Characteristics of Maternal Employment during Pregnancy: Effects on Low Birthweight

ABSTRACT

Background: Although maternal employment is considered a risk factor for low birthweight (LBW), the manner in which employment might affect birthweight is poorly understood. In this analysis, selected charateristics of employment during pregnancy were examined for effects on pregnancy outcomes.

Methods: Work characteristics included the number of hours per week, physical activities, and environmental conditions. The outcomes of interest were fetal growth retardation (<2500 grams at term) and preterm delivery (<37 weeks). The study population consisted of 2711 non-Black, married mothers who participated in the 1980 National Natality Survey (NNS). The NNS data were merged with data from the 1977 revision of *The Dictionary of Occupational Titles* (DOT) from which measures of occupational physical activities and environmental exposures were obtained. Logistic regression was used in the analysis.

Results: Those who worked 40 or more hours per week were more likely than women who worked fewer hours to have a low birthweight delivery at ≥37 weeks. No physical or environmental characterics of work were associated with low birthweight or preterm delivery.

Conclusions. Non-Black married American women may face a risk of delivering low-birthweight babies at or near term only if they work 40 or more hours each week. However, the lack of risk associated with other characteristics of work may be a function of measurement error in the DOT data source or of low levels of exposure in the analysis population. (*Am J Public Health*. 1991;81;1007–1012)

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Introduction

Infants weighing 2500 g or less at birth may be small for gestational age, the result of a preterm birth, or both.[1] The two low-birthweight (LBW) categories share many risk factors[2] but are caused by different physiological mechanisms.[3] For women who work during pregnancy, characteristics of employment have been associated inconsistently with both outcomes.

Studies in developing countries suggest that hard physical labor during pregnancy has adverse effects on fetal growth.[4–6] In industrialized nations, standing,[7–10] carrying or lifting heavy loads,[8,11] strenuous physical effort,[12–15] work on assembly lines[12] and industrial machines,[13] and some occupations that involve physical effort, such as chambermaid, janitor, and hospital worker,[8,16] have been associated with delayed fetal growth, preterm birth, or both. However, in other investigations, each of these findings has either not been supported[8,12,17–22] or has not been examined.

Studies of environmental conditions such as temperature, dust, and moisture have found few associations with either category of LBW.[8,17,23] However, one study found loud noises associated with lower birthweight,[8] while in another, an "environment" index was associated with preterm birth.[13]

Physical and environmental exposures at work may influence pregnancy by decreasing uterine blood flow,[24,25] by stimulating production of catecholamines[26,27] or both. Presumably, these processes can be accelerated or decelerated by amount of exposure. Hence, studies in which number of hours worked per day or week are taken into account are potentially informative. However, the studies that have included these variables have produced inconsistent results.[7,8,12,13,18,19,22,28]

Most of the research in this area has been done in Europe,[10–13,19,20,29] with some recent reports from Montreal.[8,16] Of the 10 American studies reported in the literature,[7,9,14,15,17–19,22,28,30] four found no significant effects of maternal employment.[17–19,28] Also, the analysis of the Collaborative Perinatal Project data of the early 1960s[7] may not be applicable to current working populations. Most of the US studies have focused on a few physical activities (notably that of standing) and on hours and duration of work to the exclusion of environmental exposures. Also, confidence in the findings of the studies of American women is tempered by measurement problems. In some cases, employment characteristics were assigned post hoc by the investigators or other experts to occupational titles.[7,9,17,18] Variations by individual or work site were not taken into account, and the validity of the coding schemes was unknown. Another approach was to collect employment data after the delivery,[19,22] when recall may

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have been clouded by elapsed time, the relative significance of the birth event, the health of the infant, or all of these factors. Homer et al.[14,30] avoided these sources of error by imputing employment characteristics from an independent data base. However, they may have introduced a new source of self-report bias because the data were collected by surveying workers.

The purpose of the present study was to examine the effects of selected physical and environmental characteristics of maternal employment and amount of work (hours/week) on fetal growth and preterm delivery in a representative sample of contemporary American women. To avoid the measurement error in assessment of job characteristics associated with self-report and expert opinion, data on employment characteristics were obtained from an independent source derived primarily from work-site observations.

Methods

Data Sources

This study is an analysis of the 1980 National Natality Survey (NNS), a follow-back survey of a probability sample of registered births in the United States. Approximately 1 in 400 live births ≥2500 g and 1 in 95 live births <2500 g are in the NNS sample, which totals 9941. Data were collected from birth certificates and requested by mail from hospitals and other health care providers. In addition, detailed sociodemographic and behavioral data as well as basic information on employment during the 12 months before the birth were requested by mail from mothers who were married at the time of delivery. The data collection process involved three mailings and an attempt to interview nonrespondents by telephone. Overall response was 79.5% from married mothers and 76.1% from hospitals. All data were collected retrospectively, within 1 year of the 1980 deliveries.[31,32]

The NNS data set was merged with the 1977 Dictionary of Occupational Titles (DOT), which includes descriptive data on more than 12 000 distinct occupations in more than 75 000 sites.[33] DOT data were collected by on-site interviews with workers and from observations of jobs as they were performed.[34] A detailed job analysis schedule[33] was completed for each job and, if feasible, verified by the worker's immediate supervisor.[34] One or two workers were observed for each job analysis. Scores on 44 work characteristics were then assigned by the analyst based on detailed guidelines and examples.[35]

Study Population

The study population consisted of 2711 non-Black (97% White) singleton live births to married mothers who worked during pregnancy and provided sufficient data on occupation and industry to match with DOT job characteristics. NNS subjects with imputed data entries on employment items, birthweight, or gestational age at delivery were not included in the 2711. The population was limited to married women because employment data were available only from the mothers' questionnaire. This restriction caused the number of Black mothers eligible for analysis to be so small (n = 399) that they were excluded from the analysis.

Two sets of analyses were conducted to distinguish between the effects of work characteristics on fetal growth and on gestational age, since the two conditions are due to different physiologic processes.[3] For analyses in which term low birthweight was the dependent variable, infants who were clearly preterm (<37 weeks) were removed from the analysis population. Similarly, in analyses of preterm births, infants who were low birthweight (fetal growth retarded) at term (≥37 weeks) were removed. The purpose of this was to exclude infants with identifiable morbidities from the groups to which low birthweight and preterm births were compared. In addition, women who started work after the eighth gestational month were excluded from analyses of preterm births.

Derivation of the analysis samples is show schematically in the Appendix. Each exclusion produced more homogeneous populations with lower risk of adverse pregnancy outcomes. In general, the analysis samples were of lower parity, had more education, received more prenatal care, and gained more weight that the exclusion groups.

Variables

The dependent variables, low birthweight (<2500, ≥2500 g) and preterm delivery (<37, ≥37 weeks), were constructed from the birth certificate source in the NNS. Number of hours worked per week in a company, business or organization was taken from the NNS mothers' questionnaire and categorized as 1 to 20, 21 to 39, and ≥40. Three measures of physical activity were constructed from DOT data. Physical strength was derived from field observations of standing, walking, sitting, lifting, carrying, pushing, and pulling objects; jobs were categorized as sedentary, light, medium, heavy, or very heavy based on these activities.[35] The other physical activities were climbing/balancing and stooping/kneeling/crouching/crawling. A score of 1 for presence or 0 for absence was recorded for each DOT job on these variables.[35]

Six DOT characteristics were used as measures of environmental conditions: (1) work performed outdoors without effective protection from the weather; (2) extreme cold with or without abrupt variations in temperature; (3) extreme heat with or without abrupt variations in temperature; (4) constant or intermittent loud noises; (5) physical hazards (e.g., work on scaffolding, exposure to electrical shock, exposure to toxic chemicals); and (6) elements in the atmosphere (i.e., fumes, odors, dusts, mists, gases, or poor ventilation.) These characteristics were also scored 1 or 0, as above.[35]

DOT job titles do not correspond exactly with the NNS census codes for occupation and industry. To merge the two files, a bridge tape created for this purpose was used. Each DOT value on the bridge tape represented the level of the characteristic for incumbents of a given occupation in the 1971 Current Population Survey. Levels for the physical exertion variable were population means, while values for the remaining DOT characteristics were percentages (of the population in the given occupation with the characteristic present).[36,37]

In this analysis, the scores described above were categorized into low, medium, and high groups, based on distribution in the NNS population. For symmetrical distributions, the lowest and highest deciles were used to designate low and high groups. In cases of asymmetrical distributions with long tails caused by large percentages of jobs in the population that did or did not have the particular DOT characteristic, cut points at the tails were used to designate low or high categories.

Six NNS variables were considered potential confounders.[2] Maternal age, parity, education, and adequacy of prenatal care[38] were categorical variables constructed from birth certificate data. Number of cigarettes smoked per day after confirmation of pregnancy was a continuous variable derived from the mothers' questionnaire. Prepregnant weight adjusted for height was based on data from hospital and mothers' questionnaires. To construct the variable, the National Center for Health Statistics (NCHS) formula,

weight/height[1.5] was applied to the population of all working women.[39] Adjusted weights were categorized as lean (≤14 percentile), normal (15 to 84 percentile), and overweight (≥85 percentile).

Pregnancy complications and weight gain were available in the NNS, but these variables were not controlled in the analysis because effects of work on fetal growth and gestational duration may occur through these conditions. Other potential confounders such as family income, wantedness of pregnancy, and interval since last pregnancy were not used because of missing data. Indicators of previous LBW or preterm birth were not available.

Data Quality

Cases with missing or imputed entries for birthweight, gestational age, and all characteristics of employment were excluded from the analysis. Fewer than 1% of missing data were imputed for the other variables, with one exception, parity at 13.1%. The imputation process and other NNS editing and cleanup processes are described elsewhere.[31,32] Birthweight and gestational age combinations were examined for plausibility according to David's criteria.[40] Forty-five subjects had implausible combinations and were excluded from the analysis. NNS occupation and industry combinations were compared with DOT job characteristics to assess face validity. The investigators concluded that correspondence between the two data sets was acceptable.

Analysis

Analysis was performed by multiple logistic regression using sampling weights. Low-birthweight infants were oversampled in the NNS, and there was differential reporting by age and birth order, resulting in unequal probabilities of selection.[41] Sampling weights were assigned to each birth in each stratum, defined by birthweight, age, and birth order. The analyses reported here involved computing weighted means and proportions and then constructing logistic regression models using the weights. The analysis was conducted using the software PROC RTI LOGIT written for fitting models to complex survey data.[42] This procedure incorporates sampling weights into the estimation of the logistic regression parameters.

Several logistic regression models were constructed with low birthweight as well as preterm delivery as dependent variables. In addition to the work characteristics, the six potential confounders were used as independent variables. Some models included interaction terms for the DOT characteristics by number of hours worked and parity. Generally, a *P* value of .05 was used to designate significance of the F tests of each parameter. Odds ratios and 95% confidence intervals (CI) were also calculated.

Findings

The study population (Table 1) had relatively low percentages of low birthweights, preterm births, and maternal risk characteristics. Each of the analysis populations had similar distributions.

In the population who delivered at term (Table 2), the percent LBW increased directly with number of hours worked, but the only DOT variable distributed in the hypothesized direction was extreme cold. When the effects of confounders were controlled, only number of hours worked was statistically significant. With 1 to 20 hours as the standard, the odds of having a LBW infant were 1.4 (CI = 0.80–2.36) times greater for women who worked 21 to 39 hours, and 1.7 (CI = 1.03–2.68) times greater for women who worked ≥40 hours (Table 3).

Among women who started work at 8 or fewer months of gestation and had infants who were not LBW at term (Table 4), there is no discernible pattern in the distribution of preterm births by number of hours worked or by the DOT characteristics, with one exception: extreme cold. None of the employment characteristics was significant when confounding variables were controlled in logistic regression analysis.

TABLE 1—Distribution of Pregnancy Outcomes and Potential Confounders for 2711 Non-Black Married Women Who Worked during Pregnancy

Characteristic	Percentage of the Population[a]
Birthweight (g)	
<2500	4.2
≥2500	95.8
Gestational age (weeks)	
<37	6.8
≥37	93.2
Maternal age (years)	
<20	6.7
20–24	34.8
25–29	37.7
≥30	20.9
Parity	
0	48.6
1–3	48.3
≥4	3.2
Education (years)	
<12	7.7
12	44.6
>12	47.7
Prenatal care	
Adequate	79.8
Less than adequate	20.2
Prepregnant weight standardized by height	
Lean	16.2
Normal	74.8
Overweight	8.9
Number of cigarettes smoked per day since pregnancy confirmed	
0	75.5
1–9	7.3
10–19	8.5
≥20	8.6

[a]Weighted for differential probabilities of selection. The sums of percentages may not add to 100 because of rounding.

Discussion

The findings suggest that working long hours during pregnancy is associated with low-birthweight deliveries at 37 or more weeks' gestation for married, non-Black women. None of the other characteristics of maternal employment are strongly related to low birthweight at term or to preterm delivery in this population.

The relationship between working long hours and delivery of a full-term, low-birthweight infant is difficult to interpret in light of the other, null, results. The relationship held when each of the other characteristics of work was included in the model, suggesting that long working hours has a strong independent effect on low birthweight. Working 40 or more hours per week may reflect elements of psychological stress or physical fatigue that were not represented in the other variables. Unlike the dramatic findings of Mamelle, et al.[13], analysis of interactions between hours worked and the other work characteristics produced no additional information. However, because interaction analyses were sometimes based on few observations in the combined categories of interest, the possibility cannot be ruled out that working long hours in jobs with identifiable characteristics is the influential factor.

Some measurement issues also must be considered in interpreting this finding. One is the retrospective nature of the NNS data. In the year following the 1980 birth, respondents probably would have provided accurate information about occupation and industry, but recall of the number of hours worked per week may

TABLE 2—Distribution of Characteristics of Work in the Analysis Population and Percent Low Birthweight in Each Category, 2379 infants of Non-Black Women Who Delivered at Term (≥37 weeks) and Worked during Pregnancy

Characteristic of Work	Percentage in the Population[a]	Percentage Weighing <2500 g[a]
Hours worked/week		
1–20	16.5	1.4
21–39	26.1	1.7
≥40	57.4	2.0
Strength		
Low	11.4	2.8
Medium	78.9	1.7
High	9.7	1.9
Climbing/balancing		
Low	41.2	1.7
Medium	47.1	2.2
High	11.7	1.1
Stooping		
Low	14.9	1.7
Medium	75.5	1.9
High	9.6	1.4
Work performed outdoors		
Low	67.6	1.9
Medium	26.6	1.7
High	5.8	1.6
Extreme cold		
Low	84.7	1.8
Medium	10.7	1.7
High	4.6	2.7
Extreme heat		
Low	66.3	1.7
Medium	24.3	2.4
High	9.4	1.8
Loud noises		
Low	32.4	1.8
Medium	63.0	1.9
High	4.6	2.1
Physical hazards		
Low	37.3	1.8
Medium	53.4	1.9
High	9.3	1.9
Atmospheric elements		
Low	65.1	1.9
Medium	24.7	1.9
High	10.2	1.5
Total	100.0	1.9

[a] Weighted for differential probabilities of selection.

have been blurred by time and subsequent events. Also, the number of hours worked per week could have changed during pregnancy, but the NNS questionnaire did not capture this dynamic aspect. Employment data were limited to the mother's chief job. Some women may have worked additional jobs that could have extended the number of hours worked per week. The effects of these deficiencies on the findings would be underestimation of the coefficients of hours worked.

The null findings from analysis of DOT physical and environmental factors should be considered from three perspectives. First, these results are consistent with other studies of American populations,[17–19,22,28] but they contrast sharply with findings from major studies in France[11–13] and Canada.[8,16] Perhaps the working conditions of US women are more favorable for birthweight and length of gestation than those in other industrialized countries, or perhaps the relatively advantaged and homogeneous character of our sample is not comparable to the diverse populations in the French and Canadian studies. Also, the quality of the DOT data (discussed below) may have been inferior to data collected directly, albeit retrospectively, from working women in the French and Canadian studies.

A second possible interpretation is derived from the fact that the low-risk status of the population may have diminished our ability to detect effects of physical and environmental exposures within the sample. Because the study population was sociodemographically advantaged, they may have tolerated physical and environmental stresses of work better than a less advantaged group. Or they may have undertaken jobs with fewer physical demands and more comfortable working environments than less advantaged women. Another analysis of the 1980 NNS data found that advantaged women tended to work in the professional, technical, and managerial sector,[43] where physical and environmental insults are likely to be few. We also found evidence that the study population had some control over work-related exposures. There were considerably higher percentages of women who stopped working in the first 3 months of pregnancy who had jobs categorized as high on each of the DOT factors. This tendency was also found, although not as consistently, for women who worked short (1 to 20) hours.

A third possibility, misclassification bias in DOT data, warrants close attention. The only positive result in this study was based on NNS data, whereas all analyses of DOT variables produced null results. We selected the DOT as our source of employment data because, as an independent source derived primarily from on-site observations, it allowed us to avoid self-report and expert opinion biases in job measurement. The DOT has been used extensively for research[44] and has been shown to correlate reasonably well with another large national employment data base.[45] Linking of macrolevel data bases with individual data is advocated as an informative tool for initial epidemiologic studies. However, an inherent bias toward the null of coefficients derived from multiple regression analysis has been reported.[45] In addition, a number of documentation and procedural problems with data collection and assignment of scores in the DOT have been identified.[34] These problems could have resulted in misclassification of the variables of interest. We attempted to identify misclassification by examining DOT values in each occupation or industry for face validity before any analyses were conducted. Also, after analyses of physical and environmental variables were completed, we created three separate measures of high vs low risk for physical exertion from NNS occupation data only, and repeated the logistic regression analysis with each. Consistent with our DOT findings, none of these measures was associated with either of the outcomes. (The definitions of these variables

TABLE 3—Results of Multiple Logistic Regression Analysis for Non-Black Women Who Worked during Pregnancy and Delivered at 37 or More Weeks' Gestation

Variable	Beta	Standard Error	F[a]	P	OR[b]	95% Confidence interval
Maternal age (years)						
<20	0.088	0.069	1.59	.207	0.9	0.80–1.05
≥30	0.253	0.056	20.37	.000	1.3	1.15–1.43
Number of cigarettes smoked per day	0.048	0.007	46.51	.000	1.1	1.03–1.06
Prenatal care less than adequate	0.4756	0.176	7.32	.007	1.6	1.14–2.27
Hours worked						
21–39	0.319	0.275	1.35	.245	1.4	0.80–2.36
≥40	0.508	0.245	4.31	.038	1.7	1.03–2.68

[a] F tests are with (1, α) *df*.
[b] OR = odds ratio.
Note: Test for overall model: F 12.60; *df* 6; $P < 0.0001$.

TABLE 4—Distribution of Characteristics of Work in the Analysis Population and Percentage of Preterm Deliveries in Each Category for 2511 Infants of Non-Black Women Who Started Work at 8 or Fewer Months' Gestation[a]

Characteristic of Work	Percentage in the Population[b]	Percentage of <37-Week Deliveries[b]
Hours worked/week		
1–20	16.4	6.4
21–39	26.2	7.6
≥40	57.4	6.9
Strength		
Low	11.4	7.9
Medium	78.7	6.6
High	9.9	8.9
Climbing/balancing		
Low	41.3	7.1
Medium	46.9	6.9
High	11.7	6.9
Stooping		
Low	14.7	6.1
Medium	75.7	7.2
High	9.6	6.9
Work performed outdoors		
Low	67.4	7.1
Medium	26.8	7.2
High	5.6	5.1
Extreme cold		
Low	84.5	6.8
Medium	10.7	6.8
High	4.8	11.1
Extreme heat		
Low	66.2	7.0
Medium	24.4	7.2
High	9.4	6.4
Loud noises		
Low	32.7	8.3
Medium	62.7	6.3
High	4.5	7.1
Physical hazards		
Low	37.2	6.9
Medium	53.7	7.2
High	9.2	6.0
Atmospheric elements		
Low	64.9	6.7
Medium	25.0	8.1
High	10.1	6.0
Total	100.0	7.0

[a] 1 month = approximately 4 weeks.
[b] Weighted for differential probabilities of selection.

and results of the analyses are available from the authors upon request.)

The promise for statistical control of potential confounders in the NNS was substantial, but because of missing data, several critical variables such as income, pregnancy interval, and alcohol consumption were not used. Other key variables (e.g., previous LBW, previous pregnancy complications, psychosocial stress, and physical activity outside of work) were not available. While it is unlikely that control of these factors would have altered the null results, they should be included in future research.

In light of the preceding observations, it is prudent to conclude that non-Black, married American women may face a risk of delivering low-birthweight babies at or near term only if they work 40 or more hours each week. However, the lack of risk associated with other characteristics of work may be a function of measurement error in the DOT data source or of low levels of exposure in this sociodemographically advantaged population. With regard to the potential effects of physical and environmental characteristics in the workplace, this study has taken the logical next step in a progression of epidemiologic investigations that includes retrospective self-reports of job exposures, post hoc assignment of exposures by expert panels, and merging of macrolevel job characteristic files with individual-level data. It is now clear that these less expensive approaches to studying maternal employment and pregnancy outcome are not sufficient. Studies based on high-quality data collected prospectively from the women themselves are imperative. □

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References

1. Institute of Medicine. *Preventing Low Birthweight.* Washington, DC: National Academy Press; 1985.
2. Kramer MS. Intrauterine growth and gestational duration determinants. *Pediatrics.* 1987;80:502–511.
3. Bragonier JR, Cushner IM, Hobel CJ. Social and personal factors in the etiology of preterm birth. *In:* Fuchs F, Stubblefield PG, eds. *Preterm Birth: Causes, Prevention and Management.* New York: Macmillan Publishing Co; 1983: chap 4.
4. Tafari N, Naeye RL, Gobezie A. Effects of maternal undernutrition and heavy physical work during pregnancy on birth weight. *Br J Obstet Gynaecol.* 1980;87:222–226.
5. Manshade J, Eckels R, Manshade-Desmit U, Vlietinck R. Rest versus heavy work during the last weeks of pregnancy: influence on fetal growth. *Br J Obstet Gynaecol.* 1987;94:1059–1067.
6. Launer L, Villar J, Kestler E, DeOnis M. The effect of maternal work on fetal growth and duration of pregnancy: a prospective study. *Br J Obstet Gynaecol.* 1990;97:62–70.
7. Naeye R, Peters E. Working during pregnancy: effects on the fetus. *Pediatrics.* 1982;69:724–727.
8. McDonald AD, McDonald JC, Armstrong B, Cherry NM, Nolin AD, Robert D. Prematurity and work in pregnancy. *Br J Ind Med.* 1988;45:56–62.

9. Teitelman AM, Welch LS, Hellenbrand KG, Bracken MB. Effect of maternal work activity on preterm birth and low birthweight. *Am J Epidemiol.* 1990;131:104–113.
10. Nurminen T, Lusa S, Ilmarinen J, Kurppa K. Physical work load, fetal development and course of pregnancy. *Scand J Work Environ Health.* 1989;15:404–414.
11. Saurel-Cubizolles M, Kaminski M, Llado-Arkhipoff J, et al: Pregnancy and its outcome among hospital personnel according to occupation and working conditions. *J. Epidemiol Community Health.* 1985; 39:129–134.
12. Saurel-Cubizolles M, Kaminski M. Pregnant women's working conditions and their changes during pregnancy. *Br J Ind Med.* 1987;44:236–243.
13. Mamelle N, Laumon B, Lazar P. Prematurity and occupational activity during pregnancy. *Am J Epidemiol.* 1984; 119:309–322.
14. Homer CJ, Beresford SA, James SA, Siegel E, Wilcox S. Work-related physical exertion and risk of preterm, low birthweight delivery. *Paediatr Perinat Epidemiol.* 1990;4:161–174.
15. Ramirez G, Grimes RM, Annegers JF, Davis BR, Slater CH. Occupational physical activity and other risk factors for preterm birth among US Army primigravidas. *Am J Public Health.* 1990;80:728–729.
16. McDonald AD, McDonald JC, Armstrong B, et al. Occupation and pregnancy outcome. *Br J Ind Med.* 1987;44:521–526.
17. Meyer B, Daling J. Activity level of mother's usual occupation and low infant birth weight. *J Occup Med.* 1985;27:841–847.
18. Zuckerman B, Frank D, Hingson R, Morelock S, Kayne H. Impact of maternal work outside the home during pregnancy on neonatal outcome. *Pediatrics.* 1986; 77:459–464.
19. Berkowitz R. Physical activity and the risk of spontaneous preterm delivery. *Reprod Med.* 1983;28:581–588.
20. Rabkin CS, Anderson HR, Bland JM, Brooke OG, Chamberlin G, Peacock JL. Maternal activity and birthweight: a prospective population-based study. *Am J Epidemiol.* 1990;131:522–531.
21. Najman JM, Morrison J, Williams GM, Andersen MJ, Keeping JD. The employment of mothers and the outcomes of their pregnancies: an Australian study. *Public Health.* 1989;103:189–198.
22. Klebanoff MA, Shiono PH, Rhoads GG. Outcomes of pregnancy in a national sample of resident physicians. *N Engl J Med.* 1990;323:1040–1045.
23. Hartikainen-Sori A, Sori M. Occupational and sociomedical factors in preterm birth. *Obstet Gynecol.* 1989;74:13–16.
24. Easterling TR, Schmucker BC, Benedetti TJ. The hemodynamic effects of orthostatic stress during pregnancy. *Obstet Gynecol.* 1988;72:550–552.
25. Hagan RD, Diaz FJ, Horvath SM. Plasma volume changes with movement to supine and standing positions. *J Appl Physiol.* 1978;45:414–417.
26. Timio M, Gentili S, Pede S. Free adrenaline and noradrenaline excretion related to occupational stress. *Br Heart J.* 1979; 42:471–474.
27. Schnider SM, Wright RG, Levinson G, et al. Uterine blood flow and plasma norepinephrine changes during maternal stress in the pregnant ewe. *Anesthesiology.* 1979; 50:524–527.
28. Marbury M, Linn S, Monson R, et al. Work and pregnancy. *J Occup Med.* 1984; 26:415–421.
29. Ahlborg G, Bodin L, Hagstedt C. Heavy lifting during pregnancy: a hazard to the fetus? A prospective study. *Int J Epidemiol.* 1990;19:90–97.
30. Homer CJ, James SA, Siegel E. Work-related psychosocial stress and risk of preterm, low birthweight delivery. *Am J Public Health.* 1990;80:173–177.
31. Placek PJ. The 1980 National Natality Survey and National Fetal Mortality Survey: methods used and PHS agency participation. *Public Health Rep.* 1984;99:111–116.
32. Keppel KG, Heuser RL, Placek PJ, et al. *Methods and response characteristics: 1980 National Natality and Fetal Mortality Surveys.* Hyattsville, Md: Public Health Service, National Center for Health Statistics; September 1986. DHHS Publication (PHS) 86-1374.
33. Cain PS, Treiman DJ. The Dictionary of Occupational Titles as a source of occupational data. *Am Soc Rev.* 1981;46:253–278.
34. Miller AR, Treiman DJ, Cain PS, Roos PA, eds. *Work, Jobs, and Occupations: A Critical Review of the Dictionary of Occupational Titles.* Washington, DC: National Academy Press; 1980.
35. US Department of Labor: *Handbook for Analyzing Jobs.* Washington, DC: US Government Printing Office; 1972.
36. US Department of Labor. *DOT Data Tape Documentation.* Washington, DC; 1977.
37. Spenner KI. Occupational characteristics and classification systems: new uses of the Dictionary of Occupational Titles in social research. *Soc Meth Res.* 1980;9:239–264.
38. Kessner DM, Singer J, Kalk CE, Schlesinger ER. *Infant Death: An Analysis by Maternal Risk and Health Care.* Washington, DC: Institute of Medicine; 1973.
39. National Center for Health Statistics. *Obese and Overweight Adults in the US.* Hyattsville, Md.; 1983. Vital and Health Statistics, National Health Survey, Ser 11, No. 230.
40. David RJ. The quality and completeness of birthweight and gestational age data in computerized birth files. *Am J Public Health.* 1980;70:964–970.
41. National Center for Health Statistics. *Public Use Data Tape Documentation: National Natality Survey 1980, National Fetal Mortality Survey 1980.* Hyattsville, Md: Public Health Service; December 1983.
42. Shah BV, Folsom RE, Harrell FE, Dillard CN. *Survey Data Analysis Software for Logistic Regression.* Research Triangle Park, NC: Research Triangle Institute; 1984. Subcontract No. A-3097 (8149)-293.
43. Savitz DA, Whelan EA, Rowland A, Kleckner RC. Maternal employment and reproductive risk factors. *Am J Epidemiol.* 1990;132:933–945.
44. Price J. Annotated bibliography of research uses of the Dictionary of Occupational Titles. *In:* Miller AR, Treiman DJ, Cain PS, Roos PA, eds. *Work, Jobs, and Occupations: A Critical Review of the Dictionary of Occupational Titles.* Washington, DC: National Academy Press; 1980.
45. Schwartz JE, Piper CF, Karasek RA. A procedure for linking psychosocial job characteristics data to health surveys. *Am J Public Health.* 1988;78:904–909.

APPENDIX—Derivation of Analysis Samples National Natality Survey, 1980

Total NNS Sample	9941
Married Subjects	7825
Singleton Live Births	7514
Mother Workded During Pregnancy	4532
Non-Black Live Births	4133
Matched DOT	3333
Complete Data on Work and Outcome Variables	2711

LBW Analysis Sample		Preterm Birth Analysis Sample	
		All Live Births except	
Term Live Births	2379	Term LBW	2511