

Are long working hours and shiftwork risk factors for subfecundity? A study among couples from southern Thailand

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Abstract

Objective—To estimate the effect of long working hours and shift work on time to pregnancy.

Methods—Cross sectional samples with retrospective data collection from two 700 bed hospitals at secondary to tertiary care level in Hatyai district, Songkhla Province, Thailand. The study was conducted from March 1995 to November 1995 among 1496 pregnant women attending the antenatal clinics. Subfecundity was defined as time to pregnancy longer than 7.8, 9.5, or 12 months (time to pregnancy was calculated from the date at which the couples started having sexual relations without any contraception until last menstrual date).

Results—The descriptive analyses were restricted to 1201 planned pregnancies and the analytical part to 907 working women. Separate analyses on primigravid women were also done. Logistic regressions adjusted for age, education, body mass index, menstrual regularity, obstetric and medical history, coital frequency, and potential exposure to reproductive toxic agents, showed an odds ratio (OR) associated with female exposure to long working hours of 2.3 (95% confidence interval (95% CI) 1.0 to 5.1) in primigravid and 1.6 (1.0 to 2.7) in all pregnant women. Male exposure to long working hours and shiftwork showed no association with subfecundity. The OR of subfecundity was highest when both partners worked >70 hours a week irrespective of the cut off point used (OR 4.1 (95% CI 1.3 to 13.4) in primigravid women; OR 2.0 (95% CI 1.1 to 3.8) in all pregnant women). **Conclusions**—Long working hours is a risk factor for subfecundity especially for women. Shiftwork was not associated with subfecundity in this study.

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Keywords: long working hours; shiftwork; subfecundity; occupational risk

Thailand has a relatively large female labour force. The 1980 census¹ showed that more than 60% of females of 11 years of age or more were employed at some time during the previous year and the percentage share of women in the labour force was 46% in 1993.² In urban areas, it is not uncommon for women to work for

wages or as independent vendors both before and after marriage. The influx of women into the labour market during the past two decades of rapid industrialisation has recruited young and sexually active women into the industrial sector where they are exposed to potential reproductive hazards. However, in rural areas, most economic activities involve unpaid family work, particularly as farmers or rubber planters.

Long working hours and shiftwork are suspected to be reproductive risk factors because they may interfere with the balance of female hormones and may reduce sexual activity. Many studies of women engaged in intense physical sports—such as marathon runners and aerobic exercise teachers—have shown menstrual dysfunction and amenorrhea. The results of these studies show that physical stress may influence hypothalamic as well as pituitary function and reproductive performance.^{3–7} However, it is questionable to generalise results from extremely fit women with low body fat to women who are exposed to typical, strenuous, occupational exertion. Additionally, most studies on women exposed to strenuous work such as shiftwork, heavy lifting, standing, and psychological job stress, have focused on adverse pregnancy outcomes.^{8–9} Very few studies have considered subfecundity.^{10–11}

Fecundity, as estimated by the time to pregnancy, is probably a sensitive and convenient marker when studying reproductive capacity. In strict terms, fecundity refers to the ability to produce live offspring; we defined the term as the ability to produce a pregnancy that survives to clinical recognition. In clinical practice, infertility is arbitrarily defined as not being able to conceive within a period of 12 months of unprotected intercourse. The variables studied in recent decades that may be related to prolonged time to pregnancy include sexually transmitted diseases, pelvic inflammatory disease,^{12–15} maternal age—which has been re-explored in the light of recent research that permits separate determination of the role of the ovary and the role of the uterus in the in vitro fertilisation process and success rates¹⁶—some male factors,¹⁷ weight loss and obesity,^{18–20} use of contraceptives,^{20–22} lifestyle factors,^{23–27} and a few occupational chemical and physical exposures.^{28–30} However, few of these factors (contraception and some chemicals) are well documented.

This study aimed at examining the problem of impaired fecundity as a result of long working hours and shiftwork in southern Thailand. Most Thai women do not smoke, or drink

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Table 1 Comparison of questionnaire content used in the ESIS study and the fecundity study in Thailand

Section	Main information in the ESIS study	Thai version
A Your recent pregnancy	Date recent baby born. How many months the woman was pregnant. Present residential area	Same
B Prepregnancy group	This section divided the women into 7 groups by choosing the one that best described how she became pregnant: 1 Gravida 1: they have never used BCM 2 Gravida 1: they became pregnant while using a BCM 3 Gravida 1: they became pregnant after stopping use of BCM 4 Gravida > 1: after their previous pregnancy, their menstrual periods started again. Since, they have used no BCM and became pregnant 5 Gravida > 1: they became pregnant while using BCM 6 Gravida > 1: after their previous pregnancy, their menstrual periods started again. Since then they used BCM for a time, gave it up, and then became pregnant 7 Gravida > 1: their periods did not start again after their previous pregnancy. They were not using any BCM then they became pregnant	Same
C For women who became pregnant in spite of using BCM	Type of BCM. Regular or irregular use of BCM. How long the woman used BCM up to her pregnancy. Her ST	Same
D For women who were not using any BCM when they became pregnant	When did they start having unprotected sexual intercourse or their ST? How long was it from ST in months or years? How many periods from ST up to their pregnancy?	Same except the periods from ST up to their pregnancy
E For women whose periods had not started again when they became pregnant	The women were asked to write down the date their pregnancy started as ST	Same
F For women who used no BCM after their previous pregnancy	When did they start unprotected sexual intercourse after their previous pregnancy? Did the menstrual periods start at ST? How many months and how many periods did it take from ST until they became pregnant?	Same except the periods up to their pregnancy
G 1-10 Maternal occupational factor at ST	Having paid job. Describe kind of work. Job title. Working h/week. Pattern of work. Working with VDUs (computers or word processors with a screen). Chemical exposure. Job stress score (Karasek 14 items)	Same except VDU exposure and job stress score
G 11-15 Maternal lifestyle at ST	Smoking. Passive smoking. Beverage and alcohol drinking. Residence at ST	Same
H Paternal exposure	Smoking. Beverage and alcohol drinking. Physical exercise or sport. Birth date and birthplace. Education level	Same except physical exercise
K Maternal health factors	Having a paid job. Describe kind of work. Job title. Working h/week. Pattern of work. Driving regularly. Working posture. Chemical exposure	Same
	Menarche, menstrual period and menstrual interval, coital frequency. Planned or unplanned pregnancy. Infertility problems and treatment. Gravida and parity. Prepregnancy weight and height	Same
L Maternal and general questions	Cesarean section. Miscarriage. Ectopic pregnancy. Stillbirth. Neonatal birth. Induced abortion. Obstetric diseases. IUD use. Oral pill use	Same
	Birth date and birthplace. Marital status. Religion. Education level	Same

BCM = birth control method; ST = start time.

alcohol or coffee; they are young when they try to become pregnant, and many work long hours under physically demanding conditions. This setting was thus considered favourable for studying the association between long working hours, shiftwork, and subfecundity because of large variations in the exposure and little variation in some potential confounders.

Subjects and methods

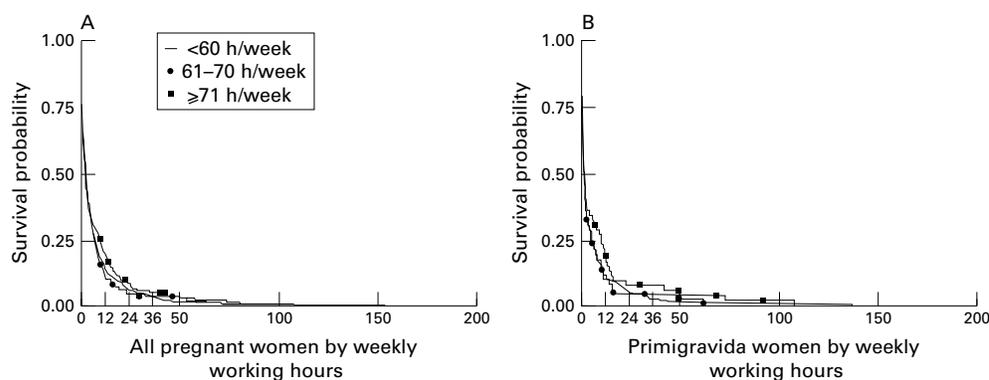
The study is based on a consecutive sample of 1496 pregnant women who received antenatal care at the two 700 bed public hospitals, Hatyai Hospital and Songklanagarind University Hospital situated in Hatyai district, Songkhla province, Thailand. The study period was from March to November 1995. Hatyai city is a trade centre of the southern part of Thailand with a population of 300 000. Both public hospitals are responsible for primary and secondary care in Hatyai and serve as tertiary care centres for the whole province. The average number of pregnant women who received antenatal care each month in 1993 was 400 at Hatyai Hospital and 120 at Songklanagarind University Hospital. The coverage of antenatal care by the public sector in Songkhla province was 68.2% in 1992. As many well off women prefer to receive antenatal care at private clinics, women of the middle and lower social classes were probably overrepresented.

The fecundity questionnaire was modified from the questionnaire used in the European study of infertility and subfecundity (ESIS, table 1).³¹ Data about husbands' exposures were obtained with women as informants. The

A-F sections of the questionnaire were aimed at specifying the starting time or the date the woman began to have regular intercourse without any contraception and to calculate time to pregnancy or the duration of time the woman exposed herself to the opportunity of becoming pregnant by unprotected intercourse. These sections divided the women into seven groups according to pregnancy order, birth control method, and menstrual period after recent delivery. Table 1 shows the content of the questionnaire and the comparison between the European study and the Thai study.

Both men and women were considered to be exposed to reproductively toxic substances if they were exposed to paints, varnish, lacquer, dyes, pigments, inks, solvents, welding fumes, insecticides, herbicides, wood preservative agents, anaesthetic gas, x ray films, or radioactive agents. Exposure was recorded at four levels (1= most of the working time, 2= two to three times a week, 3= once in a while, 4= never) but in the analysis only two levels were used (1 = most of the working time or two to three times a week, 0 = occasionally or never).

The interviewers were five trained young women. Altogether 164 women were excluded from the study because they were unwilling to wait for the interview. Women unable to communicate in Thai, who had a severe psychiatric illness, or who had more than one pregnancy in the study period were considered ineligible (n= 0). Personal interviews were thus completed for 1496 women. Data on male exposure were obtained with the women as informants. The gestational week was filled in



Kaplan-Meier survival curve by weekly working hours of (A) all pregnant women, and (B) primigravida women.

by the nurse at the antenatal clinic. The mean (SD) gestational age at interview was 19.7 (6.1) weeks; range 4–42 weeks.

STATISTICAL ANALYSIS

Time to pregnancy was calculated directly from the starting time and the last menstrual period after subtracting periods of sexual abstinence due to illness, travel, or other causes. Also, a recheck of the time to pregnancy was based on the question “How many months or years did it take you to become pregnant?” and “How many months were you having sexual intercourse without doing anything to avoid a

pregnancy?”. If the time to pregnancy calculated by the interviewers differed markedly from that recorded on the basis of these questions, the research assistants would revise the information.

No established definition of subfecundity exists and we thus used the time to pregnancy at the 75th percentile (7.8 months) as a cut off point of subfecundity in this study. The cut off point at the 80th percentile (9.5 months), which was used in the European Study Group on Infertility and Subfecundity, was also used. Both cut off points were made to avoid the censoring of time to pregnancy due to infertility treatment.

Time to pregnancy is usually well defined for couples who plan a pregnancy and the analyses were restricted to 1201 women who indicated that their pregnancy was planned; 515 of these were first pregnancies. The Kaplan-Meier survival analysis stratified by working hours (<60, 61–70, >71 hours a week) was used to analyse times to pregnancy, and logistic regression was used to analyse possible determinants of subfecundity at three different cut off points (7.8, 9.5, and 12 months). The analyses were restricted to 907 women who had had a paid job before becoming pregnant because housewives (n=294) might be different from working women in many aspects. Breast feeding and injectable contraception (depoprovera) were considered potential confounders among women who started to have sexual relations without any contraception within the first four months of breast feeding³² or within nine months after the last depoprovera injection.³³ Separate analyses were also made for the first pregnancy (n=515), mainly to evaluate the behavioural modification bias due to past pregnancy experience. All confidence intervals are presented as 95% limits.

Results

The Kaplan-Meier curve (figure) shows no difference of time to pregnancy at three levels of female working hours either for the total pregnancy sample (log rank test; p=0.31) and for the sample of primigravida women (log rank test; p=0.13). Table 2 shows the main characteristics of the study population for primigravida as well as all pregnant women. The distribution of long working hours among women and men was similar in both groups. The distributions of

Table 2 Main characteristics in the analysed subsamples, southern Thailand, 1995

Variables	Planned pregnancy (n (%))	
	Primigravida (n = 515)	All pregnant (n = 1201 (100%))
Women: age (y):		
≤ 15	3 (1)	3 (0)
16–18	58 (11)	69 (6)
19–20	100 (19)	130 (11)
21–25	223 (43)	441 (37)
26–30	95 (19)	346 (29)
≥ 31	36 (7)	212 (17)
Men: age (y):		
≤ 18	10 (2)	11 (1)
19–20	35 (7)	44 (4)
21–25	219 (42)	315 (26)
26–30	171 (33)	414 (34)
≥ 31	80 (16)	417 (35)
Gravidity:		
1	515 (100)	515 (43)
> 1		686 (57)
Gestational week at interview:		
≤ 11	46 (9)	106 (9)
12–19	225 (44)	523 (44)
20–29	217 (42)	521 (43)
30–39	26 (5)	48 (4)
≥ 40	1 (0)	3 (0)
Women: working at starting time	407 (78)	907 (76)
Men: working at starting time	509 (99)	1191 (99)
Women: working (h/week):		
≤ 40	97 (24)	258 (28)
41–50	99 (24)	203 (22)
51–60	116 (29)	224 (25)
61–70	45 (11)	98 (11)
≥ 71	50 (12)	124 (14)
Missing		
Men: working (h/week):		
≤ 40	114 (22)	295 (25)
41–50	103 (20)	218 (18)
51–60	167 (32)	338 (28)
61–70	57 (11)	149 (12)
61–70	68 (13)	191 (16)
≥ 71	6 (2)	10 (1)
Women: shiftwork	132 (32)	302 (33)
Men: shiftwork	223 (44)	523 (44)
Time to pregnancy (TTP) (months):		
≤ 3	289 (56)	632 (53)
3.1–7.8	116 (23)	268 (22)
7.9–12	48 (9)	109 (9)
≥ 12.1	62 (12)	192 (16)

Table 3 Prevalence (n (%)) of three different levels of subfecundity according to selected variables, southern Thailand, 1995

Exposure	Time to pregnancy primigravid			Time to pregnancy all pregnancies		
	> 7.8	> 9.5	> 12	> 7.8	> 9.5	> 12
Women:						
Working (h/week):						
≤ 40	21 (22)	20 (21)	15 (15)	72 (28)	61 (24)	49 (19)
41–50	26 (26)	16 (16)	9 (9)	39 (19)	27 (13)	18 (9)
51–60	18 (16)	15 (13)	9 (8)	51 (23)	44 (20)	30 (13)
61–70	8 (18)	7 (16)	4 (9)	22 (22)	17 (17)	11 (11)
≥ 71	17 (34)	16 (32)	12 (24)	40 (32)	35 (28)	27 (22)
Shift work*						
Yes	31 (23)	25 (19)	17 (13)	83 (27)	68 (23)	51 (17)
No	59 (21)	49 (18)	32 (12)	141 (23)	116 (19)	84 (14)
Reproductive toxic agents:†						
Yes	11 (20)	10 (19)	5 (9)	28 (27)	25 (24)	16 (15)
No	99 (21)	79 (17)	57 (12)	273 (25)	223 (20)	176 (16)
Men:						
Working (h/week):						
≤ 40	24 (21)	23 (20)	17 (15)	79 (27)	69 (23)	52 (18)
41–50	18 (17)	13 (13)	7 (7)	39 (18)	33 (15)	25 (11)
51–60	37 (22)	27 (16)	21 (13)	93 (28)	73 (22)	59 (17)
61–70	11 (19)	7 (12)	3 (5)	33 (22)	25 (17)	17 (11)
≥ 71	19 (28)	18 (26)	14 (21)	55 (29)	46 (24)	38 (20)
Shift work:						
Yes	49 (22)	46 (21)	33 (15)	137 (26)	122 (23)	98 (19)
No	59 (21)	42 (15)	29 (10)	160 (24)	123 (19)	93 (14)
Reproductive toxic agents:						
Yes	22 (18)	14 (12)	9 (13)	63 (25)	50 (20)	38 (15)
No	88 (22)	75 (19)	53 (13)	238 (23)	198 (21)	154 (16)

* Shiftwork; rotating shift, fixed afternoon shift, or fixed nightshift.

† Reproductive toxic agents: paints/varnishes/lacquer, dyes/pigments/inks, welding fumes, insecticides/herbicides, wood preservatives, anaesthetic gases, radioactivity, x ray films.

Table 4 The odds ratio† (OR) according to working conditions for three different levels of subfecundity in samples of primigravid and all pregnant women, southern Thailand, 1995

Variables	Primigravida‡ (adj OR (95% CI))			All pregnancies‡ (adj OR (95% CI))		
	TTP > 7.8	TTP > 9.5	TTP > 12	TTP > 7.8	TTP > 9.5	TTP > 12
Working hours, women:						
≤ 60	1	1	1	1	1	1
61–70	1.0 (0.4 to 2.5)	1.2 (0.4 to 3.2)	1.2 (0.4 to 4.0)	1.3 (0.7 to 2.4)	1.3 (0.7 to 2.5)	1.4 (0.6 to 3.0)
≥ 71	1.6 (0.7 to 3.6)	2.3 (1.0 to 5.1)	2.3 (0.9 to 5.8)	1.4 (0.9 to 2.3)	1.6 (1.0 to 2.7)	1.6 (0.9 to 3.0)
Working hours, men:						
≤ 60	1	1	1	1	1	1
61–70	0.7 (0.3 to 1.8)	0.5 (0.2 to 1.6)	0.3 (0.1 to 1.3)	0.6 (0.3 to 1.0)	0.5 (0.2 to 0.9)	0.3 (0.1 to 0.8)
≥ 71	1.4 (0.6 to 3.4)	1.5 (0.6 to 3.9)	2.1 (0.7 to 6.1)	1.0 (0.6 to 1.6)	0.9 (0.5 to 1.5)	1.0 (0.5 to 1.5)
Shift work, women:						
No	1	1	1	1	1	1
Yes	1.3 (0.7 to 2.5)	1.0 (0.5 to 2.0)	1.0 (0.4 to 2.2)	1.3 (0.9 to 2.0)	1.1 (0.7 to 1.7)	1.2 (0.7 to 1.9)
Shift work, men:						
No	1	1	1	1	1	1
Yes	0.8 (0.4 to 1.6)	1.2 (0.6 to 2.5)	1.0 (0.4 to 2.1)	0.9 (0.6 to 1.3)	1.1 (0.7 to 1.6)	1.0 (0.6 to 1.6)

* Maternal and paternal reproductive toxic substances: paints/varnishes/lacquer, dyes/pigments/inks, welding fumes, insecticides/herbicides, wood preservatives, anaesthetic gases, radioactivity, x ray films.

† Adjusted for maternal age (≤ 20, 21–25, 26–30, ≥ 31), maternal education (≤ 6, 10–12, 14–16, > 16 years), maternal body mass index (≤ 17, 17.1–19, 19.1–21, 21.1–23, 23.1–25, 25.1–27, ≥ 27.1; kg/m²), menstrual regularity (regular/irregular), obstetric disease (yes/no), medical disease (yes/no), maternal toxic agent (yes/no), paternal toxic agent (yes/no), coital frequency (≤ 4, 5–8, 9–12, ≥ 13 times a month), exposure to reproductively toxic agent (yes/no), hormonal pill injection (less or more than 9 months since last injection), and other variables in the table.

‡ 407 observations in a sample of primigravid women were analysed and 907 observations in a sample of all pregnant women were analysed.

TTP = time to pregnancy.

shiftwork and of having a paid job at the starting time among men and women were similar for primigravid and all pregnant women. In both samples, however, men were more likely to be employed at the starting time and had a higher proportion of shiftwork than women. Among all pregnant women, 53% became pregnant within the first three months of trying but about 25%, 21%, and 16% of the study population experienced a time to pregnancy longer than 7.8, 9.5, and 12 months respectively. The distribution of time to pregnancy among primigravid women was similar to the distribution among all pregnant women.

Women and men working >71 hours a week had the highest percentage of subfecundity both among first pregnancies and the total sample, and shiftwork had a similar distribution of subfecundity in both groups for both men and women (table 3). Grocery owners, owners of small to middle sized enterprises, supermarket saleswomen, construction workers, and food and beverage workers had the highest frequency of subfecundity among those working >71 hours a week. Industrial workers and labourers represent about 32% of the working women and they experienced a longer time to pregnancy than the other groups with

Table 5 The odds ratio† (OR) for three different levels of subfecundity in couples according to specific exposures to long working hours and shiftwork in samples of primigravid and all pregnant women, southern Thailand, 1995

Variables	Primigravida‡ (adj OR (95% CI))			All pregnancies‡ (adj OR (95% CI))		
	TTP > 7.8	TTP > 9.5	TTP > 12	TTP > 7.8	TTP > 9.5	TTP > 12
Working hours, couple:§						
None	1	1	1	1	1	1
Only men	1.3 (0.4 to 4.1)	1.5 (0.4 to 5.3)	2.0 (0.5 to 8.9)	0.7 (0.4 to 1.3)	0.7 (0.4 to 1.3)	0.9 (0.4 to 2.0)
Only women	1.4 (0.6 to 3.5)	2.0 (0.8 to 5.2)	1.8 (0.6 to 5.4)	0.9 (0.5 to 1.7)	0.9 (0.5 to 1.7)	1.2 (0.6 to 2.4)
Both	2.8 (0.9 to 8.8)	4.1 (1.3 to 13.4)	6.2 (1.8 to 21.8)	2.0 (1.1 to 3.8)	2.0 (1.1 to 3.8)	2.1 (1.0 to 4.3)
Shift work, couple:¶						
None	1	1	1	1	1	1
Only men	0.7 (0.3 to 1.6)	0.9 (0.4 to 2.2)	0.7 (0.2 to 1.9)	1.0 (0.6 to 1.5)	1.1 (0.7 to 1.9)	1.0 (0.6 to 1.8)
Only women	0.9 (0.3 to 2.5)	0.4 (0.1 to 1.7)	0.4 (0.1 to 2.0)	1.4 (0.8 to 2.5)	1.1 (0.6 to 2.1)	1.0 (0.5 to 2.1)
Both	1.2 (0.6 to 2.3)	1.4 (0.7 to 2.9)	1.1 (0.5 to 2.6)	1.2 (0.8 to 1.8)	1.3 (0.9 to 2.1)	1.4 (0.8 to 2.2)

* Maternal and paternal reproductive toxic substances: paints/varnishes/lacquer, dyes/pigments/inks, welding fumes, insecticides/herbicides, wood preservatives, anaesthetic gases, radioactivity, x ray films.

† Adjusted for maternal age (≤ 20, 21–25, 26–30, ≥ 31), maternal education (≤ 6, 10–12, 14–16, > 16 years), maternal body mass index (≤ 17, 17.1–19, 19.1–21, 21.1–23, 23.1–25, 25.1–27, ≥ 27.1; kg/m²), menstrual regularity (regular/irregular), obstetric disease (yes/no), medical disease (yes/no), maternal toxic agent (yes/no), paternal toxic agent (yes/no), coital frequency (≤ 4, 5–8, 9–12, ≥ 13 times a month), exposure to reproductively toxic agent (yes/no), hormonal pill injection (less or more than 9 months since last injection), and other variables in the table.

‡ 407 Observations in a sample of primigravid women were analysed and 907 observations in a sample of all pregnant women were analysed.

§ Couples' working hours (none = neither man or woman are working ≥ 71 hours/week, only men = only men working ≥ 71 hours/week, only women = only women working ≥ 71 hours/week, both = both husband and wife working ≥ 71 hours/week).

¶ Couples' shiftwork (the same as §).

long working hours. Subfecundity in shiftwork was mostly found in agriculture, the wood furniture industry, the food and beverage industry, and hotel housekeeping.

Exposure to substances potentially toxic to reproduction in men and women was not associated with subfecundity and therefore did not confound the association. The proportion of subfecundity increased in couples with increasing age, increasing female body mass index, and where men smoked traditional cigarettes or worked as lorry or minibus drivers. The women tended to be more subfecund in the lowest and highest category of education and social class (data not shown). Women working >71 hours a week were older, were more likely to have had a previous pregnancy, had less education, had a higher body mass index, had more frequent obstetric and medical diseases, experienced a higher proportion of menstrual irregularity, had fewer sexual contacts, were less likely to have unprotected sexual relations within the first nine months after stopping depopovera, and more often had husbands with longer working hours.

We analysed the odds ratios (ORs) between coital frequency (<9 times a month *v* >9 times a month) and long working hours adjusted for maternal age and marriage duration and found that long working hours was associated with low coital frequencies. The factors associated with lower coital frequency were female age (>30 years) and marriage duration of more than one year.

Tables 4 and 5 show the association between long working hours (≥71 hours a week) and subfecundity, which was analysed for men, women, and couples. Three different cut off points of time to pregnancy 7.8, 9.5, and 12 months were used. The adjusted odds ratios for a time to pregnancy of >9.5 months among women working >71 hours a week were high in first pregnancies (OR of 2.3, 95% CI 1.0–5.1) and in the entire pregnancy sample (OR of 1.6, 95% CI 1.0–2.7). Table 5 shows that subfecundity was most frequent when both partners had long working hours irrespective of which cut off

point was used. The association was strongest among first pregnancies. Male and female shiftwork was only weakly and inconsistently associated with all three different cut off points of time to pregnancy in both first and in all pregnancies.

Discussion

Our findings indicate that long working hours is a risk factor of subfecundity. Shiftwork showed no association with subfecundity.

One of the possible proximal determinants of fecundity is coital frequency as both long working hours and shift work apparently reduced sexual activity but surprisingly not when both partners had long working hours. Furthermore, long working hours among women may cause hormonal disturbance leading to irregular menstrual bleeding and prolonged time to pregnancy, but the analyses did not support such a mechanism. The OR of subfecundity after adjusting for menstrual irregularity or coital frequency showed the same trend and had almost the same magnitude. This suggests that the possible mechanism to reduce fecundity is not only through sexual activity or menstrual disorders.

This study is subject to selection bias due to recruitment of pregnant women as sterile couples were excluded and subfecund women with long waiting times to pregnancy are underrepresented. The magnitude of selection bias depends on the distribution of times to pregnancy among exposed and unexposed couples. If the exposure causes sterility as the only response, the study will not detect the adverse effect³⁴ and the study was based on the assumption that the exposure changes the distribution of time to pregnancy in general.

The reason for including only planned pregnancies in the analysis was to provide accurate data on time to pregnancy. This may, however, result in planning bias if exposed and unexposed women have different probabilities of being excluded because of unplanned pregnancies. Weinberg *et al*³⁵ indicated that the exact magnitude will depend on the prevalence of

unplanned pregnancies and the degree to which exposed and unexposed couples differed in their use of birth control. In this study, the distribution of women who had an unplanned pregnancy despite use of birth control was 6.1% among women working <60 hours a week; 6.5% among women working 61–70 hours a week, and 4.7% among women working >71 hours a week which indicates little or no planning bias. Moreover, the OR of subfecundity when including unplanned pregnancies in the model was decreased, which indicates some planning bias, but not of a magnitude which would have changed the direction of the findings.

The subgroup analysis of primigravid women was done to avoid bias due to past adverse reproductive outcome³⁶ whereby the subfecund couples may reduce their workload when trying for a subsequent pregnancy to eliminate the risk of repeating subfecundity. Basically, results remained similar among nulliparous and all pregnant women. All exposure data referred to exposures at the starting time of time to pregnancy to avoid any behavioural modifications driven by prolonged waiting times.³⁷

Female rubber planters work mainly night shifts but their working hours were short compared with the other occupations involving shiftwork. Workers in small to medium sized businesses reported very long sedentary working hours, often just waiting for the customer. To eliminate the degree of misclassified exposure measurement, rubber planters and women working in small to medium sized groceries were excluded from the analysis, which then showed a slightly increased OR for subfecundity according to working hours among primigravid and all pregnant women.

Women exercising vigorously were prone to menstrual disturbances.^{4, 38, 39} The mechanism is probably mediated by the hypothalamic gonadotrophin releasing hormone (GnRH) pulse generator, normally ensuring the integrity of the menstrual cycle. In the absence of an appropriate GnRH pulse activity, there is luteal phase deficiency, anovulation manifesting itself as irregular menses and amenorrhoea. As well as exercise, low body weight and body fat, loss of body weight, and stress of competitive games likewise diminish pulse generator activity through similar mechanisms.⁴⁰ Many women experienced a high although perhaps less strenuous and more normal physical workload in their jobs, but there are few studies on the relation between occupational physical exertion and fecundity. Florack *et al*³⁹ considered the negative influence of occupational activity on fecundity but not on menstrual disturbances. However, that study lacked details on body mass index, athletic activities, and coital frequency.

Shiftwork has been considered a possible risk for preterm delivery, low birth weight, or spontaneous abortion,^{41–43} but very few studies have considered subfecundity. A recent European study reported that female shiftwork reduced a couples' fecundity but male shiftwork did not have any effect.¹¹ In our study, shiftwork was

defined as fixed or rotating shifts and if only a rotating shift was a risk factor, our effect measure would be attenuated. Our findings imply that long working hours could have an adverse effect on the fecundity of the couple which goes beyond the effect on libido and sexual activity. This effect is most likely specific to the type of work and results may well differ from one occupational setting to another.

Further prospective studies aiming at understanding the relation between prolonged waiting time and fertility rate or other reproductive end point should be performed to evaluate the usefulness of subfecundity as a sensitive marker in reproductive epidemiology.

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