Work Activity in Pregnancy, Preventive Measures, and the Risk of Delivering a Small-for-Gestational-Age Infant

| Agathe Croteau, MD, PhD, Sylvie Marcoux, MD, PhD, and Chantal Brisson, PhD

Fetal growth retardation increases infant mortality and morbidity,[1] may lead to neurodevelopmental deficits,[2,3] and generates high social costs.[4] Maternal risk factors for this condition include smoking,[1,2,5–8] medical conditions,[1–3,5–7] and social factors.[5,8,9] Occupational factors are also considered to increase the risk.

A number of epidemiological studies[10–31] have observed a significant effect of some occupational conditions on fetal growth, including long hours of work,[13–20] shift work,[20,21] prolonged standing,[12,15,16,19,25,26,28] lifting loads,[20] and high psychosocial stress.[30,31] However, some studies showed no effect.[10,11,17,18,23] In a number of studies, limitations related to the measurement of exposure may have led to underestimation of the true effect. These limitations include having a reference group that includes moderately exposed workers,[10–12,14,15,17,18,20–24,27] measuring occupational conditions on the basis of job title,[25] and failing to take into account changes in occupational conditions that occur during pregnancy.[10,11,13,15,17,19–22,25–27,30,31] The latter limitation is important because previous studies have suggested that workers most heavily exposed during early pregnancy are more likely to experience a reduction in exposure over the course of the pregnancy or to take earlier antenatal leave.[12,14,16,23,28,29]

In the province of Québec, Canada, pregnant workers whose working conditions present a danger to the worker or the fetus have a legal right to be assigned to other tasks.[32] For each pregnant worker the pertinence of this measure is determined by the Commission de la santé et de la sécurité au travail, the governmental agency for health and safety at work, after an evaluation of the worker's working conditions by a public health physician. Recourse to preventive measures does not depend on the union's or employer's willingness or on the woman's health. If the employer cannot reassign the pregnant worker to a safe job, the worker is entitled to

Objectives. We undertook a case–control study to evaluate whether some occupational conditions during pregnancy increase the risk of delivering a small-for-gestational-age (SGA) infant and whether taking measures to eliminate these conditions decreases that risk.

Methods. The 1536 cases and 4441 controls were selected from 43 898 women who had single live births between January 1997 and March 1999 in Québec, Canada. The women were interviewed by telephone after delivery.

Results. The risk of having an SGA infant increased with an irregular or shift-work schedule alone and with a cumulative index of the following occupational conditions: night hours, irregular or shift-work schedule, standing, lifting loads, noise, and high psychological demand combined with low social support. When the conditions were not eliminated, the risk increased with the number of conditions (P_{trend} = .004; odds ratios = 1.00, 1.08, 1.28, 1.43, and 2.29 for 0, 1, 2, 3, and 4–6 conditions, respectively). Elimination of the conditions before 24 weeks of pregnancy brought the risks close to those of unexposed women.

Conclusions. Certain occupational conditions experienced by pregnant women can increase their risk of having an SGA infant, but preventive measures can reduce the risk. (*Am J Public Health.* 2006;96:846–855. doi:10.2105/AJPH.2004.058552)

withdraw from work and collect 90% of her salary until 4 weeks before the expected birthdate. After that, she can benefit from the law of parental insurance and return to her regular job after maternity leave. Discrepancies in the application of the law across the province offer a favorable context in which to evaluate the effect of elimination of hazardous occupational conditions.

We measured the association between some occupational conditions (schedule, posture, physical effort, psychosocial factors), both individually and cumulatively, and the risk of delivering a small-for-gestational-age (SGA) infant. We also assessed whether the elimination of these occupational conditions by preventive measures (change in working conditions or preventive withdrawal) before 24 or after 23 weeks of pregnancy modified the risk.

METHODS

Study Design and Population

This was a case–control study. The source population consisted of women living in 6 regions of the province of Québec who gave

birth to a live singleton between January 25, 1997, and March 7, 1999. The regional public health agencies receive copies of all birth certificates from Québec hospitals shortly after delivery. We were authorized by the Commission d'accès à l'information du Québec to obtain some personal data recorded on birth certificates: mother's name and telephone number; type of birth (single or multiple); infant's birthweight, gender, and birthdate; length of pregnancy; mother's birthdate, civil status, and education; and number of previous live births or stillbirths to the mother.

The infant's gender and birthweight and the length of the pregnancy are recorded on the birth certificate by the attending physician soon after the birth. Length of pregnancy is usually estimated by comparing the actual date of delivery with the expected birthdate, the latter determined by the physician from the date of the last menses and clinical and ultrasonic evaluations.[19]

A total of 43 898 singleton live births were reported to us by public health officials; according to government data, this number represented 94% of singleton live births in the 6

TABLE 1—Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Having a Small-for-Gestational-Age Infant, by Potential Confounding Variable: Workers Giving Birth Between January 1997 and March 1999, Québec, Canada

	Case Mothers (N = 1536), No.[a] (%)	Control Mothers (N = 4441), No.[a] (%)	OR (95% CI)
Maternal smoking, 3rd trimester, cigarettes/d			
0[b]	924 (60.2)	3679 (83.0)	1.0
1–9	224 (14.6)	287 (6.5)	3.1 (2.6, 3.8)
10–19	291 (19.0)	369 (8.3)	3.1 (2.7, 3.7)
≥ 20	96 (6.3)	100 (2.3)	3.8 (2.9, 5.1)
Congenital anomaly			
No[b]	1490 (97.0)	4384 (98.7)	1.0
Yes	46 (3.0)	57 (1.3)	2.4 (1.6, 3.5)
Maternal caffeine consumption, 3rd trimester, portions/wk[c]			
0[b]	362 (23.6)	1328 (29.9)	1.0
> 0–4	332 (21.6)	1153 (26.0)	1.1 (0.9, 1.3)
5–9	368 (24.0)	1098 (24.8)	1.2 (1.0, 1.5)
10–14	214 (14.0)	425 (9.6)	1.8 (1.5, 2.3)
≥ 15	258 (16.8)	432 (9.7)	2.2 (1.8, 2.7)
Maternal alcohol consumption, 3rd trimester, drinks/wk			
0[b]	1109 (72.3)	3169 (71.5)	1.0
> 0–2	389 (25.4)	1221 (27.5)	0.9 (0.8, 1.0)
> 2	36 (2.4)	45 (1.0)	2.3 (1.5, 3.6)
Maternal education, y			
≥ 17[b]	321 (20.9)	1337 (30.2)	1.0
14–16	464 (30.3)	1498 (33.8)	1.3 (1.1, 1.5)
12–13	581 (37.9)	1284 (29.0)	1.9 (1.6, 2.2)
< 12	168 (11.0)	313 (7.1)	2.2 (1.8, 2.8)
Age of children at home, mean, y			
No children	940 (61.2)	2193 (49.4)	1.8 (1.6, 2.1)
≤ 6[b]	471 (30.7)	2009 (45.3)	1.0
> 6	125 (8.1)	238 (5.4)	2.2 (1.8, 2.8)
Mother's height, cm			
170–188[b]	172 (11.2)	862 (19.5)	1.0
163–169	572 (37.3)	1898 (42.8)	1.5 (1.3, 1.8)
157–162	496 (32.3)	1168 (26.4)	2.1 (1.8, 2.6)
105–156	294 (19.2)	504 (11.4)	2.9 (2.3, 3.6)
Mother's body mass index, kg/m²			
25–61[b]	271 (17.7)	1110 (25.1)	1.0
22–24	383 (25.0)	1318 (29.8)	1.2 (1.0, 1.4)
20–21	440 (28.7)	1157 (26.1)	1.6 (1.3, 1.9)
14–19	439 (28.6)	842 (19.0)	2.1 (1.8, 2.6)
Father's height, cm			
186–206[b]	53 (3.5)	278 (6.3)	1.0
178–185	596 (39.0)	2049 (46.4)	1.5 (1.1, 2.1)
173–177	408 (26.7)	1134 (25.7)	1.9 (1.4, 2.6)
152–172	473 (30.9)	957 (21.7)	2.6 (1.9, 3.5)

Continued

participating regions during the study period. Using the information on birth certificates, we classified births as SGA cases (n=3409 [7.8%]) or noncases (n=40 498). SGA cases were defined as infants whose birthweight was below the 10th percentile for gestational age on the basis of gender-specific Canadian standards.[33] A random sample of 20% of the noncases (n=8130) constituted the potential control group.

Data Collection

As soon as possible after receipt of the birth certificate, but not earlier than 2 weeks after birth, interviewers contacted the women by telephone. The median interval between childbirth and interview was 30 days for both cases and controls. The interviewers introduced themselves as working for the public health department and for Laval University. They explained that access to the woman's name and phone number was authorized by the Commission d'accès à l'information du Québec and that all collected information would remain confidential and anonymous. Then they explained the study, requested the woman's participation, and verified her eligibility. Among the case mothers, 270 (7.9%) could not be contacted and 75 (2.2%) refused to participate; among the control mothers, these numbers were 442 (5.4%) and 126 (1.5%), respectively. Of the 10 626 women (3064 cases and 7562 controls) who agreed to participate, women who did not work (n=3504), those who worked less than 4 weeks from the first month of pregnancy (n=403) or less than 20 hours per week (n=495), and those with more than 1 job (n=247) were excluded. This left 5977 eligible women (1606 cases and 4371 controls) who completed the interview.

Eligible women completed a computer-assisted telephone interview of 20 to 30 minutes, either immediately or at a later, more convenient time. The questionnaire documented in detail the following working conditions: work schedule (hours worked per week, day work [6:00 AM to 5:59 PM], evening work [6:00 PM to 10:59 PM], night work [11:00 PM to 5:59 AM], schedule regularity); posture (standing and other demanding postures); physical effort (lifting [weight and frequency],

TABLE 1—Continued

Family income, Can $/y			
≥50 000[b]	452 (29.4)	1721 (38.8)	1.0
35 000–49 999	410 (26.7)	1183 (26.6)	1.3 (1.1, 1.5)
<35 000	633 (41.2)	1433 (32.3)	1.7 (1.5, 1.9)
Unknown	41 (2.7)	104 (2.3)	1.5 (1.0, 2.2)
Partner's employment status			
Employed[b]	1396 (90.9)	4141 (93.3)	1.0
Unemployed	78 (5.1)	149 (3.4)	1.6 (1.2, 2.1)
No partner	61 (4.0)	150 (3.4)	1.2 (0.9, 1.6)
Previous pregnancies, no.			
0[b]	804 (52.3)	1811 (40.8)	1.0
1–3	681 (44.3)	2524 (56.8)	0.6 (0.5, 0.7)
>3	51 (3.3)	106 (2.4)	1.1 (0.8, 1.5)
Previous adverse pregnancy outcomes, no.			
0[b]	1124 (73.2)	3354 (75.5)	1.0
1	282 (18.4)	815 (18.4)	1.0 (0.9, 1.2)
≥2	130 (8.5)	272 (6.1)	1.4 (1.2, 1.8)
Mother's age, y			
<25	334 (21.7)	806 (18.1)	1.3 (1.1, 1.5)
25–34[b]	1000 (65.1)	3154 (71.0)	1.0
≥35	202 (13.2)	481 (10.8)	1.3 (1.1, 1.6)
Mother's involvement in family responsibilities			
No children[b]	948 (61.8)	2208 (49.8)	1.0
<50%	71 (4.6)	205 (4.6)	0.8 (0.6, 1.1)
≥50%	515 (33.6)	2017 (45.5)	0.6 (0.5, 0.7)
Physical activity before pregnancy, times/mo[d]			
0[b]	1075 (70.0)	2907 (65.6)	1.0
≥1	460 (30.0)	1525 (34.4)	0.8 (0.7, 0.9)
Gestational diabetes			
No[b]	1452 (94.5)	4141 (93.2)	1.0
Yes	84 (5.5)	300 (6.8)	0.8 (0.6, 1.0)
Chronic hypertension			
No[b]	1525 (99.3)	4396 (99.0)	1.0
Yes	11 (0.7)	44 (1.0)	0.7 (0.4, 1.4)
Other chronic disease[e]			
No[b]	1472 (95.8)	4287 (96.5)	1.0
Yes	64 (4.2)	154 (3.5)	1.2 (0.9, 1.6)
White ethnicity			
Yes[b]	1514 (98.6)	4383 (98.9)	1.0
No	21 (1.4)	49 (1.1)	1.2 (0.7, 2.1)
Passive smoking, 3rd trimester[f]	1533	4432	1.1 (1.1, 1.1)
Illicit drug use during pregnancy[g]			
No[b]	1523 (99.2)	4418 (99.5)	1.0
Yes	12 (0.8)	22 (0.5)	1.6 (0.8, 3.2)

[a] Totals vary because of missing data.
[b] Reference category.
[c] One cup of coffee = 1 portion; 1 cup of tea = 0.76 portion; 1 glass of cola = 0.44 portion.
[d] Activity was defined as 20 to 30 minutes of moderate- to high-intensity activity.
[e] Examples of other chronic diseases are asthma, thyroid disorder, bowel inflammatory disease, hypoglycemia, kidney disease, heart diseases, epilepsy, and hypercholesterolemia.
[f] Here the variable was number of cigarettes smoked per day in the presence of the pregnant woman when she was not at work; OR represents the SGA risk variation for each additional cigarette per day, because this variable was continuous in the model.
[g] Examples of illicit drugs are marijuana, hashish, cocaine, heroin, amphetamines, LSD, phencyclidine (PCP), and mescaline.

pushing and pulling objects); work organization (breaks, piecework, or assembly line work; psychosocial factors) and environmental occupational conditions (e.g., noise, whole-body vibration, exposure to environmental tobacco smoke). We developed the questions after examining the questionnaires of Mamelle et al.[34] and McDonald et al.,[35] reviewing the findings of authors who have evaluated the validity of exposure data obtained by questionnaires,[36–42] and consulting ergonomists.

To evaluate psychosocial factors at work, we used Karasek's model concerning psychological demands, decision latitude, and social support at work. We measured these factors with a validated French version[43] of Karasek's questionnaire.[44,45] Psychological demand and decision latitude scales were dichotomized at the median value. Four levels of job strain were obtained by cross-stratifying psychological demands and decision latitude. The 3 highest levels of job strain were also subdivided by social support level.

As a first step, we documented working conditions at the beginning of pregnancy. If conditions were modified during pregnancy, we asked when and documented the new working conditions related to work schedule, posture, and effort. Mothers also indicated when they stopped working and why (e.g., legally justified preventive withdrawal, health problems, coming close to expected date of delivery).

The final section of the questionnaire documented obstetrical history, mother's medical profile (before and during pregnancy), newborn's characteristics (gender, weight, birthdate, expected date of delivery according to the physician, congenital anomalies), mother's involvement in family responsibilities, and mother's lifestyle (physical activity; smoking; caffeine, alcohol, and drug consumption) and sociodemographic characteristics.

For 226 (3.8%) of the 5977 women questioned, the interview data (birthweight, date of birth, and expected date of delivery) indicated a case or control status different from that determined on the basis of birth certificate data. Of these women, 168 (74.3%) gave us access to their hospital records to verify the information. Archivists responded to 161 (95.8%) of the requests. The information

TABLE 2—Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Using Preventive Measures to Eliminate Occupational Conditions That Could Increase Risk of Having a Small-for-Gestational-Age Infant, by Sociodemographic, Lifestyle, Medical, and Occupational Variables: Workers Giving Birth Between January 1997 and March 1999, Québec, Canada

	No. (N = 4752)[a]	% Using Preventive Measures	Model Excluding Occupational Conditions OR[b] (95% CI)	Model Including Occupational Conditions OR[c] (95% CI)
Mother's age, y				
<25	872	59.7	1.3 (1.1, 1.5)	1.0 (0.9, 1.3)
25–34[d]	3353	45.2	1.0	1.0
≥35	527	38.9	0.8 (0.7, 1.0)	0.8 (0.7, 1.0)
Maternal smoking, 3rd trimester, cigarettes/d				
0[d]	3871	45.8	1.0	1.0
1–9	328	50.3	0.9 (0.7, 1.1)	0.8 (0.7, 1.1)
10–19	434	53.5	1.0 (0.8, 1.2)	0.8 (0.6, 1.0)
≥20	119	60.5	1.2 (0.8, 1.8)	1.0 (0.6, 1.5)
Mother's education, y				
≥17[d]	1400	35.9	1.0	1.0
14–16	1593	45.1	1.3 (1.1, 1.5)	1.1 (1.0, 1.4)
12–13	1409	55.5	1.7 (1.5, 2.1)	1.3 (1.1, 1.6)
<12	350	68.0	2.6 (2.0, 3.4)	1.7 (1.3, 2.3)
Family income, Can $/y				
≥50 000[d]	1811	37.5	1.0	1.0
35 000–49 999	1274	48.3	1.3 (1.1, 1.5)	1.1 (1.0, 1.4)
<35 000	1566	57.9	1.6 (1.3, 1.8)	1.2 (1.0, 1.4)
Unknown	101	39.6	0.9 (0.6, 1.4)	0.7 (0.5, 1.2)
Previous pregnancies, no.				
0[d]	1979	48.6	1.0	1.0
1–3	2652	45.8	0.9 (0.8, 1.1)	0.9 (0.7, 1.0)
>3	121	54.5	1.3 (0.9, 2.1)	1.3 (0.8, 2.1)
Previous adverse pregnancy outcomes, no.				
0[d]	3579	46.8	1.0	1.0
1	871	48.7	1.1 (0.9, 1.3)	1.1 (0.9, 1.4)
≥2	302	47.4	1.0 (0.8, 1.3)	1.0 (0.7, 1.3)
Chronic hypertension				
No[d]	4708	47.1	1.0	1.0
Yes	44	54.5	1.4 (0.7, 2.5)	1.4 (0.7, 2.8)
Gestational diabetes				
No[d]	4450	46.8	1.0	1.0
Yes	302	52.3	1.3 (1.0, 1.6)	1.3 (1.0, 1.7)
Other chronic disease[e]				
No[d]	4588	47.1	1.0	1.0
Yes	164	48.8	1.1 (0.8, 1.5)	0.8 (0.6, 1.2)
Occupational conditions at beginning of pregnancy, no.[f]				
0[d]	1444	19.3		1.0
1	1318	38.8		2.6 (2.2, 3.1)
2	1078	65.1		7.1 (5.9, 8.5)
3	576	79.0		14.3 (11.2, 18.2)
≥4	336	87.5		25.9 (18.2, 37.0)

Continued

received resulted in an amendment of case or control status for 88 (54.7%) of these 161 subjects, resulting in 1536 cases and 4441 controls available for analysis.

Analysis

All analyses were performed with SAS software, versions 6.12 and 8 (SAS Institute Inc, Cary, NC). We used logistic regression to estimate the association (1) between occupational conditions or potential confounders and SGA births and (2) between potential confounders and use of preventive measures. Beta coefficients and their standard errors were used to obtain odds ratios (ORs) and 95% confidence intervals (95% CIs).

The association between each variable considered a priori as a potential confounder (obstetrical history, mother's medical profile, mother's lifestyle and sociodemographic characteristics) and the risk of having an SGA infant was determined by bivariate analysis. Factors statistically associated ($P<.05$) with SGA births and those with an OR of less than or equal to 0.8 or greater than or equal to 1.2 on at least 1 stratum were considered as covariates in the regression models. We obtained ORs relating occupational conditions to SGA births by multiple logistic regression with adjustment for the whole set of covariates. Covariates were withdrawn one by one as long as the OR was not modified by more than 10% compared with the full model. In the final model, ORs were also adjusted for other occupational conditions present at the beginning of pregnancy (see Table 3 footnotes).

We also assessed the effects of elimination of occupational conditions by early or late preventive measures (modification of working conditions or preventive withdrawal from work). Workers exposed at the beginning of pregnancy to a given working condition were divided into 3 groups according to whether the condition was eliminated during the pregnancy early (before 24 weeks), late (after 23 weeks), or not at all. The SGA risks of these 3 groups were compared with the risk for unexposed workers at the beginning of pregnancy.

We calculated a cumulative index of occupational conditions for which the adjusted OR was at least 1.2 when the condition was not eliminated by a preventive measure during the pregnancy. The association of this index

TABLE 2—Continued

with SGA risk was evaluated and adjusted for relevant covariates. We used a χ^2 test to evaluate a dose–effect relationship.[46] We also evaluated the effect of eliminating the indexed conditions during the pregnancy using the method described previously for single occupational conditions.

RESULTS

Several variables were associated with SGA risk in the bivariate analyses (Table 1). The strongest associations (ORs≥2) were observed for congenital anomalies; maternal smoking, caffeine consumption, and alcohol intake; low maternal education; mean age of children at home older than 6 years; short stature of mother and father; and low maternal body mass index. Tiring housework, physical activity in the first trimester, over-the-counter drug use, and mother's birth country were not associated with SGA risk (data not shown). All variables shown in Table 1 were considered as potential confounders and were included in the initial multivariate models.

Nearly half (48.0%) of the workers used preventive measures: preventive withdrawal from work (33.2%), modification of working conditions (21.9%), or both (7.1%). Use of preventive measures was slightly more frequent in the case group (50.8%) than in the control group (47.1%; P=.01).

Table 2 shows the associations of several variables with use of preventive measures. As expected, the number of occupational conditions was strongly related to recourse to preventive measures and was by far the most important factor explaining the use of preventive measures. The association was even stronger for early than for late preventive measures (data not shown). After adjustment

for occupational conditions, the use of preventive measures remained inversely associated with education but not with family income, maternal age, or smoking. Previous adverse pregnancy outcomes and chronic diseases of the mother, except for chronic hypertension, were not related to use of preventive measures.

Table 3 presents the associations between occupational conditions and SGA risk. Of occupational conditions present at the beginning of pregnancy, irregular or shift-work schedule and moderate-active job strain (high decision latitude and high psychological demand) or high job strain (low decision latitude and high psychological demand) combined with low social support were the only ones with ORs greater than or equal to 1.2, but neither job strain alone nor low social support alone was associated with increased SGA risk (data not shown). These associations persisted or increased slightly if the conditions were not eliminated or were eliminated after 23 weeks of pregnancy. However, when occupational conditions present at the beginning of pregnancy were stratified to take into account whether and when they were eliminated by a preventive measure during pregnancy, 4 other conditions, if not eliminated, were associated (ORs≥1.2) with SGA risk. Those conditions were night work, standing posture at least 4 hours per day, lifting loads weighing at least 7 kg, and noise. All 5 ORs declined to 1 or less than 1 when occupational conditions were eliminated early in the pregnancy.

We explored several other job characteristics and found no association with SGA risk, whether or not the worker took recourse to preventive measures. These characteristics were maximum number of hours or days worked per week, number of consecutive

days worked, proportion of time walking versus remaining in 1 spot during hours spent standing, frequency of lifting loads of a given weight, having to climb stairs, absence of breaks, very cold or very hot temperatures, whole-body vibration, long commuting time, and exposure to environmental tobacco smoke at work (data not shown).

We calculated a cumulative index, taking into account the following occupational conditions: work schedule including night hours, irregular or shift work, standing for a minimum of 4 hours per day, lifting loads of 7 kg or more, noise, and moderate-active or high job strain combined with low social support. SGA risk increased with the number of these occupational conditions present at least at the beginning of pregnancy (Table 4). The ORs for women with a cumulative index (indicating number of conditions present) of 1, 2, 3, and 4–6, compared with unexposed workers (index=0), were 1.12, 1.19, 1.24, and 1.26, respectively (χ^2_{trend}=6.45, P=.01). When the indexed conditions were not eliminated by a preventive measure, the association of the index with SGA risk was stronger, with ORs of 1.08, 1.28, 1.43, and 2.29, respectively (χ^2_{trend}=8.41, P=.004). When all indexed occupational conditions were eliminated by early preventive measures, the SGA risk was similar to that observed in women who were not exposed to the indexed conditions at the beginning of pregnancy. We recalculated the cumulative index with only 5 of the 6 conditions, excluding irregular or shift-work schedule. When the indexed conditions were not eliminated, ORs for women exposed to 1, 2, 3, and 4 or 5 of the conditions increased from 1.14 to 1.77 (P_{trend}=.02).

DISCUSSION

We found that an increased risk for having an SGA infant was significantly associated with both an irregular or shift-work schedule alone and a cumulative index of at least 2 of the following: night work, irregular or shift-work schedule, standing posture, lifting loads, noise, and moderate-active or high job strain with low social support. The OR increased from 1.0 to 2.3 as the number of job conditions that were not eliminated during pregnancy increased from 0 to 4 or more. The elimination

TABLE 3—Adjusted Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Having a Small-for-Gestational-Age Infant, by Occupational Condition at Beginning of Pregnancy and Early (<24 wk), Late (>23 wk), or No Elimination of Condition by Preventive Measures During Pregnancy: Workers Giving Birth Between January 1997 and March 1999, Québec, Canada

| | Condition Present at Beginning of Pregnancy | | | Elimination of Condition by Preventive Measures During Pregnancy | | | | | | | | |
| | | | | Early | | | Late | | | Not Eliminated | | |
	Cases, No.	Controls, No.	OR (95% CI)	Cases, No.	Controls, No.	OR (95% CI)	Cases, No.	Controls, No.	OR (95% CI)	Cases, No.	Controls, No.	OR (95% CI)
Hours worked/wk[a]												
20–34[b]	470	1284	1.0	...	...	...	...	...	...	...	...	...
35–39	526	1676	0.9 (0.8, 1.1)	116	353	0.8 (0.7, 1.1)	56	165	0.9 (0.6, 1.2)	354	1158	1.0 (0.8, 1.2)
≥40	519	1430	1.0 (0.8, 1.1)	147	356	1.0 (0.8, 1.2)	88	204	1.1 (0.8, 1.5)	284	870	1.0 (0.8, 1.2)
Work schedule[a]												
Day only[b]	900	2713	1.0	...	...	...	...	...	...	...	...	...
Evening but no night hours	432	1194	0.9 (0.8, 1.0)	124	381	0.7 (0.5, 0.9)	85	199	1.0 (0.7, 1.3)	223	614	1.0 (0.8, 1.2)
Night hours	177	463	0.8 (0.7, 1.0)	104	292	0.7 (0.6, 1.0)	23	71	0.7 (0.4, 1.1)	50	100	1.2 (0.8, 1.7)
Unknown	6	20	...	...	...	...	...	...	...	...	...	...
Schedule regularity[a]												
Regular[b]	1249	3731	1.0	...	...	...	...	...	...	...	...	...
Irregular or shift work	266	659	1.2 (1.0, 1.4)	103	290	1.0 (0.7, 1.2)	57	113	1.5* (1.0, 2.1)	106	256	1.3* (1.0, 1.7)
Standing, h/d [a]												
<2[b]	331	1125	1.0	...	...	...	...	...	...	...	...	...
2–3	331	1005	1.1 (0.9, 1.3)	38	100	1.2 (0.8, 1.9)	19	65	1.0 (0.6, 1.7)	274	840	1.1 (0.9, 1.3)
4–6	505	1354	1.1 (0.9, 1.4)	176	498	0.9 (0.7, 1.2)	100	220	1.4* (1.0, 1.9)	229	636	1.2 (0.9, 1.5)
≥7	348	906	1.0 (0.8, 1.2)	183	491	0.9 (0.7, 1.2)	66	177	0.9 (0.6, 1.3)	99	238	1.2 (0.9, 1.6)
Demanding posture, h/d[a,c]												
<1[b]	866	2728	1.0	...	...	...	...	...	...	...	...	...
≥1	649	1662	1.0 (0.9, 1.2)	293	764	0.9 (0.8, 1.1)	120	263	1.2 (0.9, 1.5)	236	635	1.1 (0.9, 1.3)
Lifting, kg[a]												
0[b]	724	2292	1.0	...	...	...	...	...	...	...	...	...
1–6	308	873	0.9 (0.8, 1.1)	95	265	0.8 (0.6, 1.1)	58	122	1.1 (0.8, 1.6)	155	486	1.0 (0.8, 1.2)
≥7	478	1197	1.0 (0.9, 1.2)	233	626	0.9 (0.7, 1.1)	80	173	1.2 (0.9, 1.6)	165	398	1.2 (0.9, 1.5)
Unknown	5	28	...	...	...	...	...	...	...	...	...	...
Pushing/pulling objects[a]												
No[b]	965	2919	1.0	...	...	...	...	...	...	...	...	...
Yes	550	1471	1.0 (0.9, 1.2)	225	651	0.9 (0.7, 1.1)	117	230	1.2 (0.9, 1.6)	208	590	1.0 (0.9, 1.3)
Piecework/assembly line[a,d]												
No[b]	1383	4112	1.0	...	...	...	...	...	...	...	...	...
Yes	132	278	0.9 (0.7, 1.2)	51	109	0.9 (0.6, 1.4)	35	60	1.2 (0.7, 1.9)	46	109	0.8 (0.6, 1.2)
Noise[a,d,e]												
No[b]	1239	3750	1.0	...	...	...	...	...	...	...	...	...
Yes	276	640	1.1 (0.9, 1.3)	102	235	1.0 (0.7, 1.3)	39	84	1.1 (0.7, 1.7)	135	321	1.2 (1.0, 1.5)
Job strain, by social support[d,f,g]												
Low strain[b]	292	972	1.0	...	...	...	...	...	...	...	...	...
Moderate-passive strain												
High or moderate support	281	750	1.1 (0.9, 1.3)	66	173	1.0 (0.7, 1.3)	56	102	1.5 (1.0, 2.1)	159	475	1.0 (0.8, 1.3)
Low support	131	335	1.0 (0.8, 1.3)	41	104	0.9 (0.6, 1.4)	22	47	1.2 (0.7, 2.0)	68	184	1.1 (0.8, 1.5)
Moderate-active strain												
High or moderate support	261	898	1.0 (0.8, 1.2)	49	130	1.1 (0.8, 1.6)	16	68	0.6 (0.3, 1.1)	196	700	1.0 (0.8, 1.2)
Low support	102	275	1.2 (0.9, 1.6)	22	56	1.0 (0.6, 1.7)	8	23	1.2 (0.5, 2.7)	72	196	1.3 (0.9, 1.7)

Continued

TABLE 3—Continued

High strain												
High or moderate support	188	536	1.0 (0.8, 1.3)	58	177	0.8 (0.6, 1.2)	32	67	1.3 (0.8, 2.1)	98	292	1.1 (0.8, 1.4)
Low support	236	540	1.2 (0.9, 1.5)	81	182	1.1 (0.8, 1.5)	38	73	1.3 (0.8, 2.0)	117	285	1.2 (0.9, 1.6)
High or moderate strain, support not applicable[h]	23	69	0.9 (0.5, 1.5)	…	…	…	…	…	…	…	…	…
Strain or support unknown	10	42	…	…	…	…	…	…	…	…	…	…

[a]Adjusted for all other occupational conditions listed at the beginning of pregnancy, smoking in third trimester (yes, no), mother's and father's height (cm), mean age of other children at home (no children, ≤6 years, >6 years). Because of missing data, N=1515 cases and 4390 controls.
[b]Reference category.
[c]Bending, squatting, arms raised above shoulder level, or other demanding posture.
[d]Considered eliminated if preventive withdrawal from work occurred.
[e]Defined as having to speak loud or shout to be heard by a person 2 m away (because of background noise).
[f]Low job strain = high decision latitude and low psychological demand; moderate-passive job strain = low decision latitude and low psychological demand; moderate-active job strain = high decision latitude and high psychological demand; high job strain = low decision latitude and high psychological demand.
[g]Adjusted for work schedule, schedule regularity, standing, demanding posture, lifting, pushing/pulling, noise, smoking in third trimester (yes, no), mother's height (cm), mean age of other children at home (no children, ≤6 years, >6 years). Because of missing data, N=1524 cases and 4417 controls.
[h]Social support was not applicable for workers without coworkers and supervisors.
*$P<.05$.

of these occupational conditions by preventive measures taken early, before 24 weeks' gestation, brought workers' risks close to those of women who were not exposed to these conditions at the beginning of pregnancy.

We found an increased SGA risk for irregular or shift-work schedule. Three earlier studies observed a deficit of fetal growth associated with shift work,[20–22] while 2 others did not.[19,23] For night work, standing, lifting loads, and noise, we observed an increase in SGA risk when the conditions were not eliminated. Although our results suggest that night work increased the risk of having an SGA infant, no association was found in 2 earlier studies.[10,19] In our study, 78.6% of the women exposed to night work had recourse to preventive measures. If this was true in the other study populations, it could have blurred the association.

Most[12,14–16,19,24–28] studies of the effect of prolonged standing on fetal growth[12,14–19,23–28] obtained results consistent with ours. In 2 of them,[19,25] SGA risk was higher when workers were exposed during late pregnancy (>23 weeks,[19] >28 weeks[25]). Half of the previous studies that evaluated the effect on fetal growth of lifting loads[12,14,16,19,20,29] reported an effect.[12,14,20] Of 6 earlier studies that evaluated the association between noise exposure and SGA risk,[13,23,47–50] 4 obtained results consistent with ours.[23,47–49] Our results suggest an increased SGA risk when workers are exposed to moderate-active or high job strain combined with low social support at work. The job strain effect is consistent with most[15,30,31] earlier studies on job strain and SGA risk,[15,16,30,31] and the modifying effect of social support at work is consistent with the isostrain hypothesis.[51]

The majority of the associations we observed, for individual occupational conditions and for cumulative index, were of low magnitude (ORs between 1.2 and 1.4). This is consistent with most of the observed associations linking ergonomic occupational conditions to SGA risk.[12,15,19,20,22,26,27,30,31] Considering the frequency of SGA births (7.8% in this study) and the proportion of workers exposed to at least 2 indexed occupational conditions (41.4% of the control group), ORs of this magnitude could have a nonnegligible impact.

The analysis by recourse to preventive measures is an interesting contribution of this study. For each indexed occupational condition, SGA risk decreased—almost to unexposed risk levels—when the condition was eliminated by an early (mean=12.3 weeks) preventive measure. Except for night work and standing at least 7 hours per day, elimination of these occupational conditions after 23 weeks (mean=28 weeks) did not decrease SGA risk. In addition, recourse to early preventive measures clearly decreased the SGA risk associated with the cumulative index. These patterns support the view that early preventive measures are effective.

Our results are consistent with those of other authors who have observed that reductions in fetal growth among women whose jobs entailed standing for long periods were more important if they continued to work later during pregnancy.[19,25] Moreover, some findings suggest that a suboptimal environment in the first trimester[52] or poor social and lifestyle factors in early pregnancy[8,9] could limit fetal growth for the remainder of the pregnancy. The fact that maximum fetal growth (expressed as percentage increase in weight relative to the previous week) occurs during the first trimester[1] also supports the plausibility of this hypothesis.

A selection bias seems improbable, since 94% of all births were reported to us, 93.8% of the women reported were contacted, and only 1.7% refused to participate. Similarly, a recall bias would not likely explain the associations we observed. Although information concerning occupational condition was obtained from the mothers following childbirth, the interviewers were unaware of the mothers' case or control status when they contacted them, and questions pertaining to pregnancy outcome were asked after those related to working conditions. In addition, several women were probably unaware that their infant was SGA according to our definition, since this information, unlike birthweight or duration of pregnancy, is not routinely provided by physicians. Finally, several occupational conditions that women may have suspected to be detrimental to their pregnancies

TABLE 4—Odds ratios (ORs) and 95% Confidence Intervals (CIs) for Having a Small-for-Gestational-Age Infant, by Cumulative Index of Occupational Conditions[a] at Beginning of Pregnancy and Early (<24 wk), Late (>23 wk), or No Elimination of Conditions by Preventive Measures During Pregnancy: Workers Giving Birth Between January 1997 and March 1999, Québec, Canada

	Case Mothers (N = 1536, No.[b] (%)	Control Mothers (N = 4441, No.[b] (%)	OR (95% CI)
Index at beginning of pregnancy[c]			
0[d]	380 (24.8)	1362 (30.7)	1.0
1	418 (27.2)	1239 (27.9)	1.1 (1.0, 1.3)
2	383 (25.0)	1002 (22.6)	1.2* (1.0, 1.4)
3	218 (14.2)	531 (12.0)	1.2* (1.0, 1.5)
4–6	136 (8.9)	301 (6.8)	1.3 (1.0, 1.6)
Index by recourse to preventive measures to eliminate indexed conditions[e]			
0[d]	380 (24.8)	1359 (30.7)	1.0
1			
Eliminated early	71 (4.6)	206 (4.6)	1.1 (0.8, 1.4)
Uncertain or late elimination[f]	78 (5.1)	191 (4.3)	1.4* (1.0, 1.9)
Not eliminated	268 (17.5)	842 (19.0)	1.1 (0.9, 1.3)
2			
Eliminated early	129 (8.4)	366 (8.3)	1.0 (0.8, 1.3)
Uncertain, partial, or total late elimination[g]	104 (6.8)	255 (5.8)	1.2 (0.9, 1.6)
Not eliminated	150 (9.8)	381 (8.6)	1.3* (1.0, 1.6)
3			
Eliminated early	94 (6.1)	250 (5.6)	1.0 (0.8, 1.4)
Uncertain, partial, or total late elimination[h]	75 (4.9)	166 (3.7)	1.4* (1.0, 1.9)
Not eliminated	49 (3.2)	114 (2.6)	1.4* (1.0, 2.1)
4–6			
Eliminated early	69 (4.5)	178 (4.0)	1.1 (0.8, 1.4)
Uncertain, partial, or total late elimination[i]	39 (2.5)	87 (2.0)	1.2 (0.8, 1.8)
Not eliminated	28 (1.8)	36 (0.8)	2.3* (1.3, 3.9)

Note. Trend for number of conditions at beginning of pregnancy: χ^2_{trend} = 6.45, P = .011; trend for number of conditions not eliminated: χ^2_{trend} = 8.41, P = .004.
[a]Number of the following occupational conditions present at the beginning of pregnancy: work schedule including night hours, irregular or shift-work schedule, standing posture at least 4 hours per day, lifting loads weighing at least 7 kg, noise, and moderate-active or high job strain combined with low social support.
[b]Totals vary because of missing data.
[c]Adjusted for smoking in third trimester (yes, no).
[d]Reference category.
[e]Adjusted for smoking in third trimester (yes, no), mother's height (cm), mean age of other children at home (no children, ≤6 years, >6 years).
[f] The proportion of workers for whom all indexed conditions were eliminated with certainty by late preventive measures was 78%.
[g]The proportion of workers for whom all indexed conditions were eliminated with certainty by late preventive measures was 60%.
[h]The proportion of workers for whom all indexed conditions were eliminated with certainty by late preventive measures was 56%.
[i]The proportion of workers for whom all indexed conditions were eliminated with certainty by late preventive measures was 57%.
*P<.05.

(e.g., demanding postures, long working hours) were not associated with SGA risk.

To minimize misclassification of outcomes, we cross-checked the case or control status established on the basis of data provided by birth certificates with the status derived from data obtained from the mothers during the interview. There was a discordance in status for only 3.8% (226/5977) of the participants, and information could be checked against hospital records for 161 (71.2%) of the 226 newborns.

Our questionnaire did not allow us to document whether, after modification of working conditions, there were modifications in psychosocial job characteristics or in exposure to noise, or to determine the nature of these modifications if they did occur. Therefore, we were not assured that these conditions were eliminated by a preventive measure unless the woman was on preventive leave. This source of possible misclassification, which is independent of SGA birthweight, leads to underestimation of the effect of preventive measures for these job characteristics.

Because the associations we observed were weak, the possibility of residual confounding needs to be considered. However, our questionnaire covered a large number of factors likely to influence SGA risk and use of preventive measures. In the full model of our multivariate analyses, we considered a set of 22 covariates. The associations were also adjusted for concurrent occupational conditions. Pregnancy complications (e.g., bleeding, gestational hypertension, preterm labor) were not included as covariates because they can be intermediate factors in the causal pathway linking occupational conditions to SGA birthweight. On the other hand, although we did our best to document the women's working conditions, it is notoriously difficult to measure these conditions by questionnaire, and this most likely leads to a nondifferential (independent of SGA birthweight) misclassification of exposure to these factors. Therefore, the most likely bias is an underestimation of the true effect of occupational conditions on SGA risk.

It is difficult to disentangle the effect of the preventive measures per se from the effect of factors leading to the use of preventive measures. One might argue that women who are more health conscious or who are working in a more favorable environment are more likely to take preventive measures. The associations shown in Table 2 do not support this argument, however. In fact, less educated women were more likely to use preventive measures, which does not support the view that women's health awareness is positively related to use of such measures. The use of preventive measures was strongly associated with the number of demanding job characteristics. This is consistent with the legal context in the province of Québec: the application of preventive

measures does not depend on the presence of a union, on the employer's willingness, or on the woman's health condition but is decided by the Commission de la santé et de la sécurité au travail after a detailed evaluation of the woman's working conditions by a public health physician.[32]

In conclusion, our results support the hypothesis that exposure to an irregular or shift-work schedule or to at least 2 of the occupational conditions we indexed is associated with increased SGA risk. In addition, the results indicate that preventive measures—reassignment to a safer job or preventive withdrawal from work—can be effective in reducing SGA risk in exposed workers, mainly when they are applied before 24 weeks of pregnancy. This study also underscores the importance of taking into account modification of working conditions over the course of pregnancy in order to adequately evaluate their effects on pregnancy outcomes. ∎

About the Authors

Agathe Croteau is with the CHUL Research Centre, Université Laval, Québec, Québec. Sylvie Marcoux and Chantal Brisson are with the Department of Social and Preventive Medicine, Faculty of Medicine, Université Laval.

Requests for reprints should be sent to Dre Agathe Croteau, Public Health Direction, 2400, avenue D'Estimauville, Québec, Québec G1E 7G9 (e-mail: agathe. croteau@ssss.gouv.qc.ca).

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Contributors

All authors contributed to the protocol development, participated in the interpretation of the findings, and reviewed the drafts of the article. A. Croteau conceived the study, was responsible for its implementation, carried out the analyses, and led the writing. S. Marcoux conceived the study, supervised its implementation, and participated in data analysis and writing. C. Brisson, in addition to participating in protocol development, provided specific input in the psychosocial aspects of the study and participated in the writing. All authors reviewed the final version of the article and approved it before submission for publication.

Human Participant Protection

This study was approved by the institutional review board of the Centre hospitalier affilié universitaire de Québec.

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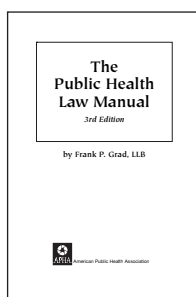50.   Zhang J, Cai WW, Lee DJ. Occupational hazards and pregnancy outcomes. *Am J Ind Med.* 1992;21: 397–408.

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