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Pregnancy outcome among working women

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AHLBORG G JR, HOGSTEDT C, BODIN L, BÁRÁNY S. Pregnancy outcome among working women. *Scand J Work Environ Health* 1989;15:227–233. The influence of occupational factors on the outcome of pregnancy was investigated in a prospective study of 3901 women who worked during their pregnancy and received prenatal care in Örebro County from October 1980 to June 1983. Data on occupational factors, social circumstances, and life-style factors were obtained from questionnaires. There were no significant differences in the incidence of adverse pregnancy outcome (spontaneous abortion, perinatal death, birth defects, or low birthweight) between the nine occupational categories used when nonoccupational factors were accounted for. No increased risk was found for exposure to organic solvents, but the adjusted risk ratio of adverse outcome was 1.28 (95 % CI 0.91–1.80) for “other chemical exposures.” The work conditions in this county have been generally favorable in recent years, and the results therefore cannot be generalized to conditions with higher exposures. Methodological problems such as misclassification of exposure and the possible bias resulting from different rates of legal abortions among occupational groups are discussed.

Key terms: birthweight, congenital malformations, occupation, perinatal death, prospective study, solvents, spontaneous abortion.

During the last two decades there has been a growing concern about reproductive health hazards in the workplace. Many pregnant women worry about potential health hazards to their offspring from chemical or physical exposures encountered at work. Most of the epidemiologic studies undertaken in order to identify possible risk factors have been retrospective with regard to pregnancy outcome (1). Such studies are usually vulnerable to response and recall biases (2). In an attempt to avoid some of the shortcomings inherent in retrospective studies when evaluating possible associations between work during pregnancy and adverse outcomes, we carried out a prospective study in Örebro County during the period October 1980–June 1983. The study was designed to provide us with data from which we would be able to estimate possible differences in rates of unfavorable pregnancy outcomes among groups with different occupational exposures during pregnancy. We also wanted to adjust for relevant nonoccupational factors. All women who contacted the prenatal care centers were therefore asked

to fill out a detailed questionnaire. Outcomes of interest were spontaneous abortion and perinatal death, birthweight, and congenital malformations.

Subjects and methods

Almost all pregnant women in Sweden receive public prenatal care, and deliveries in the home are extremely rare. In our study, women living in Örebro County were invited to participate when they first contacted the prenatal care center during a pregnancy. Usually this first contact was made by telephone. Those who agreed to participate received a postal questionnaire, which, after completion, was to be returned by mail or during the first visit to the center.

Questionnaire

The 10-page questionnaire contained questions on the following items: educational level and other social factors, outcome of previous pregnancies, health and medication during the present pregnancy, smoking, alcohol and coffee consumption, occupation and specific exposures at work (anesthetic gases, solvents, lead, other metals, “other chemical substances,” vibration, draft, heavy lifting, stress, and environmental tobacco smoke). In addition similar exposures during non-working hours were included.

Most of the women contacted the prenatal care center and filled out the questionnaire during the second or third month of pregnancy (37 and 46 %, respectively). However, the number of weeks since the first day of the last menstrual period (in this report called gestational length) at the time when the women came under observation varied considerably. For example, women who experienced their first pregnancy made an

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earlier contact, on the average, than the others. In most cases the information given in the questionnaire described the exposure situation at least during the first trimester. For each question on exposure, personal habits, etc, the women were asked about the situation both before and after the date (estimated) of the last menstrual period.

At the first visit to the prenatal care center the midwife checked that all the questions had been answered and, if necessary, repeated the questions to obtain an answer. After completion the questionnaires were checked again by project assistants and then coded.

Classification of occupation/exposure

Occupation was coded with three digits using the same code as in the Swedish Census (Nordic Classification Code of Occupations) and the coding of the employment sector was based on the International Standard Industrial Classification (ISIC) of all economic activities. The women's occupations were grouped into the following nine categories: (i) typists, clerks and other office workers, (ii) nursery school teachers and other child nursing, (iii) primary school teachers, (iv) other teachers and social workers, (v) nurses, physiotherapists and laboratory workers, (vi) nursing assistants/attendants, (vii) sales and service occupations, (viii) cleaners, waitresses and cooks, and (ix) industrial and agricultural workers. Typists, clerks, and other office workers were chosen a priori as a reference category since the sample size was expected to be sufficient and very few individuals would have been exposed to chemicals or physically heavy work.

Chemical exposure was defined as more than occasional exposure to anesthetic gases, organic solvents, metal fumes or dusts, or other chemical substances. Solvent exposure was kept as a separate category in the analyses. All other chemical exposures were grouped into a category called "other chemical exposures." An "unexposed" reference category was formed of all the women who stated that they were not exposed to any of the environmental factors asked for, either at work or at home.

Ascertainment of outcome

Hospital records were obtained for all pregnancies ending in a spontaneous abortion (fetal death at less than 28 weeks of gestation) or a perinatal death (stillbirth or death within the first week of delivery). All but four spontaneous abortions were diagnosed by a physician. These four, which occurred early in pregnancy, were preceded by a positive pregnancy test and were anamnesticly plausible.

From the delivery records the following information was obtained: date of delivery, length of gestation, complications and obstetric actions taken during labor or delivery, birthweight, sex, survival, diagnosis at delivery and at the last pediatric examination before discharge from the hospital. In 7 % of the deliveries the length of gestation was recorded as "uncertain."

At the follow-up visit to the prenatal care center a few months after delivery the women were interviewed by a midwife. Those who did not attend this check-up were interviewed by telephone. Any additional infant diagnoses which could be verified in pediatric records were also included.

All malformations listed in the 1966 International Classification of Diseases (ICD) were recorded. However, when the malformation rates were calculated, some minor and less significant deviations were excluded (ICD 744.4, 745.10, 745.40, 747.70, 752.10, 752.40, 755.02, 755.03, 755.6, 757.19).

Study population

A total of 5644 pregnancies was recorded during the study period. In 62 % of these, the women were living in the municipality of Örebro where registration started in October 1980. The rest of the women were living in smaller towns and villages in other parts of the county.

Participation

In 5059 of the recorded pregnancies (90 %), the women were willing to participate in the study. Pregnancy outcome in the participating and nonparticipating groups is shown in table 1. In the latter group the women were on the average somewhat older and had had more pregnancies. Only 65 % of the nonparticipating women

Table 1. Pregnancy outcome of the participating and nonparticipating women.

Outcome	Participating women		Nonparticipating women		Total	
	N	%	N	%	N	%
Pregnancies ^a	5035	100	581	100	5616	100
Spontaneous abortions	396	7.9	32	5.5	428	7.6
Births	4639	100	549	100	5188	100
Perinatal deaths	30	0.6	1	0.2	31	0.6
Malformations	131	2.8	17	3.1	148	2.9
Birthweight <2500 g	196	4.2	30	5.5	226	4.4
Length of gestation <37 weeks	253	5.5	35	6.4	288	5.6

^a Extrauterine pregnancies, hydratidiform moles, and pregnancies with unknown outcome excluded.

were gainfully employed compared with 85 % of the participants. The participation rate was not below 85 % in any of the main occupational categories.

The spontaneous abortion rate was lower in the non-participating group; this difference may be partly explained by the fact that these women tended to contact the prenatal care center at a later stage of pregnancy, when the risk of miscarriage is lower (figure 1).

Exclusions

A total of 270 women were registered for more than one pregnancy during the study period. Of these, only the first pregnancy was included. In addition women who were on continuous medication with a diagnosis of diabetes mellitus, epilepsy or chronic psychiatric illness were excluded, as well as women with recognized chronic alcoholism, in all, 44 pregnancies.

Women who accepted the invitation to participate in the study but had a spontaneous abortion before they filled out the questionnaire were also excluded in accordance with the prospective design of the study. With regard to pregnancy order, parity, or occupational activity this group of 75 women did not significantly differ from the participating women who had a spontaneous abortion. The proportion of women above 34 years of age was, however, higher in the excluded group.

Ectopic pregnancies and women with a hydatidiform mole were excluded, along with the only woman who gave birth to triplets. Eighteen pregnancies were lost to follow-up, mainly because the women had emigrated during pregnancy.

Remaining for study were 4701 pregnancies. In 3906 of these, the women had worked for at least one week after their last menstrual period, and this population was used in the final analyses.

Analyses

The objective of the analyses was to estimate the relative importance of occupation and environmental exposures during pregnancy for the risk of having an adverse pregnancy outcome. The statistical methods were chosen to conform with this objective and with the method employed for selecting the study population. From a statistical point of view, using Fleiss' terminology, a survey of this kind constitutes a naturalistic or cross-sectional sampling (3). In addition we wanted to model the outcome variables for a large number of individuals and continuous, polytomous as well as dichotomous explanatory variables and confounders. We therefore decided to base the analysis on multivariate regression models, linear as well as binomial. The estimation techniques were based on the routines available in GLIM (generalized linear interactive modeling) (4), supplemented with the macros outlined in Wacholder (5). Our basic principle concerning the set of explanatory variables was to include the same set of social and life-style variables in the two different

Figure 1. Spontaneous abortion rates [(spontaneous abortions) / (all pregnancies under observation), calculated for each month of pregnancy] at different lengths of gestation.

analyses. Passive and active smoking (6, 7), alcohol use (8), and coffee consumption (9, 10) are established or previously suggested risk factors with regard to reproduction, along with some biological and social factors (11). A discussion of the estimates obtained for these factors and some of the other exposures (eg, physical factors, stress, etc) included in the questionnaire is beyond the scope of this presentation.

A binomial regression model was used in the analysis of spontaneous abortion and perinatal death (spontaneous abortion-perinatal death) and the constructed variable "adverse outcome." This latter variable attained values of nonadverse and adverse outcome, where adverse outcome was defined for one or more of the following unidimensional outcomes: spontaneous abortion, perinatal death, congenital malformation, or birthweight less than 2500 g among live term births (gestational length ≥ 37 weeks). The parameter estimates from the multivariate binomial regression are estimates of the risk ratios (relative risks) (RR). In the tables they are shown together with 95 % confidence intervals (95 % CI). The latter have been calculated with large-sample formulas. The analyzed study groups have been dimensioned in the range of 2000–4000 individuals, and this range should give satisfactory validity for these formulas.

Multiple regression was applied in the analysis of birthweight, in grams. Age was used in its original coding, ie, age in years at the time of the last menstrual period, whereas it was used as a trichotomus variable in the binomial models. Sex of the infant and parity were also entered, the latter in a nonlinear form. The analyses were performed both with and without length of gestation (completed weeks since last men-

strual period) in the model. The regression coefficients and their 95 % confidence intervals are shown in the tables. The model fit is given by R^2 .

Results

The frequencies of spontaneous abortion-perinatal death, malformations, and low birthweight were 6.9, 2.7, and 4.2 %, respectively, among the women who had worked during pregnancy. Among the 795 non-working women the corresponding frequencies of 8.2, 3.4, and 4.5 % were found. When the group of working women was subdivided into three categories according to sector of employment, the rate of adverse outcome was 11.9 % among those employed in the industrial sector, 10.5 % in the health sector, and 10.1 % among all other pregnancies.

Multivariate analyses

Spontaneous abortion-perinatal death and adverse outcome. Age and previous spontaneous abortion were the strongest determinants for spontaneous abortion-

perinatal death, and adding occupation did not increase the explanatory power of the model. Consequently the adjusted relative risks for the occupational categories did not significantly deviate from unity when typists, clerks, and other office workers were used as the reference group (table 2). The highest estimate was obtained for nursing assistants/attendants (RR 1.24, 95 % CI 0.84–1.83) in the analysis of spontaneous abortion-perinatal death. The group of women who reported more than occasional exposure to solvents during pregnancy ($N = 115$) was found to have less unfavorable outcomes than the “unexposed” reference group (adjusted RR of spontaneous abortion-perinatal death 0.71, 95 % CI 0.31–1.60; RR of adverse outcome 0.57, 95 % CI 0.29–1.13). For the category “other chemical exposure” the adjusted risk estimate was elevated to 1.27 (95 % CI 0.82–1.97) for spontaneous abortion-perinatal death and 1.28 (95 % CI 0.91–1.80) for adverse outcome.

Birthweight. There was a tendency for higher birthweights in the category “cleaners, waitresses and cooks” compared with the reference group (table 3).

Table 2. Relative risks (RR) of unfavorable pregnancy outcome for different occupational categories. The regression analyses included several nonoccupational factors as independent variables.^a The calculations were done for the 3525 individuals with complete data. (95 % CI = 95 % confidence interval)

Occupational group	Spontaneous abortion-perinatal death		Adverse outcome	
	RR	95 % CI	RR	95 % CI
Typists, clerks, and other office workers	1.0	Reference	1.0	Reference
Nursery school teachers and other workers in child nursing	1.12	0.69–1.82	0.90	0.61–1.31
Primary school teachers	0.83	0.33–2.05	0.62	0.29–1.33
Other teachers and social workers	1.19	0.71–1.99	0.80	0.51–1.24
Nurses, physiotherapists, and laboratory workers	1.12	0.69–1.84	0.98	0.67–1.43
Nursing assistants/attendants	1.24	0.84–1.83	1.08	0.80–1.45
Sales and service occupations	0.90	0.54–1.50	0.79	0.54–1.17
Cleaners, waitresses, and cooks	1.19	0.70–2.02	0.77	0.49–1.19
Industrial and agricultural workers	1.10	0.68–1.77	0.81	0.56–1.19

^a Age, previous spontaneous abortion, educational level, passive and active smoking, alcohol use, and coffee consumption.

Table 3. Birthweight (g) and occupation. The multiple regression analysis included several nonoccupational factors as independent variables^a with (I) and without (II) length of gestation in the model. The calculations were done for the 3253 individuals with complete data. (95 % CI = 95 % confidence interval)

	I		II	
	Regression coefficient	95 % CI	Regression coefficient	95 % CI
Length of gestation	165.6	157.1–174.1	—	—
Occupation				
Typists, clerks, and other office workers	—	Reference	—	Reference
Nursery school teachers and other workers in child nursing	–17.6	–75.3–40.2	–22.2	–91.7–47.3
Primary school teachers	6.1	–89.3–101.6	31.4	–83.6–146.4
Other teachers and social workers	15.3	–50.3–80.9	28.0	–51.0–107.1
Nurses, physiotherapists, and laboratory workers	–27.6	–87.2–32.0	–34.6	–106.3–37.2
Nursing assistants/attendants	5.0	–44.2–54.3	–9.4	–68.7–49.9
Sales and service occupations	24.9	–34.0–83.8	37.3	–33.7–108.2
Cleaners, waitresses, and cooks	76.1	8.3–143.8	74.4	–7.1–156.0
Industrial and agricultural workers	28.3	–31.2–87.9	28.5	–43.2–100.3
	$R^2 = 0.36$		$R^2 = 0.08$	

^a Age, parity, sex of infant, previous spontaneous abortion, educational level, passive and active smoking, alcohol use, and coffee consumption.

The regression coefficient for solvent exposure was positive (165, 95 % CI 76–254), ie, the women exposed to solvents gave birth to heavier infants than the unexposed women. For “other chemical exposure” a negative coefficient of –48 (95 % CI –104–8) was obtained. None of these estimates were notably changed when length of gestation was omitted from the model.

Discussion

The data obtained in this study did not indicate any large differences in risk for unfavorable pregnancy outcomes between the occupational and exposure categories used. The limited size of the study made it necessary to keep some of these categories rather wide and nonspecific, thus allowing for possible “dilution” effects with regard to specific exposure situations.

Elevated risks for spontaneous abortion and/or malformations have been found for chemical and laboratory workers in some earlier studies (1). In many of these studies, organic solvents have been pointed out as a possible risk factor, although such a risk factor could not be confirmed in a more recent study (12). Our findings do not suggest that organic solvents are hazardous in this respect at the exposure levels common during the study period. In Örebro County solvent exposure occurred frequently in, eg, the chemical and microelectronics industry, shoe manufacturing, and hospital laboratories. In the late 1970s the neurotoxicity of organic solvents came to public attention, and efforts were made to reduce exposure in many workplaces. It is our estimation, based on knowledge from industrial health services, that most exposures to organic solvents during the study period were well below the Swedish occupational standards.

The finding of higher birthweights among the solvent-exposed than among the unexposed referents is somewhat surprising. We collected information on the height and prepregnancy weight of the women in a small sample of the study population (N = 305). There was no indication that the solvent-exposed women were bigger than the others, an occurrence which otherwise might have explained our finding (13).

There was an indication that chemical exposure other than solvents might have been associated with an increased risk of unfavorable outcome. Exposure to anesthetic gases, lead, and various other chemicals were included in this category, but the numbers of women with one specific exposure were too small for detailed statistical analysis to be meaningful. The finding is suggestive, however, especially since chemical exposures were often underreported, as will be discussed below.

Selection and participation

The source population for the study was women of reproductive ages living in Örebro County during the

study period. Less than 10 % of this population were foreign citizens, mostly Finnish. Registration started at the prenatal care center in the city of Örebro and was later extended to all centers in the county. Women from Örebro therefore accounted for almost two-thirds of the studied pregnancies, and, since the health and service sectors dominate in this municipality, the proportion of women engaged in the industrial sector is rather small in the total material. Women working in agriculture constituted only 1 %.

Participation was higher among the women who worked at the beginning of pregnancy than in the non-working group. The latter was a heterogeneous population including housewives, unemployed women, and disabled persons, who would be expected to be less motivated to participate in this kind of study. When looking at the occupational title recorded at the prenatal care center, we found the nonparticipation rate to be 13 % among cleaners, 10 % among clerks and nursing assistants/attendants, 8 % among nurses, and 4 % among nursery school teachers. This finding indicates that participation was dependent to some extent on educational level and type of work.

Eighteen percent of all the cases of spontaneous abortion registered were excluded since these women did not fill out the questionnaire before the outcome of pregnancy was known. Most of these were early spontaneous abortions (72 % before the 12th week of pregnancy). However, including length of gestation when first registered in the study in the binomial regression analysis did not change the risk estimates for the occupational categories.

Olsen (14) has estimated the “induced abortion bias” arising from differences in the legal abortion rate between an exposed group and a reference group. In a separate study (unpublished) performed at the Örebro Medical Center Hospital during the study period, we collected information on occupation for 764 women having a legally induced abortion. We then estimated the frequency of legal abortions in the main occupational categories used in the prospective study. It was found to vary by a factor of four — lowest among nurses and highest among cleaners. From this data, it was possible to calculate the influence of legal abortions on the risk estimates obtained in the regression analysis. We found that the results presented in table 2 might overestimate the “true” risk ratios by a maximum of 10–20 % when, for example, cleaners are compared with clerks. A corresponding underestimation might appear when nurses are compared with clerks.

Exposure classification and ascertainment of outcome

In order to validate the exposure data given by the women, we had an industrial hygienist visit the workplaces of 103 women during their pregnancy, shortly after registration. Without knowing what the women had answered in the questionnaire, the industrial hy-

gienist classified exposure in a way corresponding to the questions included in the questionnaire. The sensitivity and specificity of the exposure classification method (the questions in the questionnaire) could then be estimated. Generally specificity was found to be high (>0.90). Because of the limited number of workplaces investigated, sensitivity could not be estimated for all the exposures, but it was found to be rather low for solvents (0.35) and the unspecific question about "other chemical substances" (0.25) and better for heavy lifting (0.79). The closer to unity the relative risk is the less is the magnitude of the bias resulting from misclassification (15). If we suppose that 15 % of the total working population analyzed had been more than occasionally exposed to chemicals other than solvents during pregnancy and that the sensitivity of the questionnaire in this respect was 0.30, and specificity 0.98, the true risk ratio for "adverse outcome" would be 1.48 [calculated according to the formula of Flegal et al (15)] rather than 1.28.

All infant diagnoses were extracted from the hospital records. In some unclear cases the preliminary diagnosis was replaced by the diagnosis established during the pediatric follow-up. Almost all cases of spontaneous abortion were diagnosed by a physician, and the hospital records were scrutinized in order to get the best estimate of the length of gestation. In cases of "missed abortion" the date of admission to the hospital was substituted for the unknown time of death of the fetus when the gestational length was estimated.

Confounding

Gravidity and parity were not included in the final binomial regression models because they were not significantly associated with the outcome variables spontaneous abortion-perinatal death and adverse outcome when age and previous spontaneous abortion were also included. The same finding concerning spontaneous abortions has been reported by Kleine et al (16). Parity had an independent influence on birthweight, but the proportion of infants with low birthweight (<2500 g) among all pregnancies which resulted in an adverse outcome was rather small.

A woman whose pregnancy under study ended in a spontaneous abortion may have experienced a previous spontaneous abortion while engaged in the same type of work. Including previous spontaneous abortion as a separate risk factor in the regression model could make the interpretation of the results concerning, eg, the occupational categories more difficult. Omitting this factor in the analysis, however, did not change the risk estimates.

Several other nonoccupational factors may have had an influence on the course and outcome of pregnancy, but they were not likely to be associated with occupational exposure and thus would not introduce confounding into the analysis.

Concluding remarks

The prospective approach has been rather uncommon in reproductive epidemiology dealing with environmental exposures. It clearly has an advantage compared with retrospective studies when exposure information is collected from the women themselves or from other sources vulnerable to recall bias. Ideally exposure data should be collected from independent sources also in prospective studies, especially when quantification is attempted in order to evaluate dose-response relationships.

A study of the type presented, performed during a limited time in a geographic area with a limited number of female inhabitants of reproductive ages, does not yield large numbers of pregnancies with specific exposures. Our study reflects the occupational conditions for pregnant women prevailing in Örebro County during the study period. General surveys of this kind may have a value on the community level to estimate risks (and costs) with regard to broad occupational or other categories in the population. When the aim is to test the hypothesis that a specific exposure is hazardous with regard to reproduction, it is probably more effective to select the study populations most suitable for this specific purpose. The prospective design is favorable with regard to internal validity, but is more time-consuming and expensive in comparison with retrospective studies.

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