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Role of maternal occupational physical activity and psychosocial stressors on adverse birth outcomes

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Abstract

Objectives—We examined the association of an array of estimated maternal occupational physical activities and psychosocial stressors during pregnancy with odds for preterm birth (PTB) and small-for-gestational age (SGA).

Methods—Data for infants born without major birth defects delivered from 1997 to 2009 whose mothers reported working at least 1 month during pregnancy were obtained from the National Birth Defects Prevention Study. We linked occupational codes to the US Department of Labor's Occupational Information Network, which provides estimates of exposure for multiple domains of physical activity and psychosocial stressors by occupational categories. We conducted factor analysis using principal components extraction with 17 occupational activities and calculated factor scores. ORs for PTB and SGA across quartiles of factor scores in each trimester were computed using logistic regression.

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Disclaimer The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC.

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Results—Factor analysis grouped occupational domains into 4 groups based on factor loadings. These groups were 'occupational physical activity', 'interpersonal stressor', 'automated work' and 'job responsibility'. High levels of 'occupational physical activity' were significantly associated with SGA (adjusted OR (AOR) for highest quartile compared with lowest quartile of factor score: 1.36; 95% CIs 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 psychosocial stressors.

Conclusions—Our findings expand understanding of associations between occupational physical activity and psychosocial stressors and PTB and SGA and suggest that additional research is needed to further examine these relationships.

INTRODUCTION

Preterm birth (PTB), deliveries before 37 completed weeks of gestation,[1] and being born small-for-gestational age (SGA) are major contributors to infant mortality, morbidity and hospitalisation costs in the USA.[2–5] SGA, typically defined as infants whose birth weight is <10th centile for their gestational age,[6] is an important proxy measure for intrauterine growth restriction, as it distinguishes infants who are small due to growth restriction from those who are small due to PTB.[7] While several risk factors for PTB and SGA have been identified,[89] they do not explain a majority of cases.[910] 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,[11] both are still relatively common, with PTB occurring in 9.6% of 2014 births and low birth weight (<2500 g, a proxy for SGA) infants accounting for 8% of 2014 births.[11] Occupational exposures during pregnancy, including physical activity and psychosocial stressors, are important to consider, as the majority (~90%) of working women remain employed during pregnancy.[12]

There is considerable epidemiological literature on the association of certain physical activities at work (ie, prolonged standing, heavy lifting and high physical workload) and adverse birth outcomes, including PTB and SGA.[13–16] Based on a meta-analysis published in 2013,[14] prolonged standing (ie, >4 hours/day) was modestly associated with the risk for PTB (summary relative risk (RR) 1.22; 95% CIs 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 PTB (for lifting, RR range: 0.55–2.91; for physical workload, RR range: 0.71–4.10) and SGA (for lifting, RR range: 0.50–1.20; for physical workload, RR range: 0.70–2.40), potentially due to differences in exposure definitions.[14] A smaller, but growing body of research has examined the association between psychosocial stressors at work, typically defined as a combination of high job demands and low decision latitude and birth outcomes.[17–22] The majority of findings from these studies have shown an association of increased psychosocial stress with increased risk for PTB and SGA,[18–2021] although not all.[17]

There are many domains of occupational physical activity and psychosocial 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 psychosocial 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, among women who worked during pregnancy and with matching O*NET job titles, 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 ~65% of pregnant women reported jobs associated with dealing with unpleasant or angry people for at least half of their time at work.[23] Leveraging the NBDPS-O*NET linkage provides a unique opportunity to assess a broad range of occupational physical activities and psychosocial stressors and their potential association with adverse birth outcomes.

In this assessment, we examined the association between a wide range of estimated maternal occupational physical activities and psychosocial stressors in each trimester of pregnancy and two adverse birth outcomes (PTB and SGA) using data on ~6000 live births with no major birth defects in the USA from the NBDPS. Some of the individual occupational physical activities and psychosocial 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 association of these factors with PTB and SGA.

METHODS

Study participants

The NBDPS is a population-based case–control study of selected major birth defects. The details of the NBDPS methods have been published elsewhere.[24] In brief, the NBDPS includes data collected from 10 centres throughout the USA (entire state: Arkansas, Iowa, New Jersey and Utah; selected counties: California, Georgia, Massachusetts, New York, North Carolina and Texas). Each centre also 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 standardised, computer-assisted telephone interview, in English or Spanish, which lasted ~1 hour, between 6 weeks and 2 years after the estimated date of delivery. Interviewers obtained information about demographic, behavioural and clinical factors before and during pregnancy.

The study population included live born infants with no known major birth defects from the NBDPS (ie, control infants), with estimated dates of delivery between 1 October 1997 and 31 December 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 and the occupational exposures of interest could be independently associated with risks for specific birth defects.[23–25] 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 (UTHealth), 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 using the following sources in hierarchical order: (1) first trimester ultrasound estimation, (2) date of last menstrual period and (3) physical examination.[26] PTB was defined as <37 completed weeks of gestation.[1] We also considered a more refined outcomes classification such as very PTB (ie, <32 completed weeks of gestation), but we chose not to conduct additional analysis because there were too few cases in this group (n=66).

To be consistent with a previous NBDPS study,[27] SGA was estimated based on the methods of Zhang and Bowes,[28] and Overpeck et al.[29] SGA was defined as a birth weight <10th centile for gestational age, sex, race/ethnicity and maternal parity. Zhang and Bowes[28] provided reference percentiles for non-Hispanic Whites and Blacks, and Overpeck et al[29] provided reference percentiles for Hispanics in the US population. We excluded infants with missing birth weight or who weighed <500 g. Based on the methods used to define SGA,[28,29] we further excluded mothers with missing parity as well as mothers missing infant sex, race or falling outside of the range for calculated fetal growth curves. We additionally excluded infants from multiple gestation births, as multiple gestation is a strong risk factor for PTB and SGA.[9,11]

Exposure assessment

Classifying jobs held in each trimester of pregnancy—The details of methods we used for classifying jobs in the NBDPS have been reported elsewhere.[23] Briefly, during the interview, each mother provided a work history for all jobs, including part-time jobs, which lasted at least 1 month in duration from 3 months before pregnancy to the date her pregnancy ended. For each job held, mothers were 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 organisation, service or product provided by the company, the mother's typical activities or duties, and machines used. Each job description was reviewed by trained occupational coders and assigned a 2000 Standard Occupational Classification (SOC) code for occupation[30] and North American Industry Classification System (NAICS) for industry.[31]

For the present analyses, we classified 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 16% 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 psychosocial stressors—We used O*NET to assign estimated occupational physical activity and psychosocial stressors based on the mother's reported primary job. Developed by the US Department of Labor, O*NET is a publicly available database that includes detailed occupational information (http://www.onetonline.org) on over 900 jobs.[32] Briefly, O*NET is an ongoing survey of job holders (sample size of workers varies by job title) and occupational analysts; O*NET uses a standardised 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 V.9.0 using the 2000 SOC codes.[23]

We selected seven O*NET items for the present study that represented different domains of occupational physical activity: (1) general physical activities (eg, 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 psychosocial 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 (SE) and survey sample size by job title, coded in the SOC system. Since O*NET items were measured using different scales (eg, five-point scale or seven-point scale), we previously calculated standardised mean values for each job title.[23] Therefore, each O*NET item ranged from 0 (lowest) to 100 (highest) and was unitless; we treated each item as a continuous variable in our analyses.

Many of the individual occupational physical activities and psychosocial stressors had the potential to be correlated. To address the issue of correlated variables, we utilised factor analysis (described below), which is a statistical method used to assess the relationships between correlated variables and reduce the full group of variables to a smaller number of composite variables called factors.[33]

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), pregestational diabetes (no or yes), high blood pressure during the index pregnancy (no or yes), use of supplements containing folic acid 1 month before conception through the first month of pregnancy (no or yes), alcohol use (no or yes) and smoking (no or yes) 1 month before conception through the third month pregnancy, hours worked per week in the primary job (<40, 40, >40 hours/week) and category of prepregnancy body mass index (BMI). Maternal prepregnancy BMI (weight (kg)/height (m^2)) was categorised 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 cut-off points established by the National Heart, Lung and Blood Institute.[34] We also considered study centre as a potential covariate.

Statistical analysis

We previously estimated the Pearson correlation coefficients across O*NET items and found significant correlation between many of the domains.[23] In this study, we applied factor analysis on the O*NET items using principal components extraction with varimax rotation.[33] We retained factors with an eigenvalue of 1 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.[33] We assessed internal consistency among the variables with absolute loadings ≥0.70, using Cronbach's α coefficient. Factor scores were calculated as the sum of products of observed variables, weighted by the corresponding factor loadings, and they were categorised into quartiles based on the distribution of the entire study population (ie, NBDPS control infants).

Unconditional logistic regression was used to calculate crude ORs 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 by adding each variable into separate models as a covariate with the exposure factor value (as a continuous variable) and included them in the final model if inclusion resulted in ≥10% change in the estimate of association between the exposure and the outcome. Based on previous studies,[14] we included maternal age, race/ethnicity, education and smoking in all models. The Cochran-Armitage test was conducted on final models to assess linear trend across quartiles. All analyses were conducted using SAS, V.9.3 (SAS Institute, Cary, North Carolina, USA).

To better understand our factor analysis results, we also examined the association between individual O*NET items (categorised into quartiles, based on the distribution among the NBDPS control infants) and PTB and SGA in each trimester of pregnancy, using unconditional logistic regression and calculated crude OR and AOR and 95% CI.

RESULTS

Among the 10 161 live born infants with no known major birth defects included in the NBDPS for the period 1997–2009, we considered 6379 singleton infants whose mothers reported being employed for at least 1 month in the first trimester. After excluding mothers who held jobs with no matching O*NET data (n=453), there were 5926 infants available for the PTB analyses; 8.0% were born preterm (table 1). For the SGA analysis, we further excluded infants with missing information on birth weight (n=66) or who weighed <500 g (n=8); with missing information on infant sex, race or maternal parity (n=6); or who fell outside of range for calculated fetal growth curves (n=16). After these exclusions, data from 5830 infants were available for the SGA analyses; 7.8% were SGA.

Also shown in table 1 are the distributions of selected maternal characteristics in our sample by SGA and PTB status. PTB was more common among non-Hispanic Black mothers, mothers with lower education and mothers with pregestational diabetes or high blood pressure. PTB was less common among mothers who reported periconceptional alcohol use. SGA was more common among mothers of Hispanic or 'other' race/ethnicity, mothers with less education, mothers with lower BMI, mothers with high blood pressure and mothers who reported smoking during the periconceptional period. Additionally, mothers of infants born SGA were less likely to report folic acid supplement use in the month before and month after conception than mothers of infants born non-SGA.

Our factor analysis identified four main factors with eigenvalue of 1 or greater that explained 75.8% of the total variance (table 2). The first factor, which we called 'occupational physical activity', was characterised by all seven O*NET physical activity items considered in this analysis: 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 α of 0.92. The second factor ('interpersonal stressor') was characterised by three O*NET items: dealing with unpleasant or angry people, dealing with conflict situations and dealing with physically aggressive people (Cronbach's α=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 α=0.65). The last factor ('job responsibility') was predominantly characterised 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 3. 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, in crude models, the highest quartile of 'occupational physical activity' was statistically 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 with the lowest quartile. The results were attenuated in the adjusted models, although the association with SGA remained statistically significant (AOR 1.36; 95% CI 1.02 to 1.82). There was a positive linear trend across quartiles of the factor score for 'occupational physical activity' for PTB (adjusted p for trend=0.01) and SGA (adjusted p for trend=0.001). The odds of PTB or SGA were not significantly associated with any of the occupational psychosocial stressor factor categories in the adjusted analyses (ie, 'interpersonal stressor', 'automated work' and 'job responsibility'). A significant positive linear trend for odds of SGA and a factor score for 'automated work' was observed, (adjusted p for trend=0.02), although OR estimates (crude and adjusted) were consistent with the null. There were few observed differences in the association estimates across trimesters (results not shown).

When each occupational physical activity was analysed individually (see online supplementary table S1), we observed the strongest association among the examined occupational physical activity domains for bending or twisting the body in the first trimester with PTB (AOR 1.44; 95% CI 1.08 to 1.92). Significant positive associations were also found between SGA and two domains of occupational physical activity: keeping or regaining balance (AOR 1.40; 95% CI 1.04 to 1.89) and kneeling, crouching or stooping (AOR 1.37; 95% CI 1.02 to 1.85). Additionally, SGA was positively associated with a domain of psychosocial stressors, making repetitive motions (AOR 1.56; 95% CI 1.15 to 2.11); whereas, PTB was positively associated with dealing with physically aggressive people (AOR 1.38; 95% CI 1.06 to 1.79). There were few differences in the association estimates across trimesters (results now shown).

DISCUSSION

In this large, population-based study, we evaluated estimated maternal exposures to an array of occupational physical activities and psychosocial 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 (ie, ‘occupational physical activity’, ‘interpersonal stressor’, ‘automated work’ and ‘job responsibility’) that explained more than 75% of the variance in individual activities and corresponding 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. The odds of PTB or SGA were not significantly associated with any other factors in the crude and adjusted analyses. There were few differences in the effect estimates across trimesters.

The biological mechanisms by which maternal workplace exposures relating to physical activity 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,[35] as catecholamines have been shown to increase blood pressure and uterine contractibility, and decrease placental function in humans.[3536] Additionally, increased norepinephrine levels from physically demanding work could lead to uterine contractibility and PTB.[37]

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 directly compare our findings with previous work. When each occupational physical activity was analysed individually, we observed the strongest adjusted association among the examined occupational physical activity domains for bending or twisting the body with PTB; mothers who reported jobs in the highest quartile in the first trimester were 44% more likely to have a child being born preterm than mothers who reported jobs in the lowest quartile. Bending or twisting the body, which loaded highly to the ‘occupational physical activity’ factor, has been examined in previous studies.[1821] In Canadian studies, physical demand (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),[18] although it was not associated with SGA (AOR 1.0; 95% CI 0.9 to 1.2).[21] In another study among US female healthcare workers, ‘biomechanical 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, almost half of mothers in the highest quartile of bending or twisting the body reported jobs in two major groups: ‘Food preparation and serving related’ (~22%) and ‘Healthcare practitioners and technical’ (~20%), respectively (results not shown). Healthcare workers have a unique occupational environment that exposes them to physically demanding activities and several studies have examined occupational exposures of healthcare 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.

In this study, we attempted to group highly correlated psychosocial stressor domains. We observed that these composite psychosocial stressors (ie, 'interpersonal stressor', 'automated work' and 'job responsibility') were not associated with either PTB or SGA. Our results differed from previous studies on psychosocial stressors among pregnant women, which have 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 (eg, 'do you have too many tasks at work?') and low levels of control over those demands (eg, 'do you have the opportunity to influence your tasks and working conditions?').[18–21] Our findings differed somewhat from earlier studies that defined psychosocial stressors based on the demand-control model. Findings from the studies based on the demand-control model were generally consistent, showing modest associations. In a Canadian study, 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 with low strain.[1821] Among US 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.[19] In a study conducted in Mexico, high job strain (RR=1.23) and conflicts at work (RR=1.54) were independently associated with PTB.[20]

Our study should be considered in the light of certain limitations. Our findings may not be generalisable to US pregnant women. Although the NBDPS was not designed to be nationally representative, the study includes data from women in different states across the country and control participants are generally representative of the populations they were designed to represent.[25] Additionally, the proportion of PTB in our study population (~8.0%) was lower than what we would expect in the general US population. This may be in part due to our exclusion of infants from multiple gestations and infants with congenital malformations; groups with a higher risk for PTB.

The potential for exposure misclassification is another limitation in this study. The assignment of occupational physical activity and psychosocial stressors was indirect, based on linking mothers' self-reported jobs to estimates of physical activity and psychosocial stressor domains for those jobs in O*NET. This assignment was based on an average exposure from a representative sample of US workers with the same jobs and may not reflect interindividual variability in exposure that exist between workers, or work accommodations that may be provided to pregnant women.[23] 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 (eg, leisure-time physical activity and general psychosocial stress) was available only for the last 3 years of our study period and we could not take into account other sources of physical activity or psychosocial stressors outside of employment. Finally, the use of O*NET to assign occupational exposures is yet to be validated; however, O*NET has been utilised to construct job exposure matrices in several studies of pregnancy and other health outcomes.[36–40] Other important limitations of the study included the small number of very early deliveries (<32 completed weeks of gestation) and unavailability of information on subtypes of PTB (eg, spontaneous onset of labour).

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 NBDPS control infants.[23] Mothers who were excluded due to lack of matching O*NET data for their reported jobs accounted for 7% of the eligible sample.[23] This exclusion during the data linkage process was mainly due to some job titles in the 'Education, training, and library' occupational group being coded into the 'broad occupations' and no matching O*NET job titles were available.[23] As previously reported,[23] compared with 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 assessment of occupational physical activity and psychosocial stressors using O*NET was extensive, providing data on work activities that have not been examined in previous studies. Since the same occupational activity may carry different risks if it occurred late in pregnancy when compared with early in the pregnancy, we examined the role of occupational activities on PTB and SGA in each trimester. Consistent with previous studies,[14] our findings were similar across trimesters. These findings likely arose because the majority of mothers (~84%) held one job during pregnancy.[23] We did not apply a Cox regression with gestational age as the outcome because our assessment was not refined to detect differences in our exposures from 1 week of gestation to the next. Further, as (1) our analyses were restricted to NBDPS control infants, and (2) exposure assessment was based on self-reported jobs, recall bias was not a concern in this study.

In conclusion, this study expands our understanding about the occupational activity–adverse birth outcome associations relative to previous studies of more limited scope because we examined multiple domains of occupational physical activity and psychosocial stressors. In addition, the NBDPS provided an opportunity to conduct one of the largest population-based analyses to date of the association between selected occupational exposures and PTB and SGA. Our findings suggest that additional research that collects primary data on the broad range of exposures to maternal occupational physical activity and psychosocial stressors experienced during pregnancy is needed to better understand these relationships.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

- As women are increasingly likely to work while pregnant, it is important to understand the impact of specific occupational activities and psychosocial stressors on pregnancy outcomes.
- In this large, population-based study, estimated maternal occupational physical activity was associated with higher odds for preterm birth (PTB) and small-for-gestational age (SGA), with results consistent with a dose–response.
- No clear associations between estimated occupational psychosocial stressor domains and PTB or SGA were observed.
- This study expands our understanding of the associations between occupational exposures and certain adverse birth outcomes relative to previous studies of more limited scope.

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 n (%)	Non-PTB n (%)	p Value‡	SGA n (%)	Non-SGA n (%)	p Value‡
Total§	474 (8.0)	5452 (92.0)		452 (7.8)	5378 (92.3)	
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)	
Missing	0			0	0	
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)	
Missing	1	1		0	0	
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)	
Missing	0	3		0	3	
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)	
Missing	1	1		0	0	
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)	
Missing	6	116		16	103	
Pregestational 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)	
Missing	0	7		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)	

	PTB n (%)	Non-PTB n (%)	p Value‡	SGA n (%)	Non-SGA n (%)	p Value‡
Missing	0	6		0	6	
Folic acid use¶						
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)	
Missing	0	0		0	0	
Alcohol use**						
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)	
Missing	3	16		5	14	
Smoking**						
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)	
Missing	0	1		0	1	
Hours worked per week††,‡‡						
<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)	
Missing	1	20		2	18	

[*] Excluded non-working mothers, multiple gestations and mothers whose reported job did not match job codes available in Occupational Information Network (O*NET), V.9.0.

[†] For the SGA analysis, we further excluded infants with missing birth weight or weighed <500 g; missing infant sex, race or maternal parity, or fell outside of calculated fetal growth curves.

[‡] χ^2 tests.

[§] Percentages in this row are horizontal, while other percentages are across columns.

[¶] One month before conception through the first month of pregnancy.

[**] One month before conception through the third month of pregnancy.

[††] Based on primary job.

[‡‡] Jobs with<1 or >168 hours worked per week were considered missing.

Table 2

Factor analysis of occupational physical activity and psychosocial stressors: variable loading and explained variance related to each factor

	Rotated factor loadings*			
O*NET items	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
Occupational physical activity				
General physical activities†	**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 responsibility				
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 α‡	0.92	0.84	0.65	–

*Contribution of Occupational Information Network (O*NET) item to each factor. Bold numbers indicate absolute loadings ≥0.70.

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

‡Internal consistency among O*NET items with absolute loadings ≥0.70.

Table 3

Associations of quartiles of factor scores, characterised by occupational physical activity and psychosocial stressors, and preterm birth (PTB) and small-for-gestational-age (SGA) in the first trimester of pregnancy, National Birth Defects Prevention Study, 1997–2009

	PTB		SGA	
Factor*	**Crude OR (95% CI)**	**Adjusted† OR (95% CI)**	**Crude OR (95% CI)**	**Adjusted† OR (95% CI)**
Occupational physical activity				
Q1	Referent	Referent	Referent	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		0.01
Interpersonal stressor				
Q1	Referent	Referent	Referent	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	Referent	Referent	Referent	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 responsibility				
Q1	Referent	Referent	Referent	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

* Factor scores were categorised in quartiles: 'occupational physical activity' (<−0.88, −0.88 to <0.05, 0.05 to <0.91 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 responsibility' (<−0.69, −0.69 to <−0.11, −0.11 to <0.46 and ≥0.46).

† Adjusted for maternal age, race/ethnicity, education and smoking.