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AIR POLLUTION IN YOKKAICHI AREA WITH SPECIAL REGARDS TO THE PROBLEM OF "YOKKAICHI-ASTHMA"

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In Yokkaichi-city, where power stations, oil refining and related chemical plants exist, growing number of cases of asthmatic patients has been reported since these plants were put in operation in 1955. At Isozu, where air pollution is most severe, incidence of asthma reached up to 2.5% of total population in 1964.

In whole Yokkaichi-city, annual average of sulphur dioxide level by lead peroxide cylinder method in each district is well propotional to the incidence of "asthma". Furthermore, at Isozu, incidence of asthma attack in each patient is closely correlated to weekly average concentration of sulphur dioxide. Clinical features of "Asthma" have been described.

Air Pollution in Yokkaichi Area

Yokkaichi is famous as "the town of petroleum" in Japan. As far as the production of petroleum and that of related chemicals are concerned, Yokkaichi area takes the first position in Japan, producing almost a quarter of total products in this country. The ruin of the former Japanese Navy Fuel Plant in this area, which had been destroyed during World War II has been revived as oil refinery and petroleum chemical plants since 1955. Present situation of air pollution in Yokkaichi is as follows;

Distribution of Plants

Locations of plants are shown in Fig. 1, in which plants are devided into three groups, namely, electric power plants, oil refineries and petroleum chemial plants. Neighbouring districts to Shiohama oil "Combinate" i. e. Isozu, Shiohama, Mihama and Akebono have the population of about 25,000. During the period from December to March, seasonal north-western wind carries pollutants to Isozu district and from May to September, to Shiohama, Mihama and Akebono districts.

Dust-Fall

The total amounts of dust-fall in this city is at ordinary level as compared to the values observed in other cities in Japan, and pH of rain water collected in

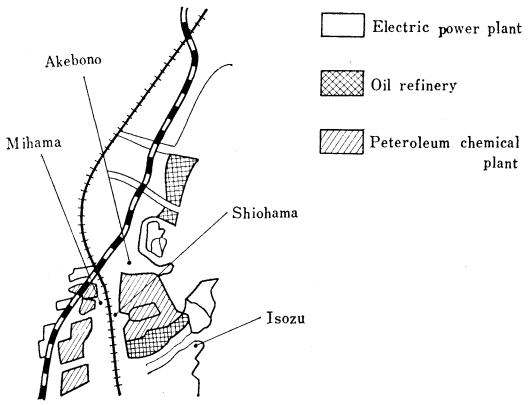


Fig. 1. Location of plants in Yokkaichi-city.

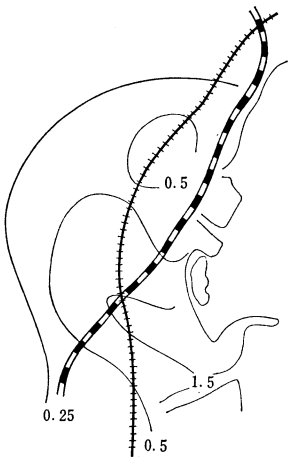


Fig. 2. Sulphur dioxide by candle method. (Summer, 1963) mg/100cm²/day

deposit gauge in this area has been lowering steadily since 1961. Most of the estimated pH of rain-water are less than 5, occasionally as low as 3.

Sulphur Dioxide

Sulphur dioxide values measured by lead-peroxide candle in this city is shown in Fig. 2. Plants in Shiohama district are appeared to be the main source of sulphur dioxide pollution, which is transfered by wind of north-east or south-west direction. Mean value obtained by lead-peroxide method did not greatly exceed that of other cities, although, incessant recording by Thomas' volumetric method showed significantly high and saw-teeth like peak concentrations as high as 1 to 2.5 ppm. For example, the frequency distribution of sulphur dioxide concentration per hour estimated by Thomas' method during the period from January 1963 to March 1963 showed that number of hours in which more than 0.3 ppm was observed was 9% of total, whereas, average concentration during this period was 0.12 ppm. Annual mean sulphur dioxide concentration has increased gradually, and it showed 62% increase in 1962 as compared to 1961. This is presumed crude oil with higher sulphur content imported from Persian Gulf has been replacing the domestic coal with much less sulphur content as fuel in these industries since 1961. Sources of

Table 1. Sources of sulphur dioxide. (October, 1963)

Power plant	Refinery	Petroleum chemicals	Ordinary chemicals	Others
58.2 %	24.0 %	9.7 %	4.7 %	3.4 %

sulphur dioxide in Yokkaichi are shown in Table 1.

Other Pollution

We have studied concentrations of hydrogen sulfide, nitrogen dioxide and various hydrocarbons, but none of these showed a noticeable concentration. We have not yet studied concentrations of heavy metals and their oxides.

THE ATTACKS OF BRONCHIAL OBSTRUCTIONS, "YOKKAICHI-ASTHMA"

Since around 1962, gradually increasing attentions have been paid to abnormally higher incidence for asthmatic disorders at Isozu and its neighbouring districts. We have studied the actual situation of these respiratory disorders since the end of 1962.

Epidemiological Observation

The survey was carried out on the number of cases appeared in the file of National Health Insurance Billing Cards from April 1962 to March 1963.

National Health Insurance and Social Employer Health Insurance are the main health insurance systems in this country.

The former is managed by local goverment and the enlisted are usually consisted of self-employed people, such as farmer, fisher and dealer, while the latter is managed by individual companies of more than 300 employees and the enlisted are regular employees. As the file of National Health Insurance Bill Cards has been made on each case at the end of each month, the number of cases which we have collected is monthly sum, therefore, a patient who received interrupted treatment through three months gives us number of 3.

Table 2 shows annual incidence for various upper respiratory diseases in per

Table. 2. Incidence of upper respiratory diseases among infantile and senile in Yokkaichi-city. (Insignificant various other disases are omitted.)

	Dust-fall ton/month	SO_2 mg/day	Common cold %	Bronchial asthma %	Laryngo-pharyngitis%	Bronchitis%
Shiohama	17.7	1.34	104.40	22.80	22.25	41.27
East-Hashikita	10.4	0.54	43.59	16.50	9.49	28.12
Hamada	15.0	0.75	40.65	15.24	16.67	30.96
Minato	17.2	0.64	46.00	14.50	11.07	32.06
Kaizo	8.8	0.50	53.69	12.76	12.76	43.67
Kyodo	11.4	0.50	52.85	11.73	12.07	29.61
Mie	5.0	0.10	28.48	9.58	12.31	32.09
Hinaga	12.5	0.57	49.41	8.74	15.83	14.74
Yogo	3.0	0.10	36.13	7.94	10.74	16.11
Hobo			23.61	7.43	5.32	16.19

cent of total number of the enlisted. Incidences for common cold, laryngopharyngitis and "asthma" are correlated well with pollution level, especially with that of sulphur dioxide. The correlation coefficients are given in Table 3. These correlations

Table 3. Correlation coefficients between sulphur dioxide or dust-fall and upper respiratory diseases.

	Total		Infantile and senile	
	Dust-fall	SO_2	Dust-fall	SO_2
Common cold	0.47	0.87	0.61	0.88
Bronchial asthma	0.60	0.82	0.72	0.87
Laryngopharyngitis	0.25	0.41	0.52	0.80
Bronchitis	0.13	0.15	0.37	0.48
Total upper respiratory diseases	0.66	0.86	0.73	0.92

are much higher when subjects are limited to infantile (0—4 yr.) and senile (more than 50 yr.) groups. As shown in Table 3, unexpected low correlation between bronchitis and air pollution may be explained by the fact that, in this country, doctors are used to include bronchitis into "commom cold". Correlation between incidence of "astham" and sulphur dioxide level is illustrated in Fig. 3. As in Fig. 3, incidence of "asthma" in Shiohama district is two or three times as high as in the other districts of the city.

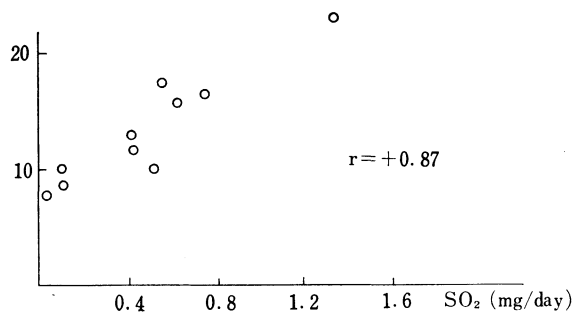


Fig. 3. Correlation between sulphur dioxide and incidence of "Asthma". (Infantile and senile groups, 1963)

Diagnosis of "asthma" in this survey, was defined as a disease, in which recurrent attacks of acute air way obstruction are complained.

Relationship between Asthma Atack and Air Pollution

Under the collaboration of Dr. Nakayama, the general practioner at Isozu district, we have made a series of survey during the period from January to March

1963 on the relation between incidence of asthma attack and sulphur dioxide concentration by Thomas' method or density of suspended dust measured by filter-paper method with automatic recorder in this district. Results are shown in Fig. 4 and Fig. 5.

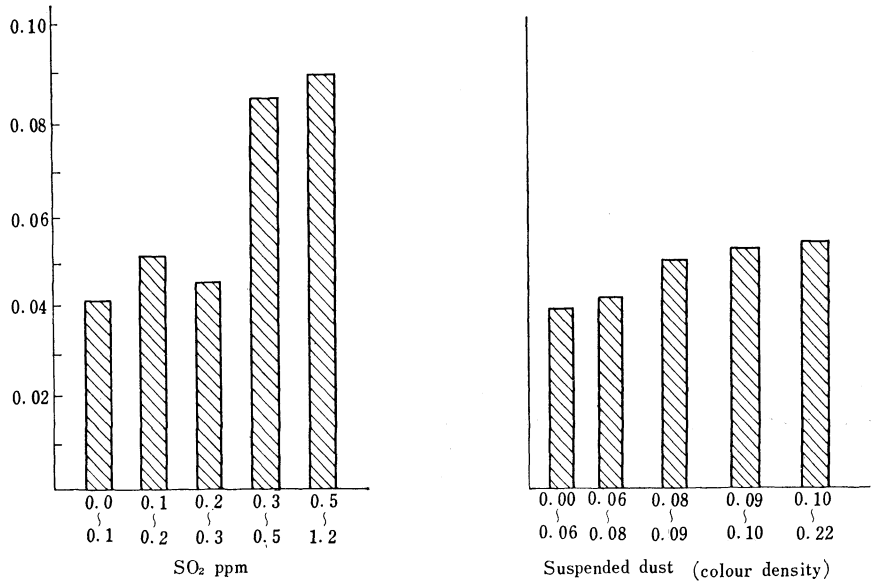


Fig. 4. Relationship between asthmatic attacks and sulphur dioxide or suspended dust.

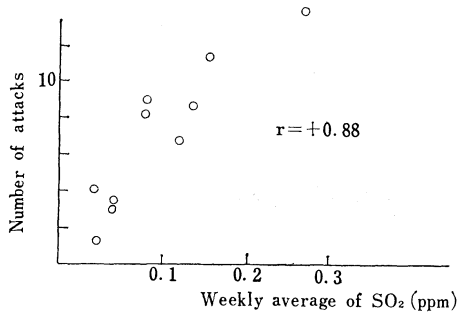


Fig. 5. Relationship between asthmatic attacks and weekly average concentrations of sulphur dioxide. (at Isozu, 13 cases)

Relationship between the incidence of asthma attack and sulphur dioxide concentration was obvious in this survey and its correlation coefficient between weekly average of sulphur dioxide concentration and number of attacks was as high as 0.88.

Clinical Features of "Asthma Attack" at Isozu District

In this district, we have reconfirmed significantly higher incidence of "asthma" through direct interviews. Sixty-six cases were found in 2,600 population, that is

to say, 2.5% of inhabitants were suffering from asthma. Details were as follows;

1. Most of the patients had rather sudden onset of attacks of expiratory difficulties without any preceeding symptoms such as "common cold" or upper respiratory infection. After the first attack, patients usually had gradually increasing number of "asthma attack".

2. Patients who had family history of allergic diseases were found in 13.3% of the whole number of cases. History of occupational exposure to dusty environment was found in only one case among 31 cases, in which we had successfully made history-takings.

We found past histories of pulmonary diseases in two cases, one had pneumonia in his childhood, and the other pulmonary tuberculosis some 40 years ago.

3. Allergic disposition of the cases was studied by the subcutaneous injection of extract of house-dust and "Tatami-dust" (Japanese traditional carpet made of a kind of weeds).

Only two cases showed positive reaction (6.4 %). The research group in University of Tokyo reported the incidence for positivity of this reaction in "classic asthma cases" as about 60%, therefore our results suggested a different character of Yokkaichi-asthma from classic asthma.

4. In Fig. 6, distribution of the years passed after the outbreak of this sysmptom is shown. As shown in the figure, most of the patients have histories less than five years since the onset, and almost half of the total number of cases have less than one year.

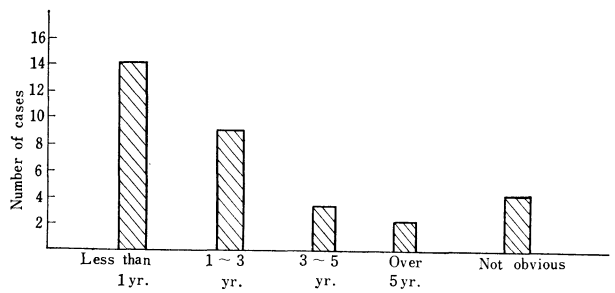


Fig. 6. Distribution of the years passed after outbreak of asthmatic condition.

As we have indicated already, the factories in this area have been put in operation since 1955, these episodes of our cases have started after the factories operation. In addition to this, most of the patients have had significant relief from attack after they moved out of the district. These facts are suggestive of very close relation between asthma attack and air pollution.

5) Sex and age-incidence are shown in Table 4. About a half of the cases were men and the people over 50 years of age was found in about fifty percent.

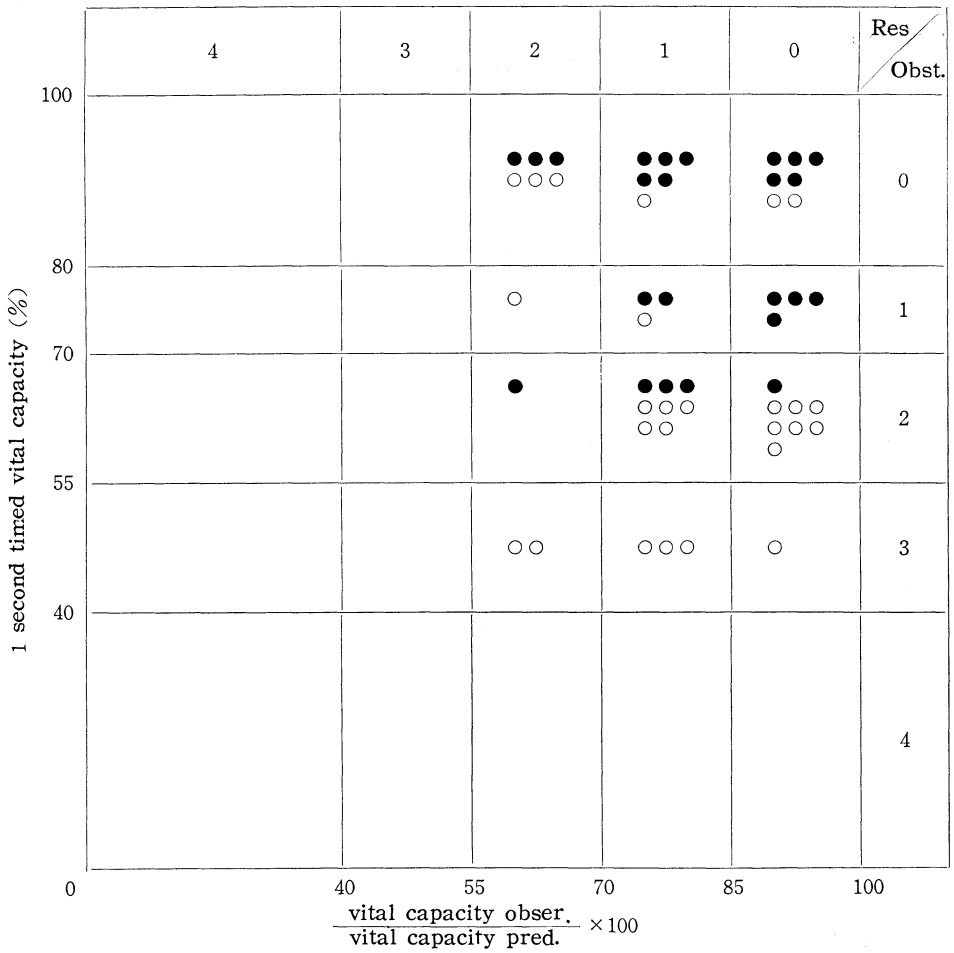
Table 4. Incidence of asthma patients by sex and age at Isozu.

	More than 50 years	Less than 50 years	% of senile
Men	26	13	66.7
Women	15	12	55.6
Total	41	25	62.1

In 16 cases, long histories of daily smoking of over 20 cigarettes (23.1 cigarettes per day in average) were found.

6. Data of pulmonary function tests are shown in Fig. 7. Judging from timed vital capacity data, most of our cases have shown relatively reversible obstructive

Fig. 7. Results of pulmonary function tests.
○ Before treatment with bronchodilator
● After treatment with bronchodilator
Res.; Grade of restriction
Obst; Grade of obstruction



pattern, some of which have shown restrictive pattern as well. ECG has shown "pulmonary P pattern" in 10 cases. We are still continuing these clinical observations and planning to publish detailed data next year.

Summary

In Yokkaichi-city, where largest number of oil and related chemical plants in Japan are located, growing number of cases of asthma attack has been reported since the setting up of the plants in 1955.

At Isozu, where atmospheric pollution is most severe in its grade, incidence of asthma reached up to 2.5% of total population of 2,600.

In Yokkaichi-city, annual average of sulphur dioxide level by candle method in each district correlated well with the incidence of "asthma". Furthermore, at Isozu, the number of asthmatic attack in each case closely correlated to weekly average concentration of sulphur dioxide by Thomas' method.

Clinical features of "Yokkaichi-asthma" are as follows;

1) Most of the cases are men and also most of the cases are those with age of over 50 years.

2) All of the attacks have been started after the setting up of these plants. Relief from attack has been experienced by most of the cases with they were out of the polluted area.

3) Family allergic disposition and possibility of occupational exposure to polluted atmosphere are appeared to be insignificant.

4) In regards to pulmonary function, it appeared to be reversibly obstructive disorder.

Acknowledgement

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