Occupation and pregnancy outcome

A D McDONALD, J C McDONALD, B ARMSTRONG, N CHERRY, C DELORME, A D-NOLIN, D ROBERT

From the Institut de Recherche en Santé et en Sécurité du Québec du Travail, Montreal, Quebec H3A 3C2, Canada

ABSTRACT Over a two year period, 1982-4, 56 067 women, delivered or treated for a spontaneous abortion in 11 Montreal hospitals covering 90% of such admissions, were interviewed in detail regarding their occupational, social, and personal characteristics in their most recent and past pregnancies—104 649 in all. These data were analysed in relation to four main adverse outcomes—spontaneous abortion, stillbirth (without defect), congenital defect, and low birth weight (≤ 2500 g). For comparison with observed numbers, expected figures were calculated by logistic regression using up to eight potentially confounding variables. Sixty occupational groups in six main industrial sectors were examined in current and previous pregnancies, with tests for heterogeneity between these two estimates of risk. Women in managerial, health, and clerical sectors had little evidence of excess of any of the four outcomes, by contrast with those in sales, service, and manufacturing sectors. Substantial and statistically significant excesses of spontaneous abortion were observed in nursing aides, women in sales occupations and food and beverage service; of stillbirth in agriculture and horticulture, leatherwork, and certain sales occupations; of congenital defects in women in child care, certain service occupations, and the manufacture of metal and electrical goods; and of low birth weight in chambermaids, cleaners, and janitors, and in women employed in the manufacture of food and drink, metal and electrical goods, and clothing.

Information as to whether work demands or workplace exposures adversely affect the outcome of pregnancy is scanty. Rather than investigate specific factors piecemeal an inquiry was undertaken with the object of assembling a large body of data which could be used to test promising hypotheses and to identify associations for further investigation. In Montreal over a two year period, 11 May 1982-10 May 1984, 56 067 women were interviewed in 11 maternity units in which about 90% of the city's births occur. The women were questioned soon after delivery or spontaneous abortion about their just completed (current) pregnancy and all previous pregnancies. Outcomes of interest were spontaneous abortion, stillbirth, prematurity, and congenital defect.

Survey methods

INTERVIEWS

Fluently bilingual nurses, acceptable to both hospital staff and patients, were employed as interviewers. After training in administration of the questionnaire they were allocated to the 11 hospitals. Each nurse

established a system for ascertaining deliveries and spontaneous abortions consecutively. The nurses met the patients when convenient and, after explaining the project, asked them to sign a form of consent; refusals were rare. An eight page mainly precoded questionnaire in English or French was completed in the language of choice. The interviews lasted 20 minutes on average but sometimes up to 45 minutes, largely depending on the number of previous pregnancies and the extent to which the women were employed. The following information was recorded:

Personal and social factors

Birth date, country of origin, height, weight, educational level, father's occupation, educational level, age, and occupation of spouse.

Current and previous pregnancies

Employment:—Detailed information with dates about paid work during each pregnancy, including job, employer (with address), hours, conditions and demands of work, and requests for reassignment.

Personal habits:—Smoking, alcohol and coffee consumption in each trimester, medicinal drugs at time of conception.

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Previous pregnancies only:—Date, duration of gestation, spontaneous and induced abortions, live and stillbirths, birth weight, and any abnormality of child's mental or physical development.

REVIEW OF MEDICAL RECORDS

All obstetric and pediatric records were reviewed after the patient's discharge by either a physician member of the research team or a nurse trained for the task and supervised by the physician. For the current pregnancies information was extracted on illnesses in the current pregnancy, ultrasound examinations, labour, delivery and placental weight, and, for the infant, on sex, birth weight, survival, and findings at the last pediatric examination before discharge from hospital.

ASCERTAINMENT OF OUTCOME

Spontaneous abortion

For the purpose of this survey, abortions were defined as fetal deaths at less than 28 weeks gestation. Induced abortions were identified as carefully as possible by questioning. Those carried out for personal or health reasons were recorded but not counted in assessing gravidity. Abortions induced because a defective fetus had been diagnosed by ultrasound or amniocentesis were included in the study if there was sufficient information to classify the malformation. Women whose diagnosis on admission was compatible with spontaneous abortion were interviewed. When the medical record was subsequently reviewed, if pregnancy was not confirmed or if the abortion only threatened, the case was excluded. Duration of gestation in current spontaneous abortions was obtained from the medical record, generally estimated from the date of the last menstrual period. For previous pregnancies, the woman was asked to include all that in her opinion or that of her physician had terminated spontaneously before the 28th week. For later fetal deaths after the 19th week further information was sought from hospital records.

Stillbirths

Fetal deaths after the 27th week (stillbirths) were considered with live births for the purpose of maternal interview. Because many of the mothers were distressed and their hospital stay short, only about half were interviewed. For stillbirths in past pregnancies for which ascertainment was thought to be fairly complete, information on duration of gestation, birth weight, and congenital defects was obtained from the mother.

Prematurity

Live born infants were considered as premature on the basis of birth weight (≤ 2500 g) or gestational age (< 37 weeks). In this first analysis the low birth weight

definition of prematurity only was used. Later both will be studied.

Congenital defect

In current pregnancies information on congenital defects was extracted from the detailed records of the paediatric examination at time of discharge. A physician member of our team made such further inquiries as necessary to establish a classifiable diagnosis. For previous pregnancies, the mother was asked whether any physical abnormality had been noted and whether the child's mental development was similar to that of other children of the same age. If the replies suggested an abnormality further information was obtained from physicians or hospital records.

CODING AND DATA STORAGE

The questionnaires were checked after completion by clerks and if necessary returned to the interviewers for clarification. Employment during pregnancy recorded as for the Canadian Census, was coded by clerk with experience of this task. The Standard Occupational Classification¹ and Standard Industrial Classification² were the basis of the system. Four digits were used for occupation and two for industrial sector. Drugs being taken at the time of the first missed period were recorded but this information was not used in the present analysis. Congenital defects were coded individually and in groups using a classification comprising some 90 specific types of abnormality. Up to two defects were separately coded, the apparently more serious first and the other second. Recognised syndromes and groups of abnormalities affecting more than one system were coded separately.

The coded data were entered on magnetic tape in five sets: (1) personal, (2) previous pregnancies and outcome, (3) employment, (4) smoking, alcohol, and spouses' employment, and (5) prenatal history, delivery, and outcome (from medical record review). Except for the first set (personal), a separate record was made for each pregnancy. After entry the information was checked for inconsistencies and stored on a CDC CYBER 835 computer using the Scientific Information Retrieval system.³

Analyses

The aim of the analysis reported in this paper was to determine the extent to which the frequency of each of the four main adverse outcomes of pregnancy was related to type of employment as classified.

For spontaneous abortion, low birth weight, and congenital defect the analyses were carried out for women at work for at least 30 hours weekly at the beginning of their pregnancies. For stillbirths

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because later exposure might be specially important, women who worked 30 or more hours a week for at least two weeks at any time during pregnancy were included in the analyses. The effect of work at various periods of pregnancy will be studied in later analyses.

Because of differences in level of ascertainment, current and previous pregnancies were considered separately. The 60 employment classes selected for study were determined by the need for homogeneous groups sufficiently detailed but with adequate numbers for analysis. The 60 fell into six main industrial sectors: managerial, health, clerical, sales, service, and manufacturing.

CORRECTION FOR CONFOUNDING VARIABLES

Since factors other than work affect the frequency of adverse pregnancy outcome, a series of ten potentially confounding variables were identified. These were age, gravidity, education and spouse's education (as indices of social class), smoking habit, alcohol consumption, ethnicity, height, previous spontaneous abortion, and previous premature birth. A preliminary logistic regression analysis using all ten variables resulted in a memory storage overflow due to the very large number of covariate patterns produced. In order to eliminate this problem previous premature birth and paternal education were removed from the

model for all the outcomes and maternal height was removed from all but the prematurity outcome. For each outcome the selected variables were entered into a logistic regression analysis and the probability of each outcome calculated from the regression coefficients. Interactions between variables were not considered.

With spontaneous abortions statistically significant associations in both current and previous pregnancies were found with maternal age, gravidity, previous spontaneous abortion, and smoking ($p < 0.01$), and with alcohol consumption ($p < 0.05$). With low birth weight, ethnic group, previous spontaneous abortion, and smoking were similarly associated ($p < 0.01$) and gravidity and alcohol ($p < 0.05$). The odds ratios for these two outcomes are shown for current and previous pregnancies in table 1. With stillbirths only the odds ratio for smoking was significantly raised ($p < 0.05$) in both current and previous pregnancies and with congenital defects only ethnic group.

STATISTICAL METHODS

Probabilities estimated as above were used to calculate the expected number of each adverse outcome by occupational category. The expected numbers (E) were then compared with the observed numbers (O) as ratios (O/E). To test the significance of raised

Table 1 Odds ratios for seven main confounding variables used to calculate expected values for the pregnancy outcomes*

Confounding variables	Spontaneous abortion < 28 weeks		Low birth weight (≤ 2500 g) without defect	
	Current	Previous	Current	Previous
Age (years):				
< 20	1.00	1.00	1.00	1.00
20-30	0.78	1.72	1.48	0.76
≥ 30	0.96	1.04	1.78	0.81
Gravidity:				
1	1.00	1.00	1.00	1.00
2	1.15	1.61	0.71	0.96
3	1.19	2.30	0.69	0.78
≥ 4	1.62	1.99	0.64	0.96
Previous spontaneous abortion:				
No	1.00	1.00	1.00	1.00
Yes	1.31	1.32	1.66	1.69
Ethnic group:				
White: Anglophone	1.00	1.00	1.00	1.00
Francophone	1.97	1.04	1.46	1.31
Black	2.82	0.92	2.60	1.71
Other and unknown	9.16	1.08	1.80	1.45
Maternal education:				
Primary only	1.00	1.00	1.00	1.00
Secondary	1.45	1.21	0.92	1.31
College/university (at least part)	1.49	1.29	0.85	1.29
Smoking:				
Nil	1.00	1.00	1.00	1.00
1-19 cigarettes daily	1.45	1.14	2.14	1.82
≥ 20 cigarettes daily	0.95	1.72	2.62	2.33
Alcohol:				
None	1.00	1.00	1.00	1.00
1-2 drinks/week	0.97	1.07	0.67	0.81
≥ 3 drinks/week	1.21	1.28	1.04	0.93

*See text for statistical significance.

ratios, a one sided Pearson chi square test was calculated from the observed and expected numbers of pregnancies with and without adverse outcome. For occupational groups in which the expected number of an adverse outcome was less than five, an exact (one sided) *p* value was calculated on the assumption that the observed number followed a Poisson distribution. Ninety per cent confidence intervals were also computed on this assumption.

For reasons already mentioned, current and previous pregnancies were first considered separately. The two sets were then added and significance tests for the combined O/E ratios calculated in the same manner. To help in the interpretation of these combined ratios, tests of the null hypothesis of homogeneity of O/E ratios from the two series were made. The test appropriate for comparing the ratios of two Poisson variables required calculation of the probability in two tails of a binomial distribution.⁴ Exact binomial probabilities were calculated for total observed outcomes less than 30 and the Gaussian approximation used otherwise.

Results

The pattern of pregnancy outcome in the six main sectors of employment is illustrated in table 2. There is little indication of any adverse effect of work in the managerial, health, or clerical occupations. The only ratios above unity are for spontaneous abortion (1.03) and low birth weight (1.01) in the health sector; these have clearly no statistical significance. The risk estimate (0.96) for low birth weight in the clerical sector, although of low homogeneity (*p* < 0.05), is based on ratios in current (1.01) and previous pregnancies (0.89) which are both low. These findings contrast with those for the sales, service, and manufacturing sectors where nine of the 12 ratios are above unity, mostly by at least 10% and six with a *p* value of 0.05. As indicated by the tests of homogeneity, the combined estimates of risk were based on ratios for cur-

rent and previous pregnancies which were mostly compatible. An exception was low birth weight in the manufacturing sector where the overall estimate (1.19) was derived from a higher ratio in previous pregnancies (1.31) than in current pregnancies (1.07). Women in the service sector had the worst experience overall, with ratios ranging from 1.11 to 1.17, three of the four outcomes at a probability level of < 0.05. Women in the sales sector had excess spontaneous abortions and possibly stillbirths but low ratios for congenital defects and prematurity. Women in manufacturing jobs had evidence of an excess of low birth weight and congenital defects.

Comparable data are presented in table 3 for the 60 occupational groups. Most groups comprised several hundred pregnancies but included also were three small groups with fewer than 100 and 15 large groups with more than a thousand. The sampling uncertainty of each risk estimate varies accordingly. The probability (*p*) values shown in this table, which make no allowance for the large number of ratios tested, are intended only to identify importantly raised ratios; however, some high risks based on small numbers must not be overlooked. For the sake of clarity, the tests of homogeneity between findings in current and previous pregnancies, although calculated, are not shown in this table, except to the extent that any raised ratio at a probability level of *p* < 0.1 is shown in parentheses if homogeneity was rejected at the same level.

Having regard for the findings in table 2, it is not surprising that few occupations in sectors 1 to 3 show evidence of increased risk. The high ratio (1.33; *p* < 0.01) for spontaneous abortion in nursing aides, consistent in both previous (1.33) and current (1.30) pregnancies, is a notable exception. The risk of prematurity in this occupation is also increased (1.28; *p* = 0.11) but only in previous pregnancies (ratio 1.84; *p* < 0.01); in current pregnancies there was no excess (ratio, 0.87; homogeneity test, *p* = 0.07). The two stillbirths in 70 pregnancies of sportswomen and

Table 2 Ratios of observed to expected (O/E) numbers of spontaneous abortions, stillbirths, congenital defects, and children of low birth weight (≤ 2500 g) by occupational sector

Sector	Total No of pregnancies	Spontaneous abortions			Stillbirth without defect			Congenital defects			Low birth weight		
		O	O/E ¹	Hom ²	O	O/E ¹	Hom ²	O	O/E ¹	Hom ²	O	O/E ¹	Hom ²
1 Managerial	8402	1147	0.97	—	39	0.85	—	251	1.03	—	339	0.90	—
2 Health	5780	857	1.03	—	32	0.98	—	143	0.83	—	268	1.01	—
3 Clerical	20222	2686	0.98	—	116	0.93	—	604	0.97	—	1039	0.96	0.05
4 Sales	2368	366	1.09**	—	20	1.39*	—	64	0.91	—	106	0.85	—
5 Service	3623	619	1.11‡	—	29	1.14	—	128	1.17**	—	240	1.12**	—
6 Manufacture	6921	1071	0.97	—	58	1.13	—	237	1.14**	—	476	1.19***	0.03

¹Chi square tests on raised ratios: **p* < 0.1; ***p* < 0.05; ****p* < 0.01.

²Tests of homogeneity of ratios derived from current and previous pregnancies; value shown only if *p* < 0.1.

Table 3 Ratios of observed/expected (O/E) spontaneous abortions in 60 occupational groups within the six sectors shown in table 2

Sector occupation (SOC and SIC)	Pregnancies	Spontaneous abortions		Stillbirth without defect		Congenital defects		Low birth weight (≤ 2500 g) without defect	
		O	O/E	O	O/E	O	O/E	O	O/E
1 Managers, lawyers (1111-49, 2341-9)	1389	172	0.94	5	0.70	40	0.97	45	0.70
Accountants and analysts (1171-3)	1084	148	1.08	4	0.71	27	0.84	51	1.02
Other administrators (1174-9)	1083	146	0.99	5	0.83	36	1.11	35	0.66
Physical scientists (2111-2119)	193	27	1.00	0	—	4	0.70	10	1.23
Life scientists (2131-9)	178	11	0.49	0	—	4	0.73	5	0.63
Architects, engineers (2141-69)	280	42	1.13	1	0.69	9	1.08	7	0.61
Mathematicians, statisticians (2181-9)	444	60	1.02	2	0.91	11	0.85	26	1.28
Social scientists (2311-39)	694	93	0.94	3	0.82	23	1.13	37	1.19
Librarians, archivists (2350-2519)	309	49	1.12	2	1.30	7	0.76	5	0.36
Teachers, university, and post-secondary (2711-19, 2791-3)	391	56	0.87	3	1.34	11	0.98	22	1.31
Teachers, secondary (2733)	576	74	0.75	3	0.82	18	1.12	21	0.87
Teachers, primary, and other (2731, 2739, 2797, 2799)	1296	196	0.98	6	0.76	44	1.25*	56	1.03
Teachers, retarded children (2795)	485	73	1.14	5	2.02(*)	17	1.21	19	0.88
2 Physicians, dentists (3111-3119)	295	30	0.69	0	—	10	1.17	10	0.80
Nursing supervisors (3130)	186	25	0.88	1	0.93	8	1.35	7	0.77
Nurses (3131a)	1983	315	1.05	10	0.88	49	0.84	86	0.97
Nurses, psychiatric (3131b)	99	15	0.97	0	—	2	0.64	8	1.52
Nurses, operating room (3131c)	83	13	0.94	1	1.90	2	0.79	5	1.32
Nursing assistants (3134)	462	70	1.06	5	1.70	11	0.78	20	0.83
Nursing aides and orderlies (3135)	371	79	1.33***	2	0.85	8	0.71	26	1.28
Physiotherapists (3137)	174	16	0.76	1	1.15	5	0.99	4	0.59
Ergotherapists, dieticians, etc. (3138-9, 3152-4, 3136, 3162-9)	459	64	1.09	3	1.29	10	0.72	19	0.95
Medical laboratory technicians (3156)	503	69	0.97	3	1.16	11	0.74	21	0.99
Radiology technicians (3155)	177	31	1.20	2	2.31	2	0.40	7	0.96
Dental hygienists, technicians (3157, 3158, 3161)	245	31	1.05	0	—	5	0.67	15	1.28
Commercial artists, photographers (3311-33, 3335-9)	427	55	0.97	2	0.91	12	0.95	22	1.09
Writers, translators (3351-9)	246	33	0.93	0	—	8	1.11	14	1.18
Sports women, dancers (3360-79, 3334)	70	11	1.31	2	5.51**	0	—	4	1.26
3 Secretaries (4110-1)—industrial sectors, 1-47	1181	142	0.83	8	1.00	32	0.91	62	1.00
Secretaries (4110-1)—other sectors, 48-99	5164	703	0.99	33	1.05	153	0.97	274	1.03
Typists and clerks (4113)—industrial sectors, 1-47	124	16	1.01	0	—	6	1.66	5	0.79
Typists and clerks (4113)—other sectors, 48-99	540	63	0.88	4	1.12	17	1.00	20	0.67
Bookkeepers (4130, 1, 5, 7, 9)	5105	655	0.97	28	0.91	139	0.88	267	0.97
Cashiers (4133)	1661	239	1.05	6	0.57	64	1.23	90	0.97
Office machine operators (4140-3)	1407	186	0.98	8	0.93	54	1.24*	61	0.79
Storekeepers, dispatchers (4150-9)	697	97	1.02	3	0.69	17	0.81	43	1.08
Record clerks (4160-9)	372	57	1.10	4	1.79	9	0.81	21	1.14
Supervising receptionists, information clerks (4170-1)	799	104	0.96	6	1.15	28	1.12	34	0.78
Telephone, postal, reception clerks (4172-9)	382	38	0.67	1	0.35	15	1.17	21	0.84
Specialised clerks (4190-5)	751	105	1.12	6	1.48	13	0.58	32	0.84
General office clerks (4197)	1295	183	1.10	7	0.91	33	0.84	66	0.95
Other clerical workers (4199)	744	98	1.03	2	0.46	24	1.04	43	1.09
4 Saleswomen, commodities (5135)	1034	164	1.12*	13	1.91**	33	1.05	46	0.80
Other sales occupations, commodities (5130-3, 5141-49)	872	126	1.00	5	0.96	18	0.69	42	0.93
Sales occupations, services (5170-99)	462	76	1.22**	2	0.85	13	0.98	18	0.80
5 Food and beverage preparation (6121, 6129)	387	57	0.99	2	0.80	15	1.27	20	0.92
Food and beverage service (6123, 6125)	1114	215	1.22***	9	1.10	38	1.16	84	1.17*
Chambermaids, cleaners, janitors (6133, 6142, 6191)	544	95	1.11	6	1.53	18	1.07	45	1.42***
Hairdressers (6143)	688	106	1.02	2	0.43	11	0.51	43	1.08
Child care workers (6147)	215	35	1.19	1	0.69	14	2.19***	13	1.07
Laundry and dry cleaners (6160-6169)	202	36	1.05	3	1.86	9	1.41	15	1.17
Other service occupations (remainder 6111-6199)	359	53	1.02	1	0.46	17	1.54**	15	0.76
Agriculture, horticulture (7113-7719)	114	22	1.14	5	5.65***	6	1.88*	5	0.93
6 Manufacture (8110-8599, 9310-9519):									
Food and drink (industrial sectors 10-12)	363	62	1.06	1	0.35	9	0.79	35	1.55***
Rubber and plastic (industrialised sectors 15-16)	159	28	1.19	1	0.80	8	1.63	12	1.22
Leather (industrial sector 17)	396	72	1.11	8	2.59***	17	1.39*	19	0.74
Textiles (industrial sectors 18-19)	457	70	0.95	7	1.90*	15	1.05	34	1.23
Clothing (industrial sector 24)	3625	537	0.90	24	0.80	110	1.05	234	1.17***
Metal, electrical (industrial sectors 29-39)	1007	172	1.09	10	1.37	42	1.36**	88	1.50***
Other occupations (8710-9199, 9530-9919) and other sectors	914	130	0.97	7	1.09	36	1.21	54	0.95

*p < 0.1; **p < 0.05; ***p < 0.01 (if in parentheses homogeneity p < 0.1).

dancers (expected 0.36) and the five in the larger number of teachers of retarded children (expected 2.47) are worth noting.

The findings of main interest are in the lower half of table 3. Abortion ratios were increased by 12% to 22% in two of the three groups of women in sales occupations and by 23% among women employed in food and beverage service—all with some degree of statistical significance and consistency (homogeneity, $p \geq 0.5$). Risk ratios for stillbirth without defect were increased importantly in four groups—agriculture and horticulture (5.65), leatherwork (2.59), commodity sales (1.91), and textile manufacture (1.90)—also with fair consistency. Only two groups were associated with substantial risk of congenital defect, child care workers (ratio, 2.19; $p < 0.01$) and a miscellaneous group of “other service occupations” (ratio 1.54; $p < 0.05$). Primary school teachers also had a raised ratio for defects but of low significance ($p < 0.1$) and consistency. Four occupations had increased ratios for low birth weight ($p < 0.01$)—chambermaids, cleaners, and janitors (1.42) and three groups of women employed in the manufacture of food and drink (1.55), metal and electrical goods (1.50), and clothing (1.17). In clothing manufacture there was significant heterogeneity ($p = 0.04$) between the ratio for current pregnancies (1.01) and for previous pregnancies (1.34).

Discussion

The results of this analysis suggest that certain occupations, especially in the sales, service, and manufacturing sectors are associated with risk for the pregnant woman. Much depends on whether adequate correction was made for confounding variables through the seven identified—eight for low birth weight—or whether there remain important selective or modifying factors that have not been considered. Women who choose or are chosen for any given type of employment differ in many ways and the results of logistic regression (table 1) have shown that confounding factors may have an appreciable effect on expected risks. Nevertheless, within sectors 4, 5, and 6 there is no uniformity in the pattern of risks for the four adverse outcomes. This suggests that the observed associations were specific to certain outcomes, an interpretation supported by three further types of evidence. Firstly, the risks are not shared equally by all occupations within a given sector but tend to be concentrated in a small number of particular types of work. Secondly, the occupations at increased risk are generally those for which there is some previous suspicion or plausible explanation. Thirdly, the findings from current and past pregnancies were generally consistent, suggesting a specific rather than chance association with the occupation, although perhaps due to selection rather

than causation.

In a preliminary report on spontaneous abortion based on less complete statistical analysis the same three occupational groups—nursing assistants and aides, saleswomen, and women engaged in food and beverage service—were identified as at increased risk.⁵ Some evidence was obtained that the risk was associated with heavy lifting, other physical effort, and long hours of work, something most women have probably believed for a long time. A full analysis of all the available data on work conditions and demands is now clearly indicated. The risk of stillbirth without defect for leatherworkers which was recently reported^{6,7} has been confirmed in this analysis after correction for confounders. The risk of stillbirth in agricultural and horticultural workers appears to be higher still, which raises the question of pesticide and herbicide exposure; chemical exposures experienced by women in sales and textile work need also to be explored. The high risks of congenital defect observed in those who work with young children suggest microbiological rather than chemical agents. It seems unlikely that our survey can follow this lead very far. A case-referent study of congenital defects based on women from this survey has thrown suspicion on exposure to aromatic solvents (especially toluene) mainly in manufacturing or laboratory work. No evidence of this was seen in the present analysis. The two service and three manufacturing occupations associated with infants of low birth weight may be used to test the hypothesis advanced by Mamellet and colleagues⁸ that an index of fatigue may be associated with premature labour.

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