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Shift work, fetal development and course of pregnancy

by Tuula Nurminen, MSc¹

NURMINEN T. Shift work, fetal development and course of pregnancy. *Scand J Work Environ Health* 1989;15:395-403. Information on 1475 mothers of infants with selected structural malformations and an equal number of mothers of "normal" babies was analyzed for a possible relationship between shift work and adverse pregnancy outcome or a complicated course of pregnancy. The primary data were obtained from the Finnish Register of Congenital Malformations supplemented by special interviews on the mothers' work conditions. No signs of a teratogenic risk were observed. The relationship between course of pregnancy and outcomes other than malformations was determined from the noncase mothers' experience. Threatened abortion and pregnancy-induced hypertension were not associated with rotating shift work alone, but in a noisy work environment moderate risks could not be ruled out. Rotating shift work was associated with a slight excess of babies small for their gestational age independently of noise exposure. The results suggest that further studies on the effects of different work schedules on pregnancy are worth consideration.

Key terms: birth defects, birthweight, length of gestation, malformations, occupation, pregnancy-induced hypertension, threatened abortion, vaginal bleeding.

Few investigations have been made on the possible relationship between shift work and fetal development or course of pregnancy. In a Japanese study (1) shift and night workers reported spontaneous abortion more frequently than day workers. Shift work in laboratories was related to a clearly higher rate of spontaneous abortion in a Swedish study (2). But this relation was not confirmed in a later investigation (3), and only a slightly increased risk was associated with work entailing irregular hours or rotating shifts as compared with day work only. In a study in Montreal (4) rotating or irregularly changing shift work was related to spontaneous abortion, and the association was confirmed in a second analysis of the same data. Shift work and night work was associated with preterm delivery in a French study (5). However, another French study (6) found no relation between preterm delivery or low birthweight and night work. In the Montreal study (7) changing shift work was related to preterm birth and low birthweight, but not consistently. Because of the large overlap between preterm birth and low birthweight, the data of the Montreal study were analyzed further, and gestational age was allowed for when birthweight was the outcome. The results suggested that shift work retarded fetal growth and increased the risk of preterm birth (8). The results of the later Swedish study (3) supported the hypothesis that irregular work schedules might have a negative influence on birthweight.

To investigate the effects of shift work on teratogenic risk, threatened abortion, pregnancy-induced hypertension, length of gestation, and birthweight, the present study scrutinized the experience of 1475 mothers of infants with selected structural malformations and an equal number of mothers of noncase babies. The study was part of a project whose original goal was to explore the possible role of occupational factors in the occurrence of birth defects (9).

Subjects and methods

Birth defects

The source information of the study was the Finnish Register of Congenital Malformations between June 1976 and December 1982. The data included 365 defects of the central nervous system, 581 orofacial clefts, 360 structural defects of the skeleton, 169 cardiovascular malformations, and 1475 noncase babies whose deliveries had preceded the case deliveries in the same maternity health care district (9). The mothers of the time- and area-matched case-noncase pairs of babies were interviewed by means of standard Register procedures about particulars of the latest and previous pregnancies, diseases, consumption of drugs and alcohol, smoking habits, etc (10). The Register data were supplemented with interviews on the mothers' work conditions. Two trained interviewers from the Finnish Institute of Occupational Health carried out the interviews. (For details, see references 9, 11, and 12.)

The special interview started with a question inquiring if the mother had worked during her pregnancy most of the time, only temporarily, or not at all. In addition to information on the employer, job title, and

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Table 1. Occupational classification of the mothers in shift work during early pregnancy.

Major occupational group ^a	Two-shift workers	Three-shift workers	Other type of shift workers	Total
0 (technical, physical science, social science, humanistic and artistic work)	53	7	111	171
1 (administrative, managerial and clerical work)	13	2	—	15
2 (sales work)	8	—	2	10
5 (transport and communication work)	5	4	1	10
6/7 (manufacturing and related work)	43	18	2	63
8 (service work)	78	6	3	87
9 (work not elsewhere classified)	8	1	3	12
Total	208	38	122	368

^a According to reference 14.

Table 2. Physical load of the mothers who did shift work and those who did nonshift work in the first trimester of their pregnancy.

Mean physical load ^a	Shift workers		Nonshift workers	
	N ^b	%	N ^c	%
Sedentary work	127	34.8	1114	57.5
Standing work	131	35.9	443	22.9
Work involving walking	81	22.2	106	5.5
Work with a moderate physical load	26	7.1	273	14.1

^a See reference 15 for a description of the assessment of physical load.

^b There were three mothers with missing data on physical load.

^c There were 43 mothers with missing data on physical load.

time of employment, the mother was asked if she had worked in shifts. Of the mothers, 2073 had worked throughout most of their pregnancy, and 603 had not worked in the first trimester, the risk period for structural malformations (10). In all, 274 mothers had worked temporarily in the first trimester, and the reason for stopping work was the termination of employment for 47 % of these mothers, maternity leave or vacation for 10 %, and sick leave or overstrain for 18 %. The rest had other reasons or the reason was unknown. The mothers who did not work in the first trimester of pregnancy were excluded from the analyses when birth defects were studied.

Altogether, 368 mothers (16 % of those who had worked) had done shift work during early pregnancy, 41 temporarily and 327 regularly. In the shift work group, 57 % of the mothers had worked in two shifts, 10 % in three shifts, and 33 % had work arrangements that differed in some manner from normal daily work, mainly periodic work. In Finland, the individuals who work in shifts usually do rotating shift work in which the work schedule changes after every week in two-shift work and after 4 d in three-shift work, while in periodic work the cycle is two or three weeks (13). In

the two-shift group almost 40 % had been in service work and about one-half had been in manufacturing or nursing work. Of the mothers working in three shifts, almost one-half had done manufacturing work. The mothers in other types of shift work were mainly in the nursing field. (See table 1.)

According to the classification of socioeconomic status of the Central Statistical Office of Finland (14), most of the mothers (96 %) in shift work during early pregnancy were lower-level employees with administrative and clerical occupations or manual workers whereas 84 % of the mothers in nonshift work belonged to these categories. None of the women in shift work had been employed in farming. Possible confounding was controlled for in additional analyses in which the subjects were restricted to nonagricultural workers in the two aforementioned socioeconomic classes.

The physical load of the occupational activities of the mothers was evaluated with a standardized method reflecting energy expenditure (15). The group in shift work included relatively more women in standing work and in work involving walking. Nonshift work was more often sedentary, but also moderate physical load was more common in nonshift work (table 2). Over one-half of the mothers in nonshift work with a moderate physical load had worked in agriculture.

Two industrial hygienists independently assessed exposure to noise blindly from a description of the mother's workday and a fixed question on noise exposure (12). In all, 17 % of the mothers in shift work in the first trimester of pregnancy had been exposed to an 8-h equivalent continuous A-weighted sound level ($L_{Aeq(8-h)}$) of around 80 dB or higher during early pregnancy, whereas the corresponding percentage was seven in the nonshift group.

Similarly, two industrial hygienists assessed the mothers' solvent exposure on the basis of the workday description and a fixed question on solvent exposure (16). A mother was considered exposed if the continuous concentrations had been at least one-third of the threshold limit values for chemical substances

Table 3. Background characteristics of the shift and nonshift workers who worked temporarily in the first trimester of their pregnancy and those who worked throughout most of their pregnancy.

Background characteristic	Temporary work		Regular work	
	Shift workers (N = 41) (%)	Nonshift workers (N = 233) (%)	Shift workers (N = 327) (%)	Nonshift workers (N = 1746) (%)
Maternal age ≥ 35 years	9.8	9.4	7.0	8.6
No previous pregnancy	41.5	41.4	39.0	37.6
Previous deliveries without an adverse pregnancy outcome	17.0	28.4	31.3	35.1
Previous adverse pregnancy outcome ^a	41.5	30.2	29.7	27.3
Menstrual irregularity	9.8	6.2	13.2	9.1
Regular smoking	21.9	14.6	12.3	12.4
Alcohol intake	39.0	43.4	43.9	42.8
Intake of drugs in the first trimester ^b	26.3	31.6	30.7	25.8
Common cold or fever in the first trimester	19.5	12.4	17.7	15.5

^a Previous induced abortion, miscarriage, preterm delivery, malformed child, or stillbirth.

^b Vitamins and tonics not included.

in workroom air (17) or peaks had been higher than the threshold limit value. Exposure to solvents did not differ much between the shift and nonshift groups.

When the relation between shift work and malformations was studied, physical work load, exposure to noise and solvents, and temporariness of employment were adjusted for in the analyses.

The mothers who had been in temporary shift work during early pregnancy had experienced more previous adverse pregnancy outcomes and were more often regular smokers than the mothers in temporary nonshift work or in regular work. More women in shift work had had menstrual irregularities than those in nonshift work. (See table 3.) Table 4 presents the maternal characteristics that were adjusted for in the analyses.

The matching procedure had not correlated the case and noncase series with respect to shift work, and therefore the data were analyzed as independent series to enhance efficiency (18, 19). Confidence intervals for the crude odds ratios were calculated with the modified Cornfield method (20, 21). The adjusted odds ratio estimates and their confidence intervals were calculated from results of unconditional logistic regression analyses, which were executed with the SAS software system (22). The independent variables were entered into the models as binary codes, or category indicators were used. Before the final models were fit, stratified analyses were performed to judge whether the stratum-specific estimates of the effect of shift work could be considered constant and to obtain estimates against which the modeling results could be checked.

Birthweight and course of pregnancy

The second part of the present study, on birthweight and course of pregnancy, was based on the noncase

Table 4. Matched odds ratio estimates of all birth defects pooled for maternal characteristics among all the 1475 case-noncase pairs.

Maternal characteristic	Odds ratio ^a
Maternal age ≥ 35 years ^b	1.0
Birth order greater than three ^c	1.2
Two or more previous induced abortions ^c	1.8
Previous miscarriage ^c	1.1
Previous stillbirth ^c	1.4
Previous malformed child ^b	3.8
Regular smoking during pregnancy ^{b, d}	1.5
Alcohol intake during pregnancy ^b	1.1
Intake of drugs in the first trimester ^{b, e}	1.6
Common cold or fever in the first trimester ^b	1.8

^a Calculated from data matched on time and area.

^b Source: the Register questionnaire.

^c Source: the records of the maternity health care center.

^d All regular smoking compared to nonsmoking or temporary smoking during pregnancy. The odds ratio was 0.9 for temporary smoking during pregnancy, 1.4 for regular smoking of less than five cigarettes daily, and 1.5 for regular smoking of five or more cigarettes daily as compared with not smoking during pregnancy. There were nine mothers who had smoked over 20 cigarettes daily during pregnancy regularly.

^e Vitamins and tonics not included.

mothers' experience. This procedure has been described in more detail elsewhere (23, 24). Information on the noncase mothers' pregnancies was obtained from the Register questionnaires and the records of the maternity health care center.

The mother was asked in the Register interview if she had experienced a threatened abortion and what symptoms she had had. In the analyses vaginal bleeding with or without lower abdominal pain was considered an indication of a threatened abortion but not lower abdominal pain only.

An increase of at least 20 mm Hg (3 kPa) in the mean arterial blood pressure between the mother's first visit to the maternity health care center and her last visit

before delivery was considered a sign of pregnancy-induced hypertension (25).

The length of gestation was calculated from the first day of the last normal menstrual period. The small size of the noncase series did not allow a study of rare outcomes like preterm birth (length of gestation less than 259 d), whose occurrence was 2.6 % (27 mothers) among those who had worked during most of their pregnancy. Instead, the occurrence of pregnancies that were shorter than 280 d was studied. The reference value for the definition of a small baby for his or her gestational age was the tenth percentile birthweight of the babies of the same sex born to mothers in nonshift work in the same gestational age group. The applied gestational age groups were <37 weeks, 37–39 weeks, 40–41 weeks, and ≥ 42 weeks. (For more details on these outcomes see references 23, 24, and 26.)

Seventeen of the 1475 noncase mothers had twin births, and for one woman information on the number of fetuses was missing. These 18 mothers were excluded from the second part of the study. Of the remaining mothers, 267 had not worked during pregnancy, 146 had worked only temporarily, and 1044 had worked regularly throughout most of their pregnancy. A total of 178 mothers had done shift work regularly and 22 temporarily. For the mothers who had been in shift work throughout most of their pregnancy, the median duration of gestation at the termination of work was 242 d with a lower quartile (Q1) of 223 d and an upper quartile (Q3) of 251 d, and in nonshift work the median was 248 (Q1 225, Q3 252) d, respectively. In regular shift work the reason for stopping was maternity leave for 39 % of the mothers, sick leave for 32 %, and the rest had other reasons, including vacation, or the reason was unknown. In nonshift work the respective percentages were 45 and 27.

When the occurrence of threatened abortion was studied, all the mothers who had worked were part of the analyses, but, when other aspects of pregnancy were under consideration, only mothers who had worked throughout most of their pregnancy were included. The mothers' socioeconomic class and agricultural work were controlled by the same restrictions that were used in the study of birth defects, and the same features of work were adjusted for in the analyses.

For threatened abortion the possible confounders maternal age, parity, outcome of previous pregnancies, history of menstrual irregularity, intake of drugs, alcohol consumption, and smoking were controlled in the analyses. For pregnancy-induced hypertension maternal age, parity, outcome of previous pregnancies, alcohol intake, and smoking were adjusted for. The models for length of gestation included the covariates maternal age, parity, outcome of previous pregnancies, history of menstrual irregularity, alcohol intake, and smoking. In the study of the occurrence of babies small for their gestational age maternal age, parity, outcome of previous pregnancies, maternal

prepregnancy weight less than 50 kg, alcohol intake, and smoking were controlled for.

The estimates and confidence limits for the crude risk ratios were calculated according to the chi-square function procedure of Miettinen & Nurminen (21). The estimates of the adjusted risk ratios were calculated from the results of binomial regression analyses executed with the generalized linear interactive modeling (GLIM) program and the macros written by Wacholder (27). Independent variables were defined and analyses were performed that corresponded to the procedures used to study birth defects. The effect of shift work on vaginal bleeding and shortened length of gestation (less than 280 d) was not homogeneous when divided into strata according to noise exposure [test for heterogeneity of risk ratio (28) for vaginal bleeding $X^2 = 4.7$ ($P = 0.03$) and for shortened length of gestation $X^2 = 5.8$ ($P = 0.02$)], and some indication of corresponding heterogeneity was found for pregnancy-induced hypertension ($X^2 = 2.4$, $P = 0.12$). Therefore the estimates of the effect of shift work on vaginal bleeding, pregnancy-induced hypertension, and shortened length of gestation were presented separately for strata according to noise exposure, and the concerned product terms were included in the models. No other noteworthy signs of heterogeneity were found in the data, the smallest P -value being 0.15.

Results

Malformations

When all the birth defects were pooled, the crude odds ratio for shift work in the first trimester of pregnancy was 0.9 with a 95 % confidence interval (95 % CI) of 0.7–1.2, and the adjusted analysis yielded similar estimates. The crude and adjusted odds ratios for the separate malformation groups under study were unity or very close to it (table 5). When analyzed using the groups restricted to the nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers, the adjusted overall odds ratio estimate was 0.9 (95 % CI 0.7–1.1). In addition, the estimates for the specific malformation groups were very similar to those obtained in the unrestricted analyses.

Vaginal bleeding (threatened abortion)

In the group of mothers who had done shift work during pregnancy, the occurrence of vaginal bleeding was 12 %, and in the nonshift group 9 % had experienced symptoms of threatened abortion (risk ratio 1.3, 95 % CI 0.8–1.9). The crude risk ratio for shift work and threatened abortion in the first trimester was 1.3 (95 % CI 0.7–2.1). When the mothers' occupations were considered, it was revealed that the mothers who had done shift work in manufacturing and related occupations had an elevated risk of vaginal bleeding when

compared with the mothers in nonshift work in manufacturing (table 6).

In manufacturing, 82 % of the mothers in shift work had been exposed to a noise level of around 80 dB L_{Aeq} (8 h) or higher as against 54 % of the mothers in nonshift work. Exposure to noise modified the relation between shift work and the occurrence of vaginal bleeding. The risk ratio for shift work among the mothers who had worked in a noisy environment was 3.0 (95 % CI 1.2–7.5), but the risk for shift work was not elevated in the case of noiseless work environments (table 7). When work conditions and maternal background characteristics were taken into account, the adjusted risk ratio for shift work in a noisy environment was 1.8 (95 % CI 0.7–4.6), and for shift work in a noiseless environment the adjusted risk ratio was 0.8 (95 % CI 0.5–1.4). When the analysis was restricted to the nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers, the adjusted risk ratio for shift work in a noisy environment was 1.8 (0.7–4.8), and for shift work in a noiseless environment the corresponding value was 0.9 (95 % CI 0.5–1.5).

Pregnancy-induced hypertension

The occurrence of pregnancy-induced hypertension was 9 % among the mothers who had been in shift work and 7 % among those who had not worked in shifts (risk ratio 1.2, 95 % CI 0.7–2.0). The risk was elevated among the mothers who had done two- or three-shift work in a noisy environment; but, without noise exposure, the mothers in shift work had experienced no more pregnancy-induced hypertension than the mothers with normal daywork (table 8). The adjusted risk ratio for shift work in a noisy environment was 2.2 (95 % CI 0.7–6.5), and for noiseless shift work it was 1.0 (95 % CI 0.5–2.0). The restricted analyses yielded an adjusted risk ratio of 1.9 (95 % CI 0.6–5.6) for an association between shift work in a noisy environment and pregnancy-induced hypertension, and the adjusted risk ratio for shift work in a noiseless environment was 1.1 (95 % CI 0.6–2.3).

Length of gestation and birthweight

In all, for 39 % of the mothers in shift work, the length of gestation was less than 280 d, whereas the corresponding percentage in nonshift work was 44 %

Table 5. Mothers in shift work and those in nonshift work in the first trimester of pregnancy according to whether their baby was a case or noncase.

	Shift workers (N)	Nonshift workers (N)	Crude odds ratio ^a	Adjusted odds ratio ^a
Cases				
Central nervous system defects	44	237	1.0 (0.7–1.4)	1.0 (0.7–1.4)
Orofacial clefts	63	387	0.8 (0.6–1.1)	0.8 (0.6–1.1)
Skeletal defects	46	243	1.0 (0.7–1.4)	1.1 (0.7–1.6)
Cardiovascular defects	23	118	1.0 (0.6–1.6)	0.9 (0.6–1.5)
All cases pooled	176	985	0.9 (0.7–1.2)	0.9 (0.7–1.1)
Noncases	192	994		

^a 95 % confidence interval in parentheses.

Table 6. Vaginal bleeding (threatened abortion) and shift work according to the mothers' occupations.

Major occupational group ^a	Number of mothers ^b	Vaginal bleeding		Crude risk ratio	95 % confidence interval
		N	%		
0 (technical, physical science, social science, humanistic, and artistic work) & 1 (administrative, managerial, and clerical work)					
Shift work	97	10	10.3	1.1	0.6–2.1
Nonshift work	473	43	9.1		
2 (sales work), 5 (transport and communication work) & 8 (service work)					
Shift work	59	5	8.5	0.8	0.3–1.8
Nonshift work	280	30	10.7		
6/7 (manufacturing and related work)					
Shift work	33	8	24.2	3.0	1.3–7.0
Nonshift work	113	9	8.0		
3 (agriculture, forestry, and fishing) & 9 (work not elsewhere classified)					
Shift work	9	—	0.0	—	—4.5
Nonshift work	122	9	7.4		

^a According to reference 14.

^b There were two mothers in shift work and two mothers in nonshift work with missing data on the symptoms.

Table 7. Vaginal bleeding (threatened abortion) among the mothers with and those without exposure to noise in shift or non-shift work during pregnancy.

	Number of mothers ^a	Vaginal bleeding		Crude risk ratio	95 % confidence interval
		N	%		
Noisy environment ^b					
Shift work					
Any shift work	34	9	26.5	3.0	1.2—7.5
Two-shift work	26	8	30.8	3.5	1.4—8.8
Three-shift work	6	1	16.7	1.9	0.3—8.7
Nonshift work	68	6	8.8		
Noiseless environment					
Shift work					
Any shift work	164	14	8.5	0.9	0.5—1.6
Two-shift work	95	7	7.4	0.8	0.4—1.6
Three-shift work	10	1	10.0	1.1	0.2—4.5
Other shift work	59	6	10.2	1.1	0.5—2.3
Nonshift work	920	85	9.2		

^a There were two shift workers and two nonshift workers with missing data on the symptoms.

^b Level of noise an 8-h equivalent continuous A-weighted sound level of around 80 dB or higher. Two mothers had been in another type of shift work, and they had not had vaginal bleeding.

Table 8. Pregnancy-induced hypertension and shift work among the mothers with and those without occupational exposure to noise throughout most of their pregnancy.

	Number of mothers ^a	Pregnancy-induced hypertension		Crude risk ratio	95 % confidence interval
		N	%		
Exposure to noise ^b					
Two- or three-shift work	28	6	21.4	2.4	0.8—6.4
Nonshift work	66	6	9.1		
No noise exposure					
Shift work					
Two- or three-shift work	92	6	6.5	0.9	0.4—1.9
Other shift work	55	4	7.3	1.0	0.4—2.5
Nonshift work	798	58	7.3		

^a There were two shift workers and two nonshift workers with missing data on blood pressure.

^b Level of noise an 8-h equivalent continuous A-weighted sound level of around 80 dB or higher. One mother had been in another type of shift work and had not had pregnancy-induced hypertension.

(crude risk ratio 0.9, 95 % CI 0.7—1.1). Table 9 shows the distributions of the gestational ages of the babies according to whether their mothers were in shift or nonshift work. In a noisy environment, 57 % of the mothers in shift work had a gestation shorter than 280 d, and for mothers in nonshift work this percentage was 37 (crude risk ratio 1.5, 95 % CI 1.0—2.4, and adjusted risk ratio 1.4, 95 % CI 0.9—2.1). For nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers the corresponding adjusted risk ratio was 1.3 (95 % CI 0.8—2.0).

The tenth percentile birthweight of the babies born to mothers who had been in two- or three-shift work was 2940 g; for the babies born to mothers who had done another type of shift work, the tenth percentile was 2900 g; and, for the babies born to mothers with

normal daily work, the tenth percentile was 3000 g (table 9).

In a noiseless environment, the crude risk ratio for the mothers in shift work giving birth to babies that were small for their gestational age was 1.4 (95 % CI 0.9—2.2) (table 10). The restriction of the study group to nonagricultural workers in the socioeconomic categories of lower-level employees with administrative and clerical occupations and manual workers yielded an adjusted risk ratio of 1.5 (95 % CI 1.0—2.4).

Placental weight

The mean placental weight was 631 (SD 132) g for the mothers in shift work and 611 (SD 125) g for the mothers in nonshift work. In all, 5 % of the mothers in shift work had placentas weighing 400 g or less as against 4 % of the mothers in nonshift work (risk ratio 1.2, 95 % CI 0.6—2.5).

Discussion

The analyses produced no indication of a teratogenic risk in connection with shift work. In light of the study data twofold or greater risks appeared implausible for all of the examined structural malformations. (See table 5.)

One-fourth of the mothers who had been in two- or three-shift work were in manufacturing and related occupations. (See table 1.) In manufacturing, the crude risk of threatened abortion was elevated for shift work, but some 80 % of these mothers had also been exposed to noise at a level of around 80 dB $L_{Aeq(8h)}$ or higher. In the study data, shift work alone was not related to the occurrence of threatened abortion, but, in a noisy work environment, the mothers in shift work showed indications of an elevated risk of both this outcome and of pregnancy-induced hypertension. In addition, shift work and noise together appeared to shorten the length of gestation, but the data did not allow an evaluation of the occurrence of preterm delivery.

The occurrence of threatened abortion or pregnancy-induced hypertension showed no associations with two- or three-shift work in environments in which the level of noise was clearly less than 80 dB $L_{Aeq(8h)}$. The women in other types of shift work had mainly done periodic work in nursing occupations, and the level of

noise in their work had been low. The risks of threatened abortion, pregnancy-induced hypertension, or shortened length of gestation were not elevated among these women. However, the study population was small, and the data were compatible with a broad range of possibilities.

The study mothers who had been in shift work had a slightly elevated risk of giving birth to babies that were small for their gestational age when the babies' birthweights were compared with the birthweights of the babies born to the mothers in nonshift work, and this excess of small babies was not necessarily related to exposure to noise. It is not unlikely that the work conditions during the last months of pregnancy are the most relevant with respect to birthweight. Therefore only mothers who had worked throughout most of their pregnancy were included when birthweight was studied. Half of the mothers in shift work had already stopped working around the middle of the 35th week (as calculated from the first day of the last normal menstrual period), while the mothers in nonshift work usually worked a little longer, half of them having stopped by the middle of the 36th week. At the time when the study data were collected, Finnish legislation stated that a pregnant woman should normally start her maternity leave 24 workdays (ie, around 29 days

Table 9. Birthweight by the gestational age of the babies according to whether their mothers were in shift or nonshift work.

Gestational age of the babies	Babies		Birthweight (g)	
	N ^a	%	Median	Tenth percentile
<37 weeks				
Shift work				
Two- or three-shift work	1	0.8	3000	-
Other shift work	2	3.6	2465	-
Nonshift work	24	2.8	2605	875
37—39 weeks				
Shift work				
Two- or three-shift work	45	37.8	3500	2770
Other shift work	20	35.7	3285	2625
Nonshift work	347	40.7	3400	2930
40—41 weeks				
Shift work				
Two- or three-shift work	59	49.6	3650	3020
Other shift work	29	51.8	3790	3000
Nonshift work	429	50.4	3660	3150
≥42 weeks				
Shift work				
Two- or three-shift work	14	11.8	3 620	3 250
Other shift work	5	8.9	4000	3700
Nonshift work	52	6.1	3750	3140
Total				
Shift work				
Two- or three-shift work	119	100	3570	2940
Other shift work	56	100	3620	2900
Nonshift work	852	100	3540	3000

^a There were three shift workers and 14 nonshift workers with missing data on the length of gestation.

Table 10. Babies small for their gestational age and maternal shift work in a noiseless environment^a among all the women who worked throughout most of their pregnancy and among those nonagricultural workers who worked throughout most of their pregnancy in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers.

Work group	Total number of babies	Babies small for gestational age	
		N	%
All mothers who worked throughout most of their pregnancy			
Shift work			
Any shift work	146	20	13.7 ^b
Two- or three-shift work	91	12	13.2
Other shift work	55	8	14.6
Nonshift work	771	74	9.6
Nonagricultural lower-level employees and manual workers			
Shift work			
Any shift work	141	18	12.8 ^c
Two- or three-shift work	87	10	11.5
Other shift work	54	8	14.8
Nonshift work	597	55	9.2

^a An 8-h equivalent continuous A-weighted sound level of <80 dB.

^b Crude risk ratio 1.4 [95 % confidence interval (95 % CI) 0.9–2.2], adjusted risk ratio 1.4 (95 % CI 0.9–2.2).

^c Crude risk ratio 1.4 (95 % CI 0.8–2.3), adjusted risk ratio 1.5 (95 % CI 1.0–2.4).

when Sundays and holidays are included) prior to the estimated date of her delivery. More study mothers in shift work had stopped working before the beginning of maternity leave than those in nonshift work.

Only a few of the mothers in shift work were in the categories of own-account (ie, self-employed) workers or upper-level employees with administrative, managerial, professional and related occupations according to the used socioeconomic classification (14). Moreover, none of the mothers in shift work had been involved in farming, which explained the fact that the group in nonshift work included relatively more mothers with a moderate physical work load. (See table 2.) In addition to comparing the groups of all mothers in shift and nonshift work, further analyses were restricted to nonagricultural workers in the two socioeconomic classes of lower-level employees with administrative and clerical occupations and manual workers. The use of these selection criteria aimed at comparisons in which occupational aspects, other than work in shifts, would be more similar and, hence, the categories of work more comparable with respect to potential determinants of risk. In addition, possible selection for certain types of employment is a cause for concern. In the restricted analyses the compared mothers would be expected to have more similar pregnancy outcomes if they had not had different work schedules. (Compare reference 29.) The restricted ana-

lyses produced results similar to those obtained with the more heterogeneous data.

In Finland, shift work usually involves rotating work schedules (13). The employee in rotating shift work must adapt each time that the schedule changes, and many bodily functions and systems which are circadian in nature can be disturbed (30). The study mothers in shift work reported more irregularities in menstruation (see table 3), but the possible relation between circadian rhythm and reproduction is not well understood (3).

The published studies provide some evidence of adverse effects of shift work, especially rotating shift work or irregularly changing work schedules, on pregnancy (1–5, 7, 8), but the results include inconsistencies. The analyses of the present study produced indications that rotating shift work could be harmful for pregnancy. Altogether, the available research data are not ample. Thus further studies on the possible effects of different work schedules on pregnancy are needed.

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