Scand J Work Environ Health [1987;13\(5\):399-403](#)

<https://doi.org/10.5271/sjweh.2021>

Issue date: Oct 1987

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The following articles refer to this text: [2013;39\(4\):335-342](#);
[2014;40\(4\):411-419](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/3324320

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Association between spontaneous abortion and ergonomic factors

A literature review of the epidemiologic evidence

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GOULET L, THÉRIAULT G. Association between spontaneous abortion and ergonomic factors: A literature review of the epidemiologic evidence. *Scand J Work Environ Health* 13 (1987) 399–403. This article presents a literature review of seven epidemiologic studies which address the issue of spontaneous abortion and ergonomic factors. The following four ergonomic factors are analyzed: (i) shift work, (ii) piece work, (iii) posture, (iv) heavy lifting and physical effort. Among these factors, the last, heavy lifting and physical effort, is the only one that seems to be associated with an increased risk of spontaneous abortion.

Key terms: heavy lifting, physical effort, piece work, posture, pregnancy, shift work, work.

Ergonomic factors represent the major occupational constraint of working women. The increasing number of women continuing their professional activity during pregnancy makes it important to assess the effect of ergonomic factors on the outcome of pregnancy. Among these outcomes, spontaneous abortion constitutes the most frequently occurring phenomenon. Between 10 and 20 % of all pregnancies surviving to four weeks from the last menstrual period end in spontaneous abortion. The percentage goes up to 40 for pregnancies which survive three weeks' gestation (11). Thus the frequency of spontaneous abortion is actually higher than the average 15 % currently diagnosed. Causes of spontaneous abortion are either fetal or maternal. The frequency of chromosomal anomalies in all spontaneous abortions stands between 30 and 50 %. The younger the abortus, the more likely it is to present a chromosomal anomaly. In general the anomaly is directly responsible for the fetal death. In cases in which the abortus does not show a chromosomal anomaly, a maternal cause can sometimes be found. Among maternal causes of spontaneous abortion, uterine malformations, hormonal deficiencies, immunologic problems, and drug intake have been reported.

Other factors are known to increase the risk of spontaneous abortion, although the mechanism of action, be it fetal or maternal, has not always been elucidated. Maternal age, parity, socioeconomic status, history of previous spontaneous abortion, and tobacco and alcohol consumption have been identified as nonoccupational risk factors. Age is probably the factor more likely to confound the association between ergonomic

constraints and spontaneous abortion since it has a relatively great effect on spontaneous abortion and it could be differentially distributed among exposed and unexposed pregnant workers.

As far as occupational risk factors are concerned, research has focused mainly on chemical exposures of pregnant workers or their spouses. An increased risk of spontaneous abortion has been suggested for female workers exposed to anesthetic gases (10), workers in laboratories (12, 15), copper smelteries (14), workers in electronics (radios and televisions) (8), workers involved in chemical sterilization (ethylene oxide and glutaraldehyde) (7), chemical manufacturers (plastics, pharmaceuticals, and laundries) (5, 12), butchers and sausage makers (12), fur bearing animal caretakers (12), textile workers (6, 12), and wives of vinyl chloride workers (9). Despite the suspected effect ergonomic factors have on spontaneous abortion, the paucity of research on this question is striking. However, published data tend to suggest that some ergonomic factors may increase the risk of spontaneous abortion. The review of these findings constitutes the objective of this article. First, relevant results of each study have been presented. Then, the methodological limitations of these studies have been discussed. Finally conclusions have been drawn.

Results from existing studies

In examining the literature, we have identified seven studies that deal with the subject of spontaneous abortion and ergonomic factors. They are presented in chronological order in the text, and the results are summarized in table 1.

In 1982, Uehata & Sasakawa (17) published a study sponsored by Japanese unions to evaluate health and social problems of night and shift workers. A questionnaire was distributed to 23 813 workers. A total of 81.9 % answered the questionnaire, including 2 264

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Table 1. Spontaneous abortion and ergonomic factors — Summary of the literature.

Reference	Occupational group or characteristic	Number of workers	Risk ratio ^a	95 % confidence interval	Ergonomic factors suspected		Confounders controlled for
					Positive	Negative	
Uehata & Sasakawa (17)	Shift/day workers	36	1.58*	..	Shift work	None	Age, parity, previous spontaneous abortion
Hemminki et al (6)	Textile factory workers/all manufacture workers	21	1.54*	..	Piece work	None	
	Seamstresses/all manufacture workers	19	1.79*	..	Piece work	None	
Figa-Talamanca (2)	Pharmaceutical workers/homemakers	67	1.28	..	None	Posture	Age, parity, education, marital status
	Pharmaceutical workers/other work	67	1.04	..	None	None	
	Plastics and rubber/homemakers	48	1.56*	..	None	None	
	Plastics and rubber/other work	48	1.69*	..	None	None	
	Standing/sitting workers		0.98	..	None	None	
	Alternate/sitting workers		1.29	..	None	None	
Axelsson et al (1)	Laboratory workers		3.2*	(1.36—7.47) +	Shift work	Heavy lifting	Age, parity, year of pregnancy, previous spontaneous abortion, smoking
Heidam (4)	Self-reported	Factory workers	46	1.7	1.0—2.9	Shift work	Age, parity, pregnancy order
	Self-reported	Painters	5	2.9	(1.0—8.8) +	None	
	Validated	Factory workers	128	1.4	1.0—1.9	None	
	Validated	Painters	5	1.4	0.4—2.5	None	
Taskinen et al (16)	Employed first trimester/general population	44	1.28	..	Heavy lifting	Posture	Age, parity, solvents
	Not employed first trimester/general population	98	1.25	..	None	None	
	Estrogens	6	4.2*	1.0—18.2	None	None	
	Heavy lifting	6	5.7**	1.3—26.0	None	None	
McDonald et al (13)	Nursing assistants ^b	64	1.24*	..	Heavy lifting	Posture	Age, parity, previous spontaneous abortion, education, smoking
	Nursing assistants ^c	156	1.13*	..	Heavy lifting	Posture	
	Cleaners and janitors ^b	87	1.31***	..	Physical effort	Shift work	
	Cleaners and janitors ^c	198	1.11***	..	Physical effort	Shift work	
	Sales workers ^b	69	1.18	..	None	Piece work	
	Sales workers ^c	162	1.12*	..	None	Piece work	
	Lifting heavy weights ^b		1.20***	..	None	None	
	Lifting heavy weights ^c		1.03***	..	None	None	

^a Ratios calculated by authors when not specified in original article.

^b Current pregnancy.

^c Previous pregnancy.

* $P < 0.05$, ** $P = 0.02$, *** $P < 0.01$.

women. Of these female respondents, 70 % were night and shift workers, mainly hospital nurses and telephone operators. Spontaneous abortion was reported significantly more frequently by female night and shift

workers (28.1 %) ($P < 0.05$) than by day workers (17.8 %).

A second study was conducted by Hemminki et al (6) in Finland between 1974 and 1977. It focused on

spontaneous abortion and the occupation of fathers and mothers in an industrialized community (30 000 inhabitants). Pregnancy outcomes were ascertained through the hospital discharge register, and information on occupation was collected from the national census of 1975. Of the women 83 % could be traced through the census data. A total of 2 693 pregnancies were studied. Compared to the crude rate of spontaneous abortion among all manufacturing workers, that for one textile factory was significantly higher (17.6 %) ($P < 0.05$), especially among seamstresses (20.4 %) ($P < 0.05$).

The authors also explored the interaction between the jobs of the fathers and mothers. The risk of spontaneous abortion was three times higher for women who worked in a textile factory and whose husbands were working in metallurgy [odds ratio 3.8 ($P < 0.05$)]. According to the authors, the textile workers did not differ from other working women with respect to age, parity, and previous spontaneous abortion.

Textile work in Finland is characterized by piece work without shift work, high noise levels, and a dusty environment. To account for the interaction, besides chance, the authors suggested a paternal effect. In their discussion they raised several potential sources of bias. The loss of women who could not be traced may have caused a small bias against the observed differences since those women were likely to belong to relevant occupational groups. It should be noted that the information on occupation was retrieved from the 1975 census, whereas the pregnancies were collected from 1974 to 1977, and therefore a possibility of misclassification existed.

Figa-Talamanca (2) published the results of a study on spontaneous abortions observed among Italian unionized female workers who were employed in the following industrial sectors in 1980–1982: textile, electromechanics, light bulbs, pharmaceuticals, plastics and rubber, and thread and wool. Interviews were conducted with 72 % of the eligible women to assess exposure and outcome. A total of 5 348 pregnancies reported by 4 121 women were studied. The abortion rates of the subjects were compared with the rates of the same women while they were employed in other work settings or when they were homemakers. The only sectors associated with a higher risk of spontaneous abortion were pharmaceuticals (abortion rate 13.3 % compared to 10.4 % for homemaking and 9.6 % for other type of work, and plastics and rubber (16.2 %) ($P < 0.05$). The association did not seem to be confounded by age, educational level, parity, or marital status although, according to the author, smoking may have been a confounder for the higher rate of spontaneous abortion observed in the pharmaceutical industry.

The author also looked at the posture of the pregnant workers. The small difference observed in the rates of spontaneous abortion between sitting (10.3 %), standing (10.1 %), and alternate positions

(13.3 %) was not statistically significant. One could criticize the fact that the information on postures was available for only 79 % of the subjects and that postures were measured crudely, not taking into account the number of hours spent in the position in question or in other activities performed, such as lifting.

The relationship between exposure to solvents and the outcome of pregnancy was studied by Axelsson et al (1) among university laboratory employees in Sweden. A questionnaire was distributed to 782 women employed between 1968 and 1979; the response rate was 95 %. An analysis of possible risk factors for miscarriage, such as infectious disease, medication, work with X-rays or radioactive isotopes, heavy lifting, stress, and shift work, was performed with a multiple regression analysis. Only validated information was kept in the analysis. Exposure to organic solvents in laboratory work was not found to be associated with a significant risk of spontaneous abortion. Shift work during pregnancy was related to a significant miscarriage risk. Factors such as stress, changes in diurnal rhythm, and population selection mechanisms for pregnancy in shift workers could explain these findings. No relation between heavy lifting and miscarriage was observed.

Another researcher, Heidam (4), based his investigation on the hypothesis that the exposure of pregnant workers to chemicals increases the risk of spontaneous abortion. This study, conducted in Denmark between 1972 and 1980, used data from a historical prospective cohort of 5 853 women exposed to various chemicals in their work. There were dental assistants exposed to nitrous oxide and inorganic mercury, factory workers and painters exposed to organic solvents, and gardening workers exposed to pesticides. Comparison groups were selected from the same occupational category and defined as workers less exposed to chemicals. In addition, factory workers and their reference group (workers in large supermarkets and warehouses) were comparable for both work postures and physical strain. Between 85 and 94 % of the female workers completed a postal questionnaire. Outcome information was validated from hospital records. After controlling for confounders, including maternal age, the author found that only factory workers and painters had odds ratios of borderline significance for self-reported spontaneous abortions. Odds ratios for hospital registered spontaneous abortions were also of borderline significance for the factory workers. The results involved small numbers. For factory workers, noise and shift work may explain the association observed. No exposure to any single chemical during pregnancy was associated with an increased risk of spontaneous abortion.

Recently, in 1986, Taskinen et al (16) published the results of a study conducted in order to determine whether Finnish pharmaceutical factory workers had a higher risk of spontaneous abortion than the general population or matched referents. During the study

period (1973 or 1975 to 1980), female workers employed in eight pharmaceutical factories experienced 1 795 pregnancies. Pregnancy data were collected from the national hospital discharge register and polyclinic records of hospitals. A questionnaire was sent to the factory physicians to evaluate occupational exposures. The response rate was 93 %. The rate of spontaneous abortion for women employed during the first trimester of their pregnancy (10.9 %) was not different from the one observed in the general population (8.5 %). For those not employed during the first trimester, the rate of spontaneous abortion was 10.6 %. A case-referent study was then carried out on the 44 subjects who had had a spontaneous abortion. Three age-matched referents were selected for each case from female factory workers who had given birth to a child during the same period. Since information on smoking and previous pregnancies was available for less than 50 % of the cases and referents, it could not be used in the analysis.

In a logistic regression model including solvent exposure, estrogen exposure, and continuous heavy lifting, the two latter were significantly associated with an increased risk of spontaneous abortion. Work position (sedentary, standing or both) did not affect the miscarriage rate. The authors concluded that "heavy lifting in early pregnancy may have some practical consequences but the result should be confirmed in an independent series."

In Canada, an investigation of spontaneous abortion and occupation was conducted by McDonald et al (13). Between May 1982 and May 1984, 56 012 women were interviewed in 11 large obstetrical units in Montreal after delivery (51 881) or treatment for a spontaneous abortion (4 127). In addition information was collected about their 48 608 previous pregnancies. The nature of all paid work undertaken at any time during pregnancy was recorded in some detail. The results showed that, after nonoccupational confounders had been controlled for, the ratios of observed to expected abortions were significantly increased for nursing assistants and attendants, cleaners and janitors, and certain sales occupations.

Analyses also looked at exposures. Women whose work entailed heavy lifting, other physical effort, long hours of standing, exposure to noise, and exposure to cold had a significantly increased risk of spontaneous abortion. Rotating shift work and piece work were unrelated to an increased risk of spontaneous abortion. The time elapsed between exposure and outcome may be different for women giving birth at or near term than for women experiencing spontaneous abortion. Since women are interviewed at the time of the outcome, women giving birth at nine months may have restricted their physical activity towards the end of pregnancy while women with spontaneous abortions are more likely not to have experienced the same kind of restrictions. To minimize problems of recall bias and time difference, a second type of analysis was performed. The percentage of pregnancies in which a par-

ticular work demand was recorded (regardless of the outcome) was calculated for each occupational group. Then the groups were reclassified according to the frequency of each work demand. Tests for trend were made. Increased risks were still found to be associated with heavy lifting and other physical effort.

Discussion

The studies reviewed in this article share methodological problems related to confirmation of outcome, accuracy of exposure data, and multiple statistical testings.

The use of hospital discharge data may not be a very sensitive method for the detection of occupational effects leading to early abortions. On the other hand, using questionnaires to identify the outcome may lead to a biased overestimation of the actual frequency of spontaneous abortion. In that sense any woman who believes that a particular job exposure is dangerous to her pregnancy could tend to declare retarded menstrual bleeding as a pregnancy loss. In any case confirmation of the outcome and accurate measurement of exposure from information from workplaces helps minimize important biases.

Finally multiple comparisons were widely used in all the studies reviewed. One should remember that such a technique may give positive results just by chance.

The following conclusions emerge from the seven reviewed studies. Four ergonomic factors were suggested as risk factors of spontaneous abortion, ie, shift work, piece work, posture, and heavy lifting and physical effort. An association between shift work and spontaneous abortion was found to be positive in three studies (1, 4, 17) but not in one (13). Different methodologies were used, some of which may have suffered from biases. The Uehata & Sasakawa (17) approach is vulnerable to selection bias since participation was requested on a voluntary basis. Moreover, in this study, no effort was made to validate the outcome of pregnancy or control for confounders. In Heidam's study (4), shift work was only a speculation or tentative interpretation of the excess risk observed among factory workers. The Axelsson et al (1) and McDonald et al (13) studies looked specifically at shift work as an independent variable and validated the cases of spontaneous abortion with hospital records. In these two studies, the use of questionnaires and interviews to assess exposure was unlikely to be a major source of recall bias since shift work is an objective piece of information. One study came up with positive results, the other with negative results. Certainly, further research is needed to shed some light on these divergent findings.

Piece work was brought forward by Hemminki et al (6) as a possible explanation for the excess risk of miscarriage among textile workers. According to the authors, the loss of 17 % of the eligible subjects could

have possibly decreased the risk level observed. Looking specifically at piece work and controlling for confounders, McDonald et al (13) found no association between this factor and spontaneous abortion. Up to now there is little evidence sustaining the association between piece work and spontaneous abortion.

Work posture has also been studied as a risk factor of spontaneous abortion. The hypothesis of an increased risk of spontaneous abortion associated with work posture was not confirmed by Figa-Talamanca (2), Taskinen et al (15), or McDonald et al (13). It is likely that, when confounders and other occupational risks are taken into account, work posture by itself fails to be significant.

The two 1986 studies showed a positive association with heavy lifting. With small numbers of cases, Taskinen et al (15) found a high risk ratio of 5.7. On the other hand, McDonald et al (13) found a small risk ratio of 1.20 for current pregnancies and 1.03 for previous pregnancies with large numbers. In both studies, a special effort was made to validate the outcome and the exposure. Axelsson et al (1) did not find an association, but small numbers may in part have been responsible for this negative result. The suggestion of an increased risk of spontaneous abortion with heavy lifting and other physical effort is interesting in the way that it substantiates the popular belief that heavy lifting is dangerous, particularly early in pregnancy. Nevertheless, the physiological mechanism of a lethal effect of physical exercise in early pregnancy remains unclear. Explanatory hypotheses such as fetal hyperthermia and changes in circulating maternal hormone levels leading to uterine contractility have been proposed (3). Hence, it seems plausible that the mechanism of action is not mediated by a chromosomal anomaly.

At the conclusion of this review, many questions remain unanswered. For example: Could the fetal response be exaggerated by other maternal or environmental factors (ie, heat)? If the association between heavy lifting and spontaneous abortion exists, is there a dose-response relationship, that is, how heavy does a weight have to be before it becomes dangerous? Experimental and epidemiologic research is certainly needed to elucidate these questions and to help establish valid guidelines for implementing preventive measures.

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Received for publication: 17 March 1987