

1. Method

Health survey and exposure assessment were conducted to analyze and evaluate the correlation between air pollutant concentrations and prevalence respiratory symptoms such as asthma in the 3-year-old and 6-year-old survey.

In the follow-up analysis, the correlation between the air pollutant concentrations and incidence of asthma was analyzed and assessed: among the 6-year-old survey in FY2021 in 35 survey areas where follow-up was possible, those who had responded to the prior 3-year-old survey in FY2017 or FY2018 were analyzed; children who did not have asthma at the time of the 3-year-old survey but had asthma at the time of the 6-year-old survey were considered to have developed asthma.

	3-year-old survey	6-year-old survey
Health survey	ATS-DLD simplified questionnaires (MOE version) were sent to all households with 3-year-old children in the survey areas to be filled out by their parents and then collected; delegated to 35 local municipalities.	ATS-DLD simplified questionnaires (MOE version) were sent to all households with first-grade children going to public primary schools in each school district of the 3-year-old survey area to be filled out by their parents and then collected; delegated to 36 local municipalities.
Exposure assessment	Air pollutant background concentrations were estimated at the residence of each child, using three-year average of the annual average concentrations (NO ₂ , NO _x , SO ₂ , SPM, O _x Y, O _x 8, and PM _{2.5}), at ambient air pollution monitoring stations in and around the study areas between FY2018 and FY2020.	

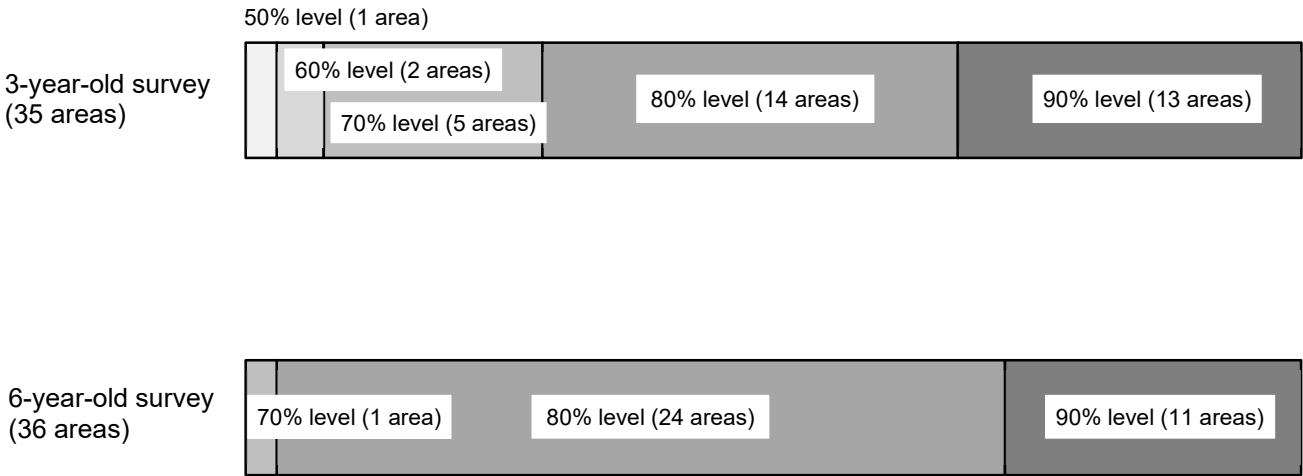
* O_xY indicates the annual average concentrations of photochemical oxidants and O_x8 the annual average 8-hour daily maximum concentrations.

2. Results

(1) Number of children surveyed and response rate

The 3-year-old survey targeted 76,639 children, and their responses were obtained from 65,234 children, with a response rate of 85.12%. The 6-year-old survey targeted 78,450 children, and their responses were obtained from 68,106 children, with a response rate of 86.81%.

Response rate and number of areas



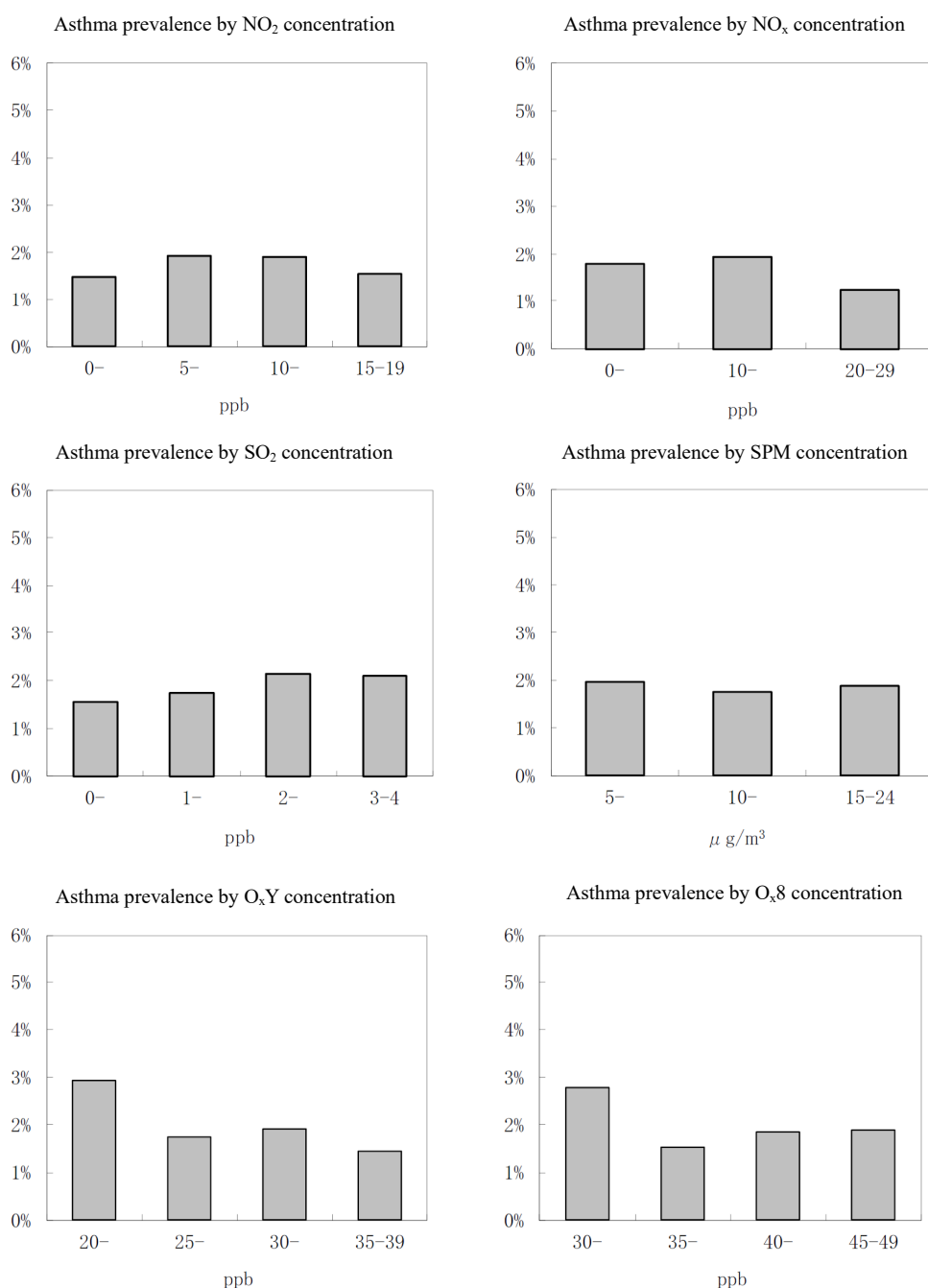
In the survey areas where follow-up was possible, 63,517 children with 6-year-old responded to the survey. Among them, 45,532 children were followed up (71.68%).

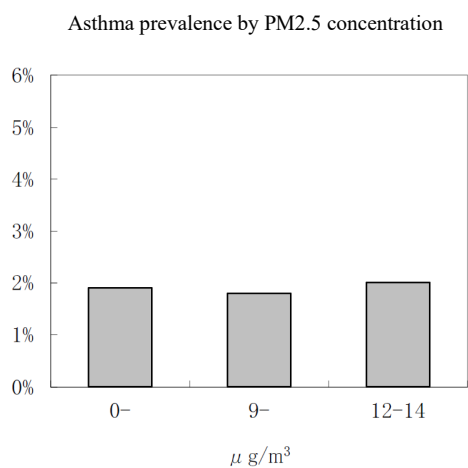
(2) Results of single-year analysis of the 3-year-old and 6-year-old surveys

1) Prevalence of respiratory symptoms according to background concentration level

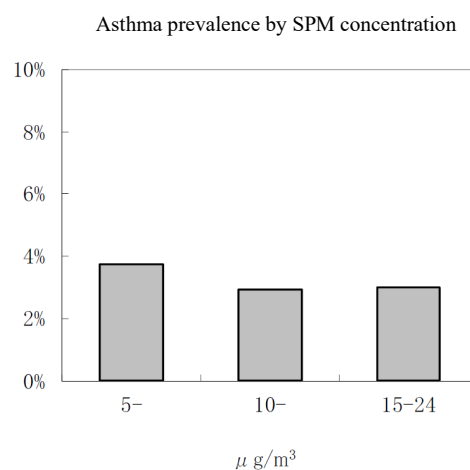
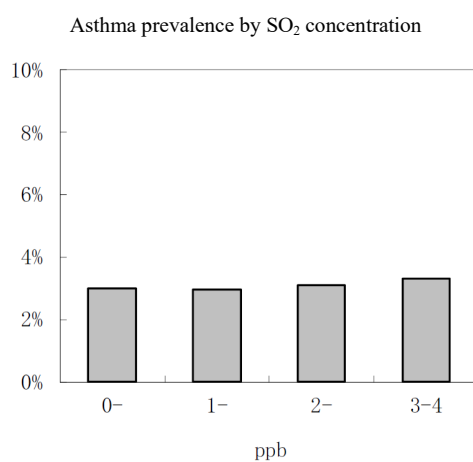
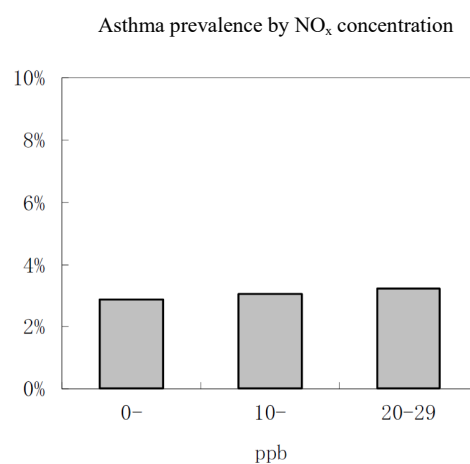
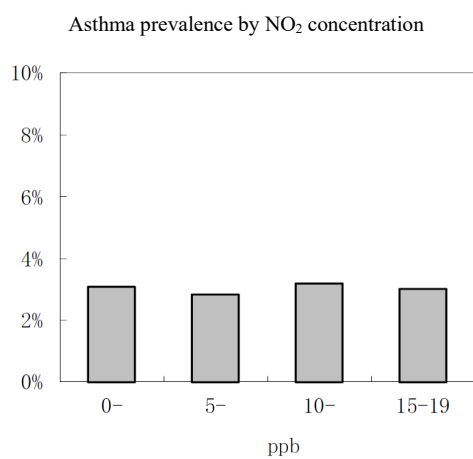
Prevalence of respiratory symptoms was analyzed according to background concentration level of air pollutants for all children. There is no tendency observed with the increase of asthma prevalence associated with the increase of concentrations for any air pollutant in the 3-year-old survey. The 6-year-old survey meanwhile indicated a tendency of the increase of prevalence, although only slightly, as the NO_x concentration level rose.

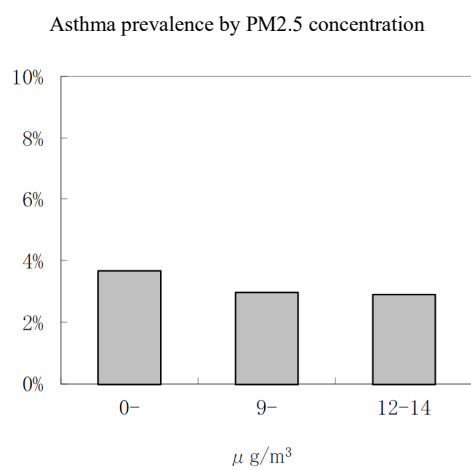
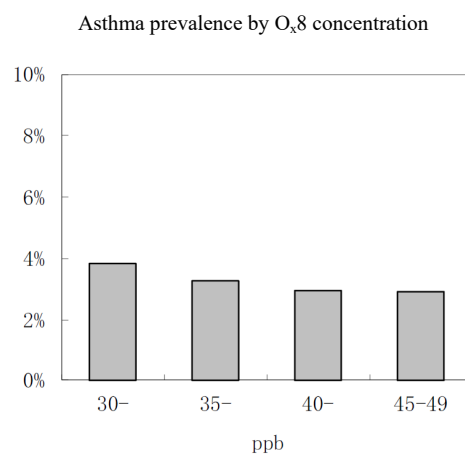
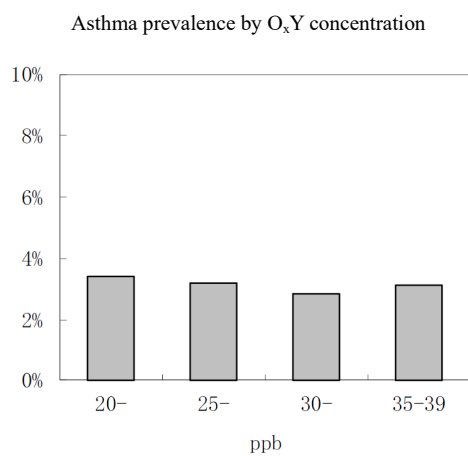
3-year-old survey





6-year-old survey



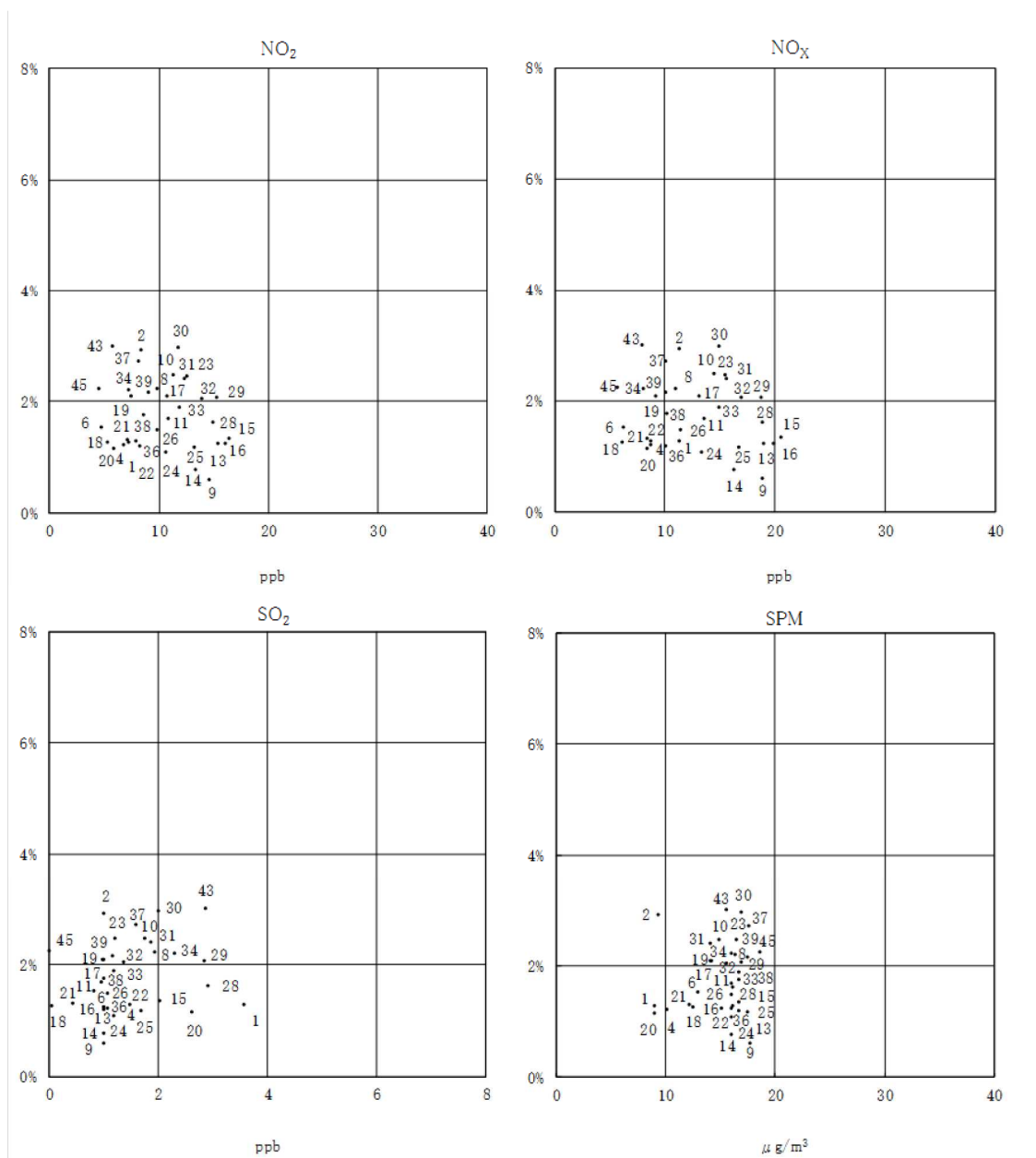


2) Average background concentration and prevalence of respiratory symptoms in each survey area

The correlation between the average background concentration and prevalence of respiratory symptoms was analyzed in each survey area. For all children (boys + girls), a positive correlation was found between the prevalence of asthma with the SO₂, SPM, O_xY, O_x8, and PM_{2.5} levels in the 3-year-old survey and with the O_xY level in the 6-year-old survey, respectively (SO₂ in the 3-year-old survey: 0.194; SPM in the 3-year-old survey: 0.109; O_xY in the 3-year-old survey: 0.187; O_x8 in the 3-year-old survey: 0.115; PM_{2.5} in the 3-year-old survey: 0.028; O_xY in the 6-year-old survey: 0.023).

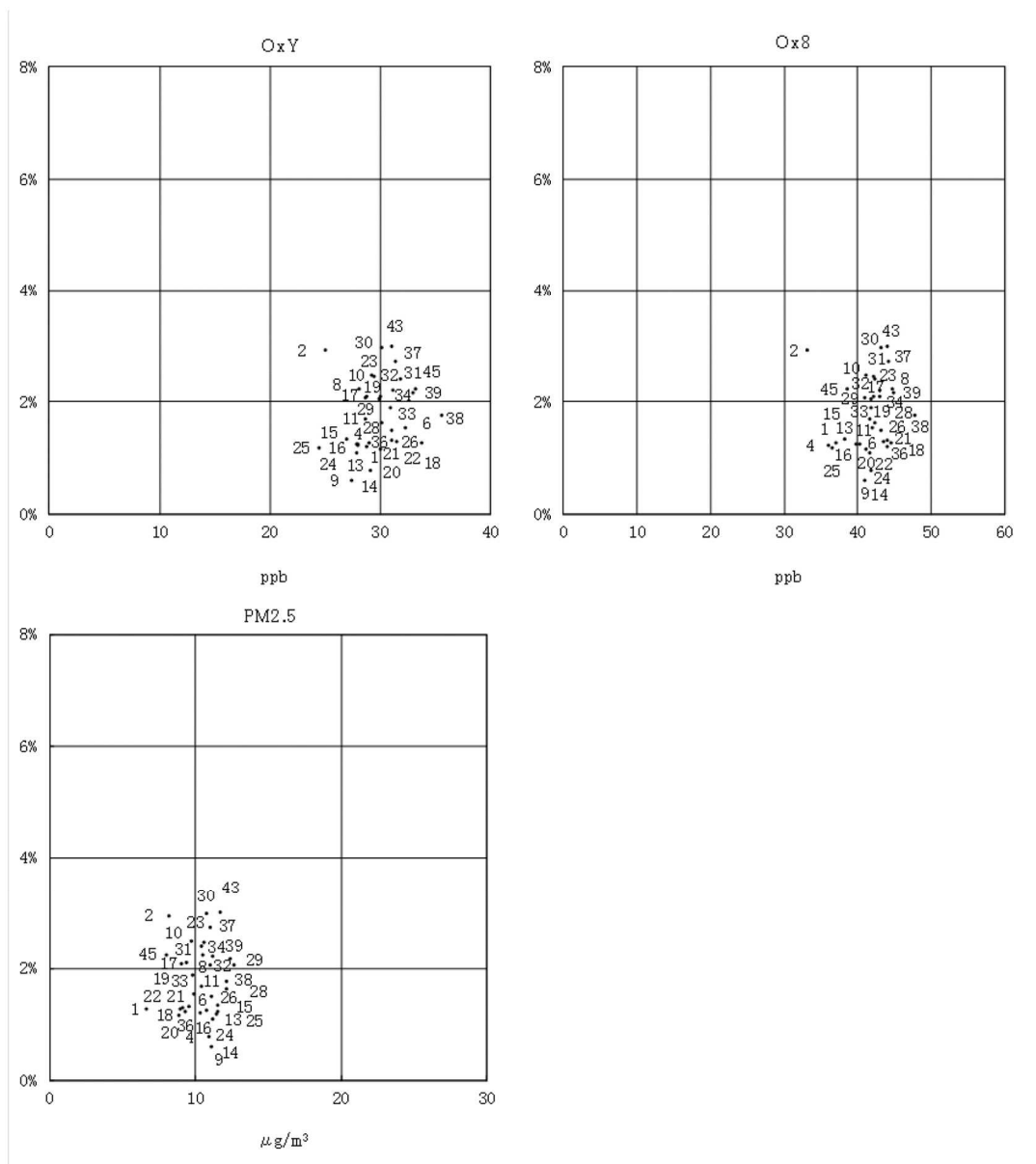
3-year-old survey

Correlation between air pollutant concentrations and asthma prevalence (adjusted rate) – All children (boys + girls)



*1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).

*2 The adjusted rate means prevalence of asthma adjusted for the composition ratio of the types of allergy history in all children.

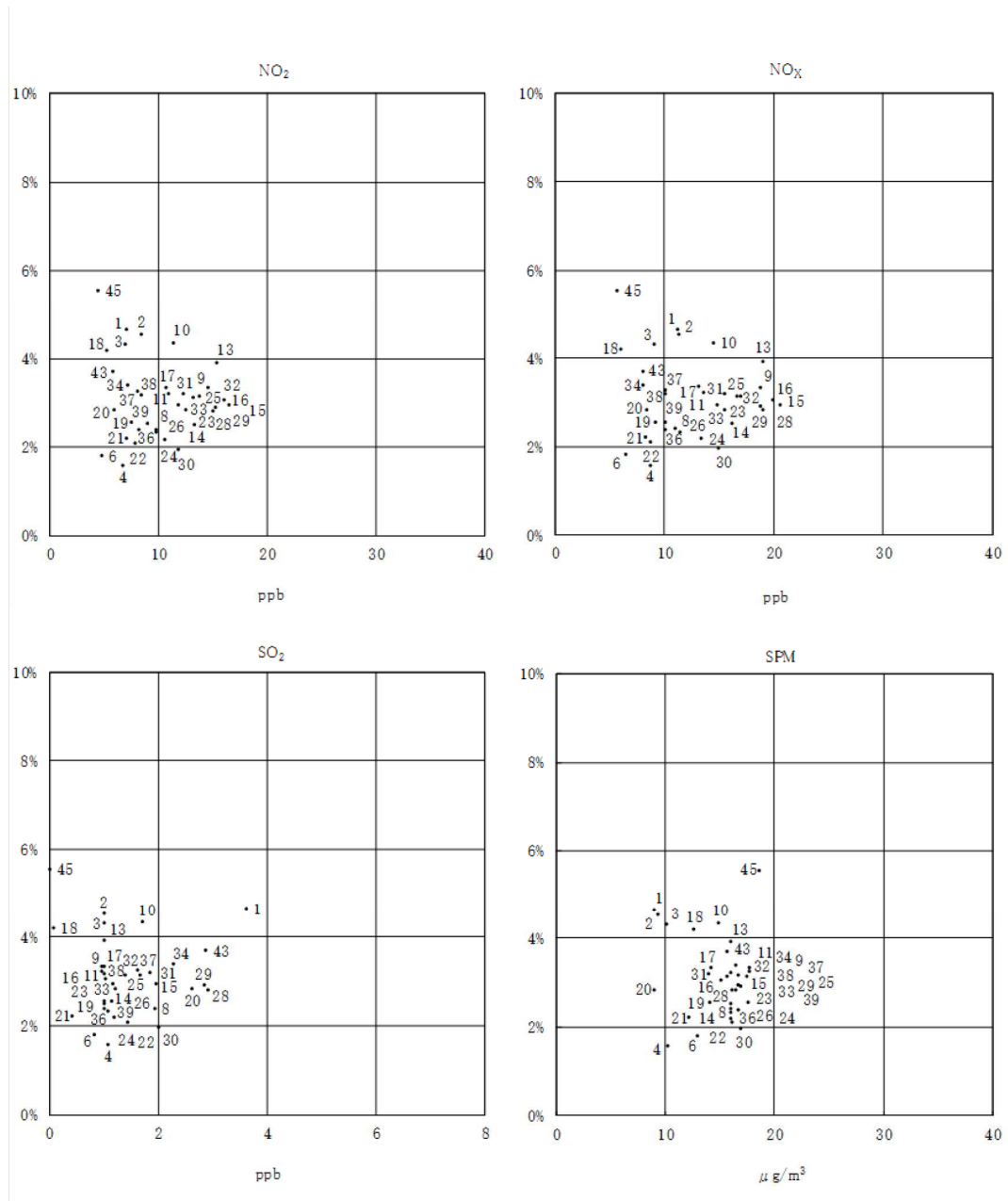


*1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).

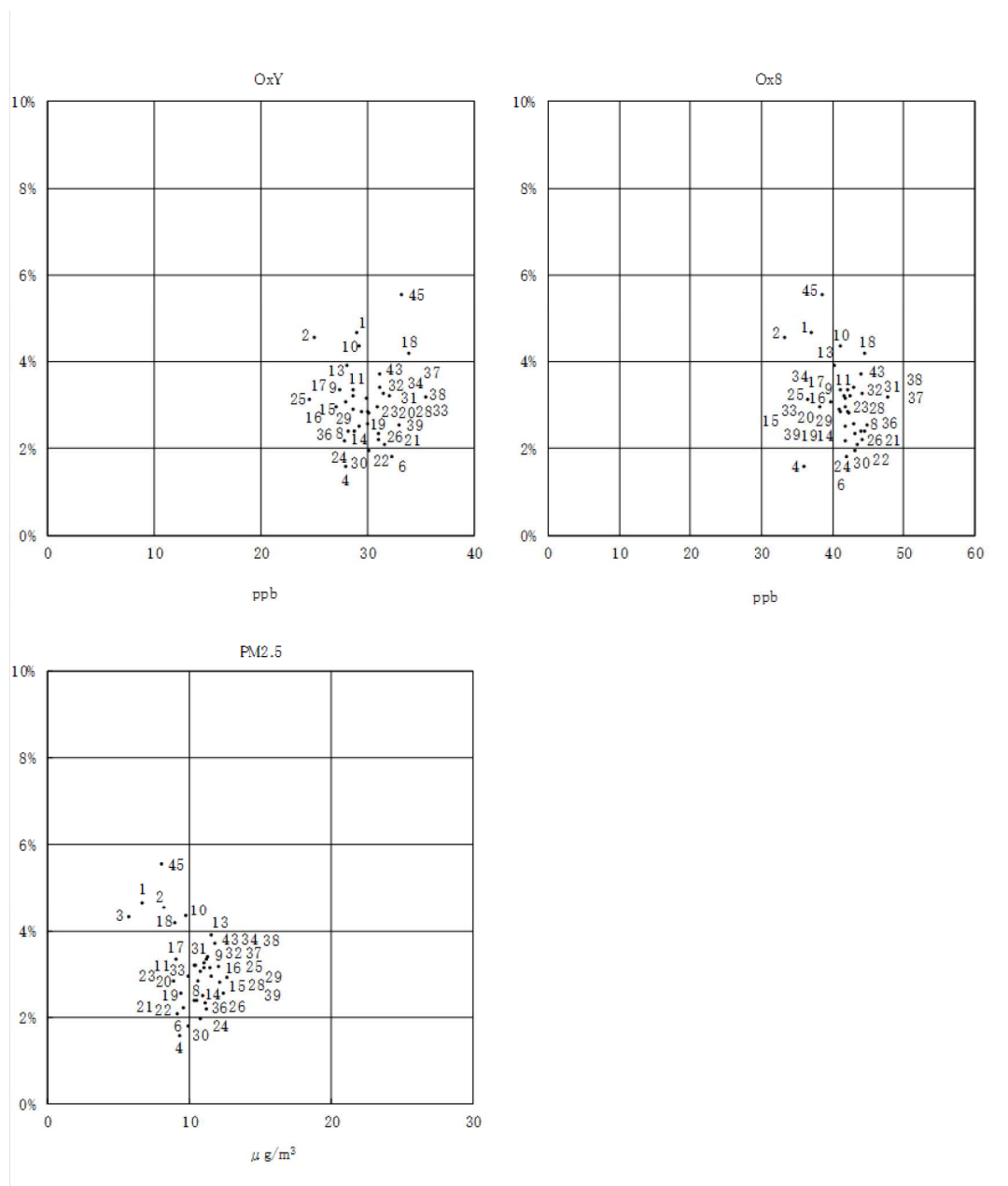
*2 The adjusted rate means prevalence of asthma adjusted for the composition ratio of the types of allergy history in all children.

6-year-old survey

Correlation between air pollutant concentrations and asthma prevalence (adjusted rate) – All children (boys + girls)



- *1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).
- *2 The adjusted rate means prevalence of asthma adjusted for the composition ratio of the types of allergy history in all children.



*1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).

*2 The adjusted rate means prevalence of asthma adjusted for the composition ratio of the types of allergy history in all children.

3) Evaluation according to the odds ratio

Contributing factors of asthma prevalence were investigated. Its statistically significant ($p < 0.05$) correlation with an odds ratio over 1 was obtained with sex (male), family member smoking (mother), pets (present), daytime caretaker (nursery center), allergy history of the children and their parents (present), and frequency of air purifier use (four times or more per week) in the 3-year-old survey; and with sex (male), family member smoking (mother), heating method (no exhaust system), pets (present), allergy history of the children and their parents (present), and frequency of air purifier use (four times or more per week) in the 6-year-old survey. With regard to air pollutants, a statistically significant ($p < 0.05$) correlation with an odds ratio over 1 was observed between SO_2 and asthma prevalence in the 3-year-old survey, while no statistically significant ($p < 0.05$) correlation with an odds ratio over 1 was obtained in the 6-year-old survey.

Results of Odds Ratios related to Asthma Prevalence

		3-year-old survey		6-year-old survey	
NO₂	Per 10 ppb increase	0.82	*	0.97	
NO_x	Per 10 ppb increase	0.87		1.00	
SO₂	Per 1 ppb increase	1.11	*	1.03	
SPM	Per 10 µg/m ³ increase	1.26		1.02	
O₃Y	Per 10 ppb increase	1.13		0.92	
O₃8	Per 10 ppb increase	1.04		0.78	*
PM2.5	Per 10 µg/m ³ increase	1.30		0.63	*
Sex	Male	1.72	*	1.48–1.49	*
	Female	1.00		1.00	
Family smoking	Mother	1.37–1.40	*	1.47–1.48	*
	Except mother	1.12–1.13		0.97–0.98	*
	No smoker	1.00		1.00	
Housing structure	Wooden house	0.91–0.95		0.85–0.87	*
	Wooden apartment building	0.94–1.00		1.01–1.08	
	Reinforced (steel-framed) house	0.83–0.87		0.90–0.92	
	Reinforced (steel-framed) apartment building	1.00		1.00	
Heating method	No exhaust system	1.13–1.16		1.14–1.16	*
	Exhaust system	1.00		1.00	
Dwelling period	Since birth	0.96–0.98		Since birth	0.88–0.90
	More than 1 year	0.98		More than 3 years	0.93–0.95
	Less than 1 year	1.00		Less than 3 years	1.00
Pets	Present	1.25–1.26	*	1.20–1.21	*
	No	1.00		1.00	
Daytime caretaker	Nursery center	1.81–1.84	*		
	Others	1.00			
Feeding during the first 3 months after birth	Milk only	1.13–1.14		1.12–1.13	
	Breast feeding and milk	1.07–1.08		0.95	
	Breast feeding only	1.00		1.00	
History of allergies (children)	Yes	1.70–1.71	*	2.16–2.18	*
	No	1.00		1.00	
History of allergies (parents)	Yes	2.91–2.96	*	2.38–2.40	*
	No	1.00		1.00	
Frequency of air purifier use	Four times or more per week	1.21–1.22	*	1.19–1.20	*
	One to three times per week	1.38–1.39		1.17–1.23	
	When unclean air is a concern	0.97–0.98		0.99	
	Not used	1.00		1.00	

*: All odds ratios estimated for each air pollutant (NO₂, NO_x, SO₂, SPM, O₃Y, O₃8, and PM2.5) are statistically significant (P<0.05).

(Note 1) The numerical ranges in the above chart indicate the range between the minimum and maximum odds ratios estimated for each air pollutants (NO₂, NO_x, SO₂, SPM, O₃Y, O₃8, and PM2.5).

(Note 2) To examine the correlation between asthma prevalence and major factors (from “sex” to “history of allergies (parents)” above) in detail, odds ratios were estimated by multiple logistic regression analysis using these major factors and air pollutant concentrations as explanatory variables.

(3) Results of longitudinal and comprehensive data analysis in the 3-year-old survey*

In the longitudinal analysis of data from FY1997 to FY2021, some areas show increase or decrease in asthma prevalence. Both the air pollutant concentrations and asthma prevalence reveal downward trend in all survey areas.

In the comprehensive analysis of integrated data from FY1997 to FY2021, with regard to prevalence of respiratory symptoms according to background concentration level and with regard to the average background concentration and prevalence of respiratory symptoms according to each survey area, there is no tendency observed with the increase of asthma prevalence associated with the increase of air pollutant concentrations. Even in those areas with low air pollutant concentrations, some areas show similar or even higher asthma prevalence as in these areas of high air pollutant concentrations. On examination of odds ratios, no statistically significant ($p < 0.05$) correlation with an odds ratio over 1 was obtained.

* Asthma prevalence in FY1996, the first year of the survey, was regarded only as a reference in the longitudinal and comprehensive analyses because the value was undoubtedly lower than those in other years.

(4) Results of longitudinal and comprehensive data analysis in the 6-year-old survey

In the longitudinal analysis of data from FY2004 to FY2021, some areas show increase or decrease in asthma prevalence. Both the air pollutant concentrations and asthma prevalence reveal downward trend in all survey areas.

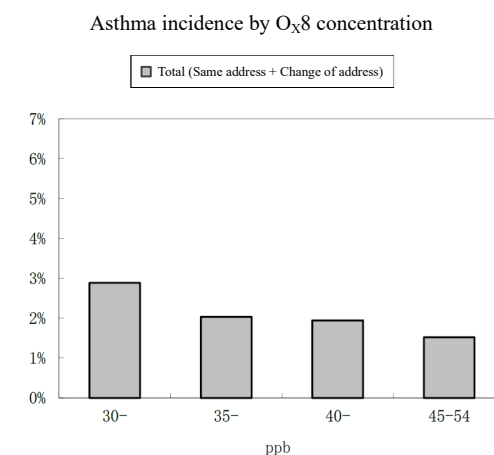
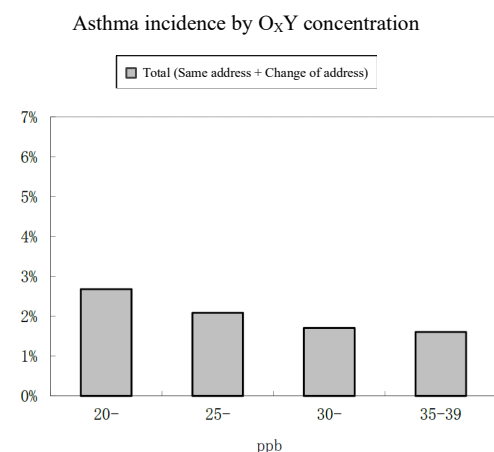
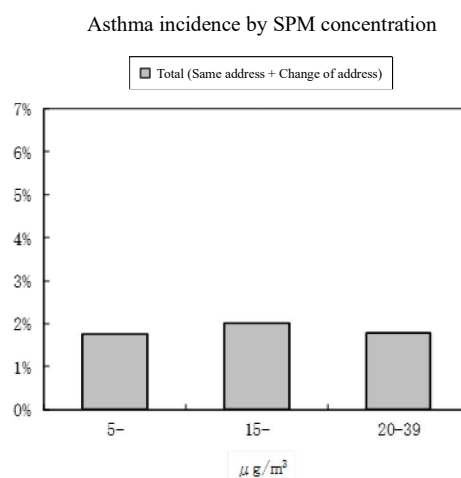
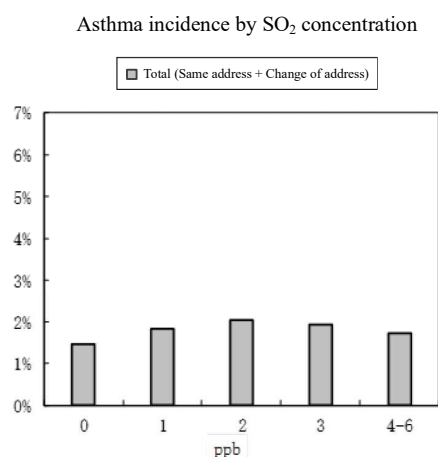
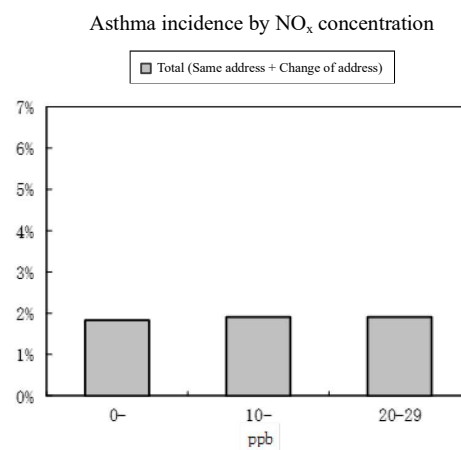
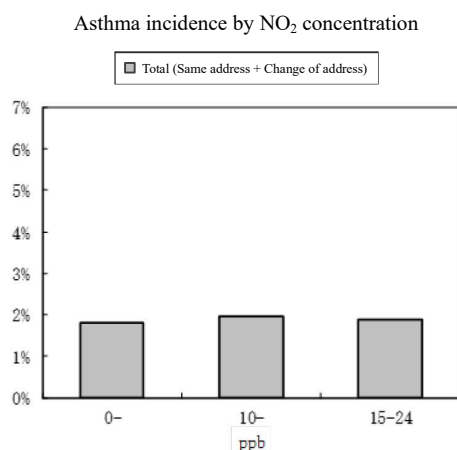
In the comprehensive analysis of integrated data from FY2004 to FY2021, with regard to prevalence of respiratory symptoms according to background concentration level and with regard to average background concentration and prevalence of respiratory symptoms according to each survey area, there is no tendency observed with the increase of asthma prevalence associated with the increase of air pollutant concentrations. Even in those areas with low air pollutant concentrations, some areas show similar or even higher asthma prevalence as in these areas of high air pollutant concentrations. On examination of odds ratios, no statistically significant ($p < 0.05$) correlation with an odds ratio over 1 was obtained.

(5) Results of the follow-up analysis

1) Asthma incidence according to background concentration level

Asthma incidence was analyzed according to background concentration level of air pollutants for all children. Examination of asthma incidence according to level of background NO_x concentration indicated a tendency with the increase of incidence associated with the increase of the concentration level.

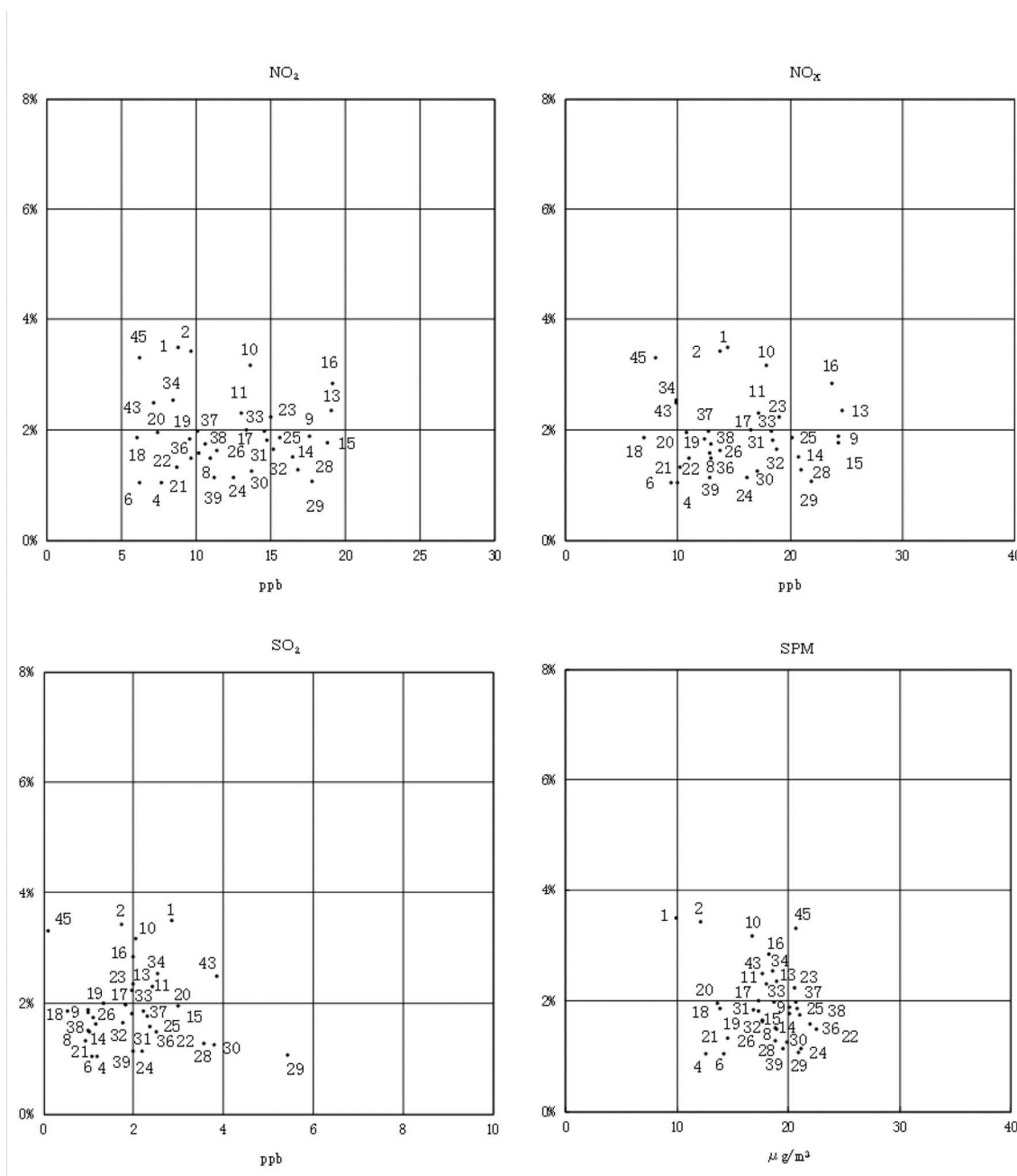
Regarding SO_2 , the background concentration was considered insufficient for this analysis.



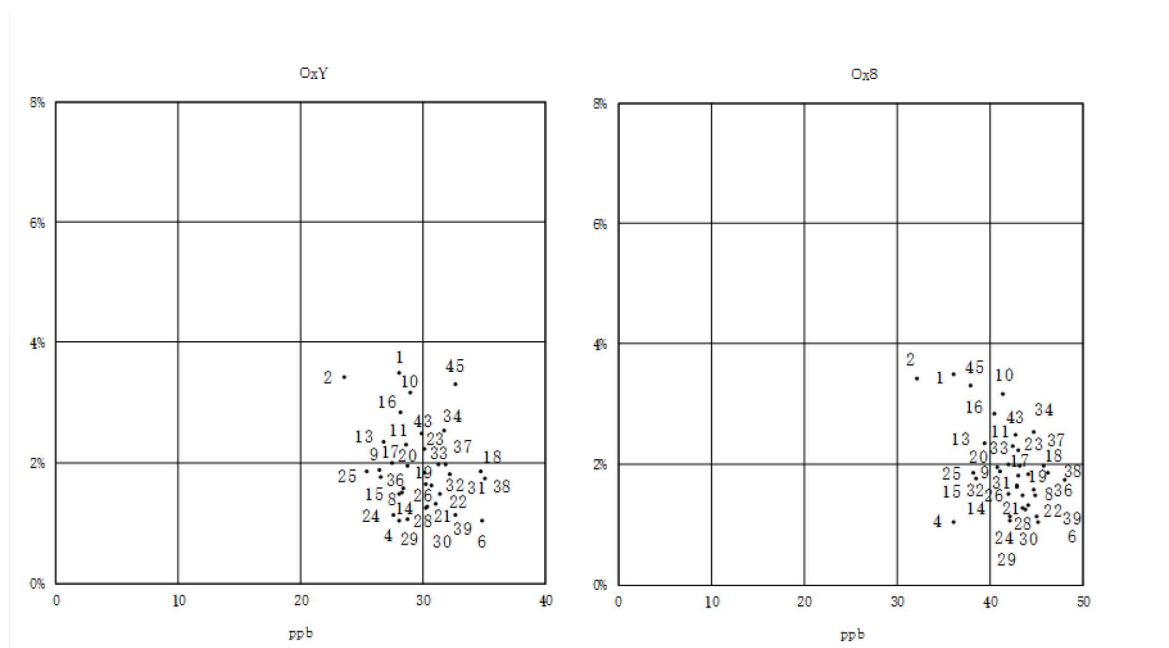
2) Average background concentration and asthma incidence in each survey area

The correlation between the average background concentration and asthma incidence was analyzed in each survey area. There is no tendency observed with the increase of asthma incidence associated with the increase of air pollutant concentrations. Even in those areas with low air pollutant concentrations, some areas show similar or even higher asthma incidence as in these areas of high air pollutant concentrations.

Correlation between air pollutant concentrations and asthma incidence (adjusted rate) – All children (boys + girls)



- *1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).
- *2 The adjusted rate means incidence of asthma adjusted for the composition ratio of the types of allergy history and the average background concentration during the follow-up period for all children in the 3-year-old survey.
- *3 The background concentration level in each survey area was the value at the time of the 3-year-old survey.



- *1 Numbers in the graph indicate their survey areas. See <Reference> FY2021 survey areas (on page 19).
- *2 The adjusted rate means incidence of asthma adjusted for the composition ratio of the types of allergy history and the average background concentration during the follow-up period for all children in the 3-year-old survey.
- *3 The background concentration level in each survey area was the value at the time of the 3-year-old survey.

3) Evaluation according to the odds ratio

Contributing factors of asthma incidence were investigated. Its statistically significant ($p<0.05$) correlation was obtained with sex (male), pets (present), and allergy history of the children and parents (present). With regard to air pollutants, no statistically significant ($p<0.05$) correlation with an odds ratio over 1 was obtained.

Odds Ratios of Factors Influencing Asthma Incidence

NO₂	Per 10 ppb increase	1.05	
NO_x	Per 10 ppb increase	1.09	
SO₂	Per 1 ppb increase	1.01	
SPM	Per 10 µg/m ³ increase	0.93	
OxY	Per 10 ppb increase	0.65	*
Ox8	Per 10 ppb increase	0.62	*
Sex	Male	1.39	*
	Female	1.00	
Family smoking	Mother	1.28–1.33	
	Except mother	1.01–1.02	
	No smoker	1.00	
Housing structure	Wooden house, wooden frame	0.96–1.00	
	Wooden house, metal frame	0.92–0.94	
	Reinforced steel, steel frame	1.00	
Heating method	No exhaust system	1.11–1.15	
	Exhaust system	1.00	
Address change	Change of address	0.97–0.98	
	Same address	1.00	
Pets	Present	1.27	*
	No	1.00	
Daytime caretaker	Nursery center	1.05–1.07	
	Others	1.00	
Feeding during the first 3 months after birth	Milk only	0.98–0.99	
	Breast feeding and milk	0.93	
	Breast feeding only	1.00	
History of allergies (children)	Yes	1.90	*
	No	1.00	
History of allergies (parents)	Yes	1.85–1.88	*
	No	1.00	

* All odds ratios estimated for each air pollutant (NO₂, NO_x, SO₂, SPM, OxY and Ox8) are statistically significant ($P<0.05$).

(Note 1) The numerical ranges in the above chart indicate the range between the minimum and maximum odds ratios estimated for each air pollutants (NO₂, NO_x, SO₂, SPM, OxY and Ox8).

(Note 2) To examine the correlation between asthma incidence and major factors (from “sex” to “history of allergies (parents)” above) in detail, odds ratios were estimated by multiple logistic regression analysis using these major factors and air pollutant concentrations as explanatory variables.

(6) Results of analysis of follow-up longitudinal data

In the longitudinal analysis of data from FY2004 to FY2021, some areas show increase or decrease in asthma incidence. Both air pollutant concentrations and asthma incidence reveal downward trend in all survey areas.