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Job Control, Substantive Complexity, and Risk for Low Birth Weight and Preterm Delivery: An Analysis From a State Birth Registry

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Background *Indices of job strain have demonstrated a variable relationship to low birth weight (LBW) and prematurity, with conflicting study results. This study sought to examine the associations of psychosocial work environment characteristics with adverse pregnancy outcomes using and comparing the demand-control model and job attributes derived from the O*NET.*

Methods *Job characteristics were imputed to maternal occupation recorded in the 2000 Connecticut state birth registry for 26,408 singleton births, using scores for psychological job demands, control, and physical demands derived from the Job Content Questionnaire, and for substantive complexity of work and physical demands using variables derived from O*NET job attributes. Odds ratios for LBW and preterm delivery were estimated while controlling for relevant covariates.*

Results *High psychological demands were not associated with pregnancy outcomes, while high physical demand scores from the O*NET were associated with LBW. Associations of term- and all-LBW with both low control and low substantive complexity were attenuated by adjustment for educational and demographic covariates. A gradient with lower scores was seen for term LBW and substantive complexity, and for prematurity and control. Both constructs were correlated with maternal education.*

Conclusions *These results suggest that low maternal job control and substantive complexity may be modestly associated with LBW and, to a lesser extent, prematurity. A greater association with control may explain why a weak link of birth outcomes to high-strain work has been noted in past studies. Observed associations with occupational are reduced after adjustment for relevant confounding variables, in particular educational level and race/ethnicity.* Am. J. Ind. Med. 50:664–675, 2007. © *2007 Wiley-Liss, Inc.*

KEY WORDS: pregnancy outcomes; work organization; job control

INTRODUCTION

The increased proportion of women in the workforce over the last half-century has resulted in a parallel increase in women who continue to work while pregnant, and who work longer during pregnancy. US Census Bureau reports in the past decade indicate that two-thirds of first-time pregnant women continued working during the pregnancy, with 53% continuing into the last month of pregnancy [Smith et al., 2001; Johnson and Downs, 2005]. A variety of factors ranging from personal preference to economic necessity play a role in this increase. Occupational hazards in pregnancy have long been acknowledged, but remain difficult to

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ascertain and quantify [Ahlborg and Hemminki, 1995; Paul, 1997; Lindbohm, 1999]. Generally, pregnancy outcomes are improved in working pregnant women when contrasted with their non-working counterparts [Murphy et al., 1984; Saurel-Cubizolles et al., 2004], partly as a consequence of the ''healthy worker effect''; partly from the real social and economic benefits that accrue to the employed, including insurance, financial stability, and social interaction. Within populations of working pregnant women, there are indications of differences in outcomes, particularly in birth weight, according to job title, although results are not consistent across studies [McDonald et al., 1987; Sanjose et al., 1991; Savitz et al., 1996].

Dual sets of forces have played a role in women's employment over the past quarter-century. Increased participation in more physically demanding and socially challenging occupations has arisen through reduction of employment barriers for women. At the same time, broad economic trends have favored a general shift into employment in the service sector over older manufacturing jobs. While employment in some areas of a service economy may reduce exposure to traditional industrial hazards, such as chemical toxicants and dusts, work in many service occupations still entails potential risks, including increased physical demands, in addition to the biological and physical hazards present in such fields as health care [Paul, 1997; Lindbohm, 1999; Mozurkewich et al., 2000; MacDonald et al., 2001; McDiarmid, 2006].

Recognition of poor work organization and the psychosocial stresses of the workplace as potential contributors to ill-health has increased in the past two decades. Outcomes including hypertension and cardiovascular disease [Muntaner et al., 1998; Landsbergis et al., 2001; Kuper et al., 2002] and musculoskeletal disorders [Warren et al., 2000; Warren, 2001] have been associated with the organization of work and the disparity between psychological work demands and the degree of worker control in meeting them. The relevance of these psychosocial and organizational factors in the workplace to adverse pregnancy outcomes in working women has been described [Hogue et al., 2001]. Indices of job strain (operationalized in several different ways as the combination of high work demands with low control over the conditions of work, constructs derived from the Job Content Questionnaire (JCQ) [Schwartz et al., 1988; Karasek et al., 1998]) have demonstrated a variable relationship to poor pregnancy outcomes, with conflicting study results. A lack of association between job strain measures and adverse pregnancy outcomes has been noted in several studies [Homer et al., 1990; Ceron-Mireles et al., 1996; Escriba-Aguir et al., 2001]. By contrast, a case-control study of work stress and preterm delivery indicated that work at a full-time high-strain job, past the 30th week of gestation, was associated with a modestly increased risk of preterm delivery [Brett et al., 1997]. An overall association of high-demand/low control work with reduced birth weight was also noted in a prospective study among women presenting early for prenatal care, with black women faring worse than whites [Oths et al., 2001]. Moreover, the one negative study that used a US population to assess birth outcomes in relation to indices of job strain [Homer et al., 1990], while it found no overall effect of psychosocial work stressors, did find increased risk for preterm and low birth weight (LBW) delivery associated with conflicts over whether to remain in work in the poorest subgroup of subjects. These studies suggest the possibility that job strain may increase risk in women with other adverse socioeconomic factors.

Characteristics of work organization may be also changing, as industrial and manufacturing jobs are replaced or supplanted by growing service sector employment. The expanded use of computers has spawned newer occupations, such as information technology and software design, and altered older jobs, such as those involving data entry and customer service. Other service occupations have become deskilled in ways analogous to manufacturing assembly line work. These changes in work that are contingent on changes in the overall economy suggest that models of work organization may need to be periodically reviewed when associations between work structure and possible health outcomes are examined. Modifications of accepted models of work strain [Marshall et al., 1997] and development of newer models that measure stressors against the background of economic conditions and opportunities [Siegrist et al., 2004] are responses that acknowledge broader changes in employment.

The study described here had two aims. The first was to use a larger administrative dataset on birth outcomes than those of previous studies to examine the association of occupational psychosocial characteristics with LBW and premature delivery, and specifically to evaluate the demand-control model for its ability to predict these outcomes. The second aim was to compare newer descriptive dimensions of work obtained from the O*NET, the successor to the Dictionary of Occupational Titles (DOT), with the demand-control model in order to determine whether the use of aggregate scales derived from this database might demonstrate a similar association with adverse pregnancy outcomes, in particular in a dataset with a high preponderance of jobs in service industries.

METHODS

Records of all live births to Connecticut residents are reported to the Connecticut Department of Public Health (CT DPH) where they are compiled and maintained. Data fields included in the Connecticut birth registry include infant birth weight, date of last menstrual period and gestational age, maternal age, race, ethnicity, occupation, and industry,

maternal tobacco use during pregnancy (yes/no), the month prenatal care was initiated and the number of prenatal visits, maternal education (years, up to 17), and history of previous live birth and stillbirth. Data from the birth registry for the calendar year 2000 was obtained from the CT DPH as a text file after being stripped of maternal and infant personal identifiers and converted into an SPSS data file (SPSS, Inc., Chicago, IL; Version 13.0) for analysis.

Coding of maternal occupation and industry was performed using procedures and algorithms for standardized occupation and industry coding developed by the National Institute for Occupational Safety and Health (CDC/NIOSH) and the National Center for Health Statistics [Division of Vital Statistics, 2003a,b]. Occupation and industry were coded to three digits using the Bureau of the Census classification framework for the 2000 Census and aggregated into minor and major occupational groups, using crosswalks and guidance documents from the 2000 Census classification and the 2000 Standard Occupational Classification System of the Bureau of Labor Statistics [Division of Vital Statistics, 2003a]. Jobs were also dichotomized by sector into industrial (which included manufacturing, construction, transportation, utilities, and agriculture/forestry/fishing industry sectors) and service work, which comprised the remaining sectors.

Composite scores for psychological job demands, decision latitude (the sum of the factors *skill discretion* and *decision authority*; hereafter simply termed ''job control''), and physical exertion derived from the Quality of Employment Surveys and the JCQ for specific occupations [Karasek et al., 1998] were obtained from the Kerr Ergonomics Institute, Department of Work Environment at the University of Massachusetts, Lowell. These scores, which were based on 1970 census occupational codes, were linked with 2000 Census codes in the birth dataset through the use of occupational- and industry-code crosswalks developed for the US Employment and Training Administration [Schwartz et al., 1988; US Department of Labor, 1998–2005; Landsbergis et al., 2000]. Each mother thus received a set of three composite scores imputed to the occupation reported in the birth dataset. Demand and control scores were dichotomized at the dataset's median value, placing each mother in one of four possible demand/control quadrants [Karasek et al., 1998]. High-strain jobs were defined as those presenting a combination of high job demands with low control over work, and contrasted with relaxed (low demands/high control), passive (both low demands and control), and active (both high demands and control) occupations. Scores for the one-item question on physical exertion were also dichotomized at the median value into high versus low groups. For additional evaluation, demand, control, and physical exertion scores were also divided into tertiles based on their distribution in the dataset, and the most extreme group (high demands or physical exertion, low control) contrasted with the others in analyses.

O*NET data on job attributes were downloaded from the O*NET Resource Center [2004]. Job attribute measures for a total of 900 occupations were represented in this version of the O*NET, which supplanted the earlier DOT. O*NET variables composing three factors termed s*ubstantive complexity*, *people versus things*, and *physical demands* (using the ten variables with the highest loadings on each factor) were aggregated according to the factor analysis described by Hadden et al. [2004]. The main factor of interest was substantive complexity, which has been described as analogous to job control in the demand-control model [Muntaner et al., 1993]. This factor was composed of job-specific variables assessing deductive reasoning, updating and using relevant knowledge, inductive reasoning, complex problem solving, active learning, making decisions and solving problems, ability utilization, critical thinking, getting information, and the importance of repeating same tasks. The physical demands factor likewise represented a ten-item score on elements that include stamina, reaction time, body equilibrium, limb movement, time spent sitting, and environmental controls at the workplace. Reverse coding of variables was used for those with negative loadings on the factors. Following the methods described above, O*NET job titles were similarly linked with 2000 census codes through occupational-code crosswalks [US Department of Labor, 1998–2005], and scores for each factor were imputed to the maternal occupation noted in the birth dataset. As with the JCQ scores, scores for each of the three O*NET-based factors were grouped into tertiles based on their distribution in the dataset and their association with outcomes contrasted.

Additional variables obtainable from the birth dataset were abstracted and coded for use as covariates in regression models. Maternal age demonstrated an association with LBW at both extremes of age, as has been previously described in Connecticut [Shmueli and Cullen, 1999], and a dichotomous variable contrasting maternal age either less than 20 years or greater than 37 years with those aged 20–37 was used to analyze age effects. Educational level was categorized as college graduate (16 or more years education), high school graduate (12–15 years), or non-high school graduate (<12 years). Elevated rates of preterm delivery and LBW in the overall birth dataset (working and non-working) were seen in mothers with race or ethnicity recorded as Hispanic, Black, or ''other.'' An indicator variable contrasting Black/Hispanic/other mothers with white non-Hispanics was used. Delivery of a previous liveborn child was associated in the overall dataset with reduced risks of LBW and prematurity; a Yes/No variable was used to code for previous delivery. Similarly an indicator variable was used to code trimester in which prenatal care was initiated. Previous preterm delivery, an important predictor of subsequent preterm delivery, was not available in this dataset and hence was not incorporated into analyses.

Analyses were performed using SPSS v 13 (SPSS, Inc.). Analyses examined outcomes for singleton deliveries only, to eliminate the effects of multiple gestation on LBW and premature delivery. Independent *t*-tests were used to compare differences in mean values between groups. LBW (defined as birth weight less than 2,500 g), term LBW (less than 2,500 g at 37 weeks gestation or greater, which eliminates the effect of prematurity on estimates of LBW and growth retardation), and prematurity (delivery before 37 weeks gestation) were used as dichotomous outcome measures in multivariate analyses. Logistic regression was used to calculate the odds of LBW, term LBW, or premature delivery for work psychosocial factors while controlling for other variables obtained from the birth dataset, including maternal age, previous birth, race/ethnicity, trimester in which prenatal care was initiated, tobacco use in pregnancy, and maternal educational level. Correlation matrices were developed using Pearson correlation coefficients for demand, control, substantive complexity, education and physical demands as continuous variables. Twenty-seven mothers with an occupation in the armed forces were excluded from analyses using job characteristics, as demand/control and related scores for their military jobs were not available. Statistical significance was set at 0.05 (two-tailed) for all tests of significance; 95% confidence intervals were calculated for estimates of effect. Approval for this study was obtained from the Institutional Review Board of the University of Connecticut Health Center and the Human Investigations Committee of the Connecticut Department of Public Health.

RESULTS

A total of 41,045 singleton deliveries with a recorded birth weight were included in the 2000 Connecticut birth registry; of these, 26,408 had a codeable occupation and industry for the mother. An additional 14,637 singleton pregnancies were considered non-working, based on entries that specified ''homemaker,'' ''not working,'' ''unemployed,'' or ''none'' for occupation, or a blank entry in the occupation data field. Demographic characteristics of mothers with singleton deliveries and an occupation noted in the birth registry are shown in Table I with crude rates for LBW and preterm delivery. Higher rates of LBW delivery were seen at both extremes of maternal age, as well as in Blacks and Hispanics, those smoking during pregnancy and with lower educational attainment. Preterm delivery followed similar patterns. Employment was predominately in service sector work, with four industry sectors accounting for over 60% of employment in this group. Crude rates for LBW and preterm delivery were elevated in mothers working in retail trade and in accommodation and food services.

The distribution of work attribute scores, the main exposures of interest, dichotomized into high and low scores, is shown in Table II, stratified by levels of the covariates extracted from the dataset. Higher proportions of low control and low substantive complexity jobs are seen in younger mothers (for those <20 years old, 85.3% worked in a low control job), in Black and Hispanic mothers (73.5% and 71.0%, respectively, in low control jobs) and in the less educated (88.4% in non-high school graduates), with parallel findings for jobs with high physical demands as classified by the O*NET. These findings for educational level were only minimally reduced when the analysis was limited to those aged 25 or older (85.3% of non-HS graduates over age 25 worked in a low control job, with 74.1% of those in this educational stratum working in a job with higher physical demands; results not shown).

Risks of term- and all-LBW delivery were increased in singleton deliveries in both high-strain jobs (high job demands with low control; for term LBW, odds ratio (OR) = 1.68) and in passive jobs (low demands coupled with low control; OR for term LBW 1.61) when compared to jobs with low demands and high control (relaxed jobs as referent subjects) in univariate analyses (Table III). A similar pattern was noted for risks of premature delivery (OR 1.35 for high-strain work and 1.20 for passive work). The associations of job demand-control characteristics with adverse outcomes were attenuated after adjustment for potential confounders, which included educational level, tobacco use, maternal age, race/ethnicity, previous birth and trimester of prenatal care initiation, leaving a significant association only between work in a high-strain job and premature delivery (adjusted odds ratio (aOR) 1.17). This pattern was similar when the analyses were limited to working women without a previous live birth, a group for whom, presumably, family stressors or conflicting work-family roles are absent or reduced (results not shown). When outcomes in high-strain (high demand/low control) jobs were contrasted with those in all other jobs grouped together, a significant, though again modest, association was noted only for premature delivery after adjustment (aOR 1.14, 95% confidence interval 1.01–1.28), while ORs did not significantly differ from unity for both term and all LBW. The pattern seen here of association of LBW and prematurity with both high-strain and passive work suggests that control over work may be more predictive of adverse pregnancy outcomes than a model that incorporates both job psychological demands and control.

Table IV examines the association of psychosocial constructs with adverse pregnancy outcomes, using factors derived from both the demand-control model and the O*NET, contrasting the most extreme tertile of each factor with the other two. Consistent with the findings in Table III, work in a job with the lowest degree of job control was associated with both term LBW (aOR 1.25) and all-LBW (aOR 1.10) as well as premature delivery (aOR 1.06), although confidence intervals after adjustment do not exclude the possibility of no association. By contrast, high

TABLE I. Demographic Characteristics, Low Birth Weight, and Premature Delivery Cases; Subjects With a Singleton Delivery and an Occupation Listed

	Number	LBW (%)	Premature (%)
All singleton deliveries	26,408	1,441 (5.5)	2,195 (8.3)
Maternal age			
<20 year	1,009	83 (8.2)	111 (11.0)
20–37	23,230	1,208 (5.2)	1,874 (8.1)
>37	2,169	150 (6.9)	210 (9.7)
Race/ethnicity			
White non-Hispanic	18,826	865 (4.6)	1,399 (7.5)
Black	3,102	289 (9.3)	373 (12.2)
Hispanic	3,116	200 (6.4)	298 (9.7)
Other	1,112	66 (5.9)	93 (8.4)
Unclassified/missing	252	21 (8.3)	32 (12.8)
Educational level			
Non-high school graduate (<12 year)	1,394	123 (8.8)	165 (11.9)
High school grad/some college (12–15 year)	13,281	790 (5.9)	1,194 (9.1)
College graduate and above (>15 year)	11,326	479 (4.2)	789 (7.0)
Unknown/missing	407	49 (12.0)	47 (11.5)
Tobacco use in pregnancy			
No	23,282	1,161 (5.0)	1,891 (8.2)
Yes	1,829	194 (10.6)	192 (10.6)
Unknown	1,297	86 (6.6)	112 (8.6)
Trimester prenatal care began			
First (months 1–3)	22,282	1,220 (5.5)	1,859 (8.4)
Second (months 4–6)	2,310	118 (5.1)	184 (8.0)
Third (months 7–9)	446	33 (7.4)	37 (8.4)
Unknown	1,370	70 (5.1)	115 (8.4)
Previous live birth			
No	10,338	569 (5.5)	853 (8.3)
Yes	14,272	769 (5.4)	1,188 (8.4)
Unknown/missing	1,798	103 (5.7)	154 (8.6)
Major industry sectors			
Healthcare & social assistance	5,910	328 (5.5)	507 (8.6)
Finance & insurance	3,001	139 (4.6)	227 (7.6)
Retail trade	2,708	194 (7.2)	266 (9.8)
Education	2,676	112 (4.2)	188 (7.0)
Professional, scientific, technical	2,495	107 (4.3)	183 (7.3)
Manufacturing	2,179	117 (5.4)	176 (8.1)
Accommodation & food services	1,303	95 (7.3)	128 (9.8)

LBW, low birth weight <2,500 g; premature, preterm delivery <37 weeks gestation. Connecticut births, 2000.

demands showed no similar association. Work entailing low substantive complexity showed a similar pattern to that of low control over work (aOR for term LBW 1.26), although there is clearly no significant association with premature delivery. Scores on the factor ''people versus things'' were not associated with adverse outcomes; this remained true when other methods of scoring this factor (such as ''high-people'' vs. ''high-things'') were used. Of note are conflicting results for the physical demands of work, which depended on the system used for scoring job characteristics. No significant effect on LBW was found using the JCQ scores for this factor, while use of the O*NET physical demands score was associated with increased risk of term LBW (aOR 1.29) and a borderline significant risk for all LBW (aOR 1.13). To reduce the possible bias that might be associated with adjustment for educational level in younger workers (who might not have completed their education), analyses were repeated excluding subjects under 25 years of age; ORs

TABLE II. Percentile Distribution of Study Covariates by Scores on Main Occupational Characteristics

		Demands		Control		Substantive complexity		Physical demands (O*NET)	
	Number	High	Low	High	Low	High	Low	High	Low
All singleton deliveries	26,408	51.2	48.8	48.4	51.6	50.0	50.0	46.8	53.2
Maternal Age									
<20 year	1,009	35.5	64.5	14.7	85.3	8.3	91.7	77.9	22.1
20–37	23,230	51.5	48.5	48.7	51.3	50.6	49.4	45.9	54.1
>37	2,169	55.3	44.7	60.9	39.1	62.8	37.2	41.9	58.1
Race/ethnicity									
White non-Hispanic	18,826	52.1	47.9	55.1	44.9	56.1	43.9	42.7	57.3
Black	3,102	47.7	52.3	26.5	73.5	25.2	74.8	50.4	49.6
Hispanic	3,116	47.8	52.2	29.0	71.0	27.8	72.2	57.0	43.0
Other	1,112	54.0	46.0	54.2	45.8	51.4	48.6	47.0	53.0
Educational level									
Non-high school graduate (<12 year)	1,394	46.1	53.9	11.6	88.4	8.5	91.5	79.3	20.7
High school grad/some college (12–15 year)	13,281	50.7	49.3	31.1	68.9	29.6	70.4	56.5	43.5
College graduate and above (>15 year)	11,326	52.3	47.7	73.9	26.1	79.7	20.3	31.7	68.3
Tobacco use in pregnancy									
No	23,282	51.2	48.8	50.3	49.7	52.1	47.9	45.4	54.6
Yes	1,829	50.7	49.3	24.2	75.8	21.9	78.1	66.1	33.9
Trimester prenatal care began									
First (months 1–3)	22,282	51.2	48.8	48.8	51.2	50.3	49.7	47.1	52.9
Second (months 4–6)	2,310	51.5	48.5	45.8	54.2	46.3	53.7	47.8	52.2
Third (months 7–9)	446	53.1	46.9	47.3	52.7	50.2	49.8	44.7	55.3
Previous live birth									
No	10,338	52.0	48.0	48.9	51.1	48.5	51.5	48.8	51.2
Yes	14,272	50.7	49.3	48.0	52.0	51.0	49.0	45.6	54.4

Values are % distribution for each characteristic within strata of covariates. Connecticut births, 2000.

were affected no more than 5% from the values shown in Table IV for all analyses (results not shown).

To examine possible trends across levels associations of outcomes across tertiles were examined, with the highest level of each psychosocial construct used as a referent. As both job control and substantive complexity decrease, prematurity and LBW demonstrate a monotonic increase (Table V). This increase in risk is attenuated with adjustment for the same covariates noted above; ORs remained significant only for an association of control with preterm birth, while a trend approached significance for the association between substantive complexity and term LBW. The close correspondence between substantive complexity and control, as well as their similar distribution within strata of covariates such as age and education, suggests that similar constructs are being measured. This is confirmed by the correlation matrix between these psychosocial factors, in which physical exertion scores, and maternal educational levels have also been included (Table VI). The strongest correlation (0.67) is seen between control and substantive complexity. Both factors show a moderate correlation with maternal educational level, although effects of both factors on adverse pregnancy outcomes still persist when controlling for educational level, both when used as an ordinal variable with clearly delineated stages (e.g. college graduate, high school graduate, etc.) and as a continuous variable.

When jobs were classified into service sector versus industrial work, lowest-tertile substantive complexity scores were better associated with both all-LBW and term LBW for service sector jobs (aOR for all LBW 1.08; 95% CI 0.93–1.24 for control; aOR 1.15; 95% CI 0.99–1.24 for substantive complexity). By contrast, lowest-tertile control scores showed a stronger, although non-significant, association with birth weight in industrial work (for all LBW: aOR 1.39; 95% CI 0.91–2.13) than was seen for substantive complexity (aOR 1.08; 95% CI 0.67–1.74). Estimates of outcomes in the industrial sector are limited in their stability by the low proportion of maternal work in manufacturing and industrial jobs, with only 11.5% of mothers in the dataset classified as working in this sector. The proportion of LBW cases did not

TABLE III. Crude and Adjusted Odds Ratios for Low Birth Weight and Premature Delivery by Demand and Control Scores: Low-Demand/High-Control (Relaxed) Work as Referent

		Term low birth weight births				All low birth weight births				Premature delivery			
			Crude	Adjusted[a]			Crude	Adjusted[a]			Crude	Adjusted[a]	
Job category	Births	#	OR	OR	95% CI	#	OR	OR	95% CI	#	OR	OR	95% CI
Relaxed (low demand/high control)	4,775	66	1.00	1.00	Referent	227	1.00	1.00	Referent	367	1.00	1.00	Referent
Passive (low demand/low control)	6,029	126	1.61	1.35	0.97–1.86	366	1.34	1.08	0.90–1.30	537	1.20	1.06	0.92–1.24
Active (high demand/high control)	5,862	87	1.08	1.14	0.82–1.59	256	0.97	1.02	0.85–1.23	412	0.93	0.95	0.82–1.11
High strain (high demand/low control)	5,107	114	1.68	1.23	0.88–1.72	336	1.43	1.11	0.92–1.34	522	1.35	1.17	1.00–1.36

[a]Adjusted in logistic regression analyses for maternal age (age <20 or >37 vs. age 20–37), tobacco use (Y/N), maternal educational level (non-high school graduate, high school graduate, college graduate and above), previous birth (Y/N), race/ethnicity (White vs. Black/Hispanic/other), trimester of initiation of prenatal care, and the physical demands of work (JCQ score). Numbers reflect cases with complete information on occupation and covariates used in adjustment.

OR, odds ratio; 95% CI, 95% confidence interval. Connecticut births, 2000.

significantly differ between sectors (5.5% in service vs. 5.2% in industrial; $\chi^2 = 0.48$; $P = 0.49$).

DISCUSSION

The findings described here are consistent with a body of evidence over the past two decades that shows a marginal or non-significant association of adverse birth outcomes with work in a high-strain job after adjustment for relevant risk factors and potential confounders. Homer et al. [1990] using the National Longitudinal Survey of Youth dataset, noted an OR of 1.7 for LBW in mothers with a high-strain job, which reduced to 1.4 (95% CI 0.75–6.8) when adjusted for age, education, smoking, and other confounders, including physical job demands. Imputed psychosocial job characteristics were found not to be associated with term LBW in a large retrospective Danish study [Brandt and Nielsen, 1992], which was at odds with their finding of a significantly increased risk (OR = 1.46) of this outcome when demand and control factors were directly assessed by questionnaire. Although the authors surmised that this finding suggested recall bias, it may as well illustrate the impact of non-differential misclassification that arises from the imputation strategy [Landsbergis et al., 2000]. Similar findings of a small non-significant effect of work in a high-strain job were noted for preterm delivery [Brett et al., 1997] using a retrospective design in a group of lower-income mothers in North Carolina. Although the findings we present here are, in effect, cross-sectional since birth outcome and occupation are both recorded at the time of delivery, this study replicates findings of these prior investigations, with the magnitude and direction of effect similar across studies, including the reduction of the association after adjustment. Further examination of the results indicates the possible importance of control over work, since risk for adverse birth outcomes was increased in both passive and high-strain jobs, both of which have equivalent levels of control. Several lines of evidence from this analysis support an association with job control:

1. The persistence of findings, although modest and attenuated after adjustment for other important predictors of LBW and prematurity present in the dataset, including maternal age, education and smoking status.
2. Indications of a gradient for prematurity across decreasing tertiles of control.
3. Similar effects and a suggestions of a similar gradient with term LBW seen on scoring of maternal work for substantive complexity, using scores obtained from the O*NET.

Overlap between the constructs of control over work (skill discretion and decision authority) and substantive complexity has been noted previously, when scales from the DOT were used and compared to those obtained from

TABLE IV. Crude and Adjusted Odds Ratios for Low Birth Weight and Premature Delivery: Odds for Outcome in Most Extreme Tertile for Each Psychosocial and Physical Work Factor Contrasted With the Other Two Tertiles

	Term low birth weight			All low birth weight			Premature delivery		
	Crude	Adjusted[a]		Crude	Adjusted[a]		Crude	Adjusted[a]	
Factor	OR	OR	95% CI	OR	OR	95% CI	OR	OR	95% CI
Highest demands	1.06	1.04	0.83–1.30	0.95	0.96	0.84–1.10	0.94	0.95	0.85–1.05
Lowest control	1.74	1.25	0.99–1.59	1.47	1.10	0.96–1.26	1.28	1.06	0.95–1.19
Lowest substantive complexity	1.80	1.26	0.98–1.62	1.54	1.13	0.98–1.31	1.24	1.00	0.88–1.12
Highest people versus things	1.00	1.00	0.97–1.03	0.99	0.99	0.97–1.00	0.99	0.99	0.98–1.01
Highest physical demands (JCQ)	0.99	1.06	0.85–1.32	0.93	0.99	0.87–1.13	1.00	1.04	0.93–1.15
Highest physical demands (O*NET)	1.55	1.29	1.03–1.62	1.31	1.13	0.99–1.29	1.19	1.09	0.98–1.22

[a]Odds ratios (ORs) adjusted in logistic regression analyses for maternal age, tobacco use, maternal educational level, previous birth, race/ethnicity, and trimester of initiation of prenatal care as noted in Table II. Adjustment was also made for the physical demands (PD) of work according to the source of job characteristics: Demands and Control were adjusted for PD scores in the JCQ; Substantive complexity and people versus things adjusted for O*NET PD scores. Odds ratios for physical demands alone (adjusted for the above variables) are also shown in the last two rows.

OR reflect comparison of most extreme tertile (e.g. lowest tertile of control) with the other two tertiles. A high score on the factor titled *people versus things* is indicative of a job emphasizing interpersonal relations in contrast to work with materials and equipment. Connecticut births, 2000.

the Quality of Employment Surveys [Schwartz et al., 1988; Muntaner et al., 1993]. The findings here, which also show a strong correlation between the two constructs when applied to the jobs in the birth dataset, help to confirm the similarity between the two. As well, these results corroborate findings that the newer O*NET scales may be used as successors to the previously constructed DOT scales in evaluating one aspect of the psychosocial work environment [Hadden et al., 2004]. The association of LBW and premature delivery with variables indicative of control over work, rather than work demands, is noteworthy, and consistent with findings of the importance of job control in the development of hypertension, cardiovascular disease, and mortality [Bosma et al., 1998; Muntaner et al., 1998; Peter et al., 2002; Steptoe and Willemsen, 2004], although the notion is far from settled that control, in the absence of psychological demands measures, may play a role [de Lange et al., 2003; Kuper and Marmot, 2003]. As job demands and control over work have not heretofore been examined separately in association with adverse pregnancy outcomes, the findings here may be considered as preliminary evidence of the importance of job control in the psychosocial work environment and its possible relationship to LBW and premature delivery, a finding for which additional evidence should be sought [Brett et al., 1997].

Of note was some evidence of the ability of the imputed scores for job control to predict term- and all-LBW in women employed in the service sector. The O*NET-derived measure

TABLE V. Crude and Adjusted Odds Ratios for Low Birth Weight and Premature Delivery: Contrast of Risk Across Tertiles of Control and Substantive Complexity

	Term low birth weight			All low birth weight			Premature delivery		
	#	Crude OR	Adjusted OR (95% CI)	#	Crude OR	Adjusted OR (95% CI)	#	Crude OR	Adjusted OR (95% CI)
Control									
Tertile 1 (highest)	115	1.00	Referent	337	1.00	Referent	531	1.00	Referent
Tertile 2	105	1.01	0.92 (0.70–1.21)	360	1.14	1.05 (0.90–1.23)	614	1.21	1.15 (1.02–1.30)
Tertile 3 (lowest)	173	1.70	1.19 (0.90–1.57)	488	1.55	1.13 (0.96–1.33)	693	1.41	1.17 (1.02–1.33)*
Substantive complexity									
Tertile 1 (highest)	94	1.00	Referent	305	1.00	Referent	519	1.00	Referent
Tertile 2	120	1.21	1.01 (0.74–1.39)	375	1.17	0.99 (0.83–1.18)	629	1.22	1.09 (0.94–1.25)
Tertile 3 (lowest)	179	1.99	1.29 (0.93–1.79)**	505	1.67	1.13 (0.94–1.37)	690	1.37	1.07 (0.92–1.24)

**P*-value for trend across tertiles 0.023.

***P*-value for trend across tertiles 0.086.

Connecticut births, 2000.

TABLE VI. Correlation Matrix for Work Psychosocial Factors, Physical Exertion, and Maternal Education

	Demand	Control	Physical demands (JCQ)	Substantive complexity	People vs. Things	Physical demands (O*NET)	Maternal education
Demand	1.00	0.06	0.26	0.19	0.04	−0.08	0.13
Control		1.00	−0.06	0.67	0.16	−0.17	0.48
Physical demands (JCQ)			1.00	−0.06	0.16	0.46	0.02
Substantive complexity				1.00	0.06	−0.29	0.58
People vs Things					1.00	0.15	0.05
Physical demands (O*NET)						1.00	−0.20
Maternal education							1.00

Pearson correlation coefficients for continuous variables. Connecticut births, 2000.

of substantive complexity, by contrast, also predicted outcomes for service sector jobs, but was much weaker in prediction for jobs classified as industrial. The slightly greater association of substantive complexity (relative to control) with outcomes in the service sector is congruent with prior observation that inclusion of variables that better describe work organization in the service economy (including interpersonal dependence and learning on the job) might enhance the validity of the demand-control model [Hadden et al., 2004]. This dataset may yield a limited ability to assess the predictive ability of work psychosocial factors in industrial jobs, as earlier noted, since fewer than one-eighth of the jobs fell into this class. Further comparisons may be useful in determining the ability of the original construct of decision latitude (job control) to predict outcomes for the high proportion of service sector jobs represented in this and other occupational datasets; this may be one step in assessing the Karasek model's robustness in describing working conditions in a changing economic climate.

One major difference between JCQ- and O*NET-derived variables was seen in the magnitude of association between physical demands and adverse pregnancy outcomes. Moderate elevations in risks for LBW were seen when the composite O*NET physical demands score was used, in contrast with the finding of no association with the JCQ physical demand score. Neither factor was associated with prematurity in this analysis. The association of LBW with the O*NET physical demand variable is partially in accord with results obtained from a large meta-analysis of physical factors and pregnancy outcomes [Mozurkewich et al., 2000] although recent work, by contrast, suggests little effect of physically demanding work [Pompeii et al., 2005]. The differences in estimation of effect between the JCQ and O*NET models may be a function of different characterization of physical demands. While the JCQ bases its score on a single-item assessment of whether the work is physically demanding, the O*NET factor is derived from variables describing activity, exertion, stamina, and the environment more broadly. Although the JCQ and O*NET physical demand variables were moderately well correlated ($r = 0.46$), they appear to describe different aspects of the physical tasks and challenges of particular types of work, reflecting a phenomenon that may contribute to the variability of attempts to draw associations between physical demands and LBW or prematurity. Evidence for shared variance in physical and psychosocial stressors should be considered as well, with work that presents high physical demands also associated with higher psychological demands or lower control, thereby presenting a greater overall risk [MacDonald et al., 2001].

Several limitations are inherent in the use of a large administrative dataset to answer research questions such as those posed here. A principal limitation is the reliability of data on maternal occupation, including both the accuracy of job title reporting, and the lack of information on work span during pregnancy. A small mail survey of recent births using the CT DPH birth registry found agreement on reported maternal occupation with that of the birth registry of 87.6%, although response rate was below 50%. This compares with previous findings of accuracy on birth certificate reporting of 71% and 72% in two studies from the early 1990s [Shaw et al., 1990; Marshall et al., 1992]. Of those in the mail survey who did work, a substantial majority reported working into the third trimester (83.5%), with 54% working into the final month of pregnancy, consistent or greater than published figures by the Census Bureau for women with initial pregnancies [Smith et al., 2001; Johnson and Downs, 2005]. However, because of the cross-sectional nature of the data collection and the low response rate of this validation survey, the possibility of misclassification bias in ascertainment of maternal occupation cannot be excluded, in particular if recording of occupation may be influenced by a poor outcome, such as maternal illness that necessitated removal from work or a medical decision to deliver prior to term [Savitz et al., 1996; Savitz et al., 2002]. In addition, imputed job characteristics from databases remain proxy and ''average'' measures of exposure, and may not reflect either individual work circumstances, or changes in occupational

stressors that may occur differentially across the course of pregnancy.

A related problem is the limited information available on covariates and potential confounders in the dataset. Some important predictors of adverse outcomes are collected by the birth registry, including maternal age, educational level, prior deliveries, and tobacco use during pregnancy. However, the practicability of collecting additional data for administrative purposes limits the variables available for analysis. Thus, strong predictors of LBW and prematurity, such as a previous occurrence, as well as other potentially important factors such as income and insurance coverage, are not available in the data. The coding of other available fields, such as smoking during pregnancy (limited to a yes/no answer) and education (truncated at 17 years) may reduce precision in testing hypothesized contributors to LBW and prematurity. Simple classification of subjects by race and ethnicity likely obscures other, perhaps better, socioeconomic determinants of outcomes. However, despite these limitations, the magnitude and direction of risks attributable to other factors derived from these data were consistent with those from other studies. For example, ORs obtained for tobacco use and LBW from these data centered around 2.0 in the multivariate logistic models we used, and a linear regression analysis on birth weight controlling for other maternal factors found a mean birth weight 181 g lower in those noted as using tobacco in pregnancy, equivalent to findings in other studies that assessed smoking and its contribution to LBW [Lieberman et al., 1994; Horta et al., 1997; Steyn et al., 2006].

A converse problem may lie in the possibility of overadjustment in multivariate models for variables considered to be confounders. Here, inclusion of variables describing maternal educational level may be problematic, since instead of representing a confounder, education as a risk factor may lie instead on a causal pathway that links workplace psychosocial attributes and poor pregnancy outcomes. A confounder, by contrast, though associated with both exposure and outcome, instead represents a third variable or ''common cause'' not found in the causal pathway between job characteristics and outcomes [Susser, 2001]. Moderately high correlations were noted between maternal education and dimensions of control and substantive complexity (Tables II and VI). This finding, and the potential covariation of educational level with many of the variables that compose the construct of substantive complexity (including deductive reasoning, updating and using relevant knowledge, complex problem solving, active learning, critical thinking) indicates that the possibility of overadjustment, and a spuriously reduced estimation of risk, might arise from inclusion of both educational and work psychosocial variables. It raises a question, relevant for future research, as to the extent to which prior educational achievement can be disentangled from occupational characteristics, or how the former might be predictive of the latter.

CONCLUSIONS

In summary, this study, using a large state birth dataset, confirms the limited association between high-strain work and adverse pregnancy outcomes noted in earlier studies. Further analysis indicates that LBW and prematurity may be more specifically associated with low job control, with consistency of findings using both the demand-control model and O*NET-derived factors. These associations are attenuated when adjusted for relevant confounders and other risk factors that could be obtained from the dataset. The variability of results across this and comparable studies should be acknowledged, as well as the modest estimates of effect when compared to other predictors of adverse outcomes. Estimations of risk from this study may be limited by the cross-sectional nature of the data, the small number of covariates that could be used in analysis of outcomes, and problem inherent in deriving measures of work characteristics through imputation. Investigation that more precisely ascertains maternal work, including the time span of work during pregnancy, would be important to confirm the results presented here. Aggregation of O*NET variables into factors that describe work organization and related constructs such as physical demands may prove useful in examining hypotheses that link job characteristics to adverse health consequences, including pregnancy outcomes.

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