Asthma-Like Disease in the Children Living in the Neighborhood of Mt. Sakurajima

Hidenori Uda 1, Suminori Akiba 1, Hiromichi Hatano 2, and Reiko Shinkura 1

We conducted self-administered questionnaire surveys of school children living in the vicinity of Mt. Sakurajima using ATS-DLD questionnaire. In this paper, we report the results of analysis comparing the proportion of children with asthma-like disease in the area exposed to the volcanic ash and gases released by Mt. Sakurajima and control areas. Asthma-like disease was ascertained using ATS-DLD questionnaire and the definition proposed by the study group established by Environmental Protection Agency in Japan. The proportion of children with asthma-like disease was not different between the exposed and control groups. The odds ratio of asthma-like disease comparing the exposed and control groups was 1.1 and its 95% confidence interval was 0.7-1.8 (P=0.583). When the exposed area was divided into Tarumizu city, Sakurajima town and Kagoshima city, none of them showed an elevated proportion of children with asthma-like disease when compared with the control area. In the entire study population including both the exposed and control groups, the proportion of children with asthma-like disease was 6 and 3 % in boys and girls, respectively. These values were quite similar to those obtained from a survey of 45,674 school children in western districts in Japan in 1992. In conclusion, the present study indicates that the proportion of children with asthma-like disease is not elevated in the exposed area. Further investigations are necessary to confirm our conclusions. J Epidemiol, 1999 ; 9 : 27-31

asthma-like disease, Mt. Sakurajima, volcano

SUBJECTS AND METHODS

We selected five primary schools in the areas that are most closely located to Mt. Sakurajima. They are Ohou and Ohshu primary schools in Sakurajima town, Tarumizu and Ushine primary schools in Tarumizu city, and Yamashita primary school in Kagoshima city. Although Ushine primary school was located quite near from Mt. Sakurajima, it was excluded from the exposed group because the number of children was small and there were no monitoring stations measuring sulfur dioxide. As a control group, we selected two primary schools in Oura and Sendai, which were 40-50 km away from Mt. Sakurajima. The data on ashfall amount and sulfur dioxide concentration in study areas were provided by Kagoshima Prefecture Environmental Research Center.

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1Department of Public Health, Faculty of Medicine, Kagoshima University, Kagoshima, Japan.
2Department of Nursing, Kurume University, Fukuoka, Japan.
Address for correspondence : Hidenori Uda. Department of Public Health, Faculty of Medicine, Kagoshima University, Sakuragaoka 8-35-1, Kagoshima, Japan.
The questionnaire used in our survey was the Japanese version of ATS-DLD questionnaire for children with some supplementary questions regarding indoor air pollution. Asthma-like disease in the present study was the positive response that a doctor diagnosed asthma, with symptoms of wheezing, whistling and dyspnea in ATS-DLD questionnaire. The definition of asthma-like disease used in the present study is the one proposed by the study group established by Environmental Protection Agency (EPA) in Japan and is widely used in epidemiological studies in Japan. Although the reliability of ATS-DLD questionnaire to identify children with bronchial asthma is well established, and the term asthma is used in some epidemiological studies using ATS-DLD questionnaire, we used the term asthma-like disease because the presence of asthma was not confirmed by medical examination in the present study. The surveys were conducted in the fall of 1991, 1992 and 1993. At the classrooms, teachers handed out the questionnaires to children, who were asked to return them to their teachers after filling them out at home. In the exposed and control areas, 4310 or 90% and 1656 or 94% of the questionnaires handed out were retrieved, respectively. The response rate in the exposed area was slightly lower than that in the control area. It was because the proportion of children who returned the questionnaire to their teachers was merely 79% in Yamashita primary school, which was located in downtown Kagoshima city. In all other schools, the response rate exceeded 90%.

Since our surveys were conducted in the identical primary schools during the three-year period, about 75% of children participated in our surveys at least twice. About 50% participated in the surveys three times. In order to avoid the duplicate use of the data obtained from the surveys of identical children in different years, we decided to use the data collected in 1992. The reason why we chose the year 1992 was that it was the year when Nishima et al conducted a large scale survey using ATS-DLD questionnaire in the western districts of Japan.

Odds ratios were calculated as measures of association. Maximum likelihood estimates of odds ratios were obtained by logistic analysis. Two sided P values and 95% confidence intervals were calculated.

### RESULTS

We analyzed the data obtained from 1371 and 733 children in the exposed and control groups, respectively. Table 1 compares the distribution of sex, grade and the variables related to indoor air pollution in the exposed and control groups. The distribution of these factors were not markedly different between the exposed and control groups.

The proportion of children with asthma-like disease was 6 and 3% in boys and girls, respectively (Table 2). The observed sex difference was statistically significant (P =0.003).

### DISCUSSION

This study showed that the proportion of children with asthma-like disease, defined by the criteria proposed by the research group established by EPA in Japan, was not different in the exposed and control groups. The proportion of children with asthma-like disease was 6 and 3% in boys and girls, respectively. The values were quite similar to those obtained from the survey of 45,674 school children in western districts.
Table 2. Proportion of children with asthma-like disease according to various factors. -Results of multiple logistic regression analysis.

| Gender | +  | N   | +/N | OR  | 95% CI |
|--------|----|-----|-----|-----|--------|
| girls  | 30 | 1008| 3   | 1@  | 1.2-3.0|
| boys   | 61 | 1096| 6   | 1.9 | P=0.003|
| grade  | 1  | 16  | 322 | 5   | 1@     |
|        | 2  | 12  | 309 | 4   | 0.8    | 0.4-1.7|
|        | 3  | 21  | 360 | 6   | 0.8    | 0.6-2.3|
|        | 4  | 18  | 353 | 5   | 1.0    | 0.5-2.0|
|        | 5  | 15  | 356 | 4   | 0.9    | 0.4-1.8|
|        | 6  | 9   | 404 | 2   | 0.5    | 0.2-1.0|

P for heterogeneity=0.204

| Smoking in Family Members | +  | N   | +/N | OR  | 95% CI |
|---------------------------|----|-----|-----|-----|--------|
| -                         | 51 | 1090| 5   | 1@  | 1.0    | 0.6-1.6|
| +                         | 40 | 1014| 4   | 1.0 | P=0.883|

P=0.182

| Passive Smoking in Bedroom | +  | N   | +/N | OR  | 95% CI |
|----------------------------|----|-----|-----|-----|--------|
| -                         | 69 | 1731| 4   | 1@  | 1.5    | 0.8-2.7|
| +                         | 22 | 373 | 1   | 1.5 | P=0.182|

P=0.182

| Wooden House Without Aluminum Framed Windows | +  | N   | +/N | OR  | 95% CI |
|----------------------------------------------|----|-----|-----|-----|--------|
| No                                           | 89 | 1960| 5   | 1@  | 1.0    | 0.1-0.9|
| Yes                                          | 2  | 144 | 1   | 0.3 | P=0.023|

P=0.023

| Exposure to Volcanic Ash and Gases from Mt. Sakurajima | +  | N  | +/N | OR  | 95% CI |
|-------------------------------------------------------|----|----|-----|-----|--------|
| Control (Oura+Sendai)                                  | 29 | 733| 4   | 1@  | 1.0    | 0.6-1.7|
| Tarumizu city                                          | 32 | 779| 4   | 1.0 | 0.6-1.7| 1767   | 0.026|
| Sakurajima town                                        | 14 | 280| 5   | 0.7 | 0.7-2.4| 1709   | 0.031|
| Kagoshima city                                        | 16 | 312| 5   | 0.7 | 0.7-2.5| 287    | 0.042|

+: number of subjects with asthma-like disease N: number of study subjects Odds ratio and 95% CI were obtained from multiple logistic analysis, where all the variables listed in the table were included in the logistic model.

@ reference category

Table 3. The proportion of children with asthma-like disease in three districts.

| Area             | +  | N  | +/N | OR  | 95% CI | ashfall amount (g/m²/month) | sulfur dioxide (ppm) |
|------------------|----|----|-----|-----|--------|----------------------------|---------------------|
| Control (Oura+Sendai) | 29 | 733| 4   | 1@  | 1.0    | 11                        | 0.006               |
| Exposed area      |    |    |     |     |        |                           |                     |
| Tarumizu city     | 32 | 779| 4   | 1.0 | 0.6-1.7| 1767                      | 0.026               |
| Sakurajima town   | 14 | 280| 5   | 0.7 | 0.7-2.4| 1709                      | 0.031               |
| Kagoshima city    | 16 | 312| 5   | 0.7 | 0.7-2.5| 287                       | 0.042               |

+: number of subjects with asthma-like disease N: number of study subjects

Odds ratio and 95% CI were obtained from multiple logistic analysis, adjusting for gender, age, passive smoking, and house structure.

Ashfall amount is average of monthly amount of ashfall in 1992.

Sulfur dioxide level is the average concentration in 1992.
in Japan conducted by Nishima et al.\(^7\) using ATS-DLD questionnaires in 1992.

Volcanic ash and gases are reported to cause transient acute irritant effects of respiratory tract. They can also exacerbate chronic lung diseases. After the eruptions of Mt. St Helens in 1980, epidemiological studies observed the increase of acute respiratory symptoms in the residents and deterioration of symptoms in the patients of chronic respiratory disease.\(^8,9\) However, the effects were transient and no chronic effects were confirmed. After the eruption of Mt. Ruapehu in New Zealand in 1995, a mail survey of adults was conducted to examine the association between asthma and living in an area exposed to volcanic ash.\(^10\) Neither asthma symptoms nor the use of asthma medication was related to the exposure to volcanic ash.

The volcanic activities of Mt. Sakurajima suddenly increased in the early 1970s. The numbers of eruptions in the 1970s and 1980s were 1621 and 2483, respectively.\(^2\) Its high activity remained unabated until the late 1990s. There are several epidemiological studies regarding the health effects of Mt. Sakurajima’s volcanic activities. In a study conducted in the neighborhood of Mt. Sakurajima, Wakisaka et al.\(^11\) found that sulfur dioxide levels, but not the levels of suspended particulate matter (SPM), were related to the monthly numbers of patients with bronchial asthma by health insurance records during the period between April 1984 and March 1985.\(^12\) Yano et al. conducted a cross-sectional epidemiological study of 2006 women aged 30-59 in 1981, using the Japanese version of ATS-DLD self-administered questionnaire. Their study suggested the increase of only mild respiratory symptoms in the areas exposed to volcanic ash.\(^12\) No increase was observed in bronchitis or other respiratory diseases. His study group conducted a similar study in 1985 and confirmed their previous findings.\(^13\) They concluded that the exposure to volcanic ash emitted by Mt. Sakurajima does not have serious detrimental effects on respiratory systems because i) ash particles are usually too large to be respired, ii) the duration of highly concentrated airborne ash is brief, and iii) volcanic ash is relatively biologically inert.

Mortality in the neighborhood of Mt. Sakurajima has also been studied. Wakisaka et al.\(^11\) reported that weekly numbers of all causes of deaths in the neighborhood of Mt. Sakurajima during the period between 1982 and 1984 were jumped in the week immediately after the week when average sulfur dioxide levels per hour recorded 0.2 ppm or higher.\(^14\) His study group also examined cause specific mortality during the period between 1975 and 1985.\(^15\) They reported that the mortality of bronchitis decreased with the increased distance from Mt. Sakurajima and that the mortality of bronchitis in 20 km-radius of Mt. Sakurajima during their 11-year observation period was related to the atmospheric concentration of sulfur dioxide. However, the association with Mt. Sakurajima’s volcanic activities was not observed in all causes of death.

There is a possibility that children are more susceptible to volcanic ash and gases when compared to adults. In the study conducted after the eruption of Mt. St. Helens, Kraemer and McCarthy found an increase in childhood asthma hospitalization rates due to the volcanic ash air pollution.\(^16\) Regarding Mt. Sakurajima, Wakisaka et al. reported that the increased prevalence of asthma ascertained by physical examinations at primary schools in the neighborhood of Mt. Sakurajima.\(^17\) In the present report we could not confirm their findings.

There are various factors related to the risk of asthma in children. For example, asthma is known to be more common in boys than in girls, as observed in the present study. On the other hand, the prevalence of asthma was not related to the age of primary school children in the study conducted by Nishima et al., the largest study of childhood asthma conducted in Japan in the 1990s. The proportion of children with asthma-like disease in the present study did not show age dependence, either. It is well known that the house structures with mal-ventilation are related to increased risk of asthma.\(^18\) The notion was supported by our observation of the low prevalence of asthma-like disease in the children living in wooden houses without aluminum framed windows. In the risk of asthma in children, allergy to mite allergen is considered to play an important role. Changes in the structure of houses in the last decades are suspected to have increased the number of the children allergic to mite allergen and, consequently, the number of asthmatic children. We did not collect any direct information on mite allergy in the present study. However, we collected the information on allergy in general. The children with allergic disorders consisted 79% and 33% of children with and without asthma-like disease, respectively, in this study (data not shown), indicating that allergy was playing an important role in the majority of asthma-like disease ascertained in this study. The proportion of children with asthma-like disease in the ash-exposed area was not significantly elevated in the analysis conducted separately for children with and without allergy. Air pollutants such as nitrous dioxide, diesel emission particles, tobacco smoke and formaldehyde are also playing important roles in the development of asthma. Although children living in a large city such as Kagoshima city are likely to be exposed to nitrous dioxide and diesel emission particles, the proportion of children with asthma-like disease was not different between Sakurajima town and Kagoshima city in the present study.

In conclusion, the present study indicated that the prevalence of asthma was not elevated in the exposed area. Further investigations are necessary to confirm our conclusions.

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