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Fathers' occupation and pregnancy outcome

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ABSTRACT Findings from a survey of 56 067 women in Montreal on maternal occupation and pregnancy outcome have been reported. Paternal occupation recorded in the same survey was analysed for spontaneous abortion in 24 occupational groups retaining the six main sectors of maternal occupation and allowing, by means of logistic regression, for seven potentially confounding variables. In only one of the 24 fathers' occupational groups was there a statistically significant excess of spontaneous abortions—mechanics, repairers, and certain assemblers (O/E = 1·10, 90% CI = 1·02–1·20); subdivision of this group suggested that this excess was mainly attributable to the large group of motor vehicle mechanics (O/E = 1·17). No significant excess of known chromosomally determined defects was found in any of the 24 occupational groups. An association of developmental defects was found with food and beverage processing (18 defects observed compared with 8·02 expected; $p < 0·05$); however, there was no specificity in type of food, beverage, or congenital defect, and no obvious explanatory mechanism.

In a survey of occupational factors and outcome of pregnancy 56 067 women were interviewed over a two year period, 1982–4, after delivery or spontaneous abortion in 11 obstetrical units in Montreal. Questions were asked on personal, social, and occupational factors, with detailed information about the mother's work, for recently completed and all previous pregnancies—104 649 in all. Mothers' job titles, work demands, conditions of employment, and exposure to chemicals have been analysed in relation to the four main adverse outcomes of pregnancy: abortion, stillbirth (without defect), congenital defect, and prematurity.[1–4]

Whereas the primary aim in this survey was to assess the effect of mothers' work, certain occupational exposures of the father might also have damaged the fetus. The main mechanism by which this could happen would be genetic. Chromosomal abnormalities, presumably the result of mutation in male or female germ cells or in the conjugated zygote, are found in some 50% of spontaneous abortions[5] and congenital defects with detectable chromosomal abnormalities are found in about seven per thousand births.[6]

In studies based on birth defects in Finland[7] and Israel[8] no association was found with the father's occupation. In the United States data obtained by interviewing parents of nearly 1000 children with congenital defects showed no convincing association between specific defects and paternal occupation.[9] Cleft palate was associated with paternal exposure to freshly printed material and to painting in the construction industry but many comparisons were made without prior hypothesis. In a record linkage study in Finland the frequency of spontaneous abortion was examined in seven large occupational groups entailing exposure to different types of potentially hazardous agent.[10] The wives of metal plate and constructional steel workers and of men employed in three small groups (crushers and grinders in chemical processes, sewers, those engaged in the care of fur bearing animals) were at increased risk.

As father's occupation was recorded for each pregnancy in the Montreal survey, the opportunity was taken to seek evidence of any relation with spontaneous abortion and selected birth defects.

Methods

FATHER'S OCCUPATION

Questions on father's employment at the time of the mother's first missed menstrual period were asked for all current and past pregnancies. The women were asked the name and description of the job, type of enterprise, and address, much as for the Canadian census. The answers to these questions were coded

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Table 1 *O/E ratios of spontaneous abortions and congenital defects* according to paternal occupation*

Sector	Occupation (SOC) group	Spontaneous abortions			Congenital defects: Chromosomal			Congenital defects: Developmental		
		Obs	O/E	(90% CI)	Obs	O/E	(90% CI)	Obs	O/E	(90% CI)
Administrative/professional (2111–2799)	Physical scientists (2111–2119)	56	1·21	(0·96–1·49)	0	0·00	(0·00–5·36)	2	0·85	(0·11–1·87)
	Remainder	1711	1·00	(0·96–1·04)	29	1·27	(0·91–1·73)	130	0·94	(0·81–1·09)
Health etc (3311–3369)	Physicians/dentists (3111–3119)	78	0·90	(0·74–1·07)	3	2·36	(0·64–6·10)	5	0·65	(0·26–1·37)
	Technicians/art occupations (3155–6, 3311–33, 3335–9)	115	1·07	(0·85–1·15)	3	1·86	(0·51–4·81)	6	0·62	(0·27–1·22)
	Remainder	150	0·94	(0·93–1·21)	1	0·54	(0·03–2·55)	12	1·07	(0·62–1·74)
Clerical (4110–4119)		4530	0·94	(0·87–1·02)	4	0·64	(0·22–1·46)	50	1·33	(1·03–1·65)
Sales (5130–5199)		643	0·98	(0·92–1·04)	5	0·58	(0·23–1·21)	39	0·75	(0·56–0·96)
Services etc (6110–7719)	Laundry/dry cleaning (6160–6169)	21	0·93	(0·62–1·33)	0	0·00	(0·00–11·11)	0	0·00	(0·00–1·88)
	Agriculture/horticulture (7113–7719)	56	1·03	(0·81–1·27)	0	0·00	(0·00–4·35)	9	2·16	(1·13–3·77)
	Remainder	512	1·04	(0·96–1·11)	8	1·32	(0·65–2·37)	26	0·71	(0·50–0·99)
Manufacturing (8110–9919)	Processing:									
	Ore, metal, stone (8110–8159)	57	1·17	(0·93–1·44)	0	0·00	(0·00–5·26)	7	2·02	(0·95–3·79)
	Chemicals (8160–8179)	28	0·91	(0·65–1·25)	0	0·00	(0·00–7·89)	0	0·00	(0·00–1·28)
	Food/bev/wood/textile (8210–8239)	176	1·02	(0·90–1·15)	1	0·50	(0·03–2·36)	21	1·72	(1·16–2·48)
	Machining:									
	Metal (8310–8399)	217	1·03	(0·92–1·15)	2	0·78	(0·14–2·44)	16	1·02	(0·64–1·56)
	Wood/stone/other (8350–8399)	31	1·17	(0·85–1·55)	0	0·00	(0·00–10·34)	3	1·71	(0·47–4·43)
	Fabricating:									
	Metal (8510–8529)	69	0·92	(0·74–1·11)	0	0·00	(0·00–2·97)	7	1·15	(0·54–2·17)
	Electrical (8530–8539)	130	0·88	(0·76–1·02)	1	0·55	(0·03–2·60)	11	1·00	(0·56–1·66)
	Wood/textile/leather (8540–8569)	208	0·95	(0·84–1·06)	4	0·57	(0·54–3·59)	17	1·10	(0·70–1·65)
	Rubber/plastic (8570–8579)	35	1·03	(0·77–1·34)	0	0·00	(0·00–8·11)	3	1·36	(0·37–3·51)
	Mechanics and repairers (8580–8599)	408	1·10	(1·02–1·20)	5	1·10	(0·43–2·32)	27	0·99	(0·77–1·36)
	Construction trades (8710–8799)	382	0·95	(0·87–1·03)	3	0·60	(0·16–1·56)	38	1·26	(0·95–1·62)
	Transport oper/matl handling (9110–9319)	448	0·96	(0·89–1·04)	8	1·47	(0·73–2·66)	38	1·14	(0·85–1·46)
	Printing operations (9510–9519)	81	0·92	(0·76–1·09)	2	1·77	(0·31–5·58)	4	0·59	(0·20–1·34)
	Stationary equip oper/misc (9530–9919)	68	1·07	(0·87–1·29)	1	1·18	(0·06–5·58)	7	1·38	(0·65–2·60)
Unknown		265	1·16	(1·05–1·28)	2	0·87	(0·16–2·75)	6	0·43	(0·19–0·85)
Not working		418	1·14	(1·05–1·23)	4	0·79	(0·27–1·81)	35	1·15	(0·85–1·50)

*Chromosomal and developmental.

according to the Standard Occupational Classification (using 4 digits) and Standard Industrial Classification (using 3 digits) of Statistics Canada (1980) by a clerk with experience of coding occupation in the Canadian census (1980). Fathers' occupations were classified under the same six main occupational sectors as have been used systematically in our analyses of maternal occupations (see table 1). Within the six main sectors 24 occupational groups were selected as having the potential for harmful exposure. The much greater number of men than women in industrial employment necessitated subdivision of the manufacturing sector into 14 groups instead of six for women.

The hypothesis that exposure of men to ionising radiation might induce chromosomal mutations and so increase the risk of spontaneous abortion in their wives was tested by identifying (1) occupations in which there was *probably* exposure to ionising radiation and (2) occupations in the health, services, and manufacturing sectors in which there was *possibly* some such exposure. The exposed occupations, selected on the basis of available information, including that from the Canadian Environmental Health Directorate are listed in table 2.[11] In these occupations the average annual whole body doses reported were mostly low and above 1 MSV only for industrial radiographers, therapeutic radiology technicians, and some occupations in nuclear energy plants.

STUDY POPULATION

The pregnancies studied were limited to those in which the women were employed 30 hours or more a week at time of conception. Other pregnancies in which the women were not employed during pregnancy, or for lesser periods, were excluded because the many

Table 2 *Occupations classified as entailing probable or possible exposure to ionising radiation*

SOC	
	Probable exposure
2156	Nuclear engineers
3113	Dentists
3115	Veterinarians
3117	Osteopaths and chiropractors
3155	Radiological technologists and technicians
3158	Dental hygienists and dental assistants
	Possible exposure
Managerial/professional sector:	
2112	Geologists
2113	Physicists
2117	Physical sciences technologists and technicians
2133	Biologists and related scientists
2135	Life sciences technologists and technicians
2142	Chemical engineers
2151	Metallurgical engineers
2165	Engineering technologists and technicians
2711	University teachers
2719	University teaching and related occupations
2791	Community college and vocational teachers
2793	Postsecondary school teachers
2797	Instructors and training officers
Health sector:	
3111	Physicians and surgeons
3119	Health diagnosing and treating occupations
3133	Operating room nurses
3156	Medical laboratory technicians and technologists
3169	Other occupations in medicine and health
Manufacturing sector:	
8116	Inspecting, testing, grading, and sampling occupations: mineral ore treating
8146	Inspecting, testing, grading, and sampling occupations: metal processing
8296	Inspecting, testing, grading, and sampling occupations: other processing
8336	Inspecting, testing, grading, and sampling occupations: metal shaping and forming, except machining
8526	Inspecting, testing, grading, and sampling occupations: fabricating and assembling metal products
8531	Electrical and related equipment installing and repairing occupations
8535	Electronic and related equipment installing and repairing occupations
8536	Inspecting, testing, grading and sampling occupations: fabricating, assembling, installing, and repairing electrical, electronic, and related equipment

SOC = Standard Occupational Classification.

potentially confounding variables for these have not yet been assessed. For the analysis of spontaneous abortion, there were 47 326 such pregnancies (24 711 current and 22 615 previous). The analysis of congenital defects was based on 47 822 pregnancies (27 472 current and 20 350 previous) of women employed 15 hours a week or more at time of conception. This total excluded spontaneous abortions of less than 20 weeks' gestation but included abortions induced for a classifiable congenital defect.

The present study was confined to (*a*) defects of known chromosomal origin and (*b*) developmental defects of the neural tube, lip and palate, heart, and of the respiratory, digestive, and urinary tracts. Congenital hernias, musculoskeletal defects, and some miscellaneous anomalies were not included in this study.

STATISTICAL ANALYSIS

Expected numbers were calculated for each paternal occupational group after accounting for non-occupational confounding variables (maternal age, gravidity, previous miscarriage, ethnic group, educational level, smoking, and alcohol consumption) by logistic regression, as previously described.[1] Adjustment for possible confounding by maternal occupation was made at a second stage by calculating expected numbers for paternal occupational group cross classified by sector of employment of the mother. The expected numbers by maternal sector were first adjusted by the ratios of observed to expected (O/E) spontaneous abortions in each maternal sector for all pregnancies, and then summed. Ninety per cent confidence intervals for the resulting O/E ratios were calculated on the assumption that the observed number followed a Poisson distribution. The significance of heterogeneity of O/E ratios over the 24 paternal occupational groups was tested by Poisson regression using the GLIM computer package.[12]

As in our previous analyses of congenital defect,[3] no allowance was made for confounding variables because of the different and often unknown

Table 3 *Congenital defects by group in selected paternal occupations*

			Processing					
	Agriculture/horticulture (n = 380)		*Food & beverage (n = 739)*		*Wood, textiles, & other (n = 376)*		*Printing (n = 625)*	
*Congenital defect**	*O*	*E*	*O*	*E*	*O*	*E*	*O*	*E*
Chromosomal	0	0·68	0	1·33	1	0·68	2	1·12
Neural tube	2	0·95	5	1·84	1	0·94	0	1·56
Cleft lip/palate	0	0·32	2	0·62	0	0·31	0	0·52
Digestive respiratory	1	0·55	3	1·06	0	0·54	1	0·90
Cardiac	1	0·41	2	2·75	1	1·40	2	2·33
Renal urinary	5	0·90	6	1·75	1	0·89	1	1·48
All	9	4·13	18	8·02	3	4·08	4	6·79

*Excluding musculoskeletal defects and hernias.

epidemiological pattern for each type of defect. The overall rate was used to estimate the number expected in each paternal occupational group. Confidence intervals and p values were calculated as above.

Results

Table 1 shows ratios (O/E) for spontaneous abortion and congenital defect. For spontaneous abortion, a global test of O/E ratios in the 24 occupational groups gave no evidence of heterogeneity ($p > 0·20$) and, considered individually, the only O/E ratio for which the 90% confidence interval excluded 1·00 was for the group of mechanics and repairers, fabricators, and assemblers of certain products (SOC 8580–8599) for which the O/E ratio was 1·10 (90% CI 1·02–1·20). One subdivision of this group—mechanics and repairers of motor vehicles (SOC 8581)—explained most of this excess with O = 168 and the O/E ratio = 1·17 (90% CI 1·03–1·32). Other subdivisions were too small to give reliable estimates of risk. Ratios were also raised in pregnancies for which the paternal occupation was unknown (O/E = 2·26, 90% CI 1·05–1·28) and in those in which the father was not employed (O/E = 1·14, 90% CI 1·05–1·23).

In the group of occupations with *probable* exposure to ionising radiation there were 18 abortions (O/E = 0·87, 90% CI 0·56–1·29). For the three groups with *possible* exposure to ionising radiation, 235 abortions were observed in the health sector (O/E = 1·0, 90% CI 0·93–1·15), 89 abortions in the service sector (O/E = 0·99, 0·82–1·17), and 76 abortions in manufacturing (O/E = 0·93, 90% CI 0·76–1·11).

Table 1 also shows the ratios of chromosomal and developmental congenital defects observed to those expected on the basis of the rates in all working women. In none of the 24 paternal occupational groups was there an excess of chromosomal defects statistically significant at a 5% level and there was no evidence of heterogeneity in the 24 occupational groups ($p > 0·20$). There was significant heterogeneity of the O/E ratios for developmental defects ($p = 0·01$). Three O/E ratios for developmental defects had confidence intervals which excluded one: processing of food, beverages, wood and textiles, agriculture and horticulture, and the large occupational group of clerical workers in which the 90% confidence interval only just excluded one. This latter group was not investigated further. Table 3 shows in the other two occupational groups numbers of developmental defects by type compared with those expected from rates for all working women. For agriculture and horticulture the excess was attributable to renal urinary defects (polycystic kidney (1) hydronephrosis (1), hypospadias (3)). Because a large occupational group was engaged in processing food, beverages, wood, and textiles and the substances handled were diverse, it was subdivided. The excess of developmental defects was confined to processing of food and beverages (18 developmental defects compared with 8·02 expected). Raised O/E ratios were found in four of the five types of developmental defect (table 3); there were no chromosomal defects. Table 4

Table 4 *Developmental defects observed and expected in food and beverage processing and related occupations (8210–8229)*

		No	*O*	*E*
8210	Foremen	55	2	0·59
8211	Baking and grain milling	17	0	0·18
8213	Baking, confectionary	167	4	1·81
8215	Slaughtering and meat cutting, canning, curing, and packing	269	5	2·92
8217	Fish canning, curing, and packing	5	1	0·05
8221	Fruit and vegetable canning, etc	6	0	0·07
8223	Milk processing	31	1	0·34
8225	Sugar processing	7	0	0·08
8226	Inspection, sampling, etc	11	0	0·12
8227	Beverage processing	54	2	0·59
8228	Labouring occupations	60	2	0·65
8229	Other	57	1	0·62
8210–8229	All	739	18	8·02

shows 12 four digit SOC occupations comprising different sections of the food and beverage industry; the excess appeared to be distributed fairly evenly between them.

Comment

The 10% increase in risk of spontaneous abortion found in the paternal occupational group of mechanics and repairers may have occurred by chance in the large number of occupations analysed. On the other hand, an association between the paternal occupation of automobile mechanic and infantile cancer has been suspected[13]; if confirmed this might also suggest the possibility of mutation in the fetus leading to spontaneous abortion. Congenital defects known to be caused by chromosomal abnormalities—in this survey trisomies and sex chromosome anomalies—were not found to be increased in any of the 24 paternal occupational groups analysed. An excess of trisomy 18 has been reported with maternal leatherwork[14]; in our survey leatherworkers were too few to confirm or refute this associaton with a rare chromosomal defect ($\sim$1:3000 births).

There is no obvious genetic mechanism for the occurrence of the developmental defects selected for analysis. Some features of the associations observed with three paternal occupational groups appear to merit mention. The large group of male clerical workers was not obviously exposed to any biologically active agent. The excess in agricultural and horticultural workers potentially exposed to chemical agents was mainly attributable to three cases of hypospadias observed compared with 0·26 expected. It is difficult to interpret the excess in food and beverage workers, the magnitude of which is not easily dismissed. It is not impossible that employees in the food industry are exposed to biologically potent agents, perhaps used for food preservation; on the other hand, there is lack of specificity in type of defect or in type of employment (table 4) and it is unlikely that any environmentally induced genetic factor could be common to them all. The significance of this finding must therefore depend on whether it finds independent support from other studies.

We failed to detect an increase in spontaneous abortion in the wives of men whose work entailed possible exposure to ionising radiation. The small group (65) of pregnancies in the wives of constructional steel workers had no significant excess of abortions (O = 14, O/E = 1·24, 90% CI 0·75–1·95), by contrast with the finding reported from Finland. No increased risk of cleft palate was observed in printing (shown in table 3)—contrary to a finding in the United States. The high O/E ratios for spontaneous abortion in the wives of men whose occupation was unknown and those who were unemployed merit comment. Perhaps there were unidentified confounding variables in these groups. Overall, we conclude that this survey provided no convincing evidence that fathers' occupations had any adverse effect on their progeny.

References

1 McDonald AD, McDonald JC, Nolin AD, *et al.* Occupation and pregnancy outcome. *Br J Ind Med* 1987;**44**:521–6.
2 McDonald AD, McDonald JC, Armstrong B, *et al.* Fetal death and work in pregnancy. *Br J Ind Med* 1988;**45**:148–57.
3 McDonald AD, McDonald JC, Nolin AD, *et al.* Congenital defects and work in pregnancy. *Br J Ind Med* 1988;**45**:581–8.
4 McDonald AD, McDonald JC, Nolin AD, *et al.* Prematurity and work in pregnancy. *Br J Ind Med* 1988;**45**:56–62.
5 Hassold T, Chen N, Funkhouser J, *et al.* A cytogenetic study of 1000 spontaneous abortions. *Ann Hum Genet* 1980;**44**:151–78.
6 Buckton KE, O'Riordan ML, Ratcliffe S, *et al.* A G-band study of chromosomes in live-born infants. *Ann Hum Genet* 1980; **43**:227–39.
7 Hemminki K, Mutanen P, Luoma K, Saloniemi I. Congenital malformations by the parental occupation in Finland. *Arch Occup Environ Health* 1980;**46**:93–8.
8 Papier CM. Parental occupation and congenital malformations in a series of 35 000 births in Israel. In: Marois M, Bennett HS, eds, *Prevention of physical and mental congenital defects*. Part B Liss: 1985;291–4.
9 Erickson JD, Cochran WM, Anderson CE. Parental occupations and birth defects—a preliminary report. *Contributions to Epidemiology and Biostatistics* 1979;**1**:107–17.
10 Lindbohm M-L, Hemminki K, Kyrronen P. Parental occupational exposure and spontaneous abortion in Finland. *Am J Epidemiol* 1984;**120**:370–8.
11 Health and Welfare, Canada. Occupational radiation exposures. *Chronic Diseases in Canada* 1987;**8**:19.
12 Baker RJ, Nelder JA. *The GLIM system*. Release 3. Oxford: Oxford Numerical Algorithms Group, 1978.
13 Fabia J, Thuy TD. Occupation of father at time of birth of children dying of malignant disease. *Br J Prev Soc Med* 1974;**28**:98–100.
14 Clarke M, Mason ES. Leatherwork: a possible hazard to reproduction. *Br Med J* 1985;**290**:1235–7.