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Association of Passive and Active Smoking with Elevated Blood Lead Levels Among Children and Adults Resided in a City of Japan

Tomoyo Sato[1], Asae Oura[1], Hideki Yoshida[2], Yuichi Ohira[3], Yasushi Itoh[4], Shouko Shimizu[5] and Mitsuru Mori[6]*

[1]Department of Public Health, Sapporo Medical University School of Medicine, South 1, West 17, Chuo-ku, Sapporo, Hokkaido 060-8556, Japan
[2]Department of Civil Engineering and Architecture, Muroran Institute of Technology, 27-1, Mizumoto-cho, Muroran, Hokkaido 050-8585, Japan
[3]Department of Applied Sciences, Muroran Institute of Technology, 27-1, Mizumoto-cho, Muroran, Hokkaido 050-8585, Japan
[4]Muroran Health Center, 1-4, Kaigan-cho, Muroran, Hokkaido 051-8555, Japan
[5]Department of Health and Welfare, Muroran City, 4-20, Higashi-cho, Muroran, Hokkaido 050-0083, Japan
[6]Hokkaido Chitose College of Rehabilitation, Satomi 2-10, Chitose, Hokkaido 066-0055, Japan

Abstract

There were no previous reports assessing the effect of tobacco smoke on blood lead levels (BLLs) simultaneously in children and adults in Japan. We investigated the association of passive and active smoking with BLLs in children and adults among the general population in Hokkaido, Japan. One hundred seventy-seven persons (78 males, 99 females) participated in the survey in May, 2014. Age groups of subjects younger than 18 years (age group A) and subjects older than or equal to 18 years (age group B) were designated. The median value of the BLLs was used for us to divide into two groups, such as high and low BLL groups. Age and sex adjusted odds ratios (OR) and 95% confidence levels (CLs) were estimated with analysis of the logistic regression model. BLLs in age group B were significantly higher than age group A (p=0.023). In age group A, the proportion of subjects living with habitual smokers other than parents in the household was significantly higher in the high BLL group than in the low BLL group (p=0.019). In age group B, currently habitual smoking was significantly associated with increased risk being in the high BLL group (OR=3.17, 95% CL, 1.28-7.86). A duration of smoking longer than or equal to 20 years was significantly associated with increased risk of being in the high BLL group (OR=2.73, 95% CL, 1.07-6.94), BLL is higher in older persons than in younger persons. Active and passive smoking may be associated with high BLLs in adults and children, respectively.

Keywords: Blood lead levels; Smoking; Passive smoking; Cross-sectional studies

Background

In 2013, a survey was conducted in a city notorious for industry in Hokkaido, Japan, and revealed that the soils were polluted with arsenic and lead compounds in an area contaminated with industrial waste. To evaluate the health effects of these contaminants, the city bureau recruited inhabitants near the contaminated area to conduct their health check-up survey in April of 2014. We had an opportunity to investigate the association of personal characteristics and lifestyle with blood lead levels (BLLs) both in children and adults, using the data obtained from the survey.

Introduction

Lead is a pleiotropic and cumulative toxicant that affects multiple body systems and is particularly harmful to young children [1]. However, due to the success of the environmental administration, a high concentration of pollution by lead has been reduced in most developed countries [2]. Although acute lead poisoning has become rare, chronic exposure to low-level lead remains a public health issue.

Tobacco smoke contains over 4,000 compounds, including heavy metals such as lead [3].

It has been reported that a single cigarette includes 600 ng~1,400 ng of lead, 60 ng of lead in mainstream smoke and 5 ng~10 ng of lead in side streamsmoke [3]. Passive or second-hand smoke has been reported to increase BLLs in children, and active or habitual smoking has been indicated to increase BLLs in adults.

Actually, the association of passive smoking with high BLLs has been suggested among Japanese children. Yoshinaga et al. [4] reported that age-adjusted mean BLLs were significantly higher in children with a family member who smoked than those with no smoking family members. Kaji et al. [5] reported that BLLs of preschool children whose parents smoked in the same room were significantly higher than those whose parents never smoked. In addition, there were two reports showing the positive relationship of BLLs to habitual tobacco smoking among the Japanese adults. Ikeda et al. [6] reported that the geometric means of BLLs in 167 female current smokers (1.71 μg/dl) was significantly higher than that for 1,216 female non-smokers (1.56 μg/dl). Fukaya [7] also reported that the arithmetic mean of BLLs for male smokers (7.8 μg/dl) were significantly higher than that for male non-smokers (5.7 μg/dl) among vinyl chloride manufacturing plant workers.

Although there are several reports showing association of active and passive smoking with high BLLs both in children and adults in countries other than Japan [3,8], there were no previous reports assessing the association of active and passive smoking with on BLLs simultaneously in children and adults resided in a city of Japan. In order to simultaneously assess the association of active and passive smoking with high BLLs both

***Corresponding author:** Mitsuru Mori, Hokkaido Chitose College of Rehabilitation, Satomi 2-10, Chitose, Hokkaido 066-0055, Japan, Tel: +81-11-611-2111; E-mail: m-mori@chitose-reha.ac.jp

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in children and adults, the present study analyzed data of children and adults obtained from the survey in the above-mentioned city.

Methods

Participants were recruited by the city bureau from the residents living near the area contaminated with arsenic and lead compounds in Hokkaido in April, 2014 and 177 persons (78 males, 99 females) participated in the survey in May, 2014 [9]. The average age (standard deviation or SD) was 39.5 (24.0) years and the range of age was from zero to 86 years, respectively. Subjects younger than 18 years (age group A) and subjects older than or equal to 18 years (age group B) were designated, because there were some differences in survey items between them. Age group A consisted of 51 persons (26 men and 25 women), and their average age (SD) was 9.0 (4.4) years. Age group B was composed of 126 persons (52 men and 74 women), and their average age (SD) was 51.8 (16.4) years.

Blood sampling was performed in a room in an adjacent elementary school in May of 2014. BLL was measured by atomic absorption spectrometry after collection (SRL, Inc., Tokyo). If the measured value was 1.0 µg/dL or less, it was reported as 1.0 µg/dL. Age group A were divided into two groups according to median BLL (1.0 µg/dL), the high BLL group (N=20) and the low BLL group (N=31). Age group B was divided into two groups according to median BLL (1.1 µg/dL), the high BLL group (N=61) and the low BLL group (N=65).

Each adult subject or person responsible for a child subject, completed a structured questionnaire, which consisted of inquiries about personal characteristics such as age, sex, body height, body weight, BMI (body mass index), duration of living near the contaminated area. Information on lifestyle was also gathered with special reference to passive smoking for age group A, and active and passive smoking for age group B. Pack years were calculated as duration of smoking in years multiplied by number of cigarettes packs per day.

The Mann-Whitney test was used for comparison of BLLs between age groups A and B. The Student's t test, the chi-square test, or the Fisher's exact probability test was used for the other univariate analyses. The multivariate analysis with the logistic regression model was performed to calculate an odds ratio (OR), and its 95% confidence level (95% CL), adjusting for age and sex as the potential confounding factors. Statistical Package for Social Science (SPSS) was utilized for these analyses. Significance level was set at 5%.

This study was approved by the Ethics Committee of Sapporo Medical University (No. 26-2-48). Written informed consent was obtained from each participant.

Results

Figure 1 shows the distribution of BLLs in age groups A and B. Geometric mean of BLLs in age groups A and B was 1.15 µg/dL and 1.31µg/dL, respectively and, BLLs in age group B was significantly higher than those in age group A (the Mann-Whitney test, p=0.023).

Table 1 show the results of comparison of personal characteristics and lifestyle with special reference to passive smoking between the high and the low BLLs groups in age group A. There was no significant difference in age, sex, anthropometric measurements, or residential history. Furthermore, there was no significant difference in smoking habits of fathers or mothers. However, a proportion of the subjects living with a habitual smoker other than their parents in the household was significantly higher in the high BLL group than in the low BLL group (the Fisher's exact probability test, p=0.019). A multivariate analysis was not able to be conducted because of zero frequency in the low BLL group.

Table 2 shows the results of comparison of personal characteristics and lifestyle with special reference to active and passive smoking between the high and the low BLL groups in age group B. There was no significant difference in age, sex, anthropometric measurements, or residential history. However, a proportion of persons who were currently habitually smoking was significantly larger in the high BLL group than in the low BLL group (the chi-square test, p=0.024). Duration of smoking in year in the high BLL group was significantly longer in the high BLL group than in the low BLL group (the Student's t test, p=0.026), but, number of cigarettes per day or pack years were not different between the two groups. A proportion of persons living with a habitual smoker other than themselves were not different either in the household or in the workplace between the two groups.

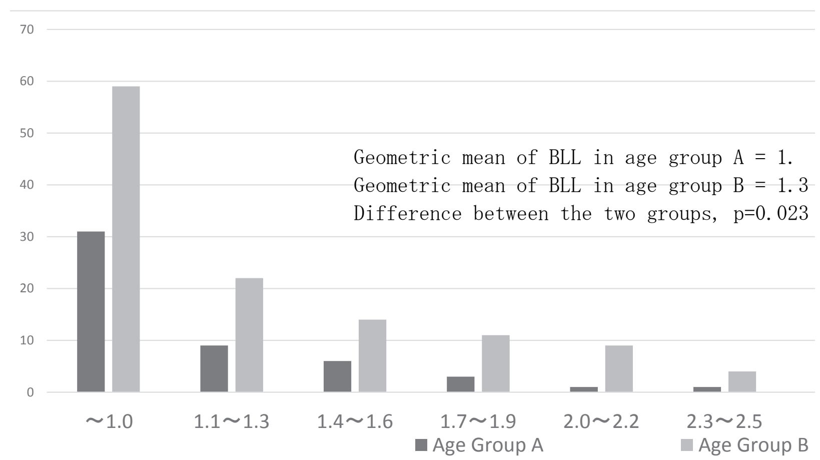

Figure 1: Distribution of blood lead levels (BLLs) in age groups A and B.
Age group A: Younger than 18 years old (N=51)
Age group B: Older than or equal to 18 years old (N=126)
#: Mann-Whitney test

Items	Contents	The high BLL Group (≧ 1.1 μg/dL)		The low BLL Group (<1.1 μg/dL)		P Value
		No.	%	No.	%	
Age (years)	Mean (SD)	20	9.0 (4.3)	31	9.1(4.5)	0.929
Sex	Male	9	45.0	17	54.8	0.493
	Female	11	55.0	14	45.2	
Body height (cm)	Mean (SD)	20	129.5 (20.0)	31	132.7 (27.8)	0.673
Body weight (kg)	Mean (SD)	20	29.8 (12.8)	31	34.5 (16.7)	0.298
Body mass index (BMI)	Mean (SD)	20	16.8 (2.2)	31	18.2 (2.7)	0.054
Body mass index (BMI)	<16.0	7	35.0	6	19.3	0.453
	16.0-18.4	7	35.0	14	45.2	
	≧ 18.5	6	30.0	11	35.5	
Residency (years)	Mean (SD)	14	7.5 (4.2)	34	8.2 (4.3)	0.563
Smoking habits of the father	Yes	8	40.0	12	38.7	0.927
	No	12	60.0	19	61.3	
Smoking habits of the mother	Yes	5	25.0	4	12.9	0.268
	No	15	75.0	27	87.1	
Habitual smoker other than parents in the household	Yes	4	26.7	0	0.0	0.019#
	No	16	73.3	31	100.0	
#: Fisher's exact probability test; SD: Standard Deviation						

Table 1: Comparison of personal characteristics and lifestyle with special reference to passive smoking between the high and low blood lead level (BLL) groups in age group A (younger than 18 years old).

Items	Contents	The high BLL group (≧ 1.1 μg/dL)		The low BLL group (<1.1 μg/dL)		P value
		No.	%	No.	%	
Age (years)	Mean (SD)	61	54.3 (15.0)	65	49.5 (17.5)	0.102
Sex	Male	27	44.3	25	38.5	0.509
	Female	34	55.7	40	61.5	
Body height (cm)	Mean (SD)	61	160.9 (7.8)	65	160.4 (8.6)	0.754
Body weight (kg)	Mean (SD)	61	60.3 (10.2)	65	60.3 (14.9)	0.991
Body mass index (BMI)	Mean (SD)	61	23.3 (3.1)	65	23.2 (4.2)	0.981
Residency (years)	Mean (SD)	45	16.1 (6.3)	65	15.6 (7.2)	0.718
Currently habitual smoking	Yes	21	34.4	11	16.9	0.024
	No	40	65.6	54	83.1	
Number of cigarettes per day	Mean (SD)	61	9.4(8.5)	65	8.3 (10.9)	0.536
Number of cigarettes per day	0	21	34.4	31	47.7	0.226
	1-19	25	41.0	18	27.7	
	≧ 20	15	24.6	16	24.6	
Duration of smoking (years)	Mean (SD)	61	16.7 (16.6)	65	10.6 (13.7)	0.026
Duration of smoking (years)	0	21	34.4	31	47.7	0.043
	1-19	12	19.7	18	27.7	
	≧ 20	28	45.9	16	24.6	
Pack years	Mean (SD)	61	12.9 (14.4)	65	9.0 (13.4)	0.126
Pack years	0	21	34.4	31	47.7	0.291
	1-14	18	29.5	17	27.7	
	≧ 15	22	36.1	17	24.6	
Habitual smoker other than himself or herself in the household	Yes	24	39.3	22	33.9	0.522
	No	37	66.7	43	66.2	
Habitual smoker other than himself or herself in the work place	Yes	36	59.0	38	58.5	0.950
	No	25	41.0	27	41.5	

Table 2: Comparison of personal characteristics and lifestyle with special reference to active and passive smoking between the high and low blood lead level (BLL) groups in age group B (older than or equal to 18 years old).

Table 3 showed ages and sex adjusted ORs and their 95% CLs of potential risk factors for the high BLL group against the low BLL group in age group B, estimated with the logistic regression model. Currently habitual smoking was significantly associated with increased risk of being in the high BLL group (OR=3.17, 95% CL, 1.28-7.86). Duration of smoking longer than or equal to 20 years was significantly associated with increased risk being in the high BLL group (OR=2.73, 95% CL, 1.07-6.94) and duration of smoking was associated with a significantly increased trend of risk being in the high BLL group (p=0.035). However, number of cigarettes smoked per day and pack years was not associated with the risk of high BLLs.

Items	Contents	OR	95% CI	P value
Current abitual smoking	Yes	3.17	1.28, 7.86	0.013
Number of cigarettes per day	0	1.00		
	1-19	2.52	1.01, 6.28	0.048
	≧ 20	1.47	0.52, 4.13	0.467
			p for trend, p=0.378	
Duration of smoking (years)	0	1.00		
	1-19	1.32	0.46, 3.78	0.610
	≧ 20	2.73	1.07, 6.94	0.035
			p for trend, p=0.035	
Pack years	0	1.00		
	1-14	2.11	0.80, 5.52	0.129
	≧ 15	2.02	0.75, 5.40	0.163
			p for trend, p=0.147	

Table 3: Age and sex adjusted odds ratio (OR) and its 95% confidence level of smoking habits for the high blood lead level (BLL) group against the low BLL group in age group B (older than or equal to 18 years old) by the logistic regression analysis.

Discussion

BLLs in age group B were shown to be significantly higher than those in age group A in our study. Some articles have reported that BLLs increased with age [3,6,10-12]. Older persons are thought to have longer duration of exposure to lead not only through passive and active smoking, but also, through paint, dust, and soil in the environment [12].

In our study, current habitual smoking and duration of smoking were shown to be significantly associated with risk of high BLLs in subjects older than or equal to 18 years of age. There are some reports which show the association of smoking with high BLLs in countries other than Japan [3,8,10,11,13-16]. Mannino et al. [3] reported that active and passive smoking were associated with increased BLLs in U.S. adults. Jeong et al. [10] reported that current smokers had significantly higher BLLs than nonsmokers in the Korean general population. Significantly positive association of habitual smoking with high BLLs was also shown in construction workers in the U.S. [11], ironworkers in the U.S. [13], the general population in West Germany [14] and southern Germany [15] and the general population in Switzerland [16].

In subjects younger than 18 years old in our study, the proportion of those living with a habitual smoker other than parents in the household was shown to be significantly higher in the high BLL group than in the low BLL group. Although parental smoking was not associated with high BLLs, this result may indicate that passive smoking in the household is associated with increased BLLs in children. If a habitual smoker is a grandfather, he would be in the house for a longer period than the parent because of retirement from a job, and this would cause a more hazardous effect of environmental tobacco smoke by him than the parents.

In countries other than Japan, there are some reports [17-20] which show that BLLs in children are raised by the smoking of their family. Significantly positive association of passive smoking with high BLLs were shown in Swedish [17] and French [18] children. Apostolou et al. [19] reported that significantly higher BLL was observed in U.S. children and adolescents aged 3 years to 19 years living with one or more smokers than those living with no smokers. Mannino et al. [20] showed that U.S. children with high cotinine levels were more likely, to have significantly higher BLLs.

Lead is present in tobacco and tobacco smoke, and both of mainstreams and side stream smoke contains lead [3]. Lead is thought to be absorbed through the respiratory system as the particulate fraction of tobacco smoke. In addition, lead in the particulate fraction could settle onto surfaces and food where it has the potential to re-expose people through either the gastrointestinal route or the respiratory system [21]. Other possible mechanisms of elevated BLL in smokers are depression of lung clearance of lead by cigarette smoke and elevation of hematocrit levels in smokers leading to an increase in the lead-carrying capacity of blood [13,15]. Once lead enters the body, it is distributed via blood to organs such as the brain, kidney, liver and bones [1].

Elevated BLLs are suggested not only to increase risk of developmental impairments in children, but also chronic diseases in adults. For example, elevated BLLs were shown to be associated with decreased height [22], decreased head circumference [22], and impaired intellectual performance measured with IQ [23]. Elevated BLLs have been indicated to be associated with an increased risk of cancer [24], cardiovascular disease [24,25] and stroke [25].

There were some limitations in this study. First, the design was a cross-sectional study, and accordingly, we could not infer a causal relationship of higher BLL with the measured variables. Second, the study subjects were not randomly selected, but voluntarily participated in the study. Therefore, an unknown selection bias might exist in the study. Because the primary aim of the survey was to assess the association of living in the area contaminated with lead with BLL, the limited information on participants' smoking experience was collected. The detailed questionnaire to measuring tobacco exposure was not used and biomarkers such as cotinine were not measured.

Conclusion

In order to simultaneously assess the association of active and passive smoking with high BLLs both in children and adults, we analyzed data of these associations among children and adults resided in a city of Japan. As a result, BLLs were shown to be higher in older persons than in younger persons. Active and passive smoking were indicated to be associated with high BLLs in adults and children, respectively. Our findings may be important to consider in studies examining health effects of elevated BLLs in both children and adults.

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