Global Warming, Cedar Pollinosis, and Health Care Budget Impact

Masahide KONDO[1*], Aiko SHONO[2] and Yasushi HONDA[1]

[1]*Department of Health Care Policy and Management, University of Tsukuba,*
1-1-1 Tennoudai, Tsukuba, Ibaraki 305-8577 Japan
e-mail: mkondo@md.tsukuba.ac.jp
[2]*Doctoral Program in Human-Care Sciences, University of Tsukuba,*
1-1-1 Tennoudai, Tsukuba, Ibaraki 305-8577 Japan
**corresponding author*

Abstract

Cedar pollinosis is one of the most common illnesses in Japan. It is known that the medical care seeking by patients with severe symptoms depends on the scatter of pollen, of which production is accelerated by the warmth of the previous summer. It is also known that high prevalence, 10% to 20% of the nation, results in a considerable amount of health care expenditure. This study aims to illustrate an impact of climate change by quantifying the health care budget impact of cedar pollinosis under global warming with scenarios of 1°C to 5°C warming *ceteris paribus* through combining the available knowledge in the literature. The estimated budget impact, 4,343 million yen with 1°C warming, 9,019 million yen with 2°C, 13,031 million yen with 3°C, 17,372 million yen with 4°C and 21,717 million yen with 5°C, is approximately 0.016% to 0.070% of the national health care budget of the late 1990s. It is suggested that the climate change in a form of global warming causes a financial burden on the government or the society, threatening the sustainability of social insurance based health system, or public finance. Our estimation depends on a number of assumptions such that "with other things being the same". Despite of these limitations, we conclude that the government needs to pay attention to the health care budget impact of cedar pollinosis and consider actions and priorities that adapt to global warming.

Key words: budget impact, cedar pollinosis, climate change, global warming, health care, seasonal allergic rhinitis

1. Introduction

Seasonal allergic rhinitis, or pollinosis, is one of the most common climate related illnesses in Japan. Ten to twenty percent of the nation suffer from the disease (Okuda, 2003; PG-MARJ committee, 2005). The pollen of Japanese cedar (*Cryptomeria japonica*) is a dominant allergen, which scatters in the air from winter to spring every year, and weather forecasts report atmospheric pollen readings everyday during the seasons, so that the sufferers can manage their exposure to allergen.

The climate model of cedar pollinosis is generally understood to indicate that the incidence of new cases and the severity of symptoms in diagnosed cases are affected by the level of atmospheric pollen scatter (Baba & Sasaki, 1997; Baba, 1998), which is affected by climate factors (Murayama, 1996, 1998). Among the climate factors, the warmth of the previous summer is identified as one of the most significant determinants of the level of pollen scatter. It is botanically explained that the growth of cedar male flowers, which scatter pollen during the seasons, is encouraged by the warmth of the previous summer (Yokoyama, 2002; Sasajima *et al.*, 2003). Given this relationship, the impact of global warming on the morbidity of cedar pollinosis becomes a matter of discussion (Takahashi *et al.*, 1996; Teranishi *et al.*, 2000). Due to high morbidity, health care resources deployed for the disease also become a matter of discussion coupled with a growing concern about the financial sustainability of the social health insurance system (Okuda, 1998; Kawaguchi *et al.*, 2001). There are, however, few studies, which aim to explore these matters comprehensively. Past studies focus rather on specific aspects of the climate model or health care resource implications.

In this study, we aim to illustrate a broad picture by quantitatively estimating the health care resource implication of cedar pollinosis under global warming in a transparent way with available knowledge. Our results expand the empirical knowledge on the consequences of climate change, which should inform social policy to adapt to global warming.

2. Method

We assume a simple health care budget impact model by extending the climate model of cedar pollinosis, which is shown in Fig. 1. It assumes that the climate factor measured by air temperature is associated with allergen exposure measured by pollen count, which is also associated with medical care seeking measured by outpatient visit and the accompanying financial burden on the society, which consists of diverse economic entities, measured by medical expenditure. An underlying assumption about the relationship between pollen count and outpatient visit is that an increase in the severity of symptoms caused by increased allergen exposure results in an increase in outpatient visit. Increased allergen exposure is also assumed to increase sensitisation, which also contributes to an increase in outpatient visit.

The health care budget impact is defined as a forecast of rates of use (or changes in rates of use) with their consequent short- and medium-term effects on budgets and other resources to help health service managers (Culyer, 2005). The budget in the context of this study is a part of national medical expenditure financed by third party payers, such as insurers or the government. In other words, it is a fund socially pooled from social security contribution and tax for health care under the social insurance system, which is collectively spent for the provision of effective services for the nation. The budget impact at this level is regarded as a financial burden on the government, which is responsible for maintaining stable health care provision and financing for the nation.

We conduct a deliberate literature survey in order to identify reports of the quantitative relationships between components in the budget impact model. We also survey estimates of medical expenditure for cedar pollinosis. We search online databases such as Japanica Centra Revuo Medicina, PubMed, CiNii and Webcat Plus with appropriate combinations of key words such as "climate", "global warming", "pollen", "pollinosis", "rhinitis", "medical care seeking", "outpatient" and "medical expenditure". At the same time, we examine reference lists of relevant literature. With identified knowledge, we calculate the budget impact of pollinosis under global warming by the degree of warming from 1°C to 5°C *ceteris paribus*.

3. Results

Table 1 shows the results of the literature survey of the quantitative relationship between air temperature and pollen count. Our search offers a number of reports which find the correlation between pollen count and various climate factors such as the monthly mean of daily maximum air temperature, monthly mean air temperature, monthly sunshine hours, monthly mean humidity, monthly precipitation, etc. (Saito & Usami, 1980; Nemoto, 1988; Kawashima & Takahashi, 2002). The significance of air temperature of the previous summer as a determinant of pollen count is concluded repeatedly in the majority of these papers (Takahashi & Kawashima, 1999; Kishikawa & Nishima, 2002). However, quantitative relationships in a form of regression equation with air temperature as an independent variable are specified only in limited literature. We identify seven air temperature – pollen count models: the Tochigi model (Wang *et al.*, 1984), the Toyama model (Kenda *et al.*, 1996), the Yamagata model (Takahashi *et al.*, 1996), the Tokyo model (Bureau of Public Health, 1998), the Okayama model (Namba *et al.*, 2000), the Chiba model (Sahashi, 2004) and the Shizuoka model (Okuda *et al.*, 2006). There are slight differences in the variables in these models. The monthly mean air temperature of the previous summer is used as an independent variable in the Tochigi model, the Toyama model, the Yamagata model, the Tokyo model and the Shizuoka model, while the monthly mean of daily maximum air temperature is used in the Okayama model and the Chiba model. However, it is well-known that there is a strong correlation between the daily mean air temperature and the daily maximum air temperature. Cedar pollens are counted in the Tochigi model, the Toyama model, the Yamagata model and the Chiba model, while *Cupressaceae* pollen count is included in the Tokyo model, the Okayama model and the Shizuoka model. We extract the contribution of air temperature to pollen count increase, δ_t, in each model, leaving these variations untreated. δ_t is constant in linear regression models: 2,326.42 counts/cm^2·year·°C by the Durham method in the Tochigi model; 1,280 and 1,267.6 in the Yamagata model; 824.2 in the Tokyo model; 1,320, 1,155 and 1,476 in the Okayama model; 382.465 in the Chiba model and 1,618.7 in the Shizuoka model. In the Toyama model, δ_t is calculated under scenarios in which the monthly mean air temperature increases from 24.3°C, which is the mean of observed monthly mean air temperatures holding other variables fixed at

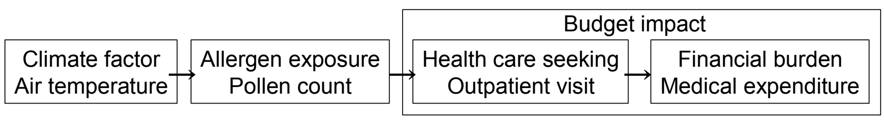

Fig. 1 Budget impact model.

their means. The results are: δ_t (1°C) = 1,716, δ_t (2°C) = 4,845, δ_t (3°C) = 10,553, δ_t (4°C) = 20,963, and δ_t (5°C) = 39,948 counts/cm^2·year. The pollen count in this model is highly responsive to air temperature, especially to high air temperature, because of the use of a logarithm in the equation. δ_t (3°C), δ_t (4°C) and δ_t (5°C) are too large compared to the maximum of observed pollen counts in the study, which is 11,854 at 2.3°C warmer than the normal value of 1995. With this regard, we make adjustment in the estimation of budget impact.

Table 2 shows the results of the literature survey of the quantitative relationship between pollen count and outpatient visit. There are a number of epidemiological reports that conclude incidence of new case correlates to pollen count (Saito, 1997; Shida *et al.*, 2000), and pathological that conclude the severity of symptoms in diagnosed cases has a similar association (Takenaka, 1999; Baba, 2002). We, however, identify only one pollen count – outpatient visit model: the Ibaraki model (Tamura *et al.*, 1995), which specifies a quantitative relationship in a form of regression equation. In this model, *Cupressaceae* pollen count is included in the independent variable, while the number of outpatients with allergic rhinitis in April, which is considered to be dominated by cedar pollenosis, is used as a dependent variable. We extract the contribution of pollen count increase to outpatient visit increase in proportion, δ_{op}. Since the dependent variable in the equation is a ratio of medical care seeking per

Table 1 Air temperature – pollen count models.

Model	Reference
1. Tochigi model (Observation period: 1979 - 1984) $y = 2{,}326.42x - 60{,}709.8$ y: estimated total cedar pollen count, x: mean air temperature in summer of the previous year → $\delta_t^* = \underline{2{,}326.42}$	Wang *et al.* (1984)
2. Toyama model (Observation period: 1983 - 1995) $Y = 0.26098X(1) - 0.01333X(2) + 0.00443X(3) + 0.00457X(4) - 2.73814$ Y: logarithm of total cedar pollen count in a year, X(1): mean air temperature in July of the previous year, X(2): hours of sunshine in January of the same year X(3): snow cover in March of the same year, X(4): hours of sunshine in March of the same year Estimated pollen count with means of observed X(1) = 24.3, X(2) = 71.3, X(3) = 22.6 and X(4) = 123.7 is 2083 With a scenario that mean air temperature increases from 24.3℃ *ceteris paribus*, → δ_t(1℃) = $\underline{1{,}716}$, δ_t(2℃) = $\underline{4{,}845}$, δ_t(3℃) = $\underline{10{,}553}$, δ_t(4℃) = $\underline{20{,}963}$, δ_t(5℃) = $\underline{39{,}948}$ Note: Maximum of observed X(1) = 11,854; therefore, δ_t(3℃) = $\underline{10{,}553}$, δ_t(4℃) = $\underline{20{,}963}$ and δ_t(5℃) = $\underline{39{,}948}$ may be out of the range of good fitness.	Kenda *et al.* (1996)
3. Yamagata model (Observation period: 1984 - 1996) $P_e = 1{,}280T_7 - 0.528P_{ob} - 24{,}729$, $P_e = 1{,}267.6T_7 - 64.4MF_b - 24{,}438$ P_e: estimated total cedar pollen count, T_7: mean air temperature in July of the previous year, P_{ob}: observed total pollen count of the previous year, MF_b: amount of male flower in the previous year (%) → $\delta_t = \underline{1{,}280}, \underline{1{,}267.6}$	Takahashi *et al.* (1996)
4. Tokyo model (Observation period: 1979-1995) $y = 824.2tm - 162.0hu - 6302.2$ y: estimated total cedar pollen count, tm: mean air temperature in July of the previous year, hu: mean humidity in July of the previous year → $\delta_t = \underline{824.2}$	Bureau of Public Health (1998)
5. Okayama model (Observation period: 1984 - 2000) Kojima site: $Y = 1{,}320T - 2.0P - 36{,}384$, Okayama site: $Y = 1{,}155T - 0.4P - 32{,}484$, Wake site: $Y = 1{,}476T - 4.4P - 40{,}169$ Y: expected total number of pollen grains per cm^2/year, T: mean value of daily maximum air temperature in July of the previous year, P: precipitation in July of the previous year → $\delta_t = \underline{1{,}320}, \underline{1{,}155}, \underline{1{,}476}$	Namba *et al.* (2000)
6. Chiba model (Observation period: 1982 - 2003) $Y = 382.465X - 9{,}257.825$ Y: estimated total cedar pollen count, X: mean value of daily maximum air temperature from 11 July to 10 August of the previous year → $\delta_t = \underline{382.465}$	Sahashi (2004)
7. Shizuoka model (Observation period: not reported) [pollen count] = –176,614.5 + 699.9 × [year] + 1,618.7 × [mean air temperature in July of the previous year] + 1.6 × [mean precipitation in July of the previous year] → $\delta_t = \underline{1{,}618.7}$	Okuda *et al.* (2006)

* Contribution of air temperature to pollen count increase.

Table 2 Pollen count – outpatient visit model.

Model	Reference
1. Ibaraki model (Observation period: 1980 - 1992) $Y = 26.28X_1 + 0.01214X_2 - 2009$ Y: medical care seeking per 100,000 population, X_1: calendar year, X_2: total cedar pollen count Increase of outpatient visit in proportion $= \dfrac{\{26.28X_1 + 0.01214(X_2 + \delta_t^*) - 2009\} - (26.28X_1 + 0.01214X_2 - 2009)}{26.28X_1 + 0.01214X_2 - 2009} = \dfrac{0.01214}{26.28X_1 + 0.01214X_2 - 2009}\delta_t$ Observed mean medical care seeking per 100,000 population = 288 → $\delta_{op}† = 0.01214 / 288 = \underline{0.00004215}$	Tamura *et al.* (1995)

* Contribution of air temperature to pollen count increase. † Contribution of pollen count increase to outpatient visit increase in proportion.

100,000 population, the coefficient of the pollen count is divided by the mean of those observed in the study in order to make the product of δ_t and δ_{op} a proportional change, which produces δ_{op} of 0.00004215.

Table 3 shows the results of the literature survey of estimates of medical expenditure for cedar pollinosis, or allergic rhinitis. Medical expenditure for cedar pollinosis in 1998 is estimated by Kawaguchi *et al.*, with which we calculate the budget, π, for pollinosis assuming a co-payment ratio of 0.3, therefore 82,040 million yen. Okuda (1998) and Practical Guideline for the Management of Allergic Rhinitis in Japan (PG-MARJ, 2005) estimate medical expenditure for allergic rhinitis including perennial allergic rhinitis. Okuda also reports the number of outpatients by the month, with which we calculate the proportion of outpatients from January to May, the months when cedar pollen scatters according to a calendar of pollens in PG-MARJ, as 0.5045. Combining these gives estimates of budgets: 28,820 million yen in 1995 from the Okuda estimate, and 30,660 - 38,325 million yen in 1994 from the PG-MARJ estimate, respectively.

Our literature survey reveals that quantitative relationships available for our budget impact estimation are never abundant although there are many studies that underpin the relationships assumed in the budget impact model. The equations and estimates found are based on observations in various areas and various years since 1980s. The definitions of the variables used are not consistent across models as already mentioned. In order to deal with these shortcomings, we make further assumptions in our estimation of budget impact with the available knowledge.

The contribution of air temperature to pollen count increase, δ_t, at national level is assumed to fall in a range from minimum to maximum among the available figures. The differences among the definitions of variables are regarded as negligible. Therefore, δ_t ranges from 382.465 at 1°C warming to 8,093.5 at 5°C warming. The contribution of a pollen count increase to an outpatient visit increase in proportion, δ_{op}, at national level is assumed to be constant, 0.004215. The budget, π, is assumed to fall in a range from minimum to maximum among the available figures. Inflation is not taken into account. Therefore, π ranges from 39,835 million yen to 82,040 million yen.

Table 4 summarises these and shows the resulting budget impact. The contribution of air temperature to

Table 3 Budget estimation.

Estimate	Source
1. Kawaguchi estimate (Observation period: 1998) Medical expenditure for pollinosis: ¥ 117,200 million → π*: 117,200 × 0.7† = <u>82,040</u>	Kawaguchi *et al.* (1998)
2. Okuda estimate (Observation period: 1995) Medical expenditure for allergic rhinitis: ¥ 112,800 million Proportion of outpatients from January to May in one whole year: 50.45% → π : 112,800 × 0.5045 × 0.7 = <u>39,835</u>	Okuda (1998)
3. Practical Guideline for the Management of Allergic Rhinitis in Japan (PG-MARJ) estimate (Observation period: 1994) Medical expenditure for allergic rhinitis: ¥ 120,000 – 150,000 million Proportion of outpatients from January to May in one whole year: 50.45%‡ → π : 120,000 – 150,000 × 0.5045 × 0.7 = <u>42,378</u> – <u>52,973</u>	PG-MARJ (2005)

* Budget for cedar pollinosis. † 1- co-payment ratio. ‡ Adopted from the Okuda estimate.

Table 4 Air temperature – budget impact estimates.

Warming (℃)	Range of contribution of air temperature to pollen count increase: δ_t	Contribution of pollen count to outpatient visit: δ_{op}	Range of contribution of air temperature to outpatient visit: $\delta_\pi = \delta_t \times \delta_{op} \times 100$ (%)	Budget π (¥ million)	Budget impact: $\delta_\pi \div 100 \times \pi$ (¥ million)
1	382.465 – 2,326.42		5.709* (1.612 – 9.806)		4,343 (642 – 8,045)
2	764.93 – 4,845		11.82 (3.224 – 20.42)		9,019 (1,284 – 16,754)
3	1147.395 – 10,553	0.00004215	24.66 (4.836 – 44.48)	39,835 – 82,040	19,209 (1,927 – 36,492)
4	1529.86 – 20,963		47.40 (6.448 – 88.36)		37,529 (2,569 – 72,490)
5	1912.325 – 39,948		88.22 (8.060 –168.4)		70,675 (3,211 – 138,140)

* Mid-point of the range.

Table 5 Air temperature – budget impact estimates with adjustment*.

Warming (℃)	Adjusted range of contribution of air temperature to pollen count increase: δ_t	Contribution of pollen count to outpatient visit: δ_{op}	Adjusted range of contribution of air temperature to outpatient visit: $\delta_\pi = \delta_t \times \delta_{op} \times 100$ (%)	Budget π (¥ million)	Adjusted budget impact: $\delta_\pi \div 100 \times \pi$ (¥ million)
1	382.465 – 2,326.42		5.709 (1.612 – 9.806)		4,343 (642 – 8,045)
2	764.93 – 4,845		11.82 (3.224 – 20.42)		9,019 (1,284 – 16,754)
3	1147.395 – 6,979.26	0.00004215	17.13 (4.836 – 29.42)	39,835 - 82,040	13,031 (1,927 – 24,136)
4	1529.86 – 9,305.68		22.84 (6.448 – 39.22)		17,372 (2,569 – 32,176)
5	1912.325 – 11,632.1		28.54 (8.060 – 49.03)		21,717 (3,211 – 40,224)

* Adjustment: δ_t(3℃) = 10,553, δ_t(4℃) = 20,963, δ_t(5℃) = 39,948 in Table 4 are discarded, judged as out of the range of good fitness in the Toyama model.

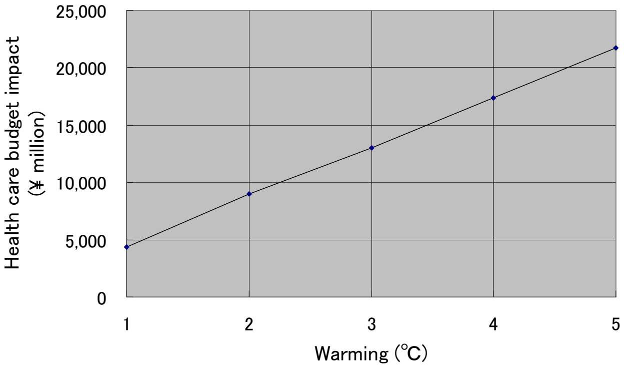

Fig. 2 Health care budget impact of cedar pollinosis under global warming.

outpatient visit, δ_π, is calculated as the product of δ_t and δ_{op}. The outpatient visit increases 5.7% with 1°C warming, 11.8% with 2°C, 24.7% with 3°C, 47.4% with 4°C and 88.2% with 5°C. The budget impact is calculated as the product of δ_π and π. It is estimated as 4,343 million yen with 1°C warming, 9,019 million yen with 2°C, 19,209 million yen with 3°C, 37,529 million yen with 4°C and 70,675 million yen with 5°C.

Table 5 shows the budget impact with a further assumption that the fitness of the Toyama model of air temperature – pollen count is limited to 2°C warming, as already argued. The adjustment according to this assumption changes the upper limit of δ_t (3°C), δ_t (4°C), and δ_t (5°C) into 6,979.26, 9,305.68 and 11,632.1, respectively. The increases in the outpatient visit become 17.1% with 3°C warming, 22.8% with 4°C, and 28.5% with 5°C; and the budget impact as 13,031 million yen, 17,372 million yen and 21,717 million yen, respectively.

Figure 2 illustrates this air temperature – budget impact relationship.

4. Discussion

Our simple combination of the available knowledge gained from our literature survey quantifies the health care budget impact of cedar pollinosis under global warming scenarios of 1°C to 5°C warming *ceteris paribus* based on our health care budget impact model. The estimated budget impact, 4,343 million yen to 21,717 million yen, depending on the scenario, accounts for approximately 0.016% to 0.070% of the national health care budget of the late 1990s. The estimated relationship between the degree of warming and the budget impact illustrates a potential impact of global warming on the society. This broad picture provides an answer to some extent to the need for research to quantify the impacts and risks beyond qualitative analyses of consequences, which is imperative for the development of policy against global warming, as brought up by the Global Warming Research Initiative in Japan (Koike, 2006).

The policy implication of this study is not prescriptive, however. There are no established rules on how to associate health care budget impact with policy making (Trueman *et al.*, 2001). The long process of global warming makes the interpretation of our results difficult, since the health care budget impact is often used for short- and medium-term prioritisation in health care policy. Yet it is arguable that the budget impact of cedar pollinosis is found to be a threat to social insurance based health system, which is one of the major and excessively increasing components of public expenditure controlled by the government. Therefore, the government needs to pay attention to this threat and consider actions and priorities to adapt to global warming. In this sense, the information revealed by this study should be useful for policy makers to develop an adaptation strategy against global warming.

Our estimation is so simple that it can be an oversimplification. One of the fundamental assumptions, which could undermine the meaning of our results, is our scenario of warming *ceteris paribus*. It is true that global warming is a long process, during which cedar vegetation, susceptibility of the population, medical care practice, etc., will transform continuously. The assumption, "with other things being the same", can be an oversimplification. We make this big assumption due to the lack of plausible scenarios to date. We also make a number of assumptions such that there is a causal relationship between pollen count and outpatient visit; that the number of outpatients with perennial allergic rhinitis during the seasons is negligible; that the co-payment ratio has been 0.3 since 1990s, which should have been lower before 2003; that the differences in the definitions of variables in the regression models are negligible; that the limited available knowledge from various regions in various years is sufficient to illustrate a nationwide picture, and so on. We make these assumptions due to the limitation of the quantitative knowledge available to date. These can be an oversimplification as well.

We acknowledge that these limitations resulting from our assumptions may make the budget impact presented herein debatable. However, we think the transparency of combining the available knowledge as in this study is a rigorous approach of estimation in the context under study. We also think that our report is a good groundwork for further study on the impact of cedar pollinosis under global warming.

Acknowledgements

This work is supported by the Global Environment Research Fund S-4 by the Ministry of the Environment, Japan.

References

Baba, K. (1998) Sugikafunsho shushokuinshi toshiteno kafunhisanryo. *Arerugi no Rinsho*, 18:170-174. (in Japanese)

Baba, K. (2002) The regulation of nasal allergic symptoms in Japanese cedar pollinosis. *Igaku no Ayumi,* 200:385-390. (in Japanese)

Baba, K. and K. Sasaki (1997) Sugikafun hisansu to hassho. *Allergology,* 3:243-252. (in Japanese)

Bureau of Public Health (1998) *Kafunsho taisaku sougou houkokusho.* Tokyo Metropolitan Government, Tokyo. (in Japanese)

Culyer, A.J. (2005) *The dictionary of health economics.* Edward Elgar, Cheltenham.

Kawaguchi, T., Y. Hoshiyama, Y. Watanabe and M. Kimura (1998) Kafunsho no iryokeizai. *Progress in Medicine,* 18:2826-2830. (in Japanese)

Kawaguchi, T., Y. Hoshiyama and Y. Watanabe (2001) Cost of cedar pollinosis. *Arerugi no Rinsho,* 22:178-182. (in Japanese)

Kawashima, S. and Y. Takahashi (2002) Studies on emission and dispersion process for airborne cedar pollen. *Tenki,* 49: 873-885. (in Japanese)

Kenda, Y., H. Teranishi, T. Katoh, E. Oura and M. Kasuya (1996) Long term trend of atmospheric sugi (Japanese cedar, *Cryptomeria japonica* D.Don) – pollen counts in Toyama Prefecture. Special reference to the highest amount of the atmospheric sugi-pollen observed in 1995. *Hokuriku Koshu Eisei Gakkaishi,* 23:6-8. (in Japanese)

Kishikawa, R. and S. Nishima (2002) Airborne pollen count in Japan – gravitational method. *Igaku no Ayumi,* 200:346-352. (in Japanese)

Koike, I. (ed.) (2006) *Chikyuondanka ha dokomade kaimei saretaka –Nihon no kagakusha no kouken to kongo no tembou 2006 (The 2nd report of climate change research group of the Global Warming Research Initiative).* Maruzen, Tokyo. (in Japanese)

Murayama, K. (1996) Sugikafun no hisanyosoku wo megutte. *Arerugi no Rinsho*, 16:170-174. (in Japanese)

Murayama, K. (1998) Sugikafunsho shushokuinshi toshiteno chiiki kisho. *Arerugi no Rinsho*, 18:199-202. (in Japanese)

Namba, H., K. Saitou and N. Sahashi (2000) Relationship between combined pollen count of *Cryptomeria japonica* and Cupressaceae and precipitation in July of the previous year. *Japanese Journal of Palynology*, 46:115-124. (in Japanese)

Nemoto, O. (1988) Sugikafun to kisho. *Tenki,* 35:171-178. (in Japanese)

Okuda, M. (1998) Arerugisei bien no chiryo ni ikurakakaruka. *Allergology,* 5:615-620. (in Japanese)

Okuda, M. (2003) Epidemiology of Japanese cedar pollinosis throughout Japan. *Annals of Allergy, Asthma, & Immunology,* 91:288-296.

Okuda, M., A. Usami and R. Kishikawa (2006) Study of recent yearly trend of increase in airborne pollen of Japanese cedar and cypress pollen. *Japanese Journal of Allergology,* 55:1531-1535. (in Japanese)

PG-MARJ committee (2005) *Practical guideline for the management of allergic rhinitis in Japan <PG-MARJ>, 5th ed.* Life Science, Tokyo. (in Japanese)

Sahashi, N. (2004) An annual transition of Japanese cedar and Japanese cypress airborne pollens and prediction for their forecast total pollen grains in 2004. *Allergology,* 17:13-20. (in Japanese)

Saito, Y. (1997) Annual change on Japanese ceder pollinosis and related matter. *Allergology,* 3:237-242. (in Japanese)

Saito, Y. and A. Usami (1980) Sugikafunsho to kisho. *Kisho,* 24:6-9. (in Japanese)

Sasajima, H., K. Takashina, S. Harada and K. Iwatani (2003) Sugikafunsho no genin tonaru sugiobana seisan ni oyobosu kishoinshi to obana seisanryo no yosokuhouhou nitsuite. *Annual report of the Akita Prefectural Institute of Public Health,* 48:88-92. (in Japanese)

Shida, T., K. Akiyama, M. Hasegawa, Y. Maeda, M. Taniguchi, A. Mori, S. Tomita, N. Yamamoto, T. Ishii, A. Saito and H. Yasueda (2000) Change in skin reactivity to common allergens in allergic patients over a 30-year period: association with aeroallergen load. *Japanese Journal of Allergology,* 49:1074-1086. (in Japanese)

Takahashi, Y., S. Kawashima and S. Aikawa (1996) Effects of global climate change on Japanese cedar pollen concentration in air – estimated results obtained from Yamagata City and its surrounding area. *Japanese Journal of Allergology,* 45:1270-1276. (in Japanese)

Takahashi, Y. and S. Kawashima (1999) A new prediction method for the total pollen counts of *Cryptomeria japonica* based on variation in annual summertime temperature. *Japanese Journal of Allergology,* 48:1217-1221. (in Japanese)

Takenaka, H. (1999) Sugikafunsho no ekigaku. *Jibiinkouka Toukeibugeka,* 71:91-95. (in Japanese)

Tamura, K., M. Ono, M. Murakami, H. Takahashi, T. Sairenchi, N. Tamiya and T. Arai (1995) Yearly changes and geographical distribution of allergic rhinitis morbidity estimated from records of the national health insurance. *Japanese Journal of Public Health,* 42:194-202. (in Japanese)

Teranishi, H., Y. Kenda, T. Katoh, M. Kasuya, E. Oura and H. Taira (2000) Possible role of climate change in the pollen scatter of Japanese cedar *Cryptomeria japonica* in Japan. *Climate Research,* 14:65-70.

Trueman, P., M. Drummond and J. Hutton (2001) Developing guidance for budget impact analysis. *Pharmacoeconomics,* 19:609-621.

Yokoyama, T. (2002) The present state and pollen production of forests of *Cryptomeria japonica* and *Chamaecyparis obtusa*. *Igaku no Ayumi,* 200:341-345. (in Japanese)

Wang, S., I. Furuuchi and H. Shinohara (1984) Kisho to kafunsho. *Arerugi no Rinsho*, 4:33-36. (in Japanese)

(Received 6 June 2007, Accepted 20 June 2007)