Passive smoking by pregnant women and fetal growth

Hiroshi Ogawa, Suketami Tominaga, Kohji Hori, Keichi Noguchi, Izumi Kanou, Mikihiro Matsubara

Abstract

Study objective—The aim was to investigate the effect of passive smoke exposure during pregnancy on fetal growth in the Japanese population.

Design—The study comprised a community based interview and clinical survey of pregnant women in Aichi Prefecture, Japan.

Setting—Participants attended for delivery at 146 private and public practices and hospital clinics in the Prefecture.

Subjects—Participants were 6831 women who delivered a live singleton without malformation during the three consecutive months from June 1987, and comprised about 34% of total deliveries in the Prefecture during the period.

Measurements and main results—35% of the women had been exposed passively to cigarette smoke for 2 h or more per day at home, in the work place, or in other places during pregnancy. At this level of passive exposure among non-smoking women with term deliveries (>37 weeks), a small effect on fetal growth was observed; mean birth weight was reduced by 10-8 g, and the relative risk of growth retardation (<2500 g birth weight) was 1-0 (95% CI 0-7-1-5), after adjusting age, parity, height, alcohol drinking, occupation, and gestation.

Conclusions—The results suggest that the reduction of fetal growth associated with passive smoke exposure during pregnancy may be small in Japanese population.

During the past 30 years, extensive evidence on the effect of maternal smoking during pregnancy on fetal growth has been accumulated. The research can be summarised as showing an approximate 200 g reduction of birth weight and a 1-6 to 2-2 relative risk of low birth weight (under 2500 g) for babies born to women who smoke during pregnancy, when compared with babies born to comparable women who do not smoke.1 The most likely explanation for the adverse effects of smoking is that it causes fetal hypoxia resulting from the increased carboxyhaemoglobin level, attenuated blood oxygen unloading, and vasoconstriction of maternal blood supply to the placenta.2

Pregnant women who do not smoke may also be at risk from passive smoking at home, the work place, and other places. The concentrations of carbon monoxide and nicotine are 2-5 and 2-7 times higher respectively in sidestream than in mainstream smoke.1 An increase in the concentration of cotinine was observed in the urine of non-smokers who live with smokers,3,4 and in the amniotic fluid of non-smoking pregnant women chronically exposed to tobacco smoke.5 6

The evidence from epidemiological investigations on the effect of passive smoking on fetal growth is inconsistent. Several studies in the USA from the early 1960s to early 1970s failed to find any relation between paternal smoking and birth weight.7-10 More recent studies showed a significant relation of low birth weight to the amount of paternal smoking,11 duration of tobacco smoke exposure,12 and serum cotinine concentration of non-smoking mothers.13 However, a study in China showed no effect of paternal smoking.14

The risk from passive smoking is a serious problem in Japan, and women of reproductive age are highly likely to be exposed to cigarette smoke at home and in the work place. The prevalence of cigarette smokers among persons aged 20 to 39 years was 70%, for males and 16%, for females in Japan in 1986 (unpublished observations from a nationwide survey on the prevalence of cigarette smokers conducted by Japan Tobacco Industry Co). The rate of employed persons in this age group was 93% for males and 58%, for females in 1985.15 These figures were enough to warrant concern about the risk. A recent study in Japan reported a rather small effect of paternal smoking on growth retardation (gestation >37 weeks and birthweight <2500 g) of babies from non-smoking mothers; crude relative risk was 1-2 (90%, CI 0-8-1-5).16 In the present study we aimed to examine the effect of passive smoke exposure among pregnant women on fetal growth in the Japanese population.

Methods

Obstetricians in Aichi Prefecture, Japan, who are members of the Aichi Society of Obstetricians and Gynaecologists, were invited to participate in the study, and 146 private or public practices and hospital clinics participated. The Society sent semi-structured questionnaire format sheets to the participating institutions. Brief instructions on the procedure for information collection were given on each sheet. Women who underwent prenatal care at these facilities were interviewed before or after delivery by physicians, midwives, or nurses. The responses were recorded on the format sheet. Information gathered on cigarette smoke exposure included smoking by women and their husbands before and after pregnancy, and the average length of passive smoke exposure during pregnancy per day at home, the work...
passive smoking, and other places. Information on alcohol drinking and occupation during pregnancy was also obtained at the interview. Data regarding pregnancy, delivery, and other clinical items were transferred from medical records to the format sheets. Between June 1 and August 31, 1987, 7313 women interviewees delivered (estimated as 36.1% of the total deliveries in Aichi Prefecture during the period). Of these, 6831 women delivered a live singleton without malformation. These women and babies were the study subjects. The associations between passive smoking and birth weight and the prevalence of growth retardation (< 2500 g birth weight in > 37 weeks gestational age) were examined. Multiple linear regression and binary multiple logistic regression were used to adjust for the possible effects of confounding factors. 17, 18 In the categorical statistical analysis, passive smoking was defined as exposure to other persons' cigarette smoke for at least 2 h per day at home, the work place, and other places, as in a previous study. 12

**Results**

**CIGARETTE SMOKING EXPOSURE**

The rate of passive exposure to cigarette smoke was 62.2% for at least 1 min per day, and 35.3%, for at least 2 h per day, as shown in table I. Mean exposure time for the exposed women was 3.1 h per day. The distribution of overall exposure time by place was 57.1% at home, 35.2% at the work place, and 7.7% for other places. The prevalence of smoking among husbands during pregnancy was 64.6%. The mean number of cigarettes smoked by them was 19.6 per day, which was not different from 20.3 per day before pregnancy. About 30%, of women whose husbands smoked during pregnancy were not exposed at all to cigarette smoke at home, and about 13% of women whose husbands never smoked were exposed at home. Only about 6%, of women smoked cigarettes during pregnancy. More than half of the women who had been smoking before pregnancy stopped smoking after becoming pregnant. Mean gestation at the time of stopping smoking was 8.2 weeks. Mean consumption of cigarettes for daily smokers was 10.2 per day, which was significantly less than the 13.7 per day before pregnancy (p < 0.01).

**CHARACTERISTICS OF PASSIVE SMOKERS**

Table II shows that women who were exposed to smoke tended to be young and nulliparous, to drink alcohol, to be employed, and to have smoking husbands, compared with those who were not exposed. This tendency was significant among women who were non-smokers (p < 0.01). Therefore, these characteristics were included as possible confounding factors in the multivariate analysis of the association between passive smoking and fetal growth. 19

**MATERIAL EXPOSURE TO CIGARETTE SMOKING AND FETAL GROWTH**

There was a small but statistically significant decrease in birth weight from passive smoke exposure in mothers who had never smoked, while no significant change was observed in smoking mothers who stopped or continued to smoke, as shown in table III. The crude relative risk of growth retardation from passive smoke exposure was almost unity for mothers who had never smoked and also for smoking mothers who

### Table I Maternal cigarette smoke exposure during pregnancy

<table>
<thead>
<tr>
<th>Exposure to cigarette smoke</th>
<th>Subjects</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive exposure*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never exposed</td>
<td>2453</td>
<td>37.8</td>
</tr>
<tr>
<td>Exposed</td>
<td>4043</td>
<td>62.2</td>
</tr>
<tr>
<td>Duration of exposure per day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 119 min</td>
<td>1748</td>
<td>43.2</td>
</tr>
<tr>
<td>120-239 min</td>
<td>1022</td>
<td>27.3</td>
</tr>
<tr>
<td>≥240 min</td>
<td>1193</td>
<td>29.5</td>
</tr>
<tr>
<td>Smoking of husband</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>2220</td>
<td>32.8</td>
</tr>
<tr>
<td>Stopped</td>
<td>171</td>
<td>2.5</td>
</tr>
<tr>
<td>Smoked every day</td>
<td>4369</td>
<td>64.6</td>
</tr>
<tr>
<td>The amount of cigarette</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoked per day for smokers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤19 cigarettes</td>
<td>1330</td>
<td>31.7</td>
</tr>
<tr>
<td>20-29 cigarettes</td>
<td>2067</td>
<td>50.0</td>
</tr>
<tr>
<td>≥30 cigarettes</td>
<td>769</td>
<td>18.3</td>
</tr>
<tr>
<td>Active smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>5784</td>
<td>85.5</td>
</tr>
<tr>
<td>Stopped</td>
<td>600</td>
<td>9.9</td>
</tr>
<tr>
<td>Smoked occasionally</td>
<td>145</td>
<td>2.1</td>
</tr>
<tr>
<td>Smoked every day</td>
<td>238</td>
<td>3.5</td>
</tr>
<tr>
<td>The amount of cigarettes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoked per day for smokers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤9 cigarettes</td>
<td>101</td>
<td>43.7</td>
</tr>
<tr>
<td>10-19 cigarettes</td>
<td>97</td>
<td>42.0</td>
</tr>
<tr>
<td>≥20 cigarettes</td>
<td>33</td>
<td>14.3</td>
</tr>
</tbody>
</table>

*Exposure at home, work place, and other places

### Table II Maternal characteristics by cigarette smoke exposure during pregnancy

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Exposure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Active</td>
<td>Passive</td>
</tr>
<tr>
<td>Percent</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Percent</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>The number of subjects</td>
<td>4018</td>
<td>2076</td>
</tr>
<tr>
<td>(% by exposure status)</td>
<td>(62.4)</td>
<td>(52.2)</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;19</td>
<td>0.6</td>
<td>1.3</td>
</tr>
<tr>
<td>20-24</td>
<td>14.6</td>
<td>22.5</td>
</tr>
<tr>
<td>25-29</td>
<td>52.3</td>
<td>50.9</td>
</tr>
<tr>
<td>30-34</td>
<td>26.3</td>
<td>20.5</td>
</tr>
<tr>
<td>≥35</td>
<td>6.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Mean</td>
<td>28.2</td>
<td>27.3</td>
</tr>
<tr>
<td>SD</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>t = 1.816*</td>
<td></td>
<td>t = 1.317*</td>
</tr>
<tr>
<td>Height (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤149</td>
<td>6.0</td>
<td>5.7</td>
</tr>
<tr>
<td>150-154</td>
<td>28.9</td>
<td>28.8</td>
</tr>
<tr>
<td>155-159</td>
<td>38.8</td>
<td>36.3</td>
</tr>
<tr>
<td>160-164</td>
<td>22.5</td>
<td>24.3</td>
</tr>
<tr>
<td>&gt;165</td>
<td>4.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Mean</td>
<td>156.3</td>
<td>156.5</td>
</tr>
<tr>
<td>SD</td>
<td>4.9</td>
<td>5.1</td>
</tr>
<tr>
<td>t = 1.37*</td>
<td></td>
<td>t = 1.37*</td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nulliparous</td>
<td>36.3</td>
<td>48.1</td>
</tr>
<tr>
<td>Multiparous</td>
<td>63.7</td>
<td>51.9</td>
</tr>
<tr>
<td>t² = 78.72*</td>
<td>x² = 4.48</td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>71.3</td>
<td>61.5</td>
</tr>
<tr>
<td>Stopped</td>
<td>16.1</td>
<td>21.9</td>
</tr>
<tr>
<td>Occasionally</td>
<td>12.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Every day</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>t² = 61.16*</td>
<td>x² = 0.86</td>
<td></td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never worked</td>
<td>66.1</td>
<td>41.8</td>
</tr>
<tr>
<td>Stopped to work</td>
<td>15.0</td>
<td>20.4</td>
</tr>
<tr>
<td>Continued/started to work</td>
<td>18.9</td>
<td>24.2</td>
</tr>
<tr>
<td>t² = 352.0*</td>
<td>x² = 2.80</td>
<td></td>
</tr>
<tr>
<td>Smoking of husband</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never/stopped</td>
<td>47.2</td>
<td>18.8</td>
</tr>
<tr>
<td>Every day</td>
<td>52.8</td>
<td>81.2</td>
</tr>
<tr>
<td>t² = 407.57*</td>
<td>x² = 13.81*</td>
<td></td>
</tr>
</tbody>
</table>

*Active exposure: + (Occasionally/every day), − (Never/stopped)

Passive exposure: + (≥2 h), − (<2 h)

p < 0.01
for factors smoked; n with gestational age less than 37 weeks excluded

Table III  Mean birth weights and growth retardation rates by maternal cigarette smoke exposure during pregnancy. Infants with gestational age less than 37 weeks excluded

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Number of subjects</th>
<th>Birth weight (g)</th>
<th>Growth retardation Rate (%)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- -</td>
<td>3606</td>
<td>3183</td>
<td>-24*</td>
<td>2.8 1.0</td>
</tr>
<tr>
<td>- +</td>
<td>1730</td>
<td>3159</td>
<td>24*</td>
<td>3.0 1.1</td>
</tr>
<tr>
<td>+ -</td>
<td>243</td>
<td>3140</td>
<td>19*</td>
<td>2.1 1.0</td>
</tr>
<tr>
<td>+ +</td>
<td>275</td>
<td>3155</td>
<td>15</td>
<td>3.6 1.8</td>
</tr>
<tr>
<td>++</td>
<td>138</td>
<td>3108</td>
<td>44*</td>
<td>4.3 1.0</td>
</tr>
<tr>
<td>+++</td>
<td>183</td>
<td>3113</td>
<td>84*</td>
<td>4.4 1.0</td>
</tr>
</tbody>
</table>

Active exposure: + (smoked occasionally or every day); - (stopped smoking); 0 (never smoked)
Passive exposure: + (exposed 2 h or more a day); - (exposed less than 2 h a day)

RR = relative risk

MULTIVARIATE ANALYSIS

A multiple regression analysis of birth weight was conducted for mothers who had never smoked. Table V shows that passive smoke exposure was not significantly related to birth weight. Adjusted weight reduction from passive smoke exposure for two hours or more was 10-8 g, which was nearly half of the crude weight reduction in table III. In another multiple regression analysis for all mothers, in which active and passive smoking were treated as continuous variables by using the number of cigarettes smoked per day and exposure time per day respectively, the adjusted weight reduction was 56-0 g for active smoking of 10 cigarettes per day.

A binary logistic regression analysis of growth retardation was conducted for mothers who had never smoked. No effect due to passive smoke exposure was observed, as shown in table VI. The adjusted relative risk was 1.0 (95% CI:0.7-1.5) in mothers who had passive exposure for 2 h or more per day. This was almost the same as the crude relative risk in table III. When active smoking by mothers was included as an independent variable in the binary logistic regression analysis, the adjusted relative risk was 1.6 (95% CI:0.9-2.8, 0.05<p<0.10) for occasional and daily smokers.

Discussion

The present study showed a rather small effect due to passive smoke exposure on fetal growth. It is difficult to account for the results in terms of selection bias or recall bias. Study subjects were pregnant women who received perinatal care from obstetricians. As almost all deliveries in Aichi Prefecture were attended by physicians (98.2% in a 1987 official report), there was little chance of selection bias due to medical care. The present study covers about one third of all deliveries in Aichi Prefecture during the study period. This may not be enough to warrant a generality from the study results, but we do not think that the results can be explained by selection bias. Subjects interviewed after delivery may have been influenced in their responses by the delivery outcome. However, we would expect that where low birth weight or growth retardation had continued to smoke. For those who stopped smoking, the risk was rather high, but not significant. Table IV shows a more detailed analysis of the effect on fetal growth for mothers who had never smoked. No statistically significant reduction of birth weight was observed at any level of passive smoke exposure. A dose-response relationship between passive smoke exposure and birth weight was not statistically significant. The relative risk of growth retardation by passive smoke exposure was also not significant.

Table IV  Mean birth weight and growth retardation rate by passive smoke exposure in mothers who had never smoked; n = 5336. Infants with gestational age less than 37 weeks excluded

<table>
<thead>
<tr>
<th>Passive exposure to cigarette smoke per day</th>
<th>Subjects</th>
<th>Birth weight (g)</th>
<th>Growth retardation Rate (%)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never exposed</td>
<td>2149</td>
<td>3176</td>
<td>29</td>
<td>1.0</td>
</tr>
<tr>
<td>&lt;2 h</td>
<td>1457</td>
<td>3193</td>
<td>17</td>
<td>2.7 0.9</td>
</tr>
<tr>
<td>2-3 h</td>
<td>859</td>
<td>3166</td>
<td>-10</td>
<td>2.9 1.0</td>
</tr>
<tr>
<td>&gt;4 h</td>
<td>871</td>
<td>3152</td>
<td>-24</td>
<td>3.1 1.1</td>
</tr>
</tbody>
</table>

RR = relative risk

Table V  Multiple linear regression analysis on birth weight in mothers who had never smoked; n = 5336. Infants with gestational age less than 37 weeks excluded. The mean and modal values were substituted for 115 cases with missing data for factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>(Unit)</th>
<th>Coefficients (SEM)</th>
<th>T values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive smoking</td>
<td>0-2h, 1-2h</td>
<td>-10.755 (10.914)</td>
<td>0.99</td>
</tr>
<tr>
<td>Age</td>
<td>(years)</td>
<td>-7.070 (1.488)</td>
<td>4.887</td>
</tr>
<tr>
<td>Parity</td>
<td>(nulliparous, parous)</td>
<td>111.902 (11.591)</td>
<td>9.657</td>
</tr>
<tr>
<td>Height</td>
<td>(cm)</td>
<td>12.589 (1.041)</td>
<td>12.097</td>
</tr>
<tr>
<td>Alcohol</td>
<td>(ever, never, stopped, occasionally, every day)</td>
<td>-0.938 (0.857)</td>
<td>1.04</td>
</tr>
<tr>
<td>Occupation</td>
<td>(ever, never, stopped, continued or started)</td>
<td>-3.148 (0.247)</td>
<td>0.50</td>
</tr>
<tr>
<td>Gestation age</td>
<td>(weeks) 101.857 (4.251)</td>
<td>23.927</td>
<td></td>
</tr>
</tbody>
</table>

Constant = 5045.8
R² = 0.30
† p < 0.01

Table VI  Binary logistic regression analysis of growth retardation in mothers who had never smoked; n = 5336. Infants with gestational age less than 37 weeks excluded. The mean and modal values were substituted for 115 cases with missing data for factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>(Risk category)</th>
<th>Coefficient (β)</th>
<th>Adjusted RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive smoking</td>
<td>(2 h or more)</td>
<td>0.034</td>
<td>1.0</td>
<td>0.71-1.5</td>
</tr>
<tr>
<td>Age</td>
<td>(35 years or more)</td>
<td>-0.175</td>
<td>0.8</td>
<td>0.4-1.8</td>
</tr>
<tr>
<td>Parity</td>
<td>(nulliparous)</td>
<td>0.720</td>
<td>2.1</td>
<td>1.5-2.9</td>
</tr>
<tr>
<td>Height</td>
<td>(154 cm or less)</td>
<td>0.752</td>
<td>2.1</td>
<td>1.5-3.0</td>
</tr>
<tr>
<td>Alcohol</td>
<td>(drank every day/occasionally)</td>
<td>0.111</td>
<td>1.1</td>
<td>0.71-1.8</td>
</tr>
<tr>
<td>Occupation</td>
<td>(continued/started)</td>
<td>-0.156</td>
<td>0.9</td>
<td>0.6-1.3</td>
</tr>
<tr>
<td>Gestation age</td>
<td>(38 weeks or less)</td>
<td>1.715</td>
<td>5.6</td>
<td>4.0-7.8</td>
</tr>
</tbody>
</table>

RR = relative risk
95% CI = EXP (β ± 1.96SEM)
† p < 0.01
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deliveries by non-smoking mothers who had passive smoke exposure of 2 h or more per day.12

These values are higher than the corresponding values of 10.8 g and 1-0, respectively, in the

present study. Another recent study, from Denmark, showed much stronger effect of passive

smoking; mean birth weight in non-smoking mothers was reduced by 120 g per pack of

cigarettes smoked per day by the father.11

Some part of the smaller effects of passive smoking in the present study and other studies in Japan12

and China4 might be attributed to lower concentrations of carbon monoxide and nicotine in cigarette smoke which is inhaled by pregnant

women. Japanese women may be more conscious about health maintenance during pregnancy than

women in Western countries, perhaps through traditional Asian sociocultural norms which put a

special pressure on women of reproductive age to maintain good health. The prevalence of smoking

and alcohol drinking was only 5.6% and 15% in the present study. This is far lower than 32% and

69% respectively in the American study,12 and 40% and 59%, respectively in the Danish study.11

The ratio of passive smoke exposure for 2 h or more per day was 35%, in the present study, which

is lower than 44% in the USA,12 contrary to the high prevalence of young adult male smokers in Japan. In addition it was found in the present

study that about 61% of smoking mothers had stopped smoking by about 8 weeks of gestation,

and that about 30% of women living with a smoking husband reported no passive smoke exposure at home. These findings suggest a

stronger health consciousness in Japanese pregnant women.

The actual amount of passive smoke exposure may be related not only to exposure time, but also to the

concentration of the residual smoke in a room, which is dependent on ventilation, room size,

building materials, number of persons smoking, and smoking behaviour. As these conditions may

be different among countries, an international comparative study using biochemical marker

assays of passive smoke exposure for pregnant women is needed.

Although this study did not show a significant effect of passive exposure on fetal growth, it is expected

that our results that heavy exposure does induce a reduction in fetal growth, just as active smoking does. Therefore passive smoking

of pregnant women is an important public health issue, especially in Japan where the prevalence of

cigarette smokers among young adults is high.

We are grateful to the members of the Aichi Prefectural Society of Obstetricians and Gynaecologists for their cooperation with this research.


