category are continually engaged in that

physical activity. If the mean value is closer to 1, most workers in that job category are never engaged in that physical activity.

In addition to raw mean values, the O*NET database includes standardized mean values ranging from 0 to 100. The standardized mean values are useful because more than 270 O*NET elements describing different aspects of the job use various types of response scales (e.g., importance, level, frequency). Therefore, we used the standardized mean of responses in each SOC group as a proxy measure of occupational physical activity exposure and assigned standardized mean exposure to each mother using her primary SOC group.

Further, we considered other domains of physical activity (e.g., time spent bending or twisting the body, time spent keeping or regaining balance), available in the O*NET database, that have not been examined in previous studies of occupational physical activity. See Appendix B for the type of survey questions the O*NET uses to gather information on the occupational physical activity exposures.

Occupational Emotional Stressors. Assessment of occupational emotional stressors using the O*NET is not well described in the literature. Several previous studies have assessed occupational emotional stressors using the demand-control model defining job stress as a combination of high job demand and low control (Ceron-Mireles, Harlow et al. 1996, Brett, Strogatz et al. 1997, Croteau, Marcoux et al. 2006, Croteau, Marcoux et al. 2007), and the JCQ has been used to obtain information about job demands and job control (Appendix C) (Karasek, Brisson et al. 1998). The O*NET contains several elements that could be used to assess emotional stressors in the workplace based on the JCQ; therefore, a set of O*NET elements that could represent job demands (e.g., work load demands, unexpected tasks, job-

related conflict) and job control (e.g., decision latitude) has been selected *a priori* using existing literature. For example, job demands may be represented by the O*NET elements such as importance of being exact or accurate, importance of repeating same tasks, level of competition, and time pressure. Additionally, the O*NET elements such as freedom to make decisions and structured versus unstructured work may represent job control. Again for these elements, we used the standardized mean of responses in each SOC group as a proxy measure of occupational emotional stressors and assign mean exposure to each mother using her primary SOC group. See Appendix B for the type of survey questions the O*NET uses to gather information on the occupational emotional stressors.

Outcome Evaluation

Information on gestational age and birth weight was collected by NBDPS staff from medical records. Gestational age was expressed in completed weeks and was determined using the following sources in hierarchical order: 1) first-trimester ultrasound dating, 2) calculation from last reported menstrual period, and 3) physical examination (Shaw, Carmichael et al. 2011). PTB was defined as less than 37 completed weeks of gestation (1977). Infants with missing gestational age were excluded. SGA was defined as infants whose birth weight is < 10^{th} percentile for their gestational age, sex, race/ethnicity, and maternal parity (Zhang and Bowes 1995, Overpeck, Hediger et al. 1999). Infants with missing gestational age or birth weight were excluded (birth weight < 500 grams is considered missing). Additionally, infants with < 25 or > 42 completed weeks of gestation were excluded from the SGA analysis based on the criteria outlined by Overpeck et al. and Zhang and Bowes (Zhang and Bowes 1995, Overpeck, Hediger et al. 1999).

The proportion of PTB in our study population (7.9%) was lower than what we would expect in the general U.S. population (10 to 12%). This was because we are excluding infants from multiple gestations and infants with congenital malformations, both of which are strongly associated with the risk of PTB.

Potential Covariates

Maternal characteristics that have been associated with two adverse birth outcomes (i.e., PTB, SGA) have been selected *a priori* as potential covariates: age at delivery (<20, 20-24, 25-30, 30-34, ≥35 years); race or ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Other); education (<12, 12, 13-15, ≥16 years); parity (0 or ≥1); household income (<10, 10-50, >50 U.S. dollars annually, thousands); pre-gestational diabetes (yes or no); and maternal pre-pregnancy body mass index (BMI) (Abrams and Newman 1991, Berkowitz and Papiernik 1993, Goldenberg, Culhane et al. 2008, Campbell, Cartier et al. 2012). Maternal pre-pregnancy BMI (kg/m^2) was categorized as underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (≥30) using cutoff points established by the National Institute of Health (National Institute of Health 2000). Because the NBDPS data was collected in 10 U.S. states, we also considered the mother's state of residence at the time of the infant's birth (i.e., study site [AR, CA, IA, MA, NJ, NY, TX, CDC, NC, UT]) as a potential fixed covariate. Gestational high blood pressure or preeclampsia during the index pregnancy (yes or no) was also considered as a potential covariate. Finally, maternal behavioral factors during each trimester of pregnancy were considered: use of any multivitamins or vitamin complexes (yes or no); alcohol use (yes or no); smoking

(nonsmoker, light [<15 cigarettes per day], moderate [15-24 cigarettes per day], or heavy [≥25 cigarettes per day]).

Data Analysis Plan

All statistical analyses were conducted in SAS (Version 9.3, Cary, North Carolina). The analyses were restricted to women who worked during their pregnancy and were assigned SOC codes for their work as the study question was related to occupational exposures. For any woman who held multiple jobs, a primary job, defined as the job with the most hours worked, was selected for each trimester of pregnancy. In the NBDPS data, only month and year were recorded for the job start and end date. For calculation of the primary occupation during each trimester of pregnancy, a day of the month was assigned. Consistent with previous NBDPS studies (Herdt-Losavio, Lin et al. 2010), start date was assigned as the first day of the month and the end day was assigned as the last day of the month. For specific details on the statistical analyses used in each study, refer to the *Statistical Analyses* sections of Chapters II and III, respectively.

Human Subjects

This study was conducted using the data from the NBDPS. All analyses were based on existing data, and there was no additional subject recruitment or data collection. The NBDPS contained de-identified data and each study participant had a unique ID number. Additionally, information that could be used to link the ID numbers to individual mothers and their infants were not available. The principal and the co-investigators have approvals from the CDC to work with the data from the NBDPS. This study was approved by the

NBDPS Data Sharing Committee on July 25, 2013. Approval for the IRB at the University of Texas Health Science Center at Houston was obtained on December 30, 2013.

CHAPTER II: DATA LINKAGE BETWEEN THE NATIONAL BIRTH DEFECTS PREVENTION STUDY AND THE OCCUPATIONAL INFORMATION NETWORK (O*NET) TO ASSESS WORKPLACE PHYSICAL ACTIVITY, SEDENTARY BEHAVIORS, AND EMOTIONAL STRESSORS DURING PREGNANCY

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Abstract

Knowledge of the prevalence of work-related physical activities, sedentary behaviors, and emotional stressors among pregnant women is limited, and the extent to which these exposures vary by maternal characteristics remains unclear. Data on mothers of 6,817 infants without major birth defects, with estimated delivery during 1997 through 2009 who worked during pregnancy were obtained from the National Birth Defects Prevention Study. Information on multiple domains of occupational exposures was gathered by linking mother's primary job to the Occupational Information Network Version 9.0. The most frequent estimated physical activity associated with jobs during pregnancy was standing. Of 6,337 mothers, 31.0% reported jobs associated with standing for ≥75% of their time. There was significant variability in estimated occupational exposures by maternal age, race/ethnicity, and educational level. Our findings augment existing literature on occupational physical activities, sedentary behaviors, emotional stressors, and occupational health disparities during pregnancy.

Introduction

Maternal workplace exposures have become particularly important in the study of birth outcomes, as women are more likely than ever to work during pregnancy. In the United

States (U.S.), more than 65% of first-time pregnant women were employed outside the home in 2006-2008, which was a substantial increase from 44% of women who worked while pregnant in 1961-1965 (Laughlin 2011). In spite of this increase, there has been little work to characterize the type and frequency of potential occupational exposures related to physical activity, sedentary behaviors, and emotional stressors pregnant women encounter. Understanding these exposures is important, because several occupational exposures have been associated with adverse pregnancy and birth outcomes in previous studies (Loomans, van Dijk et al. 2013, Palmer, Bonzini et al. 2013, Runge, Pedersen et al. 2013, Langlois, Hoyt et al. 2014). Furthermore, compared to occupational hazards such as solvents, pesticides, and radiation, other exposures including physical activity (e.g., standing), sedentary behaviors (e.g., sitting), and emotional stressors (e.g., dealing with unpleasant or angry people) that women may be more likely to encounter at work during pregnancy have been less-commonly studied, but have the potential to impact birth outcomes. Measuring and quantifying adverse working conditions among this potentially at-risk population is challenging.

There is no standardized measure of occupational physical activity, and multiple metrics have been used in previous studies (Palmer, Bonzini et al. 2013). For example, prolonged standing has been defined as standing at least 7 hours per day (e.g., (Croteau, Marcoux et al. 2006, Croteau, Marcoux et al. 2007)) or using a three-point scale ("never," "occasionally," and "often") (e.g., (Snijder, Brand et al. 2012)). Additionally, there is no consensus on how to define and measure an adverse psychosocial environment at work (Siegrist, Starke et al. 2004). The demand-control model of work stress has been the most

common method to assess psychosocial stress at work (Karasek 1979, Karasek, Brisson et al. 1998) and previous studies have defined "job strain" as the response to jobs that have high levels of demands (e.g., "do you have too many tasks at work?") in combination with low levels of control over those demands (e.g., "do you have the opportunity to influence your tasks and working conditions?") (Brett, Strogatz et al. 1997, Kuper and Marmot 2003, Lee, Ha et al. 2011, Larsen, Hannerz et al. 2014). Furthermore, while it is estimated that, in general,70% of daily sitting occurs at work (Ryan, Dall et al. 2011), whether this estimate is also reflective of U.S. women during pregnancy is not known.

The Occupational Information Network (O*NET), developed by the U.S. Department of Labor, is a publicly available database that includes detailed occupational information on over 900 jobs (O*NET Resource Center 2015). O*NET provides estimates for workers' exposure to a number of physical hazards and adverse working conditions. O*NET has been used to construct job exposure matrices in several previous studies, where specific individual-level exposure data were lacking (d'Errico, Punnett et al. 2007, Bell, Zimmerman et al. 2008, Cifuentes, Boyer et al. 2010, Choi, Hu et al. 2012, Dale, Zeringue et al. 2015). The utility of O*NET to assess a wide range of occupational physical activities, sedentary behaviors, and emotional stressors in a population-based sample of U.S. pregnant women has yet to be assessed.

Because of the need to characterize the full extent of occupational physical activities, sedentary behaviors, and emotional stressors among employed women during pregnancy, the objectives of this analysis were to 1) determine the feasibility of linking O*NET data to self-reported information about jobs held during pregnancy among mothers of control infants in

the National Birth Defects Prevention Study (NBDPS), 2) using linked NBDPS-O*NET data, describe typical frequency and level (i.e., intensity) of estimated occupational physical activities, sedentary behaviors, and emotional stressors among a large population-based sample of U.S. women during pregnancy, and 3) examine whether estimated occupational exposures to physical activities, sedentary behaviors, and emotional stressors vary by selected maternal demographic characteristics.

Materials and Methods

Study subjects

The NBDPS is a population-based case-control study of selected major birth defects that includes data collected at 10 Centers across the U.S. (entire state: Arkansas, Iowa, New Jersey, and Utah; selected counties: California, Georgia, Massachusetts, New York, North Carolina, and Texas). Institutional Review Boards at each study site approved the overall study. This analysis was approved by the Committee for the Protection of Human Subjects at the University of Texas Health Science Center at Houston. Details of the NBDPS methods have been published previously (Yoon, Rasmussen et al. 2001, Cogswell, Bitsko et al. 2009, Reefhuis, Gilboa et al. 2015). Briefly, cases in the NBDPS had at least one of over 30 eligible birth defects; control subjects were randomly selected from birth certificates or hospital birth records of live births without major structural birth defects from the same birth population as the cases. Participating mothers completed a computer-assisted telephone interview (CATI) in English or Spanish that lasted approximately one hour, between six weeks and two years after the estimated date of delivery. During the interview, mothers were

asked about demographic, behavioral, and medical factors before and during pregnancy. The present analyses included only mothers of infants without major birth defects, since the distribution of work characteristics among the control mothers was more likely to be representative of the work characteristics in the general population. Specifically, data were available on 10,161 mothers of control infants with estimated dates of delivery between October 1, 1997, and December 31, 2009 (Figure 1). Of these mothers, we excluded 3,002 who did not work during pregnancy and 260 mothers with incomplete interviews. Further exclusions were made based on the quality of the data about work histories that were available (see below).

Exposure assessment

Occupational Exposure Assessment in the National Birth Defects Prevention Study (NBDPS)

The NBDPS CATI solicited details of part-time or full-time employment lasting at least one month that was paid, volunteer work, or military service. Mothers were first asked to list their work experience from three months before conception through the end of pregnancy and were then asked for details about each job, including the job title, name of company or organization, service or product provided by the company, main activities or duties, and machines used. Additionally, mothers were asked to report the start and end date (month and year), the days per week, and the hours per day worked for each job. Jobs were then coded for occupation and industry using the 2000 Standard Occupational Classification (SOC) system and the North American Industry Classification System (NAICS)(U.S. Department of Labor Bureau of Labor Statistics 2001, U.S. Department of Labor Bureau of

Labor Statistics 2009). Most reported job titles in the NBDPS were coded into the two most specific categories of SOC code, "broad occupations" (39%) and "detailed occupations" (57%); mothers with less specific job titles, coded only in "major groups" (1%) or "minor groups" (3%) were excluded from the current analysis because they were too broadly defined to allow assignment to specific occupational characteristics in O*NET. Mothers with military occupations were also excluded, as O*NET Version 9.0 did not include data on these occupations.

Because only month and year were recorded for job start and end dates, we assigned the start date as the first day of the month and the end date as the last day of the month, consistent with a previous NBDPS study and with other NBDPS exposure assessments (e.g., medications) (Herdt-Losavio, Lin et al. 2010),. Mothers were excluded from the analysis if they exclusively held jobs with 1) unknown start or end year; 2) an end date that preceded the start date; 3) an end date before pregnancy began; or 4) a start date after pregnancy ended (Fig. 1). To be as inclusive as possible, for a job with an unknown start month but a reported start year, we assumed that it began three months prior to the estimated date of conception or the first day of the reported year, if the date three month prior to the estimated date of conception was in the previous year. Further, for a job with an unknown end month but a reported end year, we assumed that it ended three months after the estimated date of conception or the last day of the reported year, if the date three months after the estimated date of conception was in the subsequent year.

The majority of mothers (84%) who were employed during pregnancy held one job. For mothers who held two or more jobs, the primary job for the entire pregnancy was

determined based on cumulative hours worked during each period of interest (calculated using self-reported number of work hours per week and job duration). If there were two or more jobs with the same cumulative work hours, then the primary job was randomly selected. Additionally, we examined jobs held in each trimester of pregnancy (first trimester [weeks 1-12], the second trimester [weeks 13-24], and the third trimester [weeks 25-45]).

*Occupational Information Network (O*NET)*

Overview. Information on occupational physical activity, sedentary behaviors, and emotional stressors was obtained from the O*NET Version 9.0 (http://www.onetonline.org). The current version of O*NET is Version 19.0 (as of April 2015). For our study, we selected Version 9.0, updated in December 2005, based on our study period (1997- 2009) and because it included job titles coded in the 2000 SOC system.

O*NET collects detailed occupational information, including activities, tasks, abilities, skills, and education specific to each job title by surveying randomly selected male and female workers (sample size of workers surveyed varies by job title) using a standardized questionnaire. The questionnaire includes 277 elements describing various aspects of the job, using different response scales (e.g., level, frequency, importance, and extent). In the O*NET questionnaire, seven responses are possible, ranging from one (low) to seven (high) for elements measured using the level scale. For work elements using the frequency scale, five responses are possible: never, <50% of the time, 50% of the time, >50% of the time, and continually. For work elements using the importance scale, five responses are possible: not important, somewhat important, important, very important, and extremely important. For

work elements using the extent scale, five responses are possible: not at all, fairly, moderately, highly, and completely.

For each work element, the O*NET database includes a mean value, standard error, and survey sample size by job title, coded in the SOC system. Because O*NET elements were measured using different response scales and values, we calculated standardized mean values for each job title using the following formula: [(raw mean value – lowest possible value) / (highest possible value – lowest possible value)]*100. Detailed information about the formula is available online (http://www.onetonline.org/help/online/scales). Therefore, the standardized mean values, ranging from 0 (lowest) to 100 (highest), were used as proxy measures of typical exposure to each domain of physical activity, sedentary behaviors, and emotional stress.

Occupational physical activities and sedentary behaviors. From previous literature (Alterman, Grosch et al. 2008, Palmer, Bonzini et al. 2013), we selected *a priori* 11 O*NET work elements that reflected different domains of occupational physical activities or sedentary behaviors (Table 1). Nine elements were measured on a frequency scale based on the percentage of time during their occupation they spend doing the specified activity (5 levels from never to continually): (1) *bending or twisting the body*; (2) *climbing ladders, scaffolds, or poles;* (3) *keeping or regaining balance*; (4) *kneeling, crouching, or stooping*; (5) *making repetitive motions*; (6) *exposure to whole body vibration*; (7) *walking and running; (8) standing;* and (9) *sitting (sedentary behaviors);* two elements were measured on a level scale (7 levels, from low to high): (10) *performing general physical activities* (e.g.,

climbing, lifting, balancing, walking, stooping, and handling of materials) and (11) *handling and moving objects*. The O*NET survey questions used to collect information on each work element are available in Appendix B.

Occupational emotional stressors. From previous literature, we selected, *a priori,* nine O*NET work elements representing different domains of occupational emotional stressors (Karasek, Brisson et al. 1998, Alterman, Grosch et al. 2008, Fujishiro, Diez-Roux et al. 2013) (Table 1). Three elements were measured on a frequency scale: (1) *dealing with unpleasant or angry people*; (2) *dealing with conflict situations*; and (3) *dealing with physically aggressive people;* two elements were measured on a level scale: (4) *making decisions and solving problems;* and (5) *resolving conflicts and negotiating with others;* two elements were measured on an importance scale (5 levels, not important to extremely important): (6) *being exact or accurate;* and (7) *pace determined by speed of equipment*; and two elements were measured on an extent scale (5 levels, from not at all to completely): (8) *degree of automation;* and (9) *consequence of error*.

O*NET-NBDPS data linkage. O*NET often uses more detailed SOC coding than available for the NBDPS data. In order to link to the NBDPS data, we aggregated more detailed SOC codes, first to the "detailed occupations" category and then to the "broad occupations" category, and computed standardized mean values for each job title across aggregated categories. Examples of data aggregation and computation of mean values for a sample of job titles are shown in Appendix D. For instance, for performing general physical

activities, mothers who worked as “Marketing Managers” (SOC code, 11-2021) with a standardized mean value of 20.57 or “Sales Managers” (11-2022) with a standardized mean value of 36.00 were considered working as “Marketing and Sales Managers” (11-2020) and were assigned a standardized mean value of 28.29 (a simple arithmetic mean of 20.57 and 36.00).

Statistical analyses

We estimated the distribution of the following demographic and work characteristics among our population: age at delivery (<20, 20-24, 25-29, 30-34, ≥35 years), race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), education (<12, 12, 13-15, ≥16 years), annual household income (<$10,000, $10,000-$50,000, >$50,000), hours worked per week (<40, 40, >40), and major occupational groups (n=22) (U.S. Department of Labor Bureau of Labor Statistics 2001). We also computed the distribution of mothers reporting occupations associated with different domains of occupational physical activities, sedentary behaviors, or stressful working conditions associated with the primary job. For our analyses, groups were defined as: <25% of the time, 25-<50% of the time, 50-<75% of the time, and ≥75% of the time for a frequency-type domain. For a level-type domain, groups were defined as: low, medium-low, medium, and high. For an importance-type domain, groups were defined as: not important, fairly important, important, and extremely important. For degree of automation, groups were defined as: not at all automated, fairly automated, automated, and highly automated. For consequence of error, groups were defined as not at all serious, fairly serious, serious, and highly serious. For each domain, we compared

measures of estimated occupational physical activities, sedentary behaviors, and emotional stressors by different levels of demographic characteristics (age, race/ethnicity, and education) using chi-squared tests or Fisher's exact tests where appropriate at a type I error of 0.05. All statistical analyses were conducted in SAS (Version 9.3, Cary, North Carolina).

Results

There were 6,817 mothers of NBDPS control infants who reported being employed for at least one month during pregnancy (Fig 1). After excluding mothers who held jobs with no matching O*NET data (n = 480), data from 6,337 (93%) mothers were available for analysis. As compared to mothers who were included in our analyses, mothers who were excluded based on lack of matching O*NET data (data not shown) were older, had higher educational levels, and were more likely to have an annual household income between $10,000 and $50,000.

Most mothers were under the age of 30 (58.9%) and had some education beyond high school (66.1%) (Table 2). Of the mothers with available O*NET data, 63.9% were non-Hispanic White, 17.4% were Hispanic, and 11.9% were non-Hispanic Black (11.9 %). The most common major occupational groups were "Office and administrative support" (SOC code, 43-0000; 21.1%) and "Sales and related" (41-0000; 11.6%). The percentages of mothers in each of the other 20 job groups were ≤ 9% with relatively few mothers (< 1%) in Architecture and engineering (17-0000); Protective service (33-0000); Construction and extraction (47-0000); or Installation, maintenance and repair (49-0000).

Based on mother's primary job in each trimester of pregnancy, there were minimal differences in levels of physical activity, sedentary behaviors, and emotional stressors in different trimesters. We report herein on maternal work characteristics during the entire pregnancy. The most frequent physical activity associated with jobs reported by mothers who worked during pregnancy was standing (Table 3). Specifically, 31.0% of mothers reported jobs for which it is estimated that they would be standing for ≥75% of their time. Jobs associated with making repetitive motions; walking and running; and sitting were less frequently reported by mothers. For instance, 26.4% of mothers reported occupations for which it is estimated that they would be sitting for ≥75% of their time. Additionally, very few mothers reported jobs associated with experiencing whole body vibration, climbing ladders, scaffolds, or poles; keeping or regaining balance; and kneeling, crouching, or stooping. Most mothers reported jobs associated with performing "medium-low" levels of general physical activities (58.6%) and handling and moving objects (51.6%).

The most common source of emotional stress associated with reported jobs was dealing with unpleasant or angry people, estimated to occur ≥75% of the time in occupations reported by 10.3% of mothers (Table 3). Dealing with physically aggressive people was far less frequent, where 75.7% of the mothers reported jobs in which it was estimated that they spent <25% of their time at work dealing with physically aggressive people. Most mothers reported jobs with estimated moderate levels of making decisions and solving problems and resolving conflicts and negotiating with others. Being exact or accurate was either important (42.0%) or extremely important (50.2%) for jobs reported by most working mothers, while pace being determined by the speed of equipment was not important for jobs reported by

82.4% of mothers. Few mothers (8.5%) reporting working in jobs with higher estimated levels of automation.

There were differences in the frequency of estimated physical activities and sitting involved with reported jobs by age, race/ethnicity, and educational level ($P < 0.001$) (Table 4). For instance, mothers who were non-Hispanic Black or Hispanic were more likely to report jobs associated with more bending or twisting of the body than non-Hispanic White and mothers in the "Other" race/ethnicity group. Additionally, the proportion of mothers reporting jobs associated with bending or twisting the body <25% of their time increased by age and educational level. A similar pattern was observed for kneeling, crouching, or stooping. Occupations in which a substantial portion of time is estimated to be spent standing or walking and running were more commonly reported by all mothers, although a pattern was observed in which younger mothers and mothers with less education were estimated to spend a larger percentage of time at work standing or walking and running. Hispanic mothers were most likely to report occupations associated with standing ≥75% of the time (50.1%) and walking and running ≥50% (57.1%), compared with mothers in other race/ethnicity groups. The proportion of mothers reporting jobs associated with sitting <25% of their time decreased by age and educational level. In addition, non-Hispanic White mothers and mothers in the "Other" race/ethnicity group were more likely to spend ≥50% of their time sitting compared to non-Hispanic Black and Hispanic mothers. Data on other domains of occupational physical activities with little or no variations across strata of maternal characteristics (i.e., climbing ladders, scaffolds, poles; keeping or regaining balance; and whole body vibration) are reported in Appendix E.

The frequency and level of estimated emotional stressors based on reported jobs varied by maternal age, race/ethnicity, and educational level ($P < 0.001$) (Table 5). For example, the proportion of mothers reporting jobs associated with dealing with unpleasant or angry people ≥75% of their time decreased as age increased. The proportion of mothers reporting jobs associated with dealing with unpleasant or angry people <25% or ≥75% of their time decreased by educational level. Higher proportions of non-Hispanic Blacks and Hispanics reported jobs associated with dealing with unpleasant or angry people ≥75% of the time compared to non-Hispanic Whites and "Other" race/ethnicity groups. Few women reported jobs associated with spending ≥75% of their time dealing with conflict situations. The proportion of women reporting jobs associated with dealing with conflict situations for ≥50% of the time increased with increasing age and educational level and was higher among non-Hispanic White mothers than mothers of other race/ethnicity groups. While few mothers reported jobs where being exact or accurate was extremely important, the proportion of mothers reporting jobs where being exact or accurate was important increased with increasing age and educational level and was higher among non-Hispanic White mothers as compared to other race/ethnicity groups. Other domains of occupational emotional stressors (i.e., dealing with physically aggressive people, pace determined by speed of equipment, and degree of automation) varied little across selected demographic characteristics (Appendix E).

Discussion

In this large, population-based study of U.S. mothers, we estimated that standing and dealing with unpleasant or angry people at work were common during pregnancy, based on

assigned exposures from self-reported jobs linked to O*NET. Additionally, we observed that sitting was less common during pregnancy, with about 26% of the NBDPS control mothers estimated to spend most of their time at work sitting. Our study also identified domains of occupational physical activities and emotional stressors that were far less frequently experienced during pregnancy among NBDPS control mothers, with 64-98% of the mothers estimated to spend <25% of their time at work: climbing ladders, scaffolds, poles; keeping or regaining balance; kneeling, crouching, or stooping. Furthermore, most of the mothers reported jobs associated with moderate levels of occupational physical activity and emotional stressors. Finally, the distribution of occupational physical activity, sedentary behaviors, and emotional stressors differed markedly among reported jobs by maternal age, race/ethnicity, and educational level. As some of the occupational physical activities such as prolonged standing has been shown to be associated with adverse birth outcomes (Palmer, Bonzini et al. 2013), the observed racial/ethnic and educational disparities in postural strain are important findings and may represent potential prevention opportunities.

This analysis contributes to the current body of literature on workplace exposures, specifically for women during pregnancy, by describing a wide range of occupational physical activities, sedentary behaviors, and emotional stressors and identifying common (e.g., standing) and uncommon (e.g., ladder climbing) domains. Indeed, certain occupational activities such as ladder climbing and whole body vibration, which pose a greater risk for injury compared to other occupational activities examined in our study, were performed less frequently than other activities. Our findings are consistent with a previous study that found that pregnant women in Canada reported exposure to prolonged standing more than other

types of physical activities at work, with more than 51% of pregnant women spending four or more hours a day at work standing (Croteau, Marcoux et al. 2006). In a study conducted in North Carolina, prolonged standing was the most commonly reported occupational exposure among pregnant women compared to other types of physical activities, with 25% and 20% of women standing more than 30 hours a week in the first and second trimesters, respectively (Pompeii, Savitz et al. 2005). Additionally, our findings on occupational sitting during pregnancy were similar to findings in a Canadian study, where it was observed that more than half of the women spent at least three hours per day at work sitting during pregnancy (Croteau, Marcoux et al. 2007).

Our study showed that dealing with unpleasant or angry people was the most prevalent source of occupational emotional stressors based on reported jobs. Currently, there is no standardized method to define and measure work stress (Siegrist, Starke et al. 2004), and the demand-control model of work stress is the most commonly used approach to assess psychosocial stress at work (Karasek, Brisson et al. 1998). Based on the demand-control model, a 2009 study found that a small proportion (6.6%) of pregnant women in the Netherlands were exposed to high job strain (Vrijkotte, van der Wal et al. 2009). Similar findings were reported in a recent Danish study, where 6.8% of the pregnant women experienced high job strain (Larsen, Hannerz et al. 2013). Consistent with previous findings, our study showed that approximately 8% of the mothers experienced high levels of making decisions and solving problems, while the majority (50.2%) of mothers reported that being exact or accurate was extremely important in the workplace.

Few studies have examined the pattern of occupational exposures to physical activity and emotional stress by age, race/ethnicity, and educational level among women during pregnancy. A Spanish study reported that prevalence of exposure to physical loads (i.e., exposure to at least one of the following: standing for two or more hours per day or lifting more than five kilograms for two or more hours per day) was higher in younger (<25 years) women and in less educated (< primary school) women (Garcia, Gonzalez-Galarzo et al. 2012). Similarly, in a study conducted in Connecticut, higher proportions of physical demands, as defined by O*NET, were observed in Hispanics and in less educated (<12 years) women (Meyer, Warren et al. 2007), which was consistent with our findings on the level of performing general physical activities. In the same study, higher proportions of high job control, as defined by the demand-control model, were observed in older women (>37 years), and in highly educated (>16 years) women (Meyer, Warren et al. 2007), which are similar to our findings relative to making decisions and solving problems.

The differential pattern of occupational physical activity, sitting, and emotional stressors during pregnancy that we detected according to age, race/ethnicity, and education level is similar to what has been observed in female workers in the U.S. For instance, the U.S. Department of Labor reports that employed Hispanic and non-Hispanic Black women are more likely to hold service jobs compared to non-Hispanic White women (U.S. Department of Labor Bureau of Labor Statistics 2014). The differential pattern of maternal exposures to potentially hazardous domains of occupational physical activities and emotional stressors may explain disparities in birth outcomes in the U.S., where, for example, the rate of preterm birth is significantly higher for non-Hispanic Blacks than for non-Hispanic Whites

(Martin, Hamilton et al. 2015). Additional work is underway to evaluate the role of these stressors on adverse birth outcomes, and we will assess whether race/ethnicity modifies these associations in the future using the linked NBDPS and O*NET data. As the majority of working women in the U.S. remain employed during pregnancy, our findings may inform the development of prevention and intervention efforts.

Our study should be considered in the light of certain limitations. As it has been previously reported (Cogswell, Bitsko et al. 2009), NBPDS control participants are not representative of the general U.S. population with respect to several maternal characteristics such as race/ethnicity and education. The assignment of occupational physical activity and emotional stressors was indirect, based on linking mothers' self-reported jobs to estimates of physical activity and emotional stressors domains in O*NET. This assignment was based on average levels of work activities from a representative sample of U.S. workers, including men and non-pregnant women, with the same jobs and does not account for inter-individual variability in exposure between workers, or work accommodations that may be provided to pregnant women. For mothers who held two or more jobs during pregnancy (16%), the primary job was selected (based on the number of hours worked), and their assigned exposure may not reflect their total work experience. Additionally, it is possible that mothers could have inaccurately recalled their jobs such as specific work tasks, although the average length of time from birth to interview for the NBDPS control mothers was less than one year (~9 months). Furthermore, the use of the O*NET to assign occupational exposures has not been validated; however, O*NET has been utilized in several studies of pregnancy and other health outcomes, where it has been used to quantify various occupational characteristics

(Meyer, Warren et al. 2007, Alterman, Grosch et al. 2008, Bell, Zimmerman et al. 2008, Cifuentes, Boyer et al. 2010, Choi, Hu et al. 2012, Fujishiro, Diez-Roux et al. 2013). Finally, in order to link the O*NET data to the NBDPS data, we aggregated more detailed O*NET-SOC codes to broader occupational categories (i.e., "detailed occupations" and "broad occupations") and computed mean values across aggregated categories. Therefore, the jobs under the same broader groups were assumed to share similar work experiences and this may have introduced some error in the exposure assessment.

A major strength of this study was the use of a large population-based sample of mothers who were employed during pregnancy. Mothers who were excluded due to lack of matching O*NET data for their reported jobs, accounting for 7% of the eligible sample, were similar to mothers in our analyses. Specifically, as compared to mothers who were included in our analyses, mothers who were excluded based on lack of matching O*NET data were older, had more years of education, and more likely to have an annual household income between $10,000 and $50,000. The participation rate was high (64.8%) among mothers of the NBDPS controls, and these women have been determined to be representative of the base population (Cogswell, Bitsko et al. 2009). Further, the assessment of occupational physical activity and emotional stressors using O*NET was comprehensive, providing data on frequency, level, importance, and extent of work activities. To our knowledge, our study is the first to have explicitly examined differential patterns of a wide range of occupational physical activity and emotional stressors by age, race/ethnicity, and educational level among U.S. women during pregnancy. Our study indicates that linking O*NET to the NBDPS is feasible, and the linked data will allow future studies to examine the effects of estimated

occupational physical activity and emotional stressors on several birth outcomes including birth defects, which have not previously been possible due to limited individual-level occupational data in the NBDPS.

In summary, standing and dealing with unpleasant or angry people at work were the most common domains of physical activity and emotional stressors occupational exposures among mothers of control infants in the NBDPS who were employed during pregnancy, based on linkage of self-reported jobs to O*NET data. Additionally, exposures to occupational physical activity, sedentary behaviors, and occupational emotional stressors during pregnancy varied according to maternal age, race/ethnicity, and education level, which may results in health disparities. The exposure assessment developed in this study can be used in subsequent analyses to examine the role of occupational physical activity and emotional stressors on adverse birth outcomes and may point to important interventions for prevention and improving public health.

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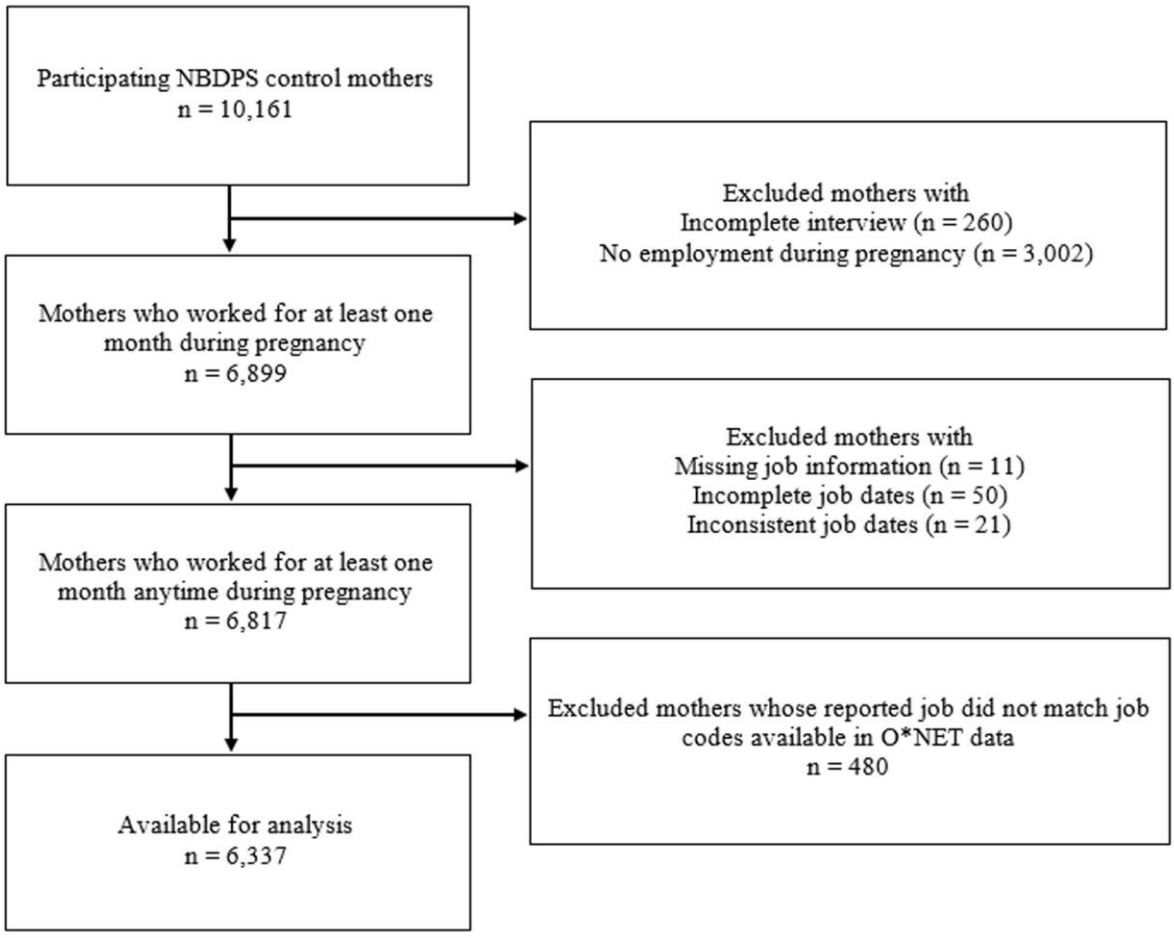

Figure 1. Population for analysis, National Birth Defects Prevention Study, 1997-2009

Table 1. Selected Occupational Information Network (O*NET) work elements

Work factor	Scale	O*NET element name
Physical activity		
	Frequency[a]	Bending or twisting the body
		Climbing ladders, scaffolds, poles
		Keeping or regaining balance
		Kneeling, crouching, stooping
		Making repetitive motions
		Exposure to whole body vibration
		Standing
		Walking and running
	Level[b]	Performing general physical activities
		Handling and moving objects
Sedentary behaviors		
	Frequency[a]	Sitting
Emotional stressors		
	Frequency[a]	Dealing with unpleasant or angry people
		Dealing with conflict situations
		Dealing with physically aggressive people
	Level[b]	Making decisions and solving problems
		Resolving conflicts and negotiating with others
	Importance[c]	Importance of being exact or accurate
		Pace determined by speed of equipment
	Extent[d]	Degree of automation
		Consequence of error

[a] Frequency: 1 (never), 2 (<50% of the time), 3 (50% of the time), 4 (>50% of the time), 5 (continually)
[b] Level: 1 (low) – 7 (high)
[c] Importance: 1 (not important), 2 (somewhat important), 3 (important), 4 (very important), 5 (extremely important)
[d] Extent: 1 (not at all), 2 (fairly), 3 (moderately), 4 (highly), 5 (completely)

Table 2. Characteristics of mothers who reported working at least one month during pregnancy with available Occupational Information Network data, National Birth Defects Prevention Study, 1997-2009 (n = 6,337)

Maternal characteristic[a]	n	%
Age (years)		
<20	462	7.3
20-24	1,469	23.2
25-29	1,798	28.4
30-34	1,684	26.6
≥35	924	14.6
Race/ethnicity		
Non-Hispanic White	4,048	63.9
Non-Hispanic Black	752	11.9
Hispanic	1,101	17.4
Other	434	6.9
Education (years)		
<12	639	10.1
12	1,504	23.7
13-15	1,927	30.4
≥16	2,264	35.7
Annual household income		
<$10,000	820	13.8
$10,000-$50,000	2,415	40.5
>$50,000	2,722	45.7
Hours worked per week[b,c]		
<40	2,365	37.4
40	2,605	41.2
>40	1,346	21.3
Occupational group[b,d]		
Management (11-0000)	544	8.6
Business and financial operations (13-0000)	259	4.1
Computer and mathematical (15-0000)	108	1.7
Architecture and engineering (17-0000)	24	0.4
Life, physical, and social science (19-0000)	87	1.4
Community and social service (21-0000)	120	1.9
Legal (23-0000)	72	1.1
Education, training, and library (25-0000)	519	8.2
Arts, design, entertainment, sports, and media (27-0000)	117	1.9
Healthcare practitioners and technical (29-0000)	543	8.6
Healthcare support (31-0000)	292	4.6
Protective service (33-0000)	46	0.7
Food preparation and serving related (35-0000)	568	9.0
Building and grounds cleaning and maintenance (37-0000)	163	2.6
Personal care and service (39-0000)	338	5.3
Sales and related (41-0000)	732	11.6
Office and administrative support (43-0000)	1337	21.1

Farming, fishing, and forestry (45-0000)	92	1.5
Construction and extraction (47-0000)	16	0.3
Installation, maintenance, and repair (49-0000)	8	0.1
Production occupations (51-0000)	223	3.5
Transportation and material moving (53-0000)	129	2.0

[a] Numbers may not sum to the total and percentages may not add to 100% because of missing data and/or rounding

[b] Based on mother's primary job

[c] Jobs with <1 or >168 hours worked per week were excluded

[d] 2000 Standard Occupational Classification Major Groups, excluding Military Specific Occupations (55-0000)

Table 3. Distribution of estimated occupational physical activities, sedentary behaviors, and emotional stressors associated with jobs reported by National Birth Defects Prevention Study control mothers during pregnancy, based on the Occupational Information Network (O*NET) Version 9.0 (n = 6,337)

Work factor and O*NET element name	%			
Physical activity				
Frequency (percentage of time at work)	<25%	25-<50%	50-<75%	≥75%
Bending or twisting the body	51.1	32.8	16.0	0.1
Climbing ladders, scaffolds, poles	97.8	2.0	0.2	0
Keeping or regaining balance	87.9	12.0	0.1	0.1
Kneeling, crouching, stooping	63.8	31.6	4.6	0
Making repetitive motions	9.1	44.3	34.8	11.9
Exposure to whole body vibration	99.4	0.5	0.1	0
Standing	10.3	26.3	32.4	31.0
Walking and running	24.8	32.9	31.9	10.4
Level	Low	Medium-low	Medium	High
Performing general physical activities	26.2	58.6	13.7	1.4
Handling and moving objects	14.8	51.6	30.8	2.7
Sedentary behaviors				
Frequency (percentage of time at work)	<25%	25-<50%	50-<75%	≥75%
Sitting	21.4	31.7	20.6	26.4
Emotional stressors				
Frequency (percentage of time at work)	<25%	25-<50%	50-<75%	≥75%
Dealing with unpleasant or angry people	10.0	24.0	55.7	10.3
Dealing with conflict situations	11.0	41.2	45.6	2.2
Dealing with physically aggressive people	75.7	23.1	0.7	0.5

Level	Low	Medium-low	Medium	High
Making decisions and solving problems	8.7	44.6	39.0	7.7
Resolving conflicts and negotiating with others	16.0	43.3	38.4	2.3
Importance	Not important	Fairly important	Important	Extremely important
Being exact or accurate	0.2	7.6	42.0	50.2
Pace determined by speed of equipment	82.4	15.1	2.4	0.2
Extent	Not at all	Fairly	Automated/Serious	Highly
Degree of automation	38.0	53.5	8.4	0.1
Consequence of error	8.2	66.1	19.4	6.3

Table 4. Distribution of occupational physical activities and sedentary behaviors during pregnancy by selected maternal characteristics, National Birth Defects Prevention Study, 1997-2009

	Maternal characteristic (%)												
	Age (years)					Race/ethnicity				Education (years)			
	<20	20-24	25-29	30-34	≥35	Non-Hispanic White	Non-Hispanic Black	Hispanic	Other	<12	12	13-15	≥16
Frequency (percentage of time at work)													
Bending or twisting the body[a]													
<25%	25.5	37.2	52.6	64.4	58.8	56.3	44.6	36.7	50.9	18.5	36.2	49.9	71.2
25-<50%	41.3	39.5	33.2	25.8	30.0	30.4	34.4	39.5	34.8	45.9	40.6	33.7	23.1
50-<75%	33.1	23.3	14.3	9.8	10.9	13.2	20.6	23.7	14.3	35.5	23.1	16.1	5.6
≥75%	0	0.1	0.1	0.1	0.3	0.1	0.4	0.1	0	0.2	0	0.2	0.1
Standing[a]													
<25%	5.8	8.3	11.0	11.4	12.7	11.2	10.0	7.7	9.9	3.6	9.2	12.2	11.4
25-<50%	7.4	16.8	26.9	35.3	33.1	30.0	20.6	15.9	28.1	5.2	17.1	26.6	38.1
50-<75%	19.3	29.8	35.3	33.4	35.4	33.5	35.5	26.3	31.1	22.2	29.3	35.6	34.5
≥75%	67.5	45.1	26.9	19.8	18.8	25.4	33.9	50.1	30.9	69.0	44.4	25.7	16.0
Walking and running[a]													
<25%	10.2	19.3	26.7	29.3	28.9	26.9	21.9	18.4	26.3	8.5	19.5	27.6	30.6
25-<50%	14.3	24.5	35.4	39.8	38.2	35.6	30.2	24.6	33.9	16.1	25.2	29.2	46.0
50-<75%	50.9	38.7	28.1	26.4	28.6	28.4	33.9	45.1	27.4	56.5	37.1	32.4	21.0
≥75%	24.7	17.4	9.7	4.5	4.3	9.1	14.0	12.0	12.4	18.9	18.3	10.9	2.5
Kneeling, crouching, stooping[a]													
<25%	47.0	56.6	62.9	71.3	71.9	67.5	58.8	53.4	65.0	43.4	56.3	66.1	72.7
25-<50%	46.3	36.9	33.0	25.4	24.2	30.1	36.2	34.0	20.7	38.7	36.6	31.2	26.6
50-<75%	6.7	6.5	4.0	3.3	3.9	2.4	4.9	12.6	4.4	17.8	7.1	2.7	0.8
≥75%	0	0	0.1	0	0	0	0.1	0	0	0.2	0	0	0
Making repetitive motions[a]													
<25%	2.2	4.1	8.0	14.3	13.0	11.2	5.9	4.2	7.6	2.0	4.4	5.5	17.3
25-<50%	23.2	35.4	48.3	50.0	50.4	47.4	44.0	31.2	47.9	23.3	35.6	43.1	56.9
50-<75%	47.2	41.6	33.4	29.6	30.0	32.0	34.7	45.1	35.0	48.4	42.2	38.7	22.7

≥75%	27.5	18.9	10.2	6.1	6.6	9.4	15.4	19.5	9.5	26.3	17.9	12.7	3.1
Sitting[a]													
<25%	56.5	35.4	16.7	10.5	10.4	17.8	25.7	32.2	20.5	46.5	34.2	21.3	5.9
25-<50%	26.4	30.8	35.0	30.5	31.2	30.5	34.3	34.6	30.2	38.7	29.8	28.0	34.1
50-<75%	5.6	13.0	20.0	28.0	27.8	23.0	16.4	14.2	21.7	7.2	14.1	19.5	29.6
≥75%	11.5	20.8	28.3	31.0	30.6	28.7	23.7	19.1	27.7	7.7	21.9	31.2	30.4
						Level							
Performing general physical activities[a]													
Low	8.4	19.1	26.7	33.7	32.1	29.1	24.3	16.4	28.6	5.8	17.8	27.5	36.6
Medium-low	73.2	63.0	57.6	53.9	54.8	58.3	59.4	60.0	56.7	64.5	63.5	56.3	55.6
Medium	17.1	16.4	14.4	11.1	11.5	11.5	14.9	21.3	12.9	25.7	17.2	14.9	7.1
High	1.3	1.5	1.3	1.4	1.6	1.2	1.3	2.4	1.8	4.1	1.5	1.3	0.8
Handling and moving objects[a]													
Low	6.7	10.4	15.5	18.3	18.4	16.1	12.8	10.9	16.4	3.9	10.2	15.5	20.4
Medium-low	49.6	48.2	50.2	55.2	54.3	54.6	54.4	39.0	51.2	35.5	48.3	51.2	58.7
Medium	42.0	39.0	31.3	23.5	24.8	26.5	30.5	47.1	30.2	54.6	39.3	30.5	18.8
High	1.7	2.5	3.0	3.1	2.5	2.7	2.4	3.1	2.3	6.0	2.1	2.8	2.2

[a] Chi-squared test or Fisher's exact test: $P < 0.001$ for comparisons across age groups, race/ethnicity groups, and education groups

Table 5. Distribution occupational emotional stressors during pregnancy by selected maternal characteristics, National Birth Defects Prevention Study, 1997-2009

	Maternal characteristic (%)												
	Age (years)					Race/ethnicity				Education (years)			
	<20	20-24	25-29	30-34	≥35	Non-Hispanic White	Non-Hispanic Black	Hispanic	Other	<12	12	13-15	≥16
Frequency (percentage of time at work)													
Dealing with unpleasant or angry people[a]													
<25%	10.6	13.0	9.9	7.8	8.8	6.8	10.8	20.5	11.1	25.8	14.8	7.4	4.5
25-<50%	12.8	17.2	25.0	28.6	30.2	25.6	20.1	19.0	28.8	16.9	19.2	22.0	30.9
50-<75%	49.8	54.3	57.5	57.8	53.9	58.5	54.7	47.9	52.3	39.8	53.1	57.8	60.2
≥75%	26.8	15.6	7.6	5.8	7.1	9.2	14.5	12.6	7.8	17.5	12.9	12.8	4.4
Dealing with conflict situations[a]													
<25%	13.0	14.8	10.9	8.2	9.3	7.9	11.6	22.6	9.9	28.5	16.6	9.1	3.9
25-<50%	44.8	43.7	41.0	39.0	39.7	41.4	44.3	36.5	45.6	38.8	45.2	44.2	36.6
50-<75%	41.8	40.7	46.7	49.0	47.2	48.1	42.3	39.8	43.6	32.6	37.6	44.9	55.3
≥75%	0.4	0.8	1.4	3.9	3.8	2.7	1.9	1.1	0.9	0.2	0.5	1.9	4.2
Level													
Resolving conflicts and negotiating with others[a]													
Low	21.0	23.8	15.9	10.6	11.4	11.5	20.1	30.1	15.2	39.4	26.1	13.7	4.7
Medium-low	65.8	52.6	42.7	35.1	33.1	40.8	47.9	48.1	46.1	48.5	51.3	54.1	27.2
Medium	12.8	23.4	39.9	50.3	50.9	44.5	30.9	21.4	37.6	12.1	22.2	30.6	63.4
High	0.4	0.3	1.6	4.0	4.7	3.1	1.2	0.5	1.2	0	0.4	1.7	4.7
Making decisions and solving problems[a]													
Low	12.6	14.3	8.7	4.2	6.3	6.4	14.5	13.7	8.5	18.5	16.2	8.0	1.6
Medium-low	76.4	59.8	43.7	32.1	29.0	39.7	49.3	60.5	41.9	69.2	60.6	54.2	18.8
Medium	10.8	24.5	41.2	50.3	51.4	44.3	32.5	23.7	39.6	12.4	22.3	33.5	62.2
High	0.2	1.4	6.5	13.4	13.3	9.7	3.7	2.1	9.9	0	0.8	4.2	17.4

						Extent							
Consequence of error[a]													
Not at all	16.5	11.2	6.4	6.8	5.4	6.8	8.5	12.6	9.7	14.7	10.6	7.3	5.6
Fairly	71.9	70.7	68.0	62.2	59.4	64.8	66.6	73.0	60.6	71.4	70.0	68.0	60.5
Serious	11.5	15.8	19.5	21.1	25.7	20.5	21.3	12.7	23.0	13.8	19.0	18.9	21.7
Highly	0.2	2.3	6.1	9.8	9.5	8.0	3.6	1.6	6.7	0.2	0.5	5.8	12.2
						Importance							
Being exact or accurate[a]													
Not at all	21.0	23.8	15.9	10.6	11.4	11.5	20.1	30.1	15.2	39.4	26.1	13.7	4.7
Fairly	65.8	52.6	42.7	35.1	33.1	40.8	47.9	48.1	46.1	48.5	51.3	54.1	27.2
Important	12.8	23.4	39.9	50.3	50.9	44.5	30.9	21.4	37.6	12.1	22.2	30.6	63.4
Extremely	0.4	0.3	1.6	4.0	4.7	3.1	1.2	0.5	1.2	0	0.4	1.7	4.7

[a] Chi-squared test or Fisher's exact test: $P < 0.001$ for comparisons across age groups, race/ethnicity groups, and education groups

CHAPTER III: THE ROLE OF MATERNAL OCCUPATIONAL PHYSICAL ACTIVITY AND EMOTIONAL STRESSORS ON SELECTED ADVERSE BIRTH OUTCOMES: RESULTS FROM LINKING THE OCCUPATIONAL INFORMATION NETWORK TO THE NATIONAL BIRTH DEFECTS PREVENTION STUDY, 1997-2009

Occupational and Environmental Medicine

Abstract

We examined the role of an array of estimated maternal occupational physical activities and emotional stressors during pregnancy on preterm birth (PTB) and small-for-gestational age (SGA). Data for infants born without major birth defects, delivered from 1997 to 2009 whose mothers reported working at least one month during pregnancy were obtained from the National Birth Defects Prevention Study. Each mother's primary job during each trimester of pregnancy was defined based on greatest hours worked. We then linked each job title to the U.S. Department of Labor's Occupational Information Network (O*NET), which provides estimates for multiple domains of physical activity and emotional stressors for occupational categories. Using factor and logistic regression analyses, we examined the role of estimated occupational physical activity and emotional stressors in each trimester on PTB and SGA. Factor analysis identified four groups of the physical activity and emotional stressor domains: "occupational physical activity," "interpersonal stressor," "automated work," and "job control." High levels of "occupational physical activity" were significantly associated with SGA (adjusted odds ratio [AOR] 1.36; 95% confidence intervals [CI] 1.02 to 1.82; *P* for trend = 0.001) and were also positively associated with PTB (AOR

1.24; 95% CI 0.93 to 1.64; *P* for trend = 0.01). No clear results were observed across domains of emotional stressors. Our findings expand understanding of associations between occupational physical activity and emotional stressors and PTB and SGA relative to previous studies of more limited scope.

Introduction

Preterm birth (PTB) and being born small-for-gestational age (SGA) are major contributors to infant mortality, morbidity, and hospitalization costs in the U.S.[1-4] While several risk factors for PTB and SGA have been identified, they do not explain a majority of cases.[5 6] Therefore, the identification of additional risk factors is important for identifying future prevention targets. Although the prevalence of PTB and SGA have decreased slightly over the past decade, both are still relatively common, with PTB occurring in 11.4% of 2013 births and low birth weight (less than 2,500 grams, a proxy for SGA) infants accounting for 8 percent of 2013 births.[7] Workplace exposures, including physical activity and emotional stressors, are important to consider, as the majority (~90%) of working women remain employed during pregnancy.

There is a considerable epidemiological literature on the association of certain physical activities at work (i.e., prolonged standing, heavy lifting, and high physical workload) and adverse birth outcomes, including PTB and SGA.[8-11] Based on a meta-analysis published in 2013,[9] prolonged standing (i.e., > 4 hours/day) was modestly associated with the risk of PTB (summary relative risk [RR] 1.22; 95% confidence interval [CI] 1.12 to 1.33; number of studies 12), while no association was observed for SGA (summary RR 1.07; 95% CI 0.94 to 1.22; number of studies 7). The findings for lifting and physical workload

varied considerably across studies for both PTB (for lifting, RR ranged from 0.55 to 2.91; for physical workload, RR range: 0.71 to 4.10) and SGA (for lifting, RR range: 0.50 to 1.20; for physical workload, RR range: 0.70 to 2.40), potentially due to differences in exposure definitions.[9] A smaller, but growing, body of research has examined the association between emotional stressors at work, typically defined as a combination of high job demands and low decision latitude, and birth outcomes.[12-17] The majority of findings from these studies have shown an association of increased emotional stress with increased risk for PTB and SGA,[13-15] [16] although not all.[12]

There are many domains of occupational physical activity and emotional stressors for which little or no research has been conducted regarding their possible association with adverse birth outcomes. Consideration of different types of occupational physical activity and emotional stressors is important because many are prevalent during pregnancy and are potentially modifiable. In a recent analysis using linked National Birth Defects Prevention Study (NBDPS) and Occupational Information Network (O*NET) data, more than 16% of women reported jobs associated with bending or twisting the body for at least half of their time at work during pregnancy, and approximately 65% of pregnant women reported jobs associated with dealing with unpleasant or angry people for at least half of their time at work.[18] Leveraging the NBDPS-O*NET linkage provides a unique opportunity to assess a broad range of occupational physical activities and emotional stressors and their potential association with selected adverse birth outcomes.

In this assessment, we examined the association between a wide range of maternal occupational physical activities and emotional stressors in each trimester of pregnancy and

two adverse birth outcomes (i.e., PTB and SGA) using data on more than 10,000 live births with no major birth defects in the U.S. from the NBDPS. Some of the individual occupational physical activities and emotional stressors are likely to be correlated and share common underlying mechanisms, and we therefore conducted a factor analysis to identify latent factors and examined the role of these factors on PTB and SGA.

Methods

Study participants

The study population included live born infants with no known major birth defects from the NBDPS (i.e., control infants), with estimated dates of delivery between October 1, 1997 and December 31, 2009. Only NBDPS infants with no major birth defects were included in our analyses, as infants with major birth defects are more likely to be delivered preterm or SGA[19] and the occupational exposures we are studying could be independently associated with risks for specific birth defects. The details of the NBDPS methods have been published elsewhere.[20 21] In brief, the NBDPS includes data collected from 10 Centers throughout the U.S. (entire state: Arkansas, Iowa, New Jersey, and Utah; selected counties: California, Georgia, Massachusetts, New York, North Carolina, and Texas). Each Center randomly selected live born infants without major birth defects from the same population that gave rise to the cases using birth certificates or birth hospital logs. Participating mothers completed a standardized, computer-assisted telephone interview (CATI), in English or Spanish that lasted approximately one hour between six weeks and two years after the estimated date of delivery. Interviewers obtained information about demographic,

behavioral, and clinical factors before and during pregnancy. Study methods were approved by the Institutional Review Board (IRB) at each study site. Additionally, this analysis was approved by the IRB of the University of Texas Health Science Center at Houston, Texas, USA.

Classification of outcome

Information on gestational age at birth and birth weight was collected by the NBDPS staff from birth records. Gestational age at birth was determined based on first trimester ultrasound estimation, date of last menstrual period, or physical examination.[22] PTB was defined as less than 37 completed weeks of gestation.[23] To be consistent with a previous NBDPS study,[24] SGA was estimated based on the methods of Zhang and Bowes,[25] and Overpeck et al.[26] SGA was defined as birth weight less than 10th percentile for gestational age, sex, race/ethnicity, and maternal parity. We excluded infants with missing birth weight or who weighed less than 500 grams. Based on the methods used to define SGA status,[25 26] we further excluded mothers with missing parity as well as mothers with missing infant sex, race, or falling outside of range for calculated fetal growth curves. We excluded infants from multiple gestation births, as multiple gestation is a strong risk factor for PTB and SGA.[5 7]

Exposure assessment

Classifying jobs held during each trimester of pregnancy

The details of methods we used for classifying jobs in the NBDPS has been reported elsewhere.[18] Briefly, during the interview each mother provided a work history for all jobs,

including part-time jobs that lasted at least one month in duration from three months before pregnancy to the date her pregnancy ended. For each job held, she was asked about the start and stop date (month and year), the days per week and hours per day worked, job title, name of company or organization, service or product provided by the company, the mother's main activities or duties and machines used. Each job was coded for occupation using the 2000 Standard Occupational Classification (SOC) system[27] and the North American Industry Classification System (NAICS).[28]

For the present analyses, we assigned exposure periods based on the estimated date of conception and defined the first trimester as weeks 0-12, the second trimester as weeks 13-24, and the third trimester as weeks 25-45. Approximately 15% of mothers reported two or more jobs during pregnancy. We considered their primary job in our analysis, defined as the job with the most hours worked, calculated using self-reported number of hours per week and job duration) for each trimester.

Assessing exposures to occupational physical activity and emotional stressors

We used O*NET to assign estimated occupational physical activity and emotional stressors based on the mother's reported primary job. Developed by the U.S. Department of Labor, O*NET is a publicly available database that includes detailed occupational information (http://www.onetonline.org) on over 900 jobs.[29] Briefly, O*NET is an on-going survey of job holders (sample size of workers varies by job title) and occupational analysts; O*NET uses a standardized questionnaire to collect information on more than 270 items describing different aspects of the job. We used data from our previous linkage in which we

linked job titles reported by mothers in the NBDPS to O*NET version 9.0 using the 2000 SOC codes.[18] We used version 9.0, published December 2005, based on the study period (1997-2009) and because it included job titles codes in the 2000 SOC system.

We selected seven O*NET items for the present study that represented different domains of occupational physical activity: 1) general physical activities (e.g., climbing, lifting, balancing, walking, stooping, and handling of materials); 2) bending or twisting the body; 3) standing; 4) handling and moving objects; 5) walking and running; 6) kneeling, crouching, or stooping; and 7) keeping or regaining balance. We considered 10 O*NET items that represented occupational emotional stressors: 1) dealing with unpleasant or angry people; 2) dealing with conflict situations; 3) dealing with physically aggressive people; 4) resolving conflicts and negotiating with others; 5) making repetitive motions; 6) pace determined by speed of equipment; 7) degree of automation; 8) consequence of error; 9) making decisions and solving problems; and 10) importance of being exact or accurate. For each item, O*NET includes a mean value, standard error, and survey sample size by job title, coded in the SOC system. Because O*NET items were measured using different scales (e.g., five-point scale or seven-point scale), we previously calculated standardized mean values for each job title.[18]

Many of the individual occupational physical activities and emotional stressors had the potential to be correlated. To address the issue of correlated variables, we utilized factor analysis (described below), which is a statistical method used to assess the relationships between correlated variables and reducing the full group of variables to a smaller number of composite variables called factors.[30]

Covariates

Maternal characteristics considered as potential confounders were: age at delivery (<20, 20-24, 25-29, 30-34, ≥35 years), race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), education (<12, 12, 13-15, ≥16 years), parity (0 or ≥1 previous live births), pre-gestational diabetes (no or yes), high blood pressure during the index pregnancy (no or yes), supplement use containing folic acid one month before conception through the first month of pregnancy (no or yes), alcohol use (no or yes) and smoking (no or yes) one month before conception through the third month pregnancy, hours worked per week in the primary job (<40, 40, >40 hours/week), and category of pre-pregnancy body mass index (BMI). Maternal pre-pregnancy BMI (weight[kg]/height[m^2]) was categorized as underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥30.0 kg/m^2) using cutoff points established by the National Heart, Lung and Blood Institute.[31] We also considered maternal study center as a potential covariate.

Statistical analysis

We estimated Pearson correlation coefficients across O*NET items as well as the mean, standard deviation, minimum, and maximum of each O*NET item. We applied factor analysis on the O*NET items using principal components extraction with varimax rotation. We retained factors with an eigenvalue of one or greater and assessed variance explained by each factor and the cumulative variance explained by selected factors. For the present study, we used variables with rotated factor loadings having absolute values of 0.70 or greater to

interpret the factors.[30] We assessed internal consistency among the variables with absolute loadings ≥0.70, using Cronbach's alpha coefficient. Factor scores were calculated as the sum of products of observed variables, weighted by the corresponding factor loadings, and they were categorized into quartiles based on the distribution of the entire study population (i.e., NBDPS control infants).

Unconditional logistic regression was used to calculate crude odds ratios (OR) and adjusted OR (AOR) and 95% CI to estimate the association between each factor and the odds of PTB and SGA in offspring. Separate analyses were conducted for each outcome where the comparison group for the PTB outcome was non-PTB and the comparison group for the SGA was non-SGA. In all analyses, the lowest quartile was selected as the reference category.

We assessed confounding for each exposure (as a continuous variable)-outcome association and incorporated other variables as confounders in the final model if inclusion resulted in ≥10% change in the estimate of effect between the exposure and the outcome. Based on previous studies,[9] we included maternal age, race/ethnicity, education, and smoking in all models. The Cochran-Armitage test was conducted on final models to test for a linear trend across quartiles. All analyses were conducted using SAS, version 9.3 (SAS Institute, Inc., Cary, North Carolina).

To better understand our factor analysis results, we also examined the association between individual O*NET items and PTB and SGA in each trimester of pregnancy, using unconditional logistic regression and calculated crude OR and AOR and 95% CI. We

categorized each O*NET item by using quartiles and selected the lowest quartile as the reference category.

Results

Among the 10,161 live born infants with no known major birth defects included in the NBDPS for the period 1997-2009, we included 6,379 singleton infants whose mothers reported being employed for at least one month in the first trimester of pregnancy in the analyses. After excluding mothers who held jobs with no matching O*NET data (n =453), there were 5,926 infants available for the PTB analyses (Table 1). PTB accounted for 8.0% of infants available for the analysis. For the SGA analysis, we further excluded infants with missing birth weight or weighed less than 500 grams (n = 113); missing infant sex, race, or maternal parity (n = 14); or fell outside of range for calculated fetal growth curves (n=47). After these exclusions, data from 5,830 infants were available for the SGA analyses. SGA accounted for 7.8% of infants available for the analysis. Also shown in Table 1 are the selected maternal characteristics in our sample by SGA and PTB status.

Mean, standard deviation, minimum, and maximum values for each occupational activity are shown in Table 2. The Pearson correlation coefficients between individual occupational physical activities ranged from 0.51 to 0.81 and were strongest for general physical activities and handling and moving objects (r = 0.81) (Appendix F). Among occupational emotional stressors, the correlation was strongest for making decisions and solving problems and resolving conflicts and negotiating with others (r = 0.79) (Appendix G).

Our factor analysis identified four main factors with eigenvalue of one or greater that explained 75.8% of the total variance (Table 3). The first factor ("occupational physical activity") was characterized by seven O*NET items: general physical activities; bending or twisting the body; standing; handling and moving objects; walking and running; kneeling, crouching, or stooping; and keeping or regaining balance. The internal reliability of the O*NET items in the first factor was high, with Cronbach's alpha of 0.92. The second factor ("interpersonal stressor") was characterized by three O*NET items: dealing with unpleasant or angry people, dealing with conflict situations, dealing with physically aggressive people (Cronbach's alpha = 0.84). The third factor was predominantly related to "automated work" and included two O*NET items: making repetitive motions and pace determined by speed of equipment (Cronbach's alpha = 0.65). The last factor ("job control") was predominantly characterized by one O*NET item: consequence of error.

Crude and adjusted associations between quartiles of factor scores in the first trimester of pregnancy and PTB and SGA are shown in Table 4. All models were adjusted for maternal age, race/ethnicity, education, and smoking, as no other variables appeared to confound the association between the exposure and the outcome. The first factor ("occupational physical activity") had similar associations with SGA as PTB. More specifically, the highest quartile of "occupational physical activity" was significantly associated with PTB (OR 1.37; 95% CI 1.05 to 1.79) and SGA (OR 1.52; 95% CI 1.15 to 2.00) when compared to the lowest quartile, and the association with SGA remained significant after adjustment (AOR 1.36; 95% 1.02 to 1.82). There was a positive linear trend across quartiles of "occupational physical activity" for PTB (*P* for trend = 0.01) and SGA (*P*

for trend = 0.001). The odds of PTB or SGA were not significantly associated with any other factors in the crude and adjusted analyses. Additionally, results were less consistent across three factors (i.e., "interpersonal stressor," "automated work," and "job control"), characterized by occupational emotional stressors. In the adjusted analyses, the two highest quartiles of "interpersonal stressor" were positively associated with PTB when compared to the lowest quartile. This same association was not seen for SGA. There was an increase in the odds of SGA with increasing "automated work," and a significant positive linear trend (*P* for trend = 0.02), while "automated work" was not associated with PTB. When compared to the lowest quartile of "job control," the highest quartile of "job control" was positively associated with PTB (AOR 1.16; 95% CI 0.88 to 1.53), whereas it was inversely associated with SGA (AOR 0.85; 95% CI 0.63 to 1.15). There were few observed differences in the association estimates across trimesters.

Discussion

In this large, population-based study we evaluated estimated maternal exposures to a comprehensive array of occupational physical activities and emotional stressors in each trimester of pregnancy and the odds of PTB and SGA in offspring. In order to address correlated exposure variables, we conducted a factor analysis and identified four underlying latent factors (i.e., "occupational physical activity," "interpersonal stressor," "automated work," and "job control") that explained more than 75% of the variance in individual activities and examined their associations with PTB and SGA. Overall, estimated maternal "occupational physical activity" was positively associated with the odds of PTB and SGA in

offspring, with a dose-response relation observed. There were little differences in the effect estimates across trimesters.

The biological mechanisms by which maternal workplace exposures relating to physical activity or emotional stressors during pregnancy might result in PTB or SGA remain unclear. Possible mechanisms include increased catecholamine levels in response to physically demanding activities such as heavy lifting and prolonged standing,[32] as catecholamines have been shown to increase the blood pressure, uterine contractibility, and decrease placental function in humans.[32 33] Additionally, increased noradrenaline levels from physically demanding work could lead to uterine contractibility and PTB.[34] There is evidence in support of an association between adverse birth outcomes and maternal psychosocial stressors from experiencing certain life events such as job loss and divorce.[35] A potential biological mechanism underlying this relationship is the increased serum concentrations of inflammatory markers and/or corticotropin releasing hormones.[5 36] It is possible that mothers experiencing emotional stressors at work may experience similar physiological changes. Further, emotional stressors at work have been shown to lead to negative health behaviors such as smoking,[37] and indirectly affect the developing fetus.

Previous studies on different domains of occupational physical activity and adverse birth outcomes differ largely with respect to how exposures were assessed, and therefore it is difficult to compare our findings with previous work. When each occupational physical activity was analyzed individually, our adjusted results suggest that mothers who reported jobs in the highest quartile of bending or twisting the body were 44% more likely to have a child being born preterm than mothers who reported jobs in the lowest quartile of bending or

twisting the body. Additionally, mothers who reported jobs in the highest quartile of keeping or regaining balance were 40% more likely to have a child being born SGA than mothers who reported jobs in the lowest quartile of keeping or regaining balance.

Bending or twisting the body, which loaded highly to "occupational physical activity" factor, has been examined as a composite occupational physical activity variable in previous studies.[13 16] In Canadian studies, physical demands (defined as bending, squatting, arms raised above shoulder level, or other demanding posture) at the beginning of pregnancy was significantly associated with PTB (AOR 1.4; 95% CI 1.2 to 1.7),[13] although it was not associated with SGA (AOR 1.0; 95% CI 0.9 and 1.2).[16] In another study, among female healthcare workers, "biomedical load," defined by bending and lifting, was significantly associated with spontaneous abortion (AOR 3.19; 95% CI 1.27 to 9.78).[38] In our data, about 22% and 20% of mothers in the highest quartile of bending or twisting the body reported jobs in two major groups: "Food preparation and serving related" (SOC code, 35-000) and "Healthcare practitioners and technical" (SOC code, 29-000), respectively. Health care workers have a unique occupational environment that expose them to physically demanding activities and several studies have examined occupational exposures of health care workers, suggesting positive associations with adverse birth outcomes.[39] Our findings may therefore provide some basis for further assessing the role of certain physical activities among pregnant workers in this occupational group.

We found that the results were not consistent in the odds ratios describing the association between three factors associated with emotional stressors (i.e., "interpersonal stressor," "automated work," and "job control") and PTB and SGA. Previous studies on

emotional stressors among pregnant women have also incorporated several domains to develop a composite psychosocial stress variable based on the demand-control model, defining "job strain" as a combination of high levels of demands (e.g., "do you have too many tasks at work?") and low levels of control over those demands (e.g., "do you have the opportunity to influence your tasks and working conditions?").[13-16] Findings from the studies based on the demand-control model were generally consistent, showing modest associations. In Canada, there were positive associations for PTB (OR = 1.2) and SGA (OR = 1.3) in mothers exposed to high job strain with low social support compared to low strain.[13 16] Among U.S. women with full-time jobs (≥35 hours/week), high-strain job was positively associated with PTB (OR = 1.4), although the association was not statistically significant.[14] In Mexico, high job strain (RR = 1.23) and conflicts at work (RR = 1.54) were independently associated with PTB.[15]

Our study should be considered in the light of certain limitations. Our findings may not be generalizable to U.S. pregnant women, as a previous study has found that NBDPS control participants are not representative of the general U.S. population with respect to several maternal characteristics such as maternal race/ethnicity and education.[21] Additionally, the proportion of PTB in our study population (~8.0%) was lower than what we would expect in the general U.S. population. This may be in part due to our exclusion of infants from multiple gestations and infants with congenital malformations, both of which are strongly associated with the risk of PTB.

The potential for exposure misclassification is another limitation in this study. The assignment of occupational physical activity and emotional stressors was indirect, based on

linking mothers' self-reported jobs to estimates of physical activity and emotional stressor domains for those jobs in O*NET. This assignment was based on average levels of work activities from a representative sample of U.S. workers, including men and non-pregnant women, with the same jobs and does not account for inter-individual variability in exposure between workers, or work accommodations that may be provided to pregnant women. The jobs under the same broader groups were assumed to share similar work experiences and this may have introduced some error in the exposure assessment. For mothers who held two or more jobs during pregnancy (~16%), the primary job was selected (based on the number of hours worked), and their assigned exposure may not reflect their total work experience. Further, information on exposures from other domains (e.g., leisure-time physical activity) was available only for the last three years of our study period, and we could not take into account other sources of physical activity or emotional stressors outside of employment. Lastly, the use of O*NET to assign occupational exposures has not been validated; however, O*NET has been utilized in several studies of pregnancy and other health outcomes, where it has been used to quantify various occupational characteristics.[33 40]

A major strength of this study was the use of a large population-based sample of mothers who were employed during pregnancy. The participation rate was high (64.8%) among mothers of the NBDPS controls. Mothers who were excluded due to lack of matching O*NET data for their reported jobs, accounting for 7% of the eligible sample, were similar to mothers in our analyses. The assessment of occupational physical activity and emotional stressors using O*NET was comprehensive, providing data on work activities that have been not been examined in previous studies.

In conclusion, by examining the role of multiple domains of occupational physical activity and emotional stressors, this study expands our understanding about the work activity-adverse birth outcome associations relative to previous studies of more limited scope. Our findings may ultimately provide an important basis for developing a more comprehensive guideline on physical activity and emotional stressors at work for pregnant women. Further, the linked NBDPS-O*NET will allow us to examine the effects of estimated occupational physical activity and emotional stressors on birth defects, which may potentially provide novel insights into their relatively unknown etiologies.

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Table 1. Selected maternal characteristics for infants by preterm birth (PTB)* and small-for-gestational age (SGA) status,** National Birth Defects Prevention Study, 1997-2009

	PTB	Non-PTB	*P* value[a]	SGA	Non-SGA	*P* value[a]
	n (%)	n (%)		n (%)	n (%)	
Total	474	5,452		452	5,378	
Maternal age (years)						
<20	37 (7.8)	364 (6.7)	0.01	30 (6.6)	369 (6.9)	0.002
20-24	112 (23.6)	1263 (23.2)		130 (28.8)	1221 (22.7)	
25-29	150 (31.7)	1567 (28.7)		122 (27.0)	1561 (29.0)	
30-34	94 (19.8)	1489 (27.3)		92 (20.4)	1467 (27.3)	
≥35	81 (17.1)	769 (14.1)		78 (17.3)	760 (14.1)	
Race/ethnicity						
Non-Hispanic White	272 (57.5)	3526 (64.7)	0.001	282 (62.4)	3459 (64.3)	0.001
Non-Hispanic Black	80 (16.9)	608 (11.2)		32 (7.1)	646 (12.0)	
Hispanic	87 (18.4)	946 (17.4)		96 (21.2)	915 (17.0)	
Other	34 (7.2)	371 (6.8)		42 (9.3)	358 (6.7)	
Education (years)						
<12	56 (11.8)	528 (9.7)	0.03	55 (12.2)	516 (9.6)	0.001
12	129 (27.2)	1261 (23.1)		123 (27.2)	1242 (23.1)	
13-15	145 (30.6)	1683 (30.9)		149 (33.0)	1643 (30.6)	
≥16	144 (30.4)	1977 (36.3)		125 (27.7)	1974 (36.7)	
Parity						
0	219 (46.3)	2445 (44.9)	0.54	193 (42.7)	2435 (45.3)	0.29
≥1	254 (53.7)	3006 (55.2)		259 (57.3)	2943 (54.7)	
Body mass index (kg/m^2)						
Underweight (<18.5)	25 (5.3)	250 (4.7)	0.34	36 (8.3)	233 (4.4)	<0.001
Normal (18.5-24.9)	241 (51.5)	2895 (54.3)		258 (59.2)	2829 (53.6)	
Overweight (25.0-29.9)	107 (22.9)	1268 (23.8)		83 (19.0)	1271 (24.1)	
Obese (≥30)	95 (20.3)	923 (17.3)		59 (13.5)	942 (17.9)	
Pre-gestational diabetes						
No	467 (98.5)	5411 (99.4)	0.03	450 (99.6)	5334 (99.3)	0.54
Yes	7 (1.5)	34 (0.6)		2 (0.4)	37 (0.7)	
High blood pressure						
No	355 (74.9)	4766 (87.5)	<0.001	367 (81.2)	4668 (86.9)	0.001
Yes	119 (25.1)	680 (12.5)		85 (18.8)	704 (13.1)	
Folic acid use[b]						
No	204 (43.0)	2435 (44.7)	0.49	228 (50.4)	2371 (44.1)	0.01
Yes	270 (57.0)	3017 (55.3)		224 (49.6)	3007 (55.9)	
Alcohol use[c]						
No	300 (63.7)	3093 (56.9)	0.004	255 (57.1)	3064 (57.1)	0.98
Yes	171 (36.3)	2343 (43.1)		192 (43.0)	2300 (42.9)	
Smoking[c]						
No	377 (79.5)	4421 (81.1)	0.40	344 (76.1)	4368 (81.2)	0.01
Yes	97 (20.5)	1030 (18.9)		108 (23.9)	1009 (18.8)	
Hours worked per week[d]						
<40	167 (35.3)	2008 (37.0)	0.71	163 (36.2)	1963 (36.6)	0.86

40	204 (43.1)	2244 (41.3)	184 (40.9)	2230 (41.6)
>40	102 (21.6)	1180 (21.7)	103 (22.9)	1167 (21.8)

*Excluded non-working mothers, multiple gestations, major birth defects, and mothers whose reported job did not match job codes available in O*NET, version 9.0

**For the SGA analysis, we further excluded infants with missing birth weight or weighed less than 500 grams; missing infant sex, race, or maternal parity, or fell outside of calculated fetal growth curves

[a] Chi-square tests

[b] One month before conception through the first month of pregnancy

[c] One month before conception through the third month of pregnancy

[d] Based on primary job

Table 2. Descriptive statistics of selected domains of occupational physical activity and emotional stressors, Occupational Information Network (O*NET) version 9.0

O*NET item	Mean	SD[a]	Minimum	Maximum
General physical activities[b]	34.69	15.94	1.43	93.86
Bending or twisting the body	30.13	17.07	0	83.25
Standing	58.87	25.10	10.00	99.75
Handling and moving objects	43.05	16.36	2.29	87.57
Walking and running	43.72	20.45	3.75	91.25
Kneeling, crouching, or stooping	21.12	13.80	0	88.75
Keeping or regaining balance	11.31	10.23	0	82.75
Making repetitive motions	49.56	18.99	0	95.25
Dealing with unpleasant or angry people	52.87	19.47	0	95.25
Dealing with conflict situations	47.80	17.32	0	91.25
Dealing with physically aggressive people	16.42	13.99	0	85.00
Resolving conflicts and negotiating with others	44.23	17.65	1.90	81.14
Making repetitive motions	49.56	18.99	0	95.25
Pace determined by speed of equipment	14.50	12.81	0	75.25
Degree of automation	30.60	13.89	1.00	78.38
Consequence of error	41.84	16.56	9.50	96.75
Making decisions and solving problems	48.90	17.74	9.43	94.00
Importance of being exact or accurate	73.03	15.43	18.75	100.00

[a] SD, standard deviation

[b] Performing physical activities that require considerable use of arms and leg and moving the body such as climbing, lifting, balancing, walking, stooping, and handling of materials

Table 3. Factor analysis of occupational physical activity and emotional stressors: variable loading and explained variance related to each factor

	Rotated factor loadings [a]			
O*NET items	Factor 1	Factor 2	Factor 3	Factor 4
"Occupational physical activity"				
General physical activities[b]	**0.86**	-0.10	-0.19	0.18
Bending or twisting the body	**0.84**	0.04	0.32	0.01
Standing	**0.84**	0.09	0.07	-0.23
Handling and moving objects	**0.81**	-0.26	0.11	0.04
Walking and running	**0.80**	0.27	0.01	-0.15
Kneeling, crouching, or stooping	**0.78**	-0.22	-0.11	-0.09
Keeping or regaining balance	**0.76**	0.17	0.22	-0.18
"Interpersonal stressor"				
Dealing with unpleasant or angry people	0.01	**0.94**	0.14	0.05
Dealing with conflict situations	-0.15	**0.85**	-0.24	0.21
Dealing with physically aggressive people	0.36	**0.71**	-0.02	0.18
Resolving conflicts and negotiating with others	-0.34	0.62	-0.37	0.37
"Automated work"				
Making repetitive motions	0.18	-0.05	**0.80**	-0.21
Pace determined by speed of equipment	0.23	-0.15	**0.76**	-0.01
Degree of automation	-0.47	0.05	0.68	0.07
"Job control"				
Consequence of error	0.09	0.20	-0.03	**0.86**
Making decisions and solving problems	-0.40	0.31	-0.33	0.66
Importance of being exact or accurate	-0.39	0.43	0.44	0.51
Proportion of explained variance (%)	35.5	20.1	13.5	6.7
Cumulative explained variance (%)	35.5	55.6	69.2	75.8
Cronbach's alpha[b]	0.92	0.84	0.65	-

[a] Contribution of O*NET item to each factor. Bold numbers indicate absolute loadings ≥0.70
[b] Internal consistency among O*NET items with absolute loadings ≥0.70

Table 4. Association of quartiles of factor scores, characterized by occupational physical activity and emotional stressors, and preterm birth (PTB) and small-for-gestational-age (SGA) in first trimester of pregnancy, National Birth Defects Prevention Study, 1997-2009

	PTB				SGA			
Factor[a]	Crude OR	(95% CI)	Adjusted[b] OR	(95% CI)	Crude OR	(95% CI)	Adjusted[b] OR	(95% CI)
"Occupational physical activity"								
Q1	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Q2	1.00	(0.75 to 1.32)	1.00	(0.76 to 1.33)	1.09	(0.81 to 1.46)	1.09	(0.81 to 1.46)
Q3	1.23	(0.94 to 1.61)	1.12	(0.85 to 1.49)	1.31	(0.99 to 1.74)	1.18	(0.88 to 1.58)
Q4	**1.37**	**(1.05 to 1.79)**	1.24	(0.93 to 1.64)	**1.52**	**(1.15 to 2.00)**	**1.36**	**(1.02 to 1.82)**
P_{trend}			**0.01**				**0.001**	
"Interpersonal stressor"								
Q1	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Q2	0.92	(0.70 to 1.22)	0.98	(0.74 to 1.30)	1.02	(0.78 to 1.33)	1.09	(0.83 to 1.43)
Q3	1.14	(0.87 to 1.48)	1.18	(0.90 to 1.54)	0.80	(0.60 to 1.05)	0.86	(0.65 to 1.14)
Q4	1.14	(0.88 to 1.49)	1.17	(0.89 to 1.53)	1.02	(0.79 to 1.33)	1.05	(0.80 to 1.37)
P_{trend}			0.15				0.70	
"Automated work"								
Q1	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Q2	0.96	(0.73 to 1.27)	0.93	(0.71 to 1.23)	1.08	(0.81 to 1.44)	1.03	(0.77 to 1.38)
Q3	1.02	(0.78 to 1.34)	0.93	(0.71 to 1.23)	1.28	(0.97 to 1.69)	1.12	(0.84 to 1.49)
Q4	1.12	(0.87 to 1.46)	1.03	(0.78 to 1.34)	1.32	(1.00 to 1.75)	1.16	(0.87 to 1.55)
P_{trend}			0.32				**0.02**	
"Job control"								
Q1	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Q2	0.82	(0.63 to 1.07)	0.92	(0.70 to 1.22)	0.77	(0.58 to 1.01)	0.86	(0.65 to 1.14)
Q3	0.77	(0.59 to 1.02)	0.82	(0.62 to 1.08)	0.88	(0.68 to 1.13)	0.94	(0.72 to 1.23)
Q4	0.99	(0.77 to 1.27)	1.16	(0.88 to 1.53)	0.72	(0.55 to 0.95)	0.85	(0.63 to 1.15)
P_{trend}			0.92				0.05	

[a] Factor scores were categorized in quartiles: “Occupational physical activity” (<-0.88, -0.88 to <0.05, 0.05 to <0.05, and ≥0.91), “interpersonal stressor” (<-0.39, -0.39 to <0.16, 0.16 to <0.65, and ≥0.65), “automated work” (<-0.77, -0.77 to <-0.05, -0.05 to <0.50, and ≥0.50), and “job control” (<-0.69, -0.69 to <-0.11, -0.11 to <0.46, and ≥0.46)

[b] Adjusted for maternal age, race/ethnicity, education, and smoking

CHAPTER IV: CONCLUSION

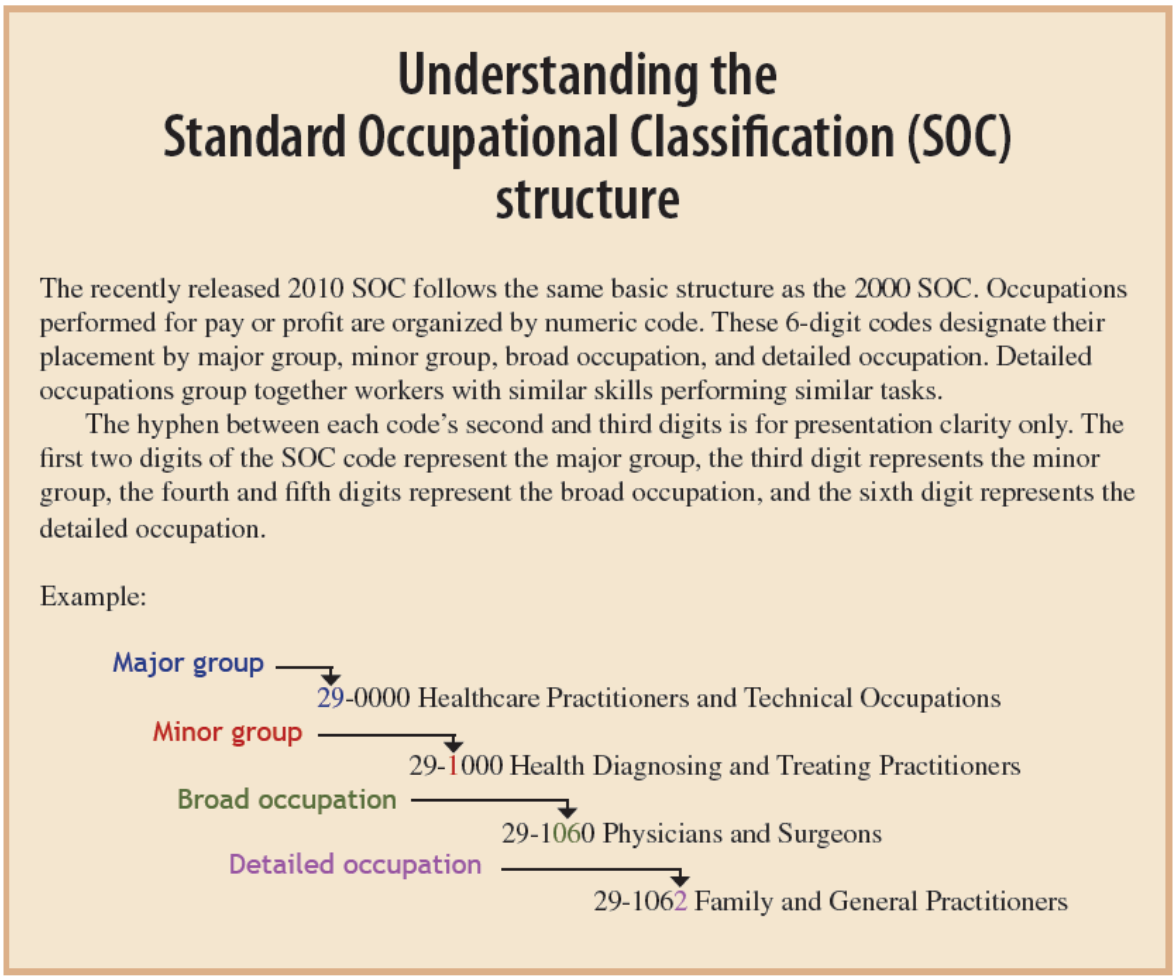
Several maternal occupational exposures have been suggested as potential risk factors for PTB and SGA. Despite increasing epidemiological literature on certain work activities and adverse birth outcomes, there are many domains of occupational physical activity and emotional stressors for which little or no research has been conducted regarding their possible associations with PTB or SGA. Additionally, knowledge of the prevalence of occupational physical activities and emotional stressors among pregnant women is limited. Studies addressing these knowledge gaps are crucial in expanding current understanding of the associations between work exposures and adverse birth outcomes. Further, findings from such studies may ultimately 1) help women of reproductive age in various occupations to decrease their risk of adverse birth outcomes and 2) inform employers to better accommodate pregnant workers from potentially hazardous occupational activities.

Using a large population-based study, this project 1) described estimated maternal occupational physical activity, sedentary behaviors, and emotional stressors during pregnancy and 2) examined the role of a wide range of maternal occupational physical activities and emotional stressors in each trimester of pregnancy on PTB and SGA. Overall, these studies suggested that the most frequent estimated physical activity and emotional stressors associated with jobs during pregnancy were standing and dealing with unpleasant or angry people, respectively. On the question of effect of maternal occupational exposures, physical activity was positively associated with both SGA and PTB, although no clear results were observed across domains for emotional stressors for either SGA or PTB.

This project leveraged two existing databases, the NBDPS and O*NET, to objectively estimate maternal occupational exposure to a wide range of physical activities and emotional stressors in each trimester of pregnancy based on mother's self-reported jobs. Linked NBDPS-O*NET data will allow future studies 1) to examine the effects of estimated occupational physical activity and emotional stressors on birth defects, which may potentially provide novel insights into their relatively unknown etiologies and 2) provide the opportunity to explore other potential risk factors for PTB and SGA.

APPENDICES

Appendix A: Structure of the Standard Occupational Classification system

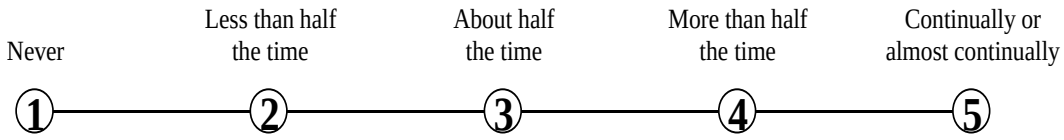


Source: http://www.bls.gov/careeroutlook/2010/summer/art02.pdf

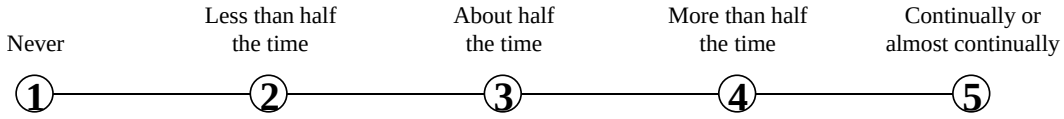
Appendix B: Selected Occupational Information Network (O*NET) work elements and survey questions

Physical activity

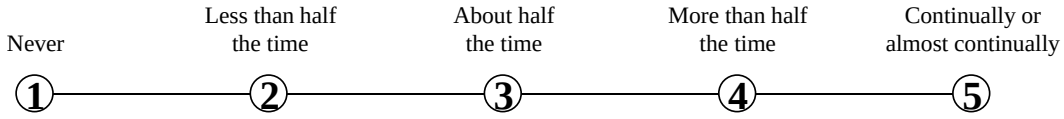
1. How much time in *your current job* do you spend bending or twisting your body?



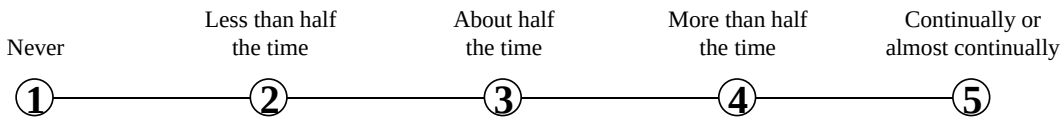
2. How much time in *your current job* do you spend climbing ladders, scaffolds, poles, etc.?



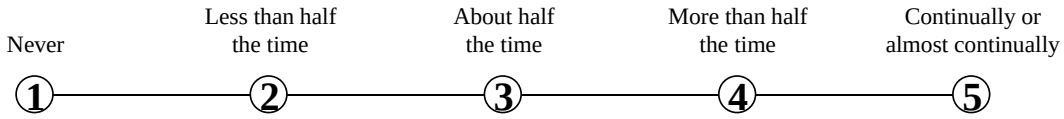
3. How much time in *your current job* do you spend keeping or regaining your balance?



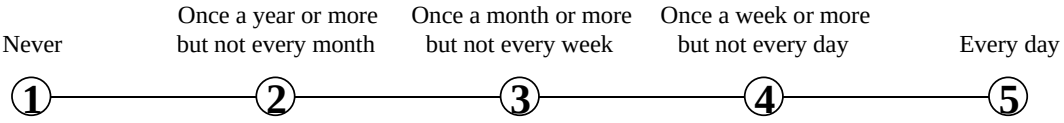
4. How much time in *your current job* do you spend kneeling, crouching, stooping, or crawling?



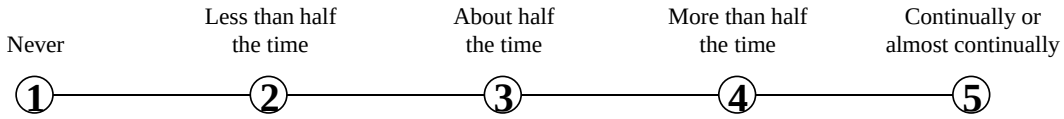
5. How much time in *your current job* do you spend making repetitive motions?



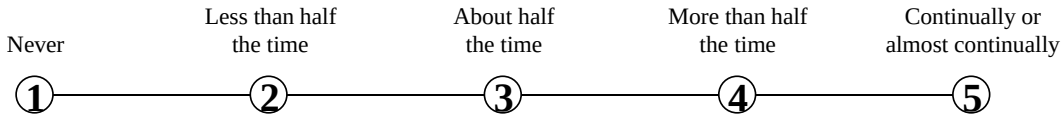
6. In *your current job*, how often are you exposed to whole body vibration (like operating a jackhammer or earth moving equipment)?



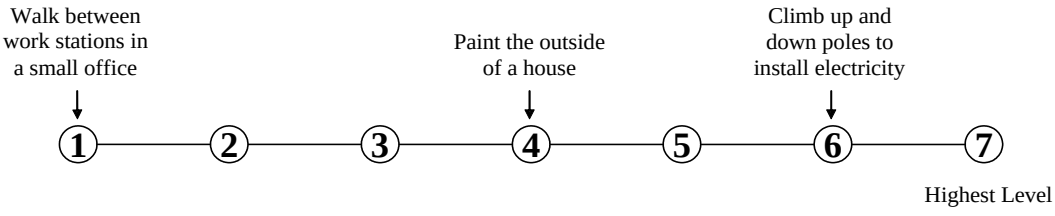
7. How much time in *your current job* do you spend standing?



8. How much time in *your current job* do you spend walking or running?



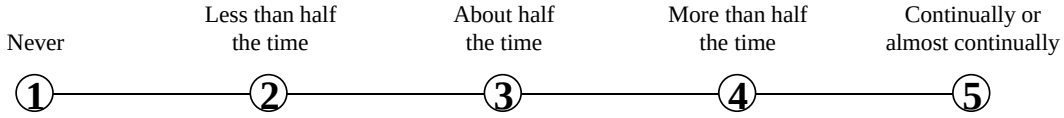
9. What level of PERFORMING GENERAL PHYSICAL ACTIVITIES is needed to perform *your current job*?



10. What level of HANDLING AND MOVING OBJECTS is needed to perform *your current job*?

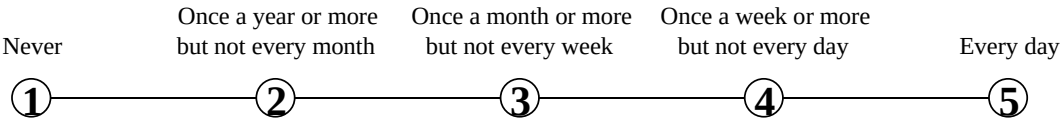
Sedentary behaviors

1. How much time in *your current job* do you spend sitting?

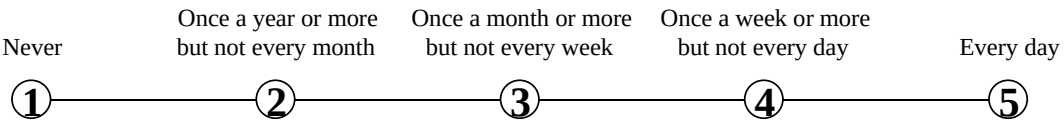


Emotional stressors

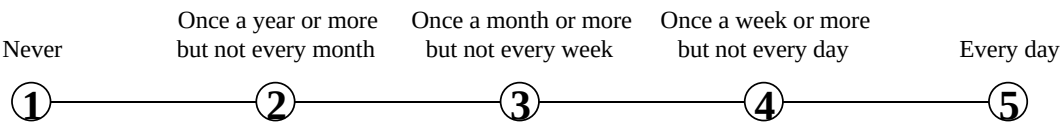
1. How often is dealing with unpleasant, angry, or discourteous people a part of *your current job*?



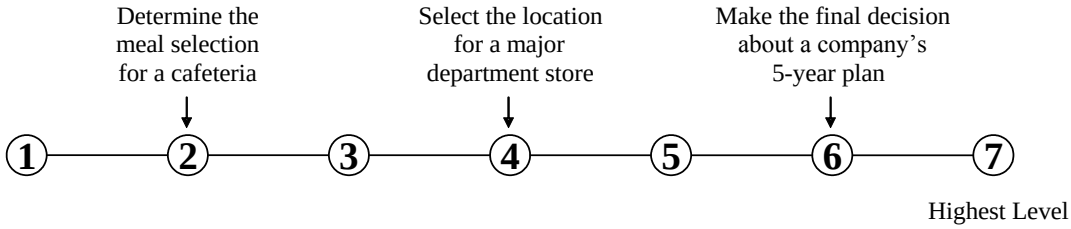
2. How often are conflict situations a part of *your current job*?



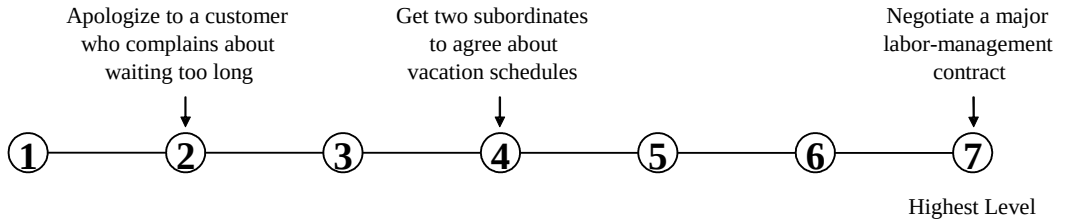
3. How often is dealing with violent or physically aggressive people a part of *your current job*?



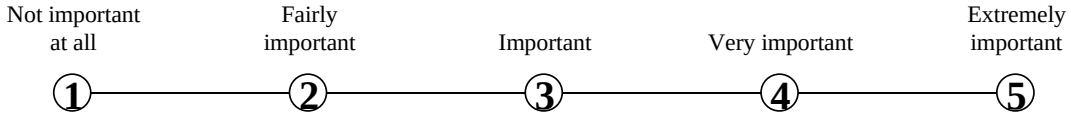
4. What level of MAKING DECISIONS AND SOLVING PROBLEMS is needed to perform *your current job*?



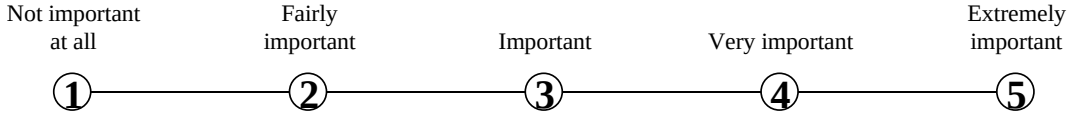
5. What level of RESOLVING CONFLICTS AND NEGOTIATING WITH OTHERS is needed to perform *your current job*?



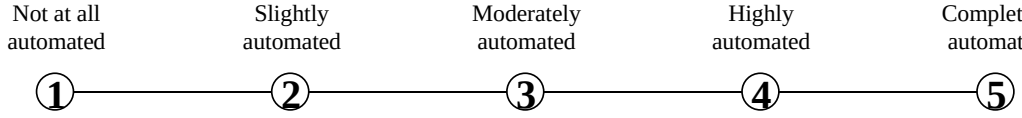
6. How important to *your current job* is being very exact or highly accurate?



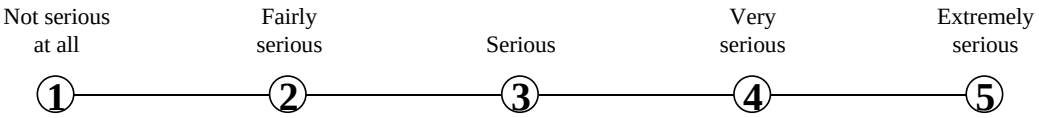
7. How important to *your current job* is keeping a pace set by machinery or equipment?



8. How automated is *your current job*?



9. How serious a mistake can you make on *your current job* (one you can't easily correct)?



Source: http://www.onetcenter.org/questionnaires.html

Appendix C: Questionnaire to measure psychosocial work characteristics

Job demands
Do you have to work very fast?
Do you have to work very intensively?
Do you have enough time to do everything?
Do different groups at work demand things from you that you think are hard to combine?

Skill discretion
Do you have the possibility of learning new things through your work?
Does your work demand a high level of skill or expertise?
Does your job require you to take the initiative?
Do you have to do the same thing over and over again?
Does your job provide you with a variety of interesting things?
Is your job boring?

Decision authority
Do you have a choice in deciding how you do your work?
Do you have a choice in deciding what you do at work?
Others take decisions concerning my work.
I have a good deal of say in decisions concerning my work.
I have a say in my own work speed.
My working time can be flexible.
I can decide when to take a break.
I have a say in choosing with whom I work.
I have a great deal of say in planning my work environment.

Social support at work
Do you get sufficient information from line management/supervisor?
Do you get consistent information from line management/supervisor?
How often do you get help and support from your colleagues?
How often are your colleagues willing to listen to your work related problems?
How often do you get help and support from your immediate superior?
How often is your immediate superior willing to listen to your problems?

Source: Kuper and Marmot. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *J Epidemiol Community Health* 2003;**57**(2):147-53.

Appendix D: Linkage of the Occupational Information Network (O*NET) Version 9.0 to the National Birth Defects Prevention Study (NBDPS) using job titles

O*NET Generalized Work Activities: Level of Performing General Physical Activities[a]					Step 1: O*NET-SOC to SOC "detailed occupations"			Step 2: SOC detailed to SOC "broad occupations"			Final O*NET data		NBDPS
O*NET-SOC code(s)	Mean[b]	Source[c]	N[d]	SE[e]	SOC detailed 2000 code(s)	Mean	Standardized mean	SOC broad 2000 code(s)	Mean	Standardized mean	O*NET job title(s)	Standardized mean	NBDPS Job title(s)
11-1011.01	1.83	Legal analyst	.	.	11-1011	1.67[f]	23.79[g]	11-1010	1.67	23.79	11-1010	23.79	11-1010
11-1011.02	1.50	Legal analyst	.	.							11-1011	23.79	-
11-1021.00	1.94	Incumbent	35	0.43	11-1021	1.94	27.71	11-1020	1.94	27.71	11-1020	27.71	11-1020
11-2011.00	1.72	Incumbent	36	0.68	11-2011	1.72	24.57	11-2010	1.72	24.57	11-1021	27.71	-
11-2021.00	1.44	Incumbent	20	0.86	11-2021	1.44	20.57	11-2020	1.98[h]	28.29[i]	-	-	11-2000
11-2022.00	2.52	Incumbent	17	0.76	11-2022	2.52	36.00				11-2010	24.57	11-2010
11-2031.00	1.48	Incumbent	22	0.52	11-2031	1.48	21.14	11-2030	1.48	21.14	11-2011	24.57	11-2011
11-3011.00	2.48	Incumbent	26	0.67	11-3011	2.48	35.43	11-3010	2.48	35.43	11-2020	28.29	11-2020
11-3021.00	2.79	Incumbent	31	0.97	11-3021	2.79	39.86	11-3020	2.79	39.86	11-2021	20.57	11-2021
11-3031.01	1.33	Legal analyst	.	.	11-3031	1.25	17.79	11-3030	1.25	17.79	11-2022	36.00	11-2022
11-3031.02	1.16	Legal analyst	.	.							11-2030	21.14	11-2030
11-3040.00	0.76	Incumbent	24	0.43	11-3040[j]	0.76	10.86	11-3040	1.37[k]	19.52	11-2031	21.14	-
11-3041.00	1.74	Incumbent	29	0.33	11-3041	1.74	24.86				11-3010	35.43	11-3010
11-3042.00	1.60	Incumbent	21	0.66	11-3042	1.60	22.86				11-3011	35.43	-
11-3051.00	3.45	Incumbent	16	0.56	11-3051	3.45	49.29	11-3050	3.45	49.29	11-3020	39.86	11-3020
11-3061.00	3.13	Incumbent	16	0.67	11-3061	3.13	44.71	11-3060	3.13	44.71	11-3021	39.86	-
11-3071.01	2.10	Incumbent	19	0.84	11-3071	2.24	31.93	11-3070	2.24	31.93	11-3030	17.79	11-3030
11-3071.02	2.37	Incumbent	24	0.38							11-3031	17.79	-
11-9011.01	2.66	Legal analyst	.	.	11-9011	2.39	34.10	11-9010	3.44	49.19	11-3040	19.52	11-3040
11-9011.02	2.50	Legal analyst	.	.							11-3041	24.86	11-3041
11-9011.03	2.00	Legal analyst	.	.							11-3042	22.86	11-3042
11-9012.00	4.50	Legal analyst	.	.	11-9012	4.50	64.29				-	-	11-3049

[a]Performing physical activities that require considerable use of arms legs and moving whole body such as climbing, lifting, balancing, walking, stooping, and handling of materials.

[b]Mean level of performing general physical activities (O*NET-SOC occupation); 1 = low (e.g., walk between work stations in a small office), 7 = high (e.g., climb up and down poles).

[c]Source of O*NET data (e.g., legal analyst, incumbents, occupational experts, analysts).

[d]Sample size of surveyed incumbents

[e]Standard error of the sample mean

[f]Mean level of performing general physical activities at work (SOC "detailed occupation"). For example, 1.67 = (1.83 + 1.50) / 2

[g]Standardized mean level of performing general physical activities at work (SOC "detailed occupation") = ((Mean – lowest possible value) / (highest possible value – lowest possible value))*100. For example, 23.79 = ((1.665-0) / (7-0))*100

[h]Mean level of performing general physical activities at work (SOC "broad occupation"). For example, 1.98 = (1.44 + 2.52) / 2

[i]Standardized mean level of performing general physical activities at work (SOC "broad occupation"). For example, 28.29 = ((1.98-0) / (7-0))*100

[j]For some SOC "broad occupations" (e.g., 11-3040) that were included in the original O*NET data, the original mean value carried over to the SOC broad level

[k]Included in the final O*NET data

Appendix E: Distribution of occupational physical activities, sedentary behaviors, and emotional stressors during pregnancy by selected maternal characteristics, National Birth Defects Prevention Study, 1997-2009

	Maternal characteristic (%)												
	Age (years)					Race/ethnicity				Education (years)			
	<20	20-24	25-29	30-34	≥35	Non-Hispanic White	Non-Hispanic Black	Hispanic	Other	<12	12	13-15	≥16
Frequency (percentage of time at work)													
Climbing ladders, scaffolds, poles													
<25%	96.8	97.4	98.2	98.0	97.8	99.0	98.4	92.8	98.4	90.1	96.8	99.2	99.5
25-<50%	3.0	2.3	1.8	1.9	1.8	0.8	1.6	7.0	1.4	9.7	2.8	0.7	0.5
50-<75%	0.2	0.3	0	0.1	0.3	0.2	0	0.2	0.2	0.2	0.4	0.1	0
≥75%	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Keeping or regaining balance[a]													
<25%	65.2	81.3	91.3	93.5	92.6	89.8	88.2	80.4	88.3	68.7	81.3	90.3	95.5
25-<50%	34.6	18.4	8.5	6.4	7.4	10.1	11.6	19.4	11.5	30.8	18.4	9.6	4.4
50-<75%	0.2	0.1	0.1	0.1	0	0.1	0.3	0.1	0	0.2	0.1	0.1	0
≥75%	0	0.2	0.1	0	0	0.1	0	0.1	0.2	0.3	0.2	0	0
Whole body vibration													
<25%	99.8	99.3	99.4	99.5	99.2	99.4	98.9	99.7	99.8	99.2	99.3	99.5	99.5
25-<50%	0.2	0.6	0.5	0.3	0.7	0.5	0.7	0.3	0.2	0.6	0.7	0.3	0.4
50-<75%	0	0.1	0.1	0.2	0.1	0.1	0.4	0	0	0.2	0.1	0.2	0.1
≥75%	0	0	0	0	0	0	0	0	0	0	0	0	0
Dealing with physically aggressive people[a]													
<25%	68.6	73.5	76.9	78.0	76.4	75.9	68.8	79.9	75.8	76.1	76.1	74.4	76.4
25-<50%	31.0	26.1	22.0	20.3	21.8	22.9	29.8	19.4	23.3	23.6	23.5	24.0	22.0
50-<75%	0.2	0.2	0.6	1.1	1.3	0.9	0.8	0	0.5	0	0.1	0.8	1.2
≥75%	02.	0.2	0.5	0.7	0.5	0.4	0.7	0.6	0.5	0.3	0.3	0.8	0.4
Importance													
Pace determined by speed of equipment[a]													
Not at all	65.6	74.5	84.6	88.5	87.6	85.9	80.1	69.6	85.3	60.1	73.8	83.9	93.1

Fairly	29.2	22.3	13.0	9.7	10.6	12.4	16.8	24.9	13.1	31.1	21.9	15.0	6.2
Important	5.0	3.0	2.2	1.7	1.6	1.6	2.7	5.3	1.6	8.3	4.1	1.0	0.8
Extremely	0.2	0.2	0.2	0.1	0.1	0.1	0.5	0.3	0	0.5	0.3	0.2	0
						Extent							
Degree of automation													
Not at all	35.1	35.4	39.6	39.6	37.6	37.0	35.1	43.1	39.2	46.0	34.9	29.7	44.9
Fairly	58.9	57.8	51.0	50.2	54.9	54.7	56.0	48.6	50.5	45.7	56.3	61.9	46.8
Automated	5.8	6.7	9.4	10.2	7.5	8.2	8.9	8.4	10.1	8.3	8.6	8.5	8.3
Highly	0.2	0.1	0	0.1	0.1	0.1	0	0	0.2	0	0.2	0	0

Appendix F: Correlations[a] between occupational physical activities, Occupational Information Network (O*NET)

O*NET item	1	2	3	4	5	6	7
1. General physical activities	1.00	0.60	0.62	0.81	0.61	0.64	0.51
2. Bending or twisting the body	0.60	1.00	0.68	0.65	0.60	0.66	0.73
3. Standing	0.62	0.68	1.00	0.67	0.79	0.54	0.63
4. Handling and moving objects	0.81	0.65	0.67	1.00	0.57	0.54	0.53
5. Walking and running	0.61	0.60	0.79	0.57	1.00	0.55	0.63
6. Kneeling, crouching, or stooping	0.64	0.66	0.54	0.54	0.55	1.00	0.62
7. Keeping or regaining balance	0.51	0.73	0.63	0.53	0.62	0.62	1.00

[a]Pearson correlation coefficients

Appendix G: Correlations[a] between occupational emotional stressors, Occupational Information Network (O*NET)

O*NET item	1	2	3	4	5	6	7	8	9	10
1. Dealing with unpleasant or angry people	1.00	0.75	0.65	0.51	0.06	-0.03	0.11	0.26	0.24	0.48
2. Dealing with conflict situations	0.75	1.00	0.51	0.76	-0.30	-0.29	-0.01	0.30	0.56	0.39
3. Dealing with physically aggressive people	0.65	0.51	1.00	0.27	-0.07	-0.02	-0.14	0.38	0.11	0.18
4. Resolving conflicts and negotiating with others	0.51	0.76	0.27	1.00	-0.42	-0.39	0.02	0.31	0.79	0.37
5. Making repetitive motions	0.06	-0.30	-0.07	-0.42	1.00	0.48	0.29	-0.23	-0.42	0.21
6. Pace determined by speed of equipment	-0.03	-0.29	-0.02	-0.39	0.48	1.00	0.43	-0.08	-0.37	0.03
7. Degree of automation	0.11	-0.01	-0.14	0.02	0.29	0.43	1.00	0.001	0.04	0.44
8. Consequence of error	0.26	0.30	0.40	0.31	-0.23	-0.08	0.0006	1.00	0.46	0.41
9. Making decisions and solving problems	0.24	0.56	0.11	0.79	-0.42	-0.37	0.04	0.46	1.00	0.46
10. Importance of being exact or accurate	0.48	0.39	0.18	0.37	0.21	0.03	0.44	0.41	0.46	1.00

[a]Pearson correlation coefficients

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