Epidemiologic studies on health effects of air pollution in Japan

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Outlines

- Air pollution and its health effects in the past
- Pollution control and its effects on human health
- Present status of air pollution in Japan
- Traffic-related air pollution and its health effects
  - Epidemiologic study in Chiba Prefecture
  - Ongoing study by the Ministry of Environment (the SORA projects)
Air Pollution in the past in Japan

- **Yokkaichi Asthma**
  - Air pollution in the 1960s, due to petroleum complex in Yokkaichi, Japan
  - Prevalence of bronchial asthma and chronic bronchitis increased among people living in the vicinity of the complex.

- In Japan, from around 1960, the concentrations of air pollutants increased in many industrial cities, and health effects of air pollution had became a major concern in the cities, including Tokyo, Kawasaki, Chiba, Fuji, Osaka, Amagasaki, Kobe.
Concentrations of sulfur dioxide in Yokkaichi


Prevalence of chronic bronchitis and COPD among adults in Yokkaichi

Asthma and sulfur dioxide in Yokkaichi

Relation between SO₂ and yearly accumulated prevalence of asthma in 13 districts
Age group over 50 yr; April 1963 – March 1964

Relation between asthma attack and weekly average concentration of SO₂
At Isozu 13 patients January to March 1963

r = 0.88

Concentrations of sulfur oxides in Fuji (1972)

Suruga Bay

Chronic bronchitis and sulfur dioxide

Adjusted prevalence of chronic bronchitis among adults aged ≥ 40 years

BMRC questionnaire

![Graph showing the relationship between sulfur oxides and prevalence of chronic bronchitis.](image)

Concentrations of sulfur oxides in Chiba

By PbO₂ method, mg/100cm²/day (1972)

![Map showing concentrations of sulfur oxides in Chiba.](image)

Steel mill (Tokyo Bay)  Power station


Relationship between prevalence of asthma and sulfur oxides
Boys in 12 elementary schools (1972)

Prevalence of asthma
1971
1972
1971+1972

Sulfur oxides

Change in concentrations of sulfur oxides in Yokkaichi
Annual average concentrations measured by the PbO₂ method


Sulfur oxides levels and mortality due to respiratory diseases in Yokkaichi

Age-adjusted mortality
- Top: Bronchial asthma
- Middle: Chronic bronchitis
- Bottom: Annual average concentration of sulfur oxides

Concentrations of Nitrogen Dioxide in Japan

![Graph of Nitrogen Dioxide Concentrations](image)

Concentrations of Suspended Particulate Matter (≤10μm in diameter) in Japan

![Graph of Suspended Particulate Matter Concentrations](image)
Changes in the problems of Air Pollution

- Industrial air pollution (factories, etc.) → Urban/Domestic air pollution (vehicles, etc.)
- Gaseous pollutants → Particulate matters
  - Fine particles, Diesel exhaust particles, etc.
  - Uncontrolled toxic air pollutants
- High concentrations → Relatively low concentrations
- Wide areas around factories → Regional areas adjacent to major roads
Prevalence of bronchial asthma among Japanese children

- **Graph:**
  - X-axis: Years (1987 to 2008)
  - Y-axis: Percentage (%)
  - Categories: Preschool, Elementary school, Junior high school, High school

- **Data Source:** School Health Survey in Japan

Health effects of automobile exhaust

Epidemiologic study in Chiba Prefecture (1985~2000)

- **Study subjects**
  - Children in 10 elementary schools (about 6,000)
  - Schools are located in urban areas, and their school districts are intersected by major trunk roads.
  - Schools are in rural areas, without major roads or factories.

- **Methods**
  - Questionnaire for respiratory symptoms
  - Pulmonary function tests
  - Blood sampling for allergic and inflammatory tests
  - Measurements of indoor environments
Prevalence of asthma


Incidence of asthma

1992~1995

Prevalence and incidence of wheeze

Prevalence of wheeze

Incidence of wheeze

Prevalence and incidence of wheeze

Odds ratios for various factors on the incidence of asthma

Adjusted for all variables using logistic regression model

<table>
<thead>
<tr>
<th>Factor</th>
<th>Males</th>
<th>Females</th>
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</thead>
<tbody>
<tr>
<td>Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-50 m</td>
<td>3.77</td>
<td>4.03</td>
</tr>
<tr>
<td>&gt; 50 m</td>
<td>1.99</td>
<td>1.74</td>
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<tr>
<td>Rural areas</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>School grade, 1 grade increase</td>
<td>1.13</td>
<td>0.94</td>
</tr>
<tr>
<td>History of allergic diseases</td>
<td>2.95</td>
<td>6.03</td>
</tr>
<tr>
<td>Respiratory diseases before 2 yr</td>
<td>1.85</td>
<td>2.08</td>
</tr>
<tr>
<td>Breast feeding in infancy</td>
<td>1.42</td>
<td>0.60</td>
</tr>
<tr>
<td>Parental history of allergic diseases</td>
<td>2.82</td>
<td>1.20</td>
</tr>
<tr>
<td>Maternal smoking habits</td>
<td>1.74</td>
<td>2.15</td>
</tr>
<tr>
<td>House of steel or reinforced concrete</td>
<td>0.92</td>
<td>0.40</td>
</tr>
<tr>
<td>Use of unvented heaters in winter</td>
<td>1.47</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Incidence of asthma by school grade

Follow-up from 1st grade to 6th grade

Urban districts
Rural districts

Incidence of asthma and outdoor nitrogen dioxide concentrations
(1992~1994)

\[ r^2 = 0.783 \]
\[ p = 0.008 \]


Associations between incidence of asthma and concentrations of NO₂ and SPM


Measurement of Indoor nitrogen dioxide concentrations

- The concentrations of indoor NO₂ over 24 hours were measured in both the heating and non-heating periods in homes of pupils.
- The badge type passive samplers (Advantec, Tokyo, Japan) were used.
- Information on factors that could influence indoor environments was collected by questionnaire.
### Indoor nitrogen dioxide concentrations


![Box plot showing indoor nitrogen dioxide concentrations across different heating periods and locations.](image)

### Odds ratios (OR) for various factors on the incidence of asthma

Adjusted for all variables using logistic regression model

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor NO₂ concentration, 0.01 ppm increase</td>
<td>2.10</td>
</tr>
<tr>
<td>Indoor NO₂ concentration, 0.01 ppm increase</td>
<td>0.87</td>
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<tr>
<td>History of allergic diseases</td>
<td>7.96</td>
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<tr>
<td>Respiratory diseases before 2 yr</td>
<td>2.86</td>
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<tr>
<td>Breastfeeding in infancy</td>
<td>0.60</td>
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<tr>
<td>Parental history of allergic diseases</td>
<td>1.02</td>
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<tr>
<td>Maternal smoking habits</td>
<td>0.51</td>
</tr>
<tr>
<td>Use of unvented heaters in winter</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Summary of epidemiologic study in Chiba, Japan

- The prevalence and incidence of asthma increased among children living near major roads relative to rural areas.
- The incidence rates of asthma were significantly increased with increases of outdoor NO₂ concentrations.
- Multiple logistic regression analysis showed that 10 ppb increase of outdoor NO₂ concentrations was associated with an increased incidence of asthma (OR = 2.10).
- These findings suggest that traffic-related air pollution may be of particular importance in the development of asthma among children living near major roads with heavy traffic.

Epidemiologic study on traffic-related air pollution in Japan

**Background**

- Many epidemiologic studies have shown associations between traffic density and asthma prevalence or morbidity. However a few studies examine the relationship between asthma incidence and traffic-related exposures.
- Well-designed studies are needed to assess the association between exposure to traffic-related air pollution and the onset of asthma and chronic respiratory diseases.
- In view of this situation, the Japanese Ministry of the Environment has decided to launch the SORA projects (Study Of Respiratory diseases and Automobile exhaust).
Study On Respiratory disease and Automobile exhaust (SORA project)

“SORA” means sky in Japanese.


These studies are conducted to estimate the health effects of traffic-related air pollution in adjacent to major trunk roads in Japan.

* http://www.env.go.jp/chemi/sora/

Cohort study among school children living along trunk roads

- **A school-based prospective cohort study** have been conducted in the three metropolitan areas in Japan.
- In fall 2005, we enrolled 16,300 children (grades 1-3) in 57 primary schools.
- Of these schools, 49 schools are located in the districts with heavy traffic density (about 30,000-120,000 vehicles/day), and the other 8 schools are in the districts that were distant from major roads.
**Schema of the study districts**

Study subjects (♂): 1st to 3rd schoolchildren (about 16,300)

**Study area**
- Distant districts
- Neighboring districts

**Major road**
- Major roads with heavy traffic density (about 30,000-120,000 vehicles/day)

**Schedule of the study**

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire survey</td>
<td>Fall (grades 1-3)</td>
<td>Fall (grades 2-4)</td>
<td>Fall (grades 3-5)</td>
<td>Fall (grades 4-6)</td>
<td>Fall (grades 5-6)</td>
</tr>
<tr>
<td>Blood sampling</td>
<td>Fall or winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mite allergen test</td>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous air monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoor and outdoor monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>four seasons</td>
</tr>
<tr>
<td>Personal exposure monitoring*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>four seasons</td>
</tr>
</tbody>
</table>

* a part of subjects

Data analysis will be performed before March, 2011.
Schematic outline of the study

Health Effect Assessment
Questionnaire
Blood sampling

Exposure Assessment
The long-term average exposure of air pollutants (EC and NOx) is estimated by simulation model at the residence and the school.

Factors related to asthma
Mite allergen test
Questionnaire

Air pollution monitoring of EC and NOx
Measurements of personal exposure to NOx

Evaluation between exposure to traffic-related air pollutants and the onset of asthma among children

Provisional results of continuous air monitoring

- The concentrations of PM$_{2.5}$, black carbon (BC), and NOx have been continuously measured at 4 sites (0m, 20m, 50m, 100m) near each of 10 major roads and 7 sites distant from major roads.

![BC concentrations in March, 2006](chart1)

![NOx concentrations in March, 2006](chart2)
Conclusions

- Various efforts during the past several decades have improved industrial air pollution.
- The problems of traffic-related air pollution have been rising in response to the increase of automobiles.
- Some studies suggest the health effects of traffic-related air pollution. However, the relationship between the incidence of asthma and traffic-related exposures should be further evaluated.
- Further studies are also needed to clarify the health effects of fine particles in relation to automobile traffic.

Thank you very much for your attention.

(Outlook from Mt. Rokko, Hyogo)