

Is Passive Smoking Associated With Sleep Disturbance Among Pregnant Women?

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Study Objective: Pregnant women suffer from sleep disturbance, which may be aggravated by passive smoking. In this study we investigated the effects of passive smoking on sleep disturbance during pregnancy.

Design: Two cross-sectional questionnaire surveys conducted in 2002 and 2006.

Setting: Clinical institutions specializing in obstetrics and gynecology that participated in the nationwide surveys: 260 in the 2002 survey and 344 in the 2006 survey.

Participants: 16,396 and 19,386 pregnant women in Japan surveyed in 2002 and 2006, respectively.

Intervention: N/A.

Measurements and Results: Pregnant women exposed to passive smoking were likely to have sleep disturbances, such as subjective insufficient sleep, difficulty in initiating sleep, short sleep duration, and snoring loudly/breathing uncomfortably. Smoking pregnant women had the same

sleep disturbances and also experienced excessive daytime sleepiness and early morning awakening. The prevalence of 5 types of sleep disturbance (insufficient sleep, difficulty in initiating sleep, short sleep duration, excessive daytime sleepiness, and snoring loudly/breathing uncomfortably) among nonsmokers with environmental tobacco smoke showed a mean value intermediate between that of active smokers and that of nonsmokers without environmental tobacco smoke.

Conclusion: Passive smoking is independently associated with increased sleep disturbance during pregnancy.

Keywords: Sleep disturbance, passive smoking, pregnant women, Japan, epidemiology

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INTRODUCTION

MANY PREVIOUS STUDIES HAVE REPORTED THAT PREGNANT WOMEN OFTEN SUFFER FROM SLEEP DISTURBANCE, AND THAT CHANGES IN SLEEP PATTERNS begin to occur during pregnancy.¹⁻¹¹ Many epidemiological studies have examined the relationship between sleep disturbance and social factors, such as socioeconomic group and lifestyle.¹²⁻¹⁵ Among lifestyle factors, an association has been observed between sleep disturbance and smoking.¹⁶⁻²² With regard to smoking, it is reported that the pharmacological effects of nicotine exacerbate sleep problems.¹⁹ Therefore, it is inferred that tobacco is detrimental to healthy sleep.

A previous study reported that pregnant women were more likely to have sleep disturbance than non-pregnant women of the same age group in the general population, and if they smoked, then the possibility of their suffering from sleep disturbance increased.

According to the report, active smoking of pregnant women is most likely to induce excessive daytime sleepiness, among other sleep disturbances.^{1,8}

Although associations between active smoking and sleep disturbance have been reported in many previous studies, to our knowledge few studies have reported associations between passive smoking and sleep disturbance. So far, only 3 studies have reported associations between passive smoking and sleep apnea, and passive smoking and snoring.²³⁻²⁵ In these 3 studies, however, apnea and snoring were the only types of sleep disturbance investigated. Therefore, associations between passive smoking and sleep related issues such as difficulty in initiating sleep, difficulty maintaining sleep, early morning awakening, and sleep duration, have not been examined.

The aim of the present study was to clarify the association between passive smoking and sleep disturbance by analyzing the results of 2 epidemiological studies conducted on 16,396 and 19,386 pregnant women in Japan in 2002 and 2006, respectively.^{1,8,26}

METHODS

The surveys were conducted in 2002 and 2006. The details of the procedure of the 2002 survey have been described elsewhere.^{8,26}

Subjects and Procedure

Our 2 studies were part of a nationwide survey on smoking, alcohol consumption and sleep among Japanese pregnant women. The study subjects were women with a confirmed pregnancy who had attended for a second or subsequent consultation at one of

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Table 1—Sociodemographic Status of a Sample of Pregnant Women Living in Japan (2002 and 2006 Surveys)

Items	2002 Survey		2006 Survey	
	N	%	N	%
Age (y)				
19 ≤	230	1.4	279	1.4
20-29	8401	51.2	8340	43.0
30-39	7509	45.8	10392	53.6
40 ≥	250	1.5	375	1.9
Unknown	6	0.0	0	-
Schooling completed				
Junior college ≥	13787	84.1	15682	80.9
College ≤	2538	15.5	3610	18.6
Unknown	71	0.4	94	0.5
Employment				
Employed	4285	26.1	5279	27.2
Unemployed	11978	73.1	13961	72.0
Unknown	133	0.8	146	0.8
Pregnancy trimester				
1st	1145	7.0	1244	6.4
2nd	5709	35.1	6793	35.0
3rd	9068	55.8	10991	56.8
Unknown	474	2.1	350	1.8
Number of pregnancies				
1st	8180	49.9	9316	48.1
2nd or subsequent	8174	49.8	10032	51.7
Unknown	42	0.3	38	0.2

these institutions during the period 1–14 February 2002 and 6–18 February 2006.

Each subject was asked to complete a self-administered questionnaire during the time that she was waiting for a consultation. The subject was then asked to seal the completed questionnaire in an envelope, which was then collected. In each of the institutions, all of the pregnant women who met the inclusion criteria were selected as subjects, and there was no sampling of this group. The questionnaires included a statement that the staff of the institution had not seen the completed questionnaires, and the questionnaires were collected in sealed envelopes. This was done in order to protect the privacy of the subjects and to obtain responses that were as candid as possible.

The 2002 and 2006 surveys differed in the number of obstetrics and gynecology clinics that participated: 260 for the 2002 survey and 344 for the 2006 survey. In the 2002 survey, 16,528 questionnaires were collected. After exclusion of 132 subjects who did not answer the questions relating to active and passive smoking, the data for the remaining 16,396 subjects were analyzed. In the 2006 survey, 19,650 questionnaires were collected, and after exclusion of 264 subjects, the data for the remaining 19,386 subjects were analyzed. The differences of the 2002 and 2006 surveys are as follows.

2002 Survey

A random sample of 500 clinical institutions with maternity patients was selected. These institutions had been stratified according to the type of institution (clinic, public hospital, or private hospital) and the area bloc, based upon 1,000 all survey points that had been fixed by the Japan Association of Obstetricians and Gynecologists (JAOG). A letter was sent to each of these 500 randomly selected institutions inviting them

to participate in our survey. A total of 390 institutions replied, of which 110 rejected the request and were excluded from the study. Study questionnaires were sent to the 280 institutions that had agreed to take part in the study, and questionnaires were returned by 260 of these institutions. The estimated response rate was 95.7%. During 2002, JAOG had a membership of approximately 13,000.

2006 Survey

The 2006 survey differed from the 2002 survey in that all of the fixed survey points in existence at the time, 940 were sent letters of invitation to participate in the survey, as opposed to selecting a random sample as was done for the 2002 survey. A total of 508 institutions responded to our request, with 360 expressing their willingness to participate (344 actually eventually participated) and 208 declining to participate. The estimated response rate was 86.6%, which was about 10 percentage points lower than that for the 2002 survey. The reason for this may be that we did not strongly enough request return of unused questionnaires from the participating institutions.

Measures

The major items included in the questionnaires used for the 2002 and 2006 surveys were: (1) active smoking status; (2) passive smoking status (whether or not a subject was exposed to environmental tobacco smoke [ETS]); (3) sleep status; and (4) personal data. The 2002 survey included 6 sleep-related items, and the 2006 survey had 7, with the addition of the question “Do you wake up during nocturnal sleep because of snoring loudly or breathing uncomfortably?” (hereafter, SB stands for snoring loudly/breathing uncomfortably). Questions on 7 items

Table 2—Prevalence of Sleep Disturbances According to Self-Reported Smoking Status

	2002 Survey					2006 Survey				
	Nonsmoker without ETS	Nonsmoker with ETS	Active smoker	Total	Sig.	Nonsmoker without ETS	Nonsmoker with ETS	Active smoker	Total	Sig.
SIS (N)	15.0% (6050)	19.1% (8606)	25.0% (1621)	18.1% (16277)	*	13.4% (9037)	16.9% (8,837)	23.5% (1474)	15.8% (19348)	*
DIS (N)	16.6% (6049)	18.0% (8604)	27.9% (1621)	18.5% (16274)	*	13.2% (9037)	15.1% (8837)	23.2% (1474)	14.9% (19348)	*
DMS (N)	43.3% (6048)	42.5% (8594)	45.6% (1623)	43.1% (16265)	ns	37.6% (9035)	39.4% (8836)	40.5% (1474)	38.7% (19345)	**
EMA (N)	9.5% (6045)	9.2% (8598)	12.5% (1622)	9.6% (16265)	*	8.5% (9037)	8.8% (8837)	11.7% (1474)	8.9% (19348)	*
SSD (N)	20.2% (6036)	25.2% (8569)	31.6% (1612)	24.0% (16217)	*	21.4% (9005)	26.5% (8789)	32.1% (1460)	24.5% (19254)	*
EDS (N)	24.2% (6033)	25.1% (8582)	32.6% (1614)	25.5% (16229)	*	23.1% (9020)	24.3% (8791)	32.7% (1463)	24.4% (19274)	*
SB (N)						2.3% (9023)	2.9% (8803)	3.3% (1466)	2.6% (19292)	*

Note: SIS; subjective insufficient sleep, DIS; difficulty in initiating sleep, DMS; difficulty maintaining sleep, EMS; early-morning awakening, SSD; short sleep duration (<7 h), EDS; excessive daytime sleepiness, SB; snoring loudly/breathing uncomfortably, ETS; environmental tobacco smoke χ^2 -test: *P<0.01, **P<0.05, ns: not significant.
Sig.: Significance.

related to sleep status during the previous month were included in the questionnaire: (1) subjective insufficient sleep (SIS); (2) difficulty in initiating sleep (DIS); (3) difficulty maintaining sleep (DMS); (4) early morning awakening (EMA); (5) short sleep duration (SSD); (6) excessive daytime sleepiness (EDS); and (7) snoring loudly or breathing uncomfortably (SB). The definitions of sleep disorders in the present study were as follows: SSD was defined as getting <7 h sleep per night. SIS was ascribed to subjects who answered “insufficient” or “very insufficient” for the corresponding question. The remaining 5 items (DIS, DMS, EMA, EDS, and SB) were ascribed to subjects who answered “often” or “always” for the corresponding questions.

The questionnaire also included items on active and passive smoking at the time of the survey, when pregnancy had been confirmed. A question on who had exposed the pregnant women to ETS ([1] family, [2] friends or coworkers, and [3] others) was also included.

The demographic variables were age (younger than 20 years, 20-29 years, 30-39 years, or 40 years or older), schooling completed (junior college or lower, college or higher), employment status (employed, unemployed), and alcohol consumption (yes, no). There were also questions on pregnancy status, including the number of pregnancies (1st, 2nd, or subsequent) and pregnancy trimester (1st, 2nd, 3rd). These 5 items of personal data, including missing data on the subjects, are shown in Table 1. Details of the sleep questions used in the 2002 survey have been described elsewhere.^{1,8,26}

Analysis

We divided the sample into 3 groups according to smoking status: (1) nonsmokers without ETS: Nonsmoking; (2) nonsmokers with ETS: Passive smoking; and (3) active smokers: Smoking at the time of the survey, when pregnancy had been confirmed. We then calculated the prevalence of each of the 7 sleep-related items.

In Table 3, excluding active smokers, only nonsmokers with and without ETS are divided into 5 groups in a similar manner to Table 2, with the calculated prevalence of each sleep related item. The subjects in the 5 groups were all nonsmokers, with those in Group 1 not exposed to ETS; those in Group 2 exposed to ETS from family, friends, and coworkers; those in Group 3 exposed to ETS from family, but not from friends or coworkers; those in Group 4 exposed to ETS from friends or coworkers, but not from family; and those in Group 5 exposed to ETS from sources other than family, friends, and coworkers.

Logistic regression analyses was used to compare the odds of suffering from 7 types of sleep disturbances (SIS, DIS, DMS, EMA, SSD, EDS, and SB) by smoking status, while controlling for age, highest educational level, employment status, alcohol consumption, pregnancy trimester, and number of pregnancies. Logistic regression was also used to compare the odds of suffering these same sleep disturbances by the source of the passive smoke exposure (family & friend smoker, family smoker & friend nonsmoker, family nonsmoker & friend smoker, other smoker). Subjects who failed to answer any one of the questions pertaining to the covariates were excluded from the analyses. SPSS for Windows, Version 11.0 was used for all statistical analyses.

Table 3—Sleep Disturbances Among Only Nonsmokers With and Without ETS

	2002 Survey							2006 Survey						
	Nonsmoker with ETS							Nonsmoker with ETS						
	Group 1 Nonsmoker without ETS	Group 2 Family & Friends smoker	Group 3 Family smoker & friend nonsmoker	Group 4 Family nonsmoker & friend smoker	Group 5 Other Smoker	Total	Sig.	Group 1 Nonsmoker without ETS	Group 2 Family & friend smoker nonsmoker	Group 3 Family smoker & friend smoker	Group 4 Family nonsmoker & friend	Group 5 Other smoker	Total	Sig.
Prevalence of SIS (N)	15.0% (6050)	22.4% (1827)	17.5% (5667)	24.4% (832)	14.9% (363)	17.4% (14739)	*	13.4% (9037)	19.2% (1648)	15.7% (6011)	21.9% (745)	16.2% (433)	15.1% (17874)	*
Prevalence of DIS (N)	16.6% (6049)	18.5% (1826)	18.6% (5668)	14.3% (830)	14.9% (363)	17.5% (14736)	*	13.2% (9037)	16.5% (1647)	14.7% (6013)	14.4% (745)	17.4% (432)	14.2% (17874)	*
Prevalence of DMS (N)	43.3% (6048)	42.7% (1862)	43.2% (5660)	38.7% (830)	40.4% (361)	42.9% (14725)	ns	37.6% (9035)	39.6% (1648)	39.9% (6012)	35.4% (743)	38.6% (433)	38.5% (17871)	**
Prevalence of EMA (N)	9.5% (6045)	10.0% (1822)	9.0% (5666)	8.4% (830)	9.6% (363)	9.3% (14726)	ns	8.5% (9037)	10.0% (1648)	8.7% (6011)	7.0% (745)	8.5% (433)	8.6% (17874)	ns
Prevalence of SSD (N)	20.2% (6036)	27.8% (1817)	23.3% (5645)	34.9% (827)	20.1% (363)	23.1% (14688)	*	21.4% (9005)	30.0% (1640)	25.0% (5979)	32.9% (742)	21.7% (428)	23.9% (17794)	*
Prevalence of EDS (N)	24.2% (6033)	26.9% (1818)	25.3% (5660)	21.9% (826)	21.9% (361)	24.8% (14698)	**	23.1% (9020)	26.5% (1637)	24.3% (5980)	19.9% (742)	25.0% (432)	23.7% (17811)	*
Prevalence of SB (N)								2.3% (9023)	3.5% (1638)	2.6% (5992)	3.0% (741)	3.5% (432)	2.6% (17826)	**

Note: friend; friends and coworkers

χ^2 -test: **P<0.01, *P<0.05, ns: not significant.

Sig.: Significance.

SIS; subjective insufficient sleep, DIS; difficulty in initiating sleep, DMS; difficulty maintaining sleep, EMS; early-morning awakening, SSD; short sleep duration (<7 h), EDS; excessive daytime sleepiness, SB; snoring loudly/breathing uncomfortably, ETS; environmental tobacco smoke

RESULTS

The prevalence of smoking among Japanese pregnant women was 9.9% in 2002 and 7.8% in 2006. The percentages of pregnant women exposed to ETS were 62.1% in 2002 and 52.7% in 2006. In both studies, the spouse was the source of the environmental tobacco smoke for 80% or more of pregnant women who responded that they had been exposed to ETS.

As shown in Table 2, active smokers showed the highest prevalence of all 6 items related to sleep disturbance in 2002 and all 7 in 2006. In the meantime, the prevalence of each sleep related item among nonsmokers with ETS (Passive smoking) showed a mean value intermediate between that among active smokers (Smoking) and that among nonsmokers without ETS (Nonsmoking).

Among nonsmoking women, the prevalence of all sleep disturbance items was higher in those exposed to ETS than those not exposed to ETS (Table 3). After further dividing the nonsmokers with ETS into 4 groups based upon the source of the smoke exposure and comparing among these groups, no trend could be distinguished. However, when the 6 sleep related items included in the 2002 survey and the 7 included in the 2006 survey were compared among the 4 groups, the prevalence of sleep disturbance was found to be comparatively higher among nonsmokers whose family and friends smoked.

Tables 4 and 5 show the results of multiple logistic regression analyses to estimate the association between sleep disorders and smoking status after adjusting for covariates. Nonsmoking pregnant women who were exposed to ETS were significantly more likely than those not exposed to ETS to suffer from SIS (subjective insufficient sleep), DIS (difficulty in initiating sleep), and

SSD (short sleep duration) in the 2002 survey and significantly more likely to suffer from SIS, DIS, EMA (early morning awakening), SSD, and SB (snoring loudly or breathing uncomfortably) in 2006 survey (Table 4). As shown in Table 5, nonsmokers with family and friends who smoked were significantly more likely to suffer from SIS, DIS, EMA, SSD, EDS (excessive daytime sleepiness) than nonsmokers without ETS in both the 2002 and 2006 surveys.

DISCUSSION

We found statistically significant associations in the 2 nationwide surveys conducted in 2002 and 2006 between passive smoking and sleep disturbances among pregnant women. Previous studies have explored associations between active smoking among pregnant women and sleep disturbances,^{1,8,26} but to our knowledge, the present study is the first to report an association between passive smoking exposure among pregnant women and sleep disturbances.

In the surveys, the spouse was the source of the environmental tobacco smoke for 80% or more of pregnant women. The prevalence of smoking among Japanese men was 53%, which is higher than that among men in the United States (26%) or in the United Kingdom (27%).²⁷ With this in mind, it is important to study the issue of passive smoking among Japanese pregnant women and their health.

It is known that pregnant women tend to suffer from sleep disturbance caused by diverse factors, such as nocturia, difficulty assuming the habitual sleep posture owing to enlargement of the abdomen, fetal movements, lower back pain during pregnancy,

Table 4—Multiple Logistic Regression Results for Prediction of Sleep Disturbance Items Among Japanese Pregnant Women

	SIS OR	DIS OR	DMS OR	EMA OR	SSD OR	EDS OR	SB OR
2002 Survey							
Nonsmokers without ETS	1.00	1.00	1.00	1.00	1.00	1.00	
Nonsmokers with ETS	1.38 (1.12-1.44)	1.11 (1.01-1.21)	0.99 (0.93-1.07)	1.03 (0.91-1.15)	1.51 (1.29-1.76)	1.04 (0.96-1.13)	
Active smokers	1.74 (1.51-2.01)	1.87 (1.63-2.15)	1.06 (0.94-1.19)	1.32 (1.10-1.59)	2.75 (2.23-3.38)	1.53 (1.34-1.73)	
2006 Survey							
Nonsmokers without ETS	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Nonsmokers with ETS	1.31 (1.20-1.43)	1.15 (1.05-1.26)	1.11 (1.04-1.18)	1.07 (0.96-1.19)	1.30 (1.20-1.39)	1.07 (0.99-1.15)	1.25 (1.03-1.52)
Active smokers	1.87 (1.62-2.16)	1.93 (1.67-2.23)	1.08 (0.96-1.21)	1.45 (1.20-1.74)	1.74 (1.52-1.97)	1.61 (1.42-1.83)	2.23 (1.50-3.32)

Note: (); 95% confidence interval, OR; odds ratio.

Adjusted for sociodemographic (age, final academic background, employment status and drinking status) and pregnancy-status (number of pregnancies and pregnancy trimester) factors in multiple logistic regression

SIS; subjective insufficient sleep, DIS; difficulty in initiating sleep, DMS; difficulty maintaining sleep, EMS; early-morning awakening, SSD; short sleep duration (<7 h), EDS; excessive daytime sleepiness, SB; snoring loudly/breathing uncomfortably, ETS; environmental tobacco smoke

Table 5—Multiple Logistic Regression Results for Prediction of Sleep Disturbance Items Among Japanese Pregnant Women

	SIS OR	DIS OR	DMS OR	EMA OR	SSD OR	EDS OR	SB OR
2002 Survey							
Nonsmoker without ETS	1.00	1.00	1.00	1.00	1.00	1.00	
Nonsmokers with ETS							
Family & friend smoker	1.52 (1.32-1.76)	1.24 (1.07-1.44)	1.08 (0.97-1.21)	1.24 (1.03-1.51)	1.94 (1.56-2.42)	1.16 (1.02-1.32)	
Family smoker & friend nonsmoker	1.23 (1.11-1.37)	1.07 (0.97-1.19)	0.97 (0.90-1.05)	0.95 (0.84-1.09)	1.38 (1.17-1.64)	1.04 (0.95-1.13)	
Family nonsmoker & friend smoker	1.55 (1.29-1.88)	1.27 (1.01-1.59)	1.09 (0.92-1.28)	1.22 (0.92-1.62)	1.76 (1.30-2.37)	0.93 (0.77-1.13)	
Other smoker	1.01 (0.74-1.38)	0.88 (0.65-1.19)	0.90 (0.71-1.21)	1.06 (0.73-1.52)	0.99 (0.58-1.69)	0.89 (0.68-1.15)	
2006 Survey							
Nonsmoker without ETS	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Nonsmokers with ETS							
Family & friend smoker	1.51 (1.30-1.74)	1.40 (1.20-1.63)	1.25 (1.11-1.40)	1.31 (1.09-1.59)	1.42 (1.25-1.61)	1.24 (1.10-1.41)	1.64 (1.19-2.25)
Family smoker & friend nonsmoker	1.22 (1.10-1.34)	1.06 (0.96-1.17)	1.07 (0.99-1.15)	1.01 (0.90-1.14)	1.26 (1.16-1.37)	1.05 (0.97-1.14)	1.10 (0.88-1.36)
Family nonsmoker & friend smoker	1.63 (1.31-1.98)	1.51 (1.20-1.90)	1.16 (0.98-1.37)	1.01 (0.74-1.37)	1.40 (1.18-1.67)	0.90 (0.74-1.10)	1.64 (1.03-2.60)
Other smoker	1.39 (1.06-1.82)	1.31 (1.01-1.70)	1.09 (0.89-1.34)	1.05 (0.73-1.48)	1.07 (0.84-1.36)	1.08 (0.86-1.36)	1.48 (0.86-2.54)

Note: (); 95% confidence interval, OR; odds ratio.

Adjusted for sociodemographic (age, final academic background, employment status and drinking status) and pregnancy-status (number of pregnancies and pregnancy trimester) factors in multiple logistic regression

SIS; subjective insufficient sleep, DIS; difficulty in initiating sleep, DMS; difficulty maintaining sleep, EMS; early-morning awakening, SSD; short sleep duration (<7 h), EDS; excessive daytime sleepiness, SB; snoring loudly/breathing uncomfortably, ETS; environmental tobacco smoke.

and hormonal effects.¹⁻⁶ Sleep disturbance is more commonly reported among pregnant women than among the general female population.¹ Therefore, pregnant women are considered to be a group prone to sleep disturbance.

As mentioned above, many epidemiological studies have already suggested associations between active smoking and sleep disturbance.^{1,16-26,29} Wetter et al, in an epidemiological study, reported that active smoking was associated with difficulty initiating sleep (DIS), excessive daytime sleepiness (EDS), non-restorative sleep, and difficulty waking up.²⁸ In addition, both

polysomnography and questionnaire studies have revealed increased sleep latency, increased arousal, and difficulty staying asleep at night among active smokers, compared with nonsmokers. In the present study, we also observed an association between active smoking and sleep disturbances (SIS: subjective insufficient sleep, DIS: difficulty in initiating sleep, EMA: early morning awakening, SSD: short sleep duration, EDS: excessive daytime sleepiness, and SB: snoring loudly or breathing uncomfortably) suggesting that active smoking contributes to sleep disturbances.

As to the association of passive smoking with sleep disturbance among the general population, to our knowledge, only an association with snoring²³⁻²⁵ has been reported, but no epidemiological study among pregnant women has reported an association with snoring. Therefore, this study is significant in that it focused on the association between passive smoking and SB (snoring loudly or breathing uncomfortably) specifically in pregnant women, who are prone to suffer from sleep disturbance.

Our findings suggest that exposure to ETS might increase nocturnal awakening in nonsmoking pregnant women by contributing toward snoring or sleep disordered breathing. As shown in Table 4, the odds ratio (OR) for loud snoring or uncomfortable breathing (SB) among nonsmokers with ETS was 1.25 (95% CI: 1.03-1.52) after adjusting for the 6 covariates. Nonsmokers who were exposed to ETS were significantly more likely to suffer from SB than nonsmokers who were not exposed to ETS and active smokers were over twice as likely (OR=2.23, 95%CI: 1.50-3.32) to suffer from loud snoring or uncomfortable breathing (SB) than nonsmokers who were not exposed to ETS. Moreover, we found a significant association between exposure to ETS from family and friends and loud snoring or uncomfortable breathing (SB). Franklin et al,²³ on the basis of a large population-based sample, reported that snoring was more prevalent among people who had never smoked but who were exposed to passive smoking than among nonsmokers without such exposure. However, as a limitation to their study, they pointed out that no question on alcohol consumption had been posed. Previous studies reported that pregnant women tend to snore more often than before they became pregnant.⁹⁻¹¹ From the present study, it is inferred that pregnant women who have been exposed to tobacco smoke tend to snore even more often. In the present study, the ORs were also calculated after adjusting for alcohol consumption as a potential confounding factor.

Our results suggest that pregnant women who are exposed to passive smoking are prone to sleep disturbance. It has been reported that nicotine stimulates the central nervous system and promotes wakefulness, resulting in an increase of sleep latency and a reduction of both total sleep time and REM sleep.¹⁹ However, as the amount of nicotine absorbed by passive smoking is smaller than that absorbed by active smoking,³⁰ there is doubt as to whether the amount absorbed by passive smoking is large enough to cause sleep disturbance. In addition, as shown in Table 5, the ORs for SIS (subjective insufficient sleep), and DIS (difficulty in initiating sleep) among nonsmokers who were exposed to tobacco smoke from family and friends were lower than those among nonsmokers who were exposed to tobacco smoke from friends but not from family. This indicates that the dose-response relationship has not yet been clarified. Associations between active smoking and sleep disturbance have been sufficiently shown in previous studies.⁸ Family or friends who suffer from sleep disturbance because of smoking may also directly affect the sleep of nonsmoking pregnant women. Replication studies are needed to help clarify the association that we found between passive smoke exposure and sleep disturbance.

The present study, which is the first epidemiological study to investigate the association between passive smoking and sleep disturbance among pregnant women in Japan, had some limitations. First, since this was a cross-sectional survey, a causal relationship could not be determined. Second, the data on sleep, smoking, and alcohol consumption were all self-reported. However, several

studies have indicated that self-reported data on sleep status show at least moderate agreement with data from laboratory studies.³¹ Third, as this was a cross-sectional study conducted on women whose pregnancy had been confirmed, the reliability of data on smoking status before pregnancy collected via questionnaires needs to be studied further. As most pregnant women probably knew that smoking had an adverse effect on their health, some may not have answered the questions truthfully. Fourth, the questionnaire used in the present study did not include items on unhealthy lifestyles, poor general health, stress, and worries.^{13,16,30-32} Furthermore, there was no question on caffeine intake in the questionnaire, which is a limitation of the present study. Previous studies indicated that regular caffeinated beverage drinkers had difficulty in initiating sleep (DIS), short sleep duration (SSD), and sleep deprivation, and that the combination of alcohol and caffeine could synergistically induce insomnia.³³⁻³⁵ In this study, it is possible that caffeine might have contributed to sleep disturbance, especially to difficulty initiating sleep and short sleep duration. Therefore, epidemiological studies using questionnaires that include these 2 items should be conducted in the future.

In conclusion, this study found a positive relationship between exposure to environmental tobacco smoke and sleep disruption in pregnant women. The relationship between passive smoking exposure and some negative health outcomes in pregnant women could therefore be mediated by the ability of passing smoke to disrupt sleep. Educational programs that point out the adverse effects of passive smoking during pregnancy could help improve sleep hygiene in this group of individuals and help prevent other negative health outcomes associated with disrupted sleep.

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