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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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Background *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.*

Methods *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.*

Results *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.*

Conclusions *Our findings augment existing literature on occupational physical activities, sedentary behaviors, emotional stressors, and occupational health disparities during pregnancy.* Am. J. Ind. Med. 59:137–149, 2016.

KEY WORDS: occupational physical activity; occupational stressors; exposure assessment; O*NET; NBDPS

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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 et al., 2013; Palmer et al., 2013; Runge et al., 2013; Langlois 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 et al., 2013]. For example, prolonged standing has been defined as standing at least 7 hr per day (e.g., [Croteau et al., 2006, 2007]) or using a three-point scale ("never," "occasionally," and "often") (e.g., [Snijder et al., 2012]). Additionally, there is no consensus on how to define and measure an adverse psychosocial environment at work [Siegrist 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 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 et al., 1997; Kuper and Marmot 2003; Lee et al., 2011; Larsen et al., 2014]. Furthermore, while it is estimated that, in general, 70% of daily sitting occurs at work [Ryan 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 et al., 2007; Bell et al., 2008; Cifuentes et al., 2010; Choi et al., 2012; Dale 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 (i) 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), (ii) 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 (iii) 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 et al., 2001; Cogswell et al., 2009; Reefhuis 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 1 hr, between 6 weeks and 2 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 (Fig. 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 3 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 hr 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, 2009]. Industrial hygienists at the National Institute for Occupational Safety and Health (NIOSH) coded jobs using 2000 SOC system and NAICS. 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 et al., 2010]. Mothers were excluded from the analysis if they exclusively held jobs with (i) unknown start or end year; (ii) an end date that preceded the start date; (iii) an end date before pregnancy began; or (iv) a start date after pregnancy ended (Fig. 1). To be as inclusive as possible, for a

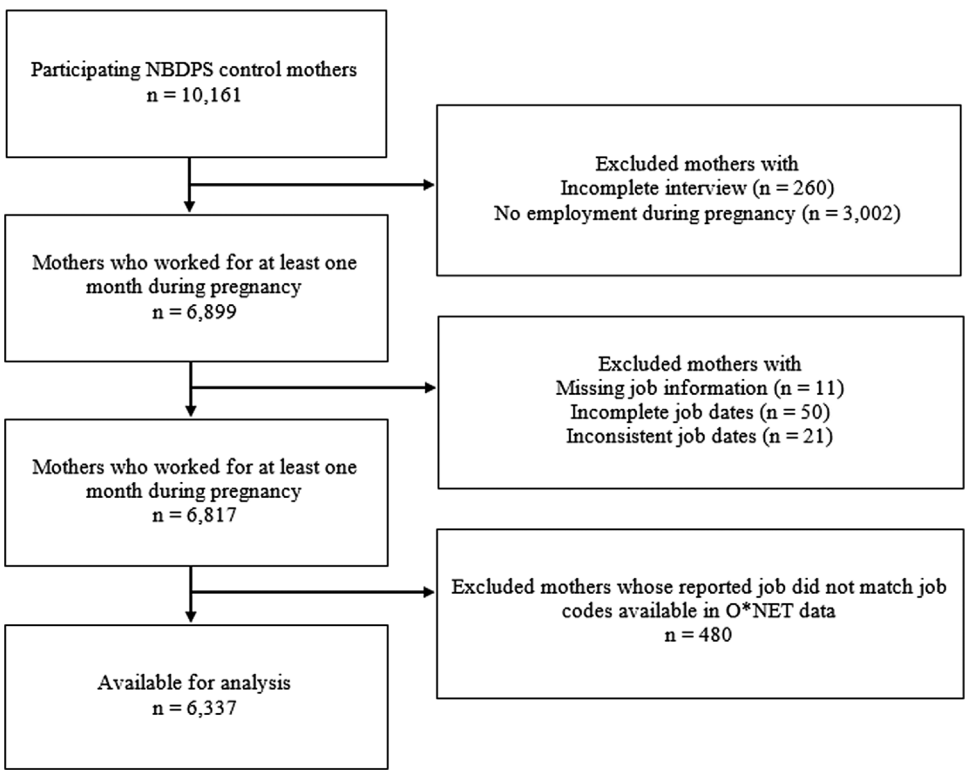

FIGURE 1. Population for analysis, National Birth Defects Prevention Study, 1997–2009.

job with an unknown start month but a reported start year, we assumed that it began 3 months prior to the estimated date of conception or the first day of the reported year, if the date 3 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 3 months after the estimated date of conception or the last day of the reported year, if the date 3 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 hr worked during each period of interest (calculated using self-reported number of work hr per week and job duration). If there were two or more jobs with the same cumulative work hr, 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 et al., 2008; Palmer et al., 2013], we selected a priori 11 O*NET work elements that reflected different domains of occupational physical activities or sedentary

TABLE I. 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).

behaviors (Table I). 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): (i) bending or twisting the body; (ii) climbing ladders, scaffolds, or poles; (iii) keeping or regaining balance; (iv) kneeling, crouching, or stooping; (v) making repetitive motions; (vi) exposure to whole body vibration; (vii) walking and running; (viii) standing; and (ix) sitting (sedentary behaviors); two elements were measured on a level scale (7 levels, from low to high): (x) performing general physical activities (e.g., climbing, lifting, balancing, walking, stooping, and handling of materials) and (xi) handling and moving objects. The O*NET survey questions used to collect information on each work element are available in Table SI.

Occupational emotional stressors. From previous literature, we selected, a priori, nine O*NET work elements representing different domains of [Karasek et al., 1998; Alterman et al., 2008; Fujishiro et al., 2013] (Table I). Three elements were measured on a frequency scale: (i) dealing with unpleasant or angry people; (ii) dealing with conflict situations; and (iii) dealing with physically aggressive people; two elements were measured on a level scale: (iv) making decisions and solving problems; and (v) resolving conflicts and negotiating with others; two elements were measured on an importance scale (5 levels, not important to extremely important): (vi) being exact or accurate; and (vii) pace determined by speed of equipment; and two elements were measured on an extent scale (5 levels, from not at all to completely): (viii) degree of automation; and (ix) 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 Table SII. 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), hr worked per week (<35, 35–45, >45), 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. In order to better understand the selected occupational physical activities, sedentary behaviors, and emotional stressors, we also examined the relationship between O*NET domains using Pearson correlation coefficients. 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 1 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 II). 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

TABLE II. Characteristics of Mothers Who Reported Working at Least 1 Month During Pregnancy With Available Occupational Information Network Data, National Birth Defects Prevention Study, 1997–2009 (n = 6,337)[a]

Maternal characteristic	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]		
<35	1,880	29.8
35–45	3,572	56.6
>45	864	13.7
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 hrs worked per week were excluded.
[d]2000 Standard Occupational Classification Major Groups, excluding Military Specific Occupations (55-0000).

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 III). 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 Pearson correlation coefficients for occupational physical activity domains ranged from −0.01 (making repetitive motions and general physical activities) to 0.81 (handling and moving objects and general physical activities) (Table SIII). As expected, sitting was negatively correlated to all of the examined occupational physical activity domains.

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 III). 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. The Pearson correlation coefficients for emotional stressor domains ranged from −0.42 (resolving conflicts and negotiating with others and making repetitive motions) to 0.79 (resolving conflicts and negotiating with others and making decisions and solving problems) (Table SIV).

There were differences in the frequency of estimated physical activities and sitting involved with reported jobs by

TABLE III. 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

age, race/ethnicity, and educational level ($P < 0.001$) (Table IV). 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 Table SV.

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 V). For example, the proportion of mothers reporting jobs

TABLE IV. 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 V. 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	0	0.3	0.2	0.3	0	0.3	0.1	0.1	0	0	0.5	0.2	0.1
Fairly	11.0	9.8	6.8	6.1	6.7	4.7	7.3	19.1	6.5	26.0	10.4	4.7	3.1
Important	53.7	47.9	41.4	37.6	36.1	40.9	47.5	42.3	41.7	46.0	49.9	39.8	37.7
Extremely	35.3	41.9	51.6	56.0	57.2	54.1	45.1	38.5	51.8	28.0	39.2	55.4	59.1

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

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. The proportion of mothers reporting jobs where being exact or accurate was extremely 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 (Table SV).

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 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 4 or more hr a day at work standing [Croteau 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 hr a week in the first and second trimesters, respectively [Pompeii 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 3 hr per day at work sitting during pregnancy [Croteau 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 et al., 2004], and the demand-control model of work stress is the most commonly used approach to assess psychosocial stress at work [Karasek 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 et al., 2009]. Similar findings were reported in a recent Danish study, where 6.8% of the pregnant women experienced high job strain [Larsen 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 2 or more hr per day or lifting more than 5 kg for 2 or more hr per day) was higher in younger (<25 years) women and in less educated (<primary school) women [Garcia 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 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 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 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 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 hr 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 1 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 et al., 2007; Alterman et al., 2008; Bell et al., 2008; Cifuentes et al., 2010; Choi et al., 2012; Fujishiro 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 on several characteristics such as race/ethnicity and hr worked per week. However, 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. This was partly due to the fact that some of the job titles in the "Education, training, and library" (25-0000) occupational group were coded into the "broad occupations" by industrial hygienists at the NIOSH and matching ONET job titles were not available; therefore, we excluded several mothers in this occupational group. 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 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.

AUTHORS' CONTRIBUTIONS

LL designed the study, conducted all the analyses, and led manuscript preparation. Dr. ES was the principal investigator of the project and oversaw all aspects of study design and analysis, interpretation of results, and preparation of the manuscript. Drs. PL, ST, and HR gave feedback on aspects of the analysis and on the Introduction, Materials and

Methods, and the Discussion sections of the manuscript. Dr. HR also assisted in data management and analysis (replication). Dr. LP gave feedback on the Introduction section of the manuscript. AH and Dr. MC assisted in the field activities of the NBDPS. Dr. WC provided feedback on the analysis.

ETHICS REVIEW AND APPROVAL

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. Approval for the IRB at the University of Texas Health Science Center at Houston was obtained prior to initiating the study.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web-site.

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