



This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

<http://www.elsevier.com/copyright>

Contents lists available at [SciVerse ScienceDirect](http://www.sciencedirect.com)

## Preventive Medicine

journal homepage: [www.elsevier.com/locate/ypmed](http://www.elsevier.com/locate/ypmed)

Brief Original Report

## Longitudinal study of parental smoking habits and development of asthma in early childhood

Miki Kanoh<sup>a</sup>, Yoshitaka Kaneita<sup>a,\*</sup>, Megumi Hara<sup>b</sup>, Shohei Harada<sup>c</sup>, Yasuhiro Gon<sup>d</sup>, Hiroshi Kanamaru<sup>e</sup>, Takashi Ohida<sup>a</sup><sup>a</sup> Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, Tokyo, Japan<sup>b</sup> Division of Preventive Medicine, Department of Social Medicine, Faculty of Medicine, Saga University, Saga, Japan<sup>c</sup> Division of Clinical Practice Policy, Department of Health Policy, National Research Institute for Child Health and Development, Tokyo, Japan<sup>d</sup> Division of General Medicine, Department of Medicine, Nihon University School of Medicine, Tokyo, Japan<sup>e</sup> Department of Pediatrics and Child Health, Nihon University School of Medicine, Tokyo, Japan

## ARTICLE INFO

Available online 26 October 2011

## Keywords:

Parental smoking  
Child  
Asthma

## ABSTRACT

**Objective.** This study examined the association between parental smoking habits and the development of asthma in early childhood by using representative samples.**Methods.** The survey subjects included all of the 53,575 babies born in Japan during the periods January 10–17 and July 10–17, 2001. The families of the subjects were asked to complete questionnaires that were delivered by post at 6 months, 1 year 6 months, 2 years 6 months, 3 years 6 months, and 4 years 6 months postpartum. The first survey contained questions regarding the smoking habits of the parents. The second to fifth surveys asked if the child had needed medical attention for the treatment of asthma.**Results.** Data from 36,888 subjects (collection rate: 68.9%) were analyzed. The 4-year cumulative incidence of asthma was 12.0%. Maternal indoor smoking significantly increased the risk of asthma development in children, 4-year risk 14.4% vs. 11.7%, risk ratio = 1.24, 95% CI: 1.11 to 1.38. No statistically significant association was found between paternal smoking and asthma development in children.**Conclusions.** In order to prevent the development of asthma in early childhood, it is necessary to formulate measures to stop or discourage maternal smoking.

© 2011 Elsevier Inc. All rights reserved.

## Introduction

As childhood is a period when various organs and functions are developing rapidly, it is possible that exposure to passive smoking during this period could pose serious health hazards. Therefore, much attention has been focused on the effects of passive smoking on children, and a large volume of epidemiological findings have been accumulated (Crone et al., 2001; Lund et al., 1998; Schuster et al., 2002).

The respiratory organs are susceptible to passive smoking, and the associations between respiratory diseases and passive smoking have been aggressively studied. Previous epidemiological studies showed that exposure of children to passive smoking increased the risk of developing asthma and wheezing (Jaakkola et al., 2001; Martinez et al., 1992, 1995; Royal College of Physicians, 2010; Strachan and Cook, 1998; Tanaka et al., 2008; Tariq et al., 2000; Taylor et al., 1983). However,

insufficient epidemiological studies have been conducted in Japan to confirm the associations between passive smoking and asthma or wheezing in children because no longitudinal study has included a sufficient number of highly representative subjects. In the present study, therefore, we examined the association between parental smoking behavior and asthma development in children using the data obtained in a nationwide cohort study of infants and young children in Japan.

## Methods

In this study, we used data that had been collected from the first to the fifth Longitudinal Surveys of Babies in the 21st Century and the records of births in the Vital Statistics of Japan. The subjects of the Longitudinal Survey of Babies in the 21st Century included babies (53,575) who were born in Japan during the eight days from January 10–17, 2001 (January children), and also during the eight days from July 10–17 of the same year (July children). For the survey, the self-administered questionnaires were sent by mail from the Ministry to each subject household, filled out by a family member, and sent back to the Ministry by mail. The first survey was conducted at 6 months postpartum and the conditions of the subjects as of August 1, 2001 and February 1, 2002 were sought in the questionnaire for the January children and July children, respectively. The second to the fifth surveys were

\* Corresponding author at: Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, 30-1, Ohyaguchikamimachi, Itabashi-ku, Tokyo 173-8610, Japan. Fax: +81 3 3972 5878.

E-mail address: [kaneita.yoshitaka@nihon-u.ac.jp](mailto:kaneita.yoshitaka@nihon-u.ac.jp) (Y. Kaneita).

conducted at 1 year 6 months, 2 years 6 months, 3 years 6 months, and 4 years 6 months postpartum at each corresponding time, i.e. every year.

The first and the fifth questionnaires contained questions regarding parental smoking behavior at the time of the survey. The first survey questionnaire included questions inquiring whether parents had a smoking habit at the time of the survey, and also asked those who were smokers to state the number of cigarettes smoked per day and whether they smoked indoors. In the fifth survey, parents were asked whether they smoked at the time of the survey. On the other hand, the second, third, and fourth questionnaires did not contain any items regarding parental smoking behavior, nor were there any questions on parental smoking behavior before and during pregnancy. In the second through the fifth surveys, the question "Was the child seen in a medical institution for asthma in the previous 1 year?" was posed, and two answer options (Yes and No) were provided.

The statistical analysis was limited to cases where both parents lived with the subjects at the time of the first and the fifth surveys and for whom information on parental smoking behavior had been obtainable. First, we calculated the cumulative incidence of asthma in children by the type of parental smoking behavior. Second, the Cox's proportional hazard model analyses were performed to obtain the adjusted hazard ratio for asthma development in children according to the type of parental smoking behavior. For this purpose, we established four models. Model 1 examined the association between the location where parents smoked at first survey and asthma development in their children, Model 2 examined the association between the number of cigarettes smoked at first survey by a parent and asthma development in the children, Model 3 examined the association between the trend in parental smoking behavior and asthma development in the children, and Model 4 examined the association between the smoking behavior by households at first survey and asthma development in the children. We adopted four different models in order to avoid multicollinearity. For each of these models, we used asthma development in children as the dependent variable and information on parental smoking as the independent variable. In all of these models, the population size in the place of residence, child's sex, single/multiple birth, birth weight, the number of siblings, breast feeding, presence of a pet animal in the home, and annual income of the household were input as covariates, followed by adjustment for confounding factors.

## Results

In the first Longitudinal Survey of Babies in the 21st Century, questionnaires were collected from 47,015 out of a total of 53,575 children. Among them, 36,888 children met all of the conditions, i.e. participation in the fifth survey, both parents living with the child, and information obtained on parental smoking behavior. The response rate for the subject children overall was 68.9%. Table 1 shows the background factors of the subjects who were analyzed.

The 4-year cumulative incidence of asthma was 12.0% (95% CI, 11.7%–12.3%) for the analyzed cases as a whole. Table 2 shows the 4-year cumulative incidence of asthma and the results of the Cox's proportional hazard model analyses. In Model 1, the location where mothers smoked showed a significant association with asthma development in children. Maternal smoking indoors increased the risk of asthma development in children. However, no significant association was found between the smoking location for fathers and asthma development in children. In Model 2, the number of cigarettes smoked by mothers was significantly associated with asthma development in children. Even smoking a relatively small number of cigarettes, i.e. 1–10 cigarettes a day, increased the risk of asthma development in children. On the other hand, the number of cigarettes smoked by fathers was not significantly associated with asthma development in children. In Model 3, a significant association was found between the trend in maternal smoking behavior and asthma development in children. On the other hand, the trend in paternal smoking behavior was not associated with asthma development in children. In Model 4, the risk of asthma development in children was significantly high at the home which both a mother and a father smoke.

**Table 1**  
Background factors of the participants, Japan, 2001–2006.

	Present study		Vital statistics	
	n	%	%	Survey year
Places of residence			21.2	2001
Urban	7958	21.6		
Suburban	21,929	59.4		
Rural	7001	19.0		
Child's sex				
Male	19,199	52.0	51.3	2001
Female	17,689	48.0	48.7	2001
Single birth or multiple births				
Single birth	36,130	97.9	98	2000
Multiple births	758	2.1	2	2000
Birth weight				
<2500 g	3042	8.2	7.4	2000
2500 g ≤	33,837	91.7	92.6	2000
Unknown	9	0.0		
Number of siblings				
0	18,278	49.5	49.0	2001
1 or more	18,610	50.5	51.0	2001
Exclusive breast-feeding				
No	28,548	77.4		
Yes	8091	21.9		
Unknown	249	0.7		
Presence of a pet animal in the home				
No	22,416	60.8		
Yes	12,497	33.9		
Unknown	1975	5.4		
Annual income of the household				
<4 million yen	7599	20.6		
4 ≤ <8 million yen	20,731	56.2		
8 million yen ≤	6705	18.2		
Unknown	1853	5.0		

The results of the analysis, after dividing the period of onset of asthma into 2 periods (the first 2 and latter 2 years), showed that maternal smoking behavior was associated with asthma development in children during the first 2 years. Maternal smoking indoors significantly increased the risk of asthma development in children during the first 2 years. However, no significant association was observed between maternal smoking behavior and asthma development in children during the latter 2 years. With regard to the association between paternal smoking behavior and asthma development in children, no significant association was observed during either the first or latter 2 years (data not shown).

## Discussion

The samples used in this study can be considered sufficiently representative of infants, young children, and their parents in Japan for three reasons: First, as shown in Table 1, the characteristics of the analyzed subjects were similar to those represented in the Vital Statistics of Japan. Second, the response rate was sufficiently high. Third, over 30,000 samples were collected from all over Japan.

This study had a few limitations. First, as the information was based on self-reported data, there may have been some underestimation. However, several previous studies have reported that self-responses to questions about one's own smoking tend to be valid (Coghlin et al., 1989; Pirkle et al., 1996). Second, smoking habits of persons other than parents were not examined as a cause of passive smoking around children. Third, discussion remains regarding the validity of the definition of asthma development. As the questionnaires were completed mostly by the children's parents, some degree of subjectivity may have been involved in the responses. Fourth, a non-response bias may have been present. In this longitudinal study, the households in which mothers or fathers smoked tended to drop out during the follow-up surveys. Therefore, a non-

**Table 2**  
Cox's proportional hazard model for prediction of asthma development in Japanese children, Japan, 2001–2006.

	n	Cumulative incidence of asthma		Cox's proportional hazard model for prediction of asthma development		
		%	pValue	AHR	95% CI	pValue
<i>Model 1</i>						
Smoking location at the first survey						
Mother			<0.01			<0.01
Non smoking	31,769	11.7		1.00		
Smoking-yes, indoor	1473	12.4		1.06	0.90	1.25
smoking-no						
Smoking-yes, indoor	3551	14.4		1.24	1.11	1.38
Father			0.01			0.14
Non smoking	14,487	11.4		1.00		
Smoking-yes, indoor	9546	12.2		1.09	1.00	1.18
smoking-no						
Smoking-yes, indoor	12,358	12.6		1.04	0.96	1.13
<i>Model 2</i>						
Number of cigarettes smoked at the first survey						
Mother			<0.01			<0.01
Non smoking	31,769	11.7		1.00		
1–10 Cigarettes per day	3481	13.8		1.17	1.06	1.30
11 Cigarettes or more	1602	13.7		1.19	1.03	1.39
per day						
Father			0.03			0.40
Non smoking	14,487	11.4		1.00		
1–10 Cigarettes per day	5406	12.1		1.04	0.94	1.14
11–20 Cigarettes per day	12,638	12.4		1.06	0.98	1.15
21 Cigarettes or more per day	3787	12.8		1.08	0.96	1.20
<i>Model 3</i>						
Trend in smoking behavior from the first to the fifth surveys						
Mother			<0.01			<0.01
From "no" to "no"	29,892	11.6		1.00		
From "yes" to "no,"from "no" to "yes"	2825	13.2		1.14	1.02	1.28
From "yes" to "yes"	4171	14.0		1.20	1.09	1.32
Father			<0.01			0.15
From "no" to "no"	13,650	11.3		1.00		
From "yes" to "no,"from "no" to "yes"	4160	11.8		1.04	0.93	1.15
From "yes" to "yes"	19,078	12.5		1.07	1.00	1.15
<i>Model 4</i>						
Smoking behavior by households at the first survey						
No smoking parents	14,075	11.4		1.00		
Only maternal smoking	412	13.8		1.23	0.92	1.63
Only paternal smoking	17,694	12.0		1.06	0.99	1.13
Maternal and paternal smoking	4707	13.8		1.25	1.13	1.38

The first survey was conducted in August, 2001 or February, 2002. The fifth survey was conducted in August, 2005 or February, 2006. In all of these models, the population size in the place of residence, child's sex, single/multiple birth, birth weight, the number of siblings, breast feeding, presence of a pet animal in the home, and annual income of the household were input as covariates. In each section, the missing data have been excluded from the statistical analyses. AHR: adjusted hazard ratio. CI: confidence interval.

response bias must be considered when translating the results of the analysis. Fifth, unfortunately, as the study questionnaire did not inquire about smoking history during pregnancy, we were unable to consider the effects of maternal smoking during pregnancy. Sixth, the question about parents' smoking was not divided into workplace smoking and smoking in home. In future studies, questions, which were not included in this study, must be included in questionnaires in order to improve studies.

**Conclusions**

Maternal smoking behavior significantly increased the risk of asthma development in infants and young children. For the prevention of asthma development in infants and young children induced by passive smoking, the creation of strategies targeting maternal smoking should be given first priority.

**Conflict of interest statement**

The authors declare that there are no conflicts of interest.

**Acknowledgments**

We wish to express our thanks to Dr. Itsuro Yoshimi (Tokyo Metropolitan Government) for his help in this study. This study was supported by a Health Science Research Grant from the Ministry of Health, Labour and Welfare of the Japanese Government (H18-GANRINSHO-WAKATE-004).

**References**

Coghlin, J., Hammond, S.K., Gann, P.H., 1989. Development of epidemiologic tools for measuring environmental tobacco smoke exposure. *Am. J. Epidemiol.* 130, 696–704.

Crone, M.R., Reijneveld, S.A., Burgmeijer, R.J., Hirasings, R.A., 2001. Factors that influence passive smoking in infancy: a study among mothers of newborn babies in The Netherlands. *Prev. Med.* 32, 209–217.

Jaakkola, J., Nafstad, P., Magnus, P., 2001. Environmental tobacco smoke, parental atopy, and childhood asthma. *Environ. Health Perspect.* 109, 579–582.

Lund, K.E., Skrondal, A., Vertio, H., Helgason, A.R., 1998. To what extent do parents strive to protect their children from environmental tobacco smoke in the Nordic countries? A population-based study. *Tob. Control* 7, 56–60.

Martinez, F.D., Cline, M., Burrows, B., 1992. Increased incidence of asthma in children of smoking mothers. *Pediatrics* 89, 21–26.

Martinez, F.D., Wright, A.L., Taussig, L.M., Holberg, C.J., Halonen, M., Morgan, W.J., 1995. Asthma and wheezing in the first six years of life. The Group Health Medical Associates. *N. Engl. J. Med.* 332, 133–138.

Pirkle, J.L., Flegal, K.M., Bernert, J.T., Brody, D.J., Etzel, R.A., Maurer, K.R., 1996. Exposure of the US population to environmental tobacco smoke: the Third National Health and Nutrition Examination Survey, 1988 to 1991. *JAMA* 275, 1233–1240.

Royal College of Physicians, 2010. Passive smoking and children, a report of the Tobacco Advisory Group of the Royal College of Physicians available from <http://bookshop.rcplondon.ac.uk/details.aspx?e=3052010>.

Schuster, M.A., Franke, T., Pham, C.B., 2002. Smoking patterns of household members and visitors in homes with children in the United States. *Arch. Pediatr. Adolesc. Med.* 156, 1094–1100.

Strachan, D.P., Cook, D.G., 1998. Health effects of passive smoking. 6. Parental smoking and childhood asthma: longitudinal and case-control studies. *Thorax* 53, 204–212.

Tanaka, K., Miyake, Y., Sasaki, S., Ohya, Y., Hirota, Y., Osaka Maternal and Child Health Study Group, 2008. Maternal smoking and environmental tobacco smoke exposure and the risk of allergic diseases in Japanese infants: the Osaka Maternal and Child Health Study. *J. Asthma* 45, 833–838.

Tariq, M., Hakim, A., Matthews, M., Arshad, H., 2000. Influence of smoking on asthmatic symptoms and allergen sensitisation in early childhood. *Postgrad. Med. J.* 76, 694–699.

Taylor, B., Wadsworth, J., Golding, J., Butler, N., 1983. Breast feeding, eczema, asthma, and hayfever. *J. Epidemiol. Community Health* 37, 95–99.