Original Article

Cadmium Absorption from Smoking Cigarettes: Calculation Using Recent Findings from Japan

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Abstract

   Consumed substances, including food, drink, and tobacco, produced in the environment are exposure sources of Cd. The object of the present study was to estimate Cd exposure and absorption amount from smoking cigarettes, one exposure source of Cd, using recent findings from Japan. The market share of cigarettes produced in foreign countries has increased in Japan, the proportion of tobacco leaves harvested in foreign countries has increased in cigarettes produced in Japan, and the percentage of smokers in Japan has changed. Therefore, obtaining the absorption value of Cd from smoking cigarettes using recent findings from Japan is significant.

   We collected information on (1) the concentrations of Cd in tobacco leaves by country of harvest and in cigarettes by country of production, (2) the concentrations of Cd in cigarette smoke, (3) the proportion of tobacco leaves harvested in foreign countries used in cigarettes made and sold in Japan, (4) the absorption rate of Cd in the airways for cigarette smoke, (5) the smoking rate by gender, age, and year in Japan, (6) the number of cigarettes sold in Japan by year and country of production, (7) the number of cigarettes smoked by smokers per day according to gender and age in Japan, and (8) the population size in 1998 by gender and age in Japan. The mean amount of Cd absorbed via the airways by smoking for smokers in Japan was calculated to be 0.89–1.78 µg/day from the above information. The values are not small in comparison with the amount of Cd absorbed from the digestive organs.

   The concentration of Cd in tobacco leaves harvested in Japan and cigarettes produced in Japan is generally higher than that of leaves harvested and cigarettes produced in foreign countries. The increase in the market share of cigarettes produced in foreign countries and sold in Japan and the increase in the proportion of tobacco leaves harvested in foreign countries used in cigarettes made and sold in Japan have decreased the amount of Cd absorbed by smoking for smokers in Japan.

   Key words: smoking, cadmium exposure, cadmium absorption, Japan

Introduction

   The exposure sources of cadmium (Cd) are environmental media i.e. air, water, and soil. Food, drink, and tobacco produced in the environment are exposure sources of Cd in a narrow sense. Cd is absorbed via ingestion and respiratory routes. Cd in food and drinking water is ingested orally and absorbed in the digestive organs, and Cd in air dust and cigarette smoke is inhaled and absorbed in the respiratory organs. To estimate exposure levels of Cd, it is effective to obtain the concentrations of Cd in the above substances. The exposure level of Cd is modified by lifestyle, e.g. how deeply cigarette smoke is inhaled affects the amount of Cd absorbed.

   The object of the present study was to estimate the amount of Cd absorbed from smoking cigarettes, which is one of the exposure sources of Cd, using recent findings from Japan. We intend to discuss the relation between their values and Cd body burden calculated from accumulation data in organs in other studies. The market share of cigarettes produced in foreign countries has increased in Japan[1], the proportion of tobacco leaves harvested in foreign countries used in cigarettes produced in Japan has increased, and the percentage of smokers in Japan has changed[1]. Thus, obtaining the absorption value of Cd from smoking cigarettes using recent findings in Japan is significant.

Materials and Methods

1. Materials

   We collected information on (1) the concentrations of Cd in tobacco leaves by country of harvest and in cigarettes by country of production, (2) the concentrations of Cd in cigarette smoke,

(3) the proportion of tobacco leaves harvested in foreign countries used in cigarettes made and sold in Japan, (4) the absorption rate of Cd in the airways via cigarette smoke, (5) the smoking rate by gender, age, and year in Japan, (6) the number of cigarettes sold in Japan by year and country of production, (7) the number of cigarettes smoked by smokers per day according to gender and age in Japan, and (8) the population size in 1998 by gender and age in Japan, from various references and the Internet. The articles and information cited in the present study were collected through searches using MEDLINE, *Japana Centra Revuo Medicana*, Chemical Abstracts, and the Internet.

2. Methods

The calculation methods for obtaining the amount of Cd absorbed from smoking cigarettes are as follows. Let x_J, x_A, and x_F be the amounts of Cd in one cigarette produced in Japan, the USA, and countries other than Japan. It is assumed that s_J is the market share in Japan for cigarettes produced in Japan. Let m_J be the proportion of tobacco leaves harvested in Japan used in cigarettes produced and sold in Japan. The mean amount of Cd in one cigarette sold in Japan y_J is obtained as:

$$y_J=s_J \cdot \{x_J \cdot m_J+x_F \cdot (1-m_J)\}+(1-s_J) \cdot x_A. \qquad [1]$$

Therefore, x_J means the amount of Cd in one cigarette made from 100% tobacco leaves harvested in Japan.

We assume that c is the number of cigarettes sold in one year in Japan, i is the proportion of Cd in cigarette smoke to the Cd amount in one cigarette, a is the absorption rate of Cd in the airways via cigarette smoke, p is the population, t is the smoking rate in Japan, and n is the mean number of cigarettes smoked in one day for all residents in Japan. As subscripts, 's' is smoker, 'm' and 'f' indicate male and female, 'k' means the k-th age group, and no subscript indicates total or mean for all Japan.

The mean amount of Cd absorbed from smoking cigarettes in one day for all residents in Japan b is estimated to be:

$$b=y_J \cdot c \cdot i \cdot a/(365.25p), \qquad [2]$$

the smoking population p_s is calculated as:

$$p_s=\Sigma p_{km} \cdot t_{km}+\Sigma p_{kf} \cdot t_{kf}, \qquad [3]$$

the mean amount of Cd absorbed from smoking cigarettes in one day for smokers in Japan b_s is obtained as:

$$b_s=y_J \cdot c \cdot i \cdot a/(365.25p_s)=b \cdot p/p_s. \qquad [4]$$

The mean number of cigarettes smoked in one day for all residents in Japan is obtained as:

$$n=c/(365.25p), \qquad [5]$$

and the number of cigarettes for all smokers n_s is calculated as:

$$n_s=c/(365.25p_s)=n \cdot p/p_s. \qquad [6]$$

The above equations are based on the assumption that the numbers of cigarettes smoked do not vary by gender and age.

However, it must be assumed that the number of cigarettes smoked varies by gender and age. Let n_{ks} be the mean number of cigarettes smoked for the k-th age group smokers, and the mean absorption amount of Cd from smoking cigarettes in one day for the k-th age group smokers b_{ks} is obtained as:

$$b_{ks}=b_s \cdot n_{ks}/n_s. \qquad [7]$$

Results

1. Concentration of Cd in tobacco leaves and cigarettes

Table 1 shows the concentrations of Cd in tobacco leaf or cigarettes by country of harvest or production from references after 1980[2–11]. The concentration in Table 1 is shown in dry or wet weight. Concentrations of Cd in cigarettes produced in Japan were in general high (Table 1). The concentrations of Cd in cigarettes made in countries other than Japan from the study by Elinder[2] were not tabulated.

The percentages of water included in tobacco leaves and cigarettes were 12.56±0.33% (mean±S.D.) and 11.94±0.47%[6], and cigarette weight was 0.82±0.17 g[5], which were not tabulated.

The amount of Cd in one cigarette is not shown, because the number of studies in which the amount of Cd was described is not large and the amount of Cd varied by cigarette weight. Elinder[2] reported that the amount of Cd in one cigarette produced in Japan was 1.75±0.26 μg/cigarette and 1.36–2.03 μg/cigarette (minimum-maximum). In the present study, the amount of Cd in one cigarette produced in Japan was employed from the study[2] as:

$$x_J=1.75 \ \mu g/cigarette. \qquad [8]$$

Watanabe[5] reported that the amount of Cd in one cigarette produced in Japan was 1.25±0.21 μg/cigarette and 0.64–1.74 μg/cigarette, that in all countries the amount was 1.15±0.43 μg/cigarette and 0.21–2.79 μg/cigarette, and that in the USA from where most cigarettes are imported to Japan the amount was 1.07±0.11 μg/cigarette and 0.84–1.30 μg/cigarette, and that in countries excluding Japan it was 1.08 μg/cigarette. We employed the amounts of Cd in one cigarette produced in the USA and in countries other than Japan using the study[5] as:

$$x_A=1.07 \ \mu g/cigarette, \qquad [9]$$
$$x_F=1.08 \ \mu g/cigarette. \qquad [10]$$

2. Concentrations of Cd in cigarette smoke

The proportions of the amount of Cd in the main stream of cigarette smoke to the amount of Cd in one cigarette were reported to be nearly 10%[2,12], 4.4–10.2%[9], 0–50%[13], 5.1%[14], and 13.6%[15]. Those in the side stream were indicated to be 40.6–57.8%[9], nearly 35%[12], 0.8–9.4%[13], and 26.1–49.9%[15]. The proportion of the amount of Cd in the main stream cigarette smoke to the amount of Cd in one cigarette by Szadkowski[12] and Elinder[2] was adopted in the present study as:

$$i=10\%. \qquad [11]$$

It was shown that the filter could catch 1.6–12.9% of Cd in cigarette smoke[9,15]. The amounts of Cd in the main stream cigarette smoke in one cigarette were reported to be 0.15 μg/cigarette[12], 0.5–1.12 μg/cigarette[13], 0.02–0.10 μg/cigarette[15], 0.10–0.12 μg/cigarette[16], 0.075 μg/cigarette[17], 0.05–0.07 μg/cigarette[18], and 0–6.67 μg/cigarette[19].

3. Proportion of tobacco leaves harvested in foreign countries in cigarettes made and sold in Japan

The exact proportions of tobacco leaves harvested in foreign countries in cigarettes made and sold in Japan have not been published because the tobacco companies guard this information. However, the available information indicating that the proportion of tobacco leaves harvested in foreign countries and used in ciga-

Table 1   Cadmium concentration (µg/g) in tobacco by country

Author	Published year	Country	Source	Mean±S.D.	Range
Elinder	1983	Japan	cigarette	1.98±0.25	0.60–2.25
Galas	1997	Poland	leaf	1.12±0.12	
Jung	1998	Korea	cigarette	1.02±0.05 DW	0.91–1.13
		U.K.	cigarette	0.90±0.14 DW	0.69–1.10
Kalcher	1993	France	cigarette	2.32±0.25	
Lin	1992	China	cigarette	1.48 DW	0.10–4.95
Murty	1986	India	leaf		0.22–0.49
Mussalo-Rauhamaa	1986	Finland	cigarette	1.70 DW	0.70–1.90
Saldivar	1991	Mexico	cigarette	4.41±0.67	3.46–5.95
		Mexico	leaf	2.49±0.99	0.86–4.87
Shaikh	1992	India	cigarette	0.9	0.3–1.4
Watanabe	1987	Canada	cigarette	2.01±0.16	1.74–2.18
		China	cigarette	1.27±0.50	0.59–2.96
		Finland	cigarette	1.54±0.23	1.22–1.90
		France	cigarette	1.66±0.81	0.76–2.83
		Germany (West)	cigarette	1.36±0.19	1.13–1.65
		India	cigarette	0.43±0.10	0.29–0.60
		Indonesia	cigarette	0.79±0.22	0.63–1.12
		Ireland	cigarette	0.86±0.13	0.77–1.10
		Italy	cigarette	1.17±0.30	0.42–1.53
		Japan	cigarette	1.71±0.27	0.86–2.50
		Korea	cigarette	1.41±0.13	1.27–1.59
		Mexico	cigarette	2.70±0.37	1.87–3.38
		Pakistan	cigarette	0.51±0.11	0.40–0.70
		Philippines	cigarette	1.36±0.09	1.24–1.44
		Singapore	cigarette	1.33±0.21	1.03–1.82
		Spain	cigarette	1.59±0.46	0.86–2.23
		Thailand	cigarette	1.39±0.20	1.19–1.98
		UK	cigarette	0.86±0.13	0.65–1.04
		USA	cigarette	1.48±0.12	1.23–1.76
		USSR	cigarette	1.88±0.55	1.02–2.77
		Total	cigarette	1.45±0.59	0.29–3.38

Remarks: DW, dry weight.

rettes made and sold in Japan was recently nearly 50% and that the percentage has increased was obtained. In the present study the proportion of tobacco leaves harvested in Japan in cigarettes made and sold in Japan was assumed to be:

$$m_J = 50\%. \tag{12}$$

4. Absorption rate of Cd in the airways via cigarette smoke

The absorption rate of Cd in the airways via cigarette smoke was concluded to be 25–50%[20,21]. The absorption rate of Cd in the airways used in the present study is:

$$a = 25\%, 37.5\%, 50\%. \tag{13}$$

5. Numbers of cigarettes sold in Japan

The numbers of cigarettes sold in Japan by year and country of production[1] are shown in Table 2. Table 2 shows that the number of cigarettes sold in Japan was:

$$c = 336{,}600{,}000{,}000/\text{year}, \tag{14}$$

and the market share of Japan Tobacco Incorporated in Japan was:

$$s_J = 76.5\%, \tag{15}$$

and this share has decreased.

Table 2   Total number of cigarettes sold and market share by year and country of production

Year	JT product	Foreign product	Total
1985	303.2×10^9 (97.6%)	7.5×10^9 (2.4%)	310.8×10^9 (100%)
1986	296.5×10^9 (96.1%)	11.9×10^9 (3.9%)	308.4×10^9 (100%)
1987	277.9×10^9 (90.2%)	30.3×10^9 (9.8%)	308.3×10^9 (100%)
1988	269.2×10^9 (87.9%)	37.2×10^9 (12.1%)	306.4×10^9 (100%)
1989	267.7×10^9 (85.3%)	46.1×10^9 (14.7%)	313.8×10^9 (100%)
1990	270.8×10^9 (84.1%)	51.1×10^9 (15.9%)	322.0×10^9 (100%)
1991	274.1×10^9 (83.5%)	54.2×10^9 (16.5%)	328.3×10^9 (100%)
1992	272.6×10^9 (82.9%)	56.2×10^9 (17.1%)	328.9×10^9 (100%)
1993	272.9×10^9 (82.1%)	59.7×10^9 (17.9%)	332.6×10^9 (100%)
1994	268.8×10^9 (80.4%)	65.5×10^9 (19.6%)	334.4×10^9 (100%)
1995	263.7×10^9 (78.8%)	71.0×10^9 (21.2%)	334.7×10^9 (100%)
1996	270.6×10^9 (77.7%)	77.7×10^9 (22.3%)	348.3×10^9 (100%)
1997	254.5×10^9 (77.6%)	73.5×10^9 (22.4%)	328.0×10^9 (100%)
1998	257.5×10^9 (76.5%)	79.0×10^9 (23.5%)	336.6×10^9 (100%)

Remarks: JT, Japan Tobacco Incorporated.

6. Smoking rate and number of cigarettes smoked per smoker in Japan

Table 3 shows the smoking rate and the number of smokers in Japan by gender and year[1]. Table 3 shows the smoking rates of males and females in 1998 to be 54.0% and 14.5%, respectively.

Table 3   Percentage and number of smokers in Japan by gender and year

Year	Male		Female		Total	
	Percentage	Number	Percentage	Number	Percentage	Number
1990	60.5%		14.3%		36.7%	
1991	61.2%		14.2%		36.9%	
1992	60.4%		13.3%		36.1%	
1993	59.8%		13.8%		36.1%	
1994	59.0%	27.16×10^6	14.8%	7.27×10^6	36.2%	34.43×10^6
1995	58.8%	27.36×10^6	15.2%	7.55×10^6	36.3%	34.91×10^6
1996	57.5%	27.08×10^6	14.2%	7.14×10^6	35.1%	34.22×10^6
1997	56.1%	26.69×10^6	14.5%	7.36×10^6	34.6%	34.05×10^6
1998	55.2%	26.47×10^6	13.3%	6.81×10^6	33.6%	33.28×10^6
1999	54.0%	26.08×10^6	14.5%	7.49×10^6	33.6%	33.57×10^6

The values in Table 3 are those for persons 20 years of age or older. Mean numbers of cigarettes smoked per smoker per day were shown to be 24.3 cigarettes/day and 16.1 cigarettes/day for adult males and females in Japan from Japan Tobacco Incorporated to news media in 1999. The mean numbers of cigarettes smoked for adults are indicated in Table 4.

We must also consider the values for juvenile persons under 20 years old. The smoking rate for first-year male university students was 27.4%[22] in 1995 and that for female first and second-year students in nursing college was 16%[23] in 1999. Osaki[24] investigated smoking rates and numbers of cigarettes smoked for junior and senior high school students. Smoking rates of male and female senior high school students were 13.9% and 2.2%, respectively, and those for junior high school students were 2.5% and 0.9%, respectively. For convenience, we regard the age of junior high school students as 12–14 years old, the age of senior high school students as 15–17 years old, and the age of first and second-year students of universities or colleges as 18–19 years old. Mean numbers of cigarettes smoked for male and female senior high school student smokers were 11.4 cigarettes/day and 8.5 cigarettes/day, respectively, those for junior high school students were 8.0 cigarettes/day and 7.7 cigarettes/day, respectively. These values, t_k's and n_{ks}'s, are shown in Table 4. The mean numbers of cigarettes smoked for university and college student smokers under 20 years old could not be obtained.

7. Population in Japan

Table 5 shows the populations of residents in Japan by gender and age group in 1998 p_k's calculated from a table compiled by the Health and Welfare Statistics Association[25]. The adult male and female populations are indicated in Table 5 to be 48,153,000 and 51,467,000, respectively. In the table made by the Health and Welfare Statistics Association, populations are expressed in five-year age groups by gender. Then the populations in age groups 12–14, 15–17, and 18–19 years old were calculated by proportional

Table 4   Percentage of smokers and mean numbers of cigarettes smoked daily by smokers according to gender and age group in Japan

Sample	Age	Percentage of smokers		Number of cigarettes	
		Male	Female	Male	Female
Junior high school	12–14	2.5%	0.9%	8.0/day	7.7/day
Senior high school	15–17	13.9%	2.2%	11.4/day	8.5/day
College	18–19	27.4%	16.0%	—	—
Adult	20+	54.0%	14.5%	24.3/day	16.1/day

Table 5   Population size by gender and age group in Japan in 1998

Age	Male	Female	Total
12–14	2,146,200	2,043,600	4,189,800
15–17	2,401,200	2,283,600	4,684,800
18–19	1,600,800	1,522,400	3,123,200
20+	48,153,000	51,467,000	99,620,000
0+	61,919,000	64,568,000	126,486,000

distribution using the populations in the five-year age groups.

8. Amount of Cd in cigarettes sold in Japan

Using equation [1], the mean amount of Cd in one cigarette sold in Japan was calculated from [8]–[10], [12], and [15] as:

$$y_J = 1.33 \ \mu g/cigarette. \qquad [16]$$

9. Amount of Cd absorbed from smoking cigarettes

We calculated the mean amount of Cd absorbed from smoking cigarettes in one day for all residents in Japan from [11], [13], [14], [16], and Table 5 using equation [2] as:

$$b = 0.24, \ 0.36, \ 0.49 \ \mu g/day, \qquad [17]$$

and that for smokers from [3], [17], and Table 5 using equation [4] as:

$$b_s = 0.89, \ 1.33, \ 1.78 \ \mu g/day, \qquad [18]$$

where the smoking population in Japan p_s in equation [3] was obtained from Tables 4–5. We calculated the mean number of cigarettes smoked in one day for all residents in Japan from [14] and Table 5 using equation [5] as:

$$n = 7.3 \ cigarettes/day, \qquad [19]$$

and that of smokers from [3] and [14] using equation [6] as:

$$n_s = 26.6 \ cigarettes/day. \qquad [20]$$

The above values are based on the assumption that the numbers of cigarettes smoked do not vary by gender and age.

With due consideration for differences among the numbers of cigarettes smoked by smokers according to gender and age, the mean amounts of Cd absorbed from smoking cigarettes in one day for the smokers by gender and age group b_{ks}'s were obtained from [18], [20], and Table 4 using equation [7], and the obtained values are shown in Table 6.

Table 6 Daily mean amount (μg/day) of cadmium absorbed by smokers smoking cigarettes in Japan according to gender and age group with due consideration for differences among smoking amounts according to gender and age group

	Male			Female		
	Respiratory absorption rate			Respiratory absorption rate		
Age	25%	37.5%	50%	25%	37.5%	50%
12–14	0.27	0.40	0.53	0.26	0.39	0.51
15–17	0.38	0.57	0.76	0.28	0.43	0.57
18–19	—	—	—	—	—	—
20+	0.81	1.22	1.62	0.54	0.81	1.07

Discussion

Studies on the concentrations of Cd in tobacco leaves and cigarettes and the amounts of Cd in one cigarette published after 1980 were selected for the present study, because measurement quality control programs have sometimes been carried out after 1980[26], and measurement accuracy has been improved by the programs. Therefore, the relative value, e.g. absorption rate of Cd in digestive organs, which was described in studies prior to 1980, is an adequate indicator, while the absolute value, e.g. concentration of Cd in cigarettes, may not be an adequate indicator for comparison with values among many measurement lots.

The proportions of tobacco leaves harvested in foreign countries in cigarettes made and sold in Japan is not published because this information is guarded by tobacco companies. In Japan political protection for domestic agriculture against imports of foreign agricultural products is very strong, and imports of tobacco leaves from foreign countries have faced strong opposition. However, political pressure to import agricultural products has been increasing from foreign countries. Imports of foreign tobacco leaves were finally accepted even though there was no recognition of free trade of tobacco leaves. Therefore, it is reasonable to assume that the proportion of tobacco leaves harvested in Japan is larger in older cigarettes produced and sold in Japan than in newer cigarettes. In the present study, we adopted the Cd amounts in one cigarette made from 100% tobacco leaf harvested in Japan as x_J=1.75 μg/cigarette from a study by Elinder[2] and did not use the figure in the study by Watanabe[5].

Differences among concentrations of Cd in tobacco leaf and cigarettes by country are notable (Table 1). When we consider differences in measurement values among measurement lots, the differences in the Cd concentrations in Table 1 may not express the true differences. However, it is reasonable to compare concentrations of Cd with each other within one study. In the studies by both Elinder[2] and Watanabe[5], the mean concentrations of Cd in cigarettes made in Japan were higher than that in foreign countries.

This suggests that concentrations of Cd in cigarettes made in Japan are higher in general than that in foreign countries, and concentrations of Cd in tobacco leaves harvested in Japan may also be higher. In the study by Elinder[2], the concentrations of Cd in cigarettes made in the USA were not given. Therefore, we used the concentrations of Cd in cigarettes made in the USA and other countries outside Japan, x_A and x_F, from the study by Watanabe[5]. As shown in [9] and [10], x_A and x_F are nearly equal. Therefore, almost equal value of the mean amount of Cd in one cigarette sold in Japan to the value [16] is obtained using equation [1], if both

are combined.

The market share of cigarettes produced in foreign countries has increased in Japan (Table 2), and this trend will no doubt continue. The proportion of tobacco leaves harvested in foreign countries used in cigarettes made and sold in Japan has increased, and the trend will continue in order to decrease manufacturing cost, because the price of tobacco leaves harvested in Japan is much higher than that in foreign countries. A decrease in the smoking rate may be notable in the future. Therefore, exposure and absorption of Cd from smoking cigarettes for residents in Japan may also decrease.

Cd exposure to environmental tobacco smoke (ETS) was not considered in the present study. Concentrations of Cd in the side stream cigarette smoke are not low[9,12,15], and studies on inhalation and absorption of Cd from ETS are needed. When smokers are completely prohibited from smoking in public places in the future, the mean amount of Cd absorbed by smoking including ETS for residents in Japan will decrease. However, it is impossible to study the amount of Cd absorbed from ETS using the information available in the present study.

The proportion of Cd amount in the main stream cigarette smoke to the Cd amount in cigarettes by Elinder[2] and Szadkowski[12] was adopted in the present study as i=10%. The range of the proportion of Cd amount was very wide, 2.6–50% in published studies. The value used in the present study is moderate. We calculated the mean amount of Cd absorbed from smoking cigarettes in one day for smokers in Japan as 0.89–1.78 μg/day, and these values are not significantly different from values in previous studies[21]. It is clear that the more cigarettes a smoker smokes, the more Cd is absorbed from smoking cigarettes.

The mean amount of Cd absorption by smoking for smokers in Japan 0.89–1.78 μg/day [18] calculated without due consideration for differences among smoking amounts according to gender and age was greater than the values in Table 6 with due consideration for the differences. These differences are derived from the difference between (i) the mean number of cigarettes smoked in one day 26.6 cigarettes/day [20] calculated from the percentages of smokers by gender and age and (ii) smoking amounts by gender and age (Table 4). This means that the percentages of smokers or smoking amounts by gender and age must be underestimated. Notable differences between values derived from different sources are sometimes found in an indicator.

When the amount of Cd inhaled from smoking cigarettes is obtained, it is generally accepted practice to measure 35 ml of the inhaled main stream for 2 seconds/minute and the uninhaled side stream for 58 seconds/minute[20]. When smokers inhale the main stream smoke for longer than 2 seconds/minute and smokers inhale the side stream, the amount of Cd absorbed from smoking cigarettes is greater than that in the present study.

From the findings that the oral intake amount of Cd in Japan is 31–59 μg/day[21] and the absorption rate of Cd in the digestive organs is 5%[21], the amount of Cd absorbed from the digestive organs in Japan is calculated to be 1.55–2.95 μg/day, while we obtained the mean amount of Cd absorbed from smoking cigarettes for smokers in Japan based on recent findings as 0.89–1.78 μg/day in the present study. These values are not small compared with the amount of Cd absorbed from the digestive organs in Japan. Therefore, it is not appropriate to make light of the absorption amount of Cd from smoking cigarettes in Japan. However, this does not mean that Cd absorption via smoking is a

health hazard.

Conclusion

(1) We obtained the mean amount of Cd absorbed from smoking cigarettes for smokers in Japan based on recent findings as 0.89–1.78 µg/day in the present study. These values are not small in comparison with the amount of Cd absorbed from the digestive organs in Japan. We should not take lightly the amount of Cd absorbed from smoking cigarettes in Japan.

(2) The concentration of Cd in tobacco leaves harvested in Japan and cigarettes produced in Japan is generally higher than in foreign countries. The increase in market share of cigarettes produced in foreign countries in Japan and the increase in the proportion of tobacco leaves harvested in foreign countries used in cigarettes made and sold in Japan have decreased the absorption amount of Cd by smoking for smokers in Japan. When the number of cigarettes sold decreases and smokers are completely prohibited from smoking in public places in the future, the mean amount of Cd absorbed by smoking for residents in Japan will decrease.

Acknowledgment

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