

O V I D[®] Full Text

[Main Search Page](#) [Help](#) [LOGOFF](#)

[PayPerView Account](#) [View Cart](#)



EPIDEMIOLOGY

© 2000 Lippincott Williams & Wilkins, Inc. Volume 11(1), January 2000, pp 64-70

[About this Journal](#)

[Table of Contents](#) | [Browse TOC](#)

[Find Citing Articles](#) | [Email Jumpstart](#)

[Save Article Text](#) | [Email Article Text](#) | [Print Preview](#)

Links

[Abstract](#)
[Complete Reference](#)
[Catalogo Biblioteca ISS](#)
[Internet Resources](#)

Outline

- [Abstract](#)
- [Subjects and Methods](#)
 - [Study Locations](#)
 - [Population](#)
 - [Air Pollution Assessment](#)
 - [History of Diagnoses Made by a Child's Physician](#)
 - [Eczema and Determination of Atopic Sensitization](#)
 - [Symptom Diary](#)
 - [Potential Confounders](#)
 - [Statistical Analysis](#)
- [Results](#)
 - [Air Pollution Exposure](#)
 - [Participation](#)
 - [Description of Allergy-Related Variables and Potential Confounders](#)
 - [Exposure and Potential Confounders](#)
 - [Exposure and Allergy-Related Variables](#)
- [Discussion](#)
- [Acknowledgments](#)
- [References](#)

Graphics

- [Table 1](#)
- [Table 2](#)
- [Table 3](#)
- [Table 4](#)
- [Figure 1](#)
- [Table 5](#)

Recent History

Traffic-Related Air Pollu...



Traffic-Related Air Pollution Is Associated with Atopy in Children Living in Urban Areas [Original Articles]

Krämer, Ursula^{1 2}; Koch, Thilo¹; Ranft, Ulrich¹; Ring, Johannes²; Behrendt, Heidrun³

From the ¹Medical Institute of Environmental Hygiene at the Heinrich-Heine University, Düsseldorf; ²Department of Dermatology and Allergology, Technical University Munich; and ³Division of Environmental Dermatology and Allergology, GSF-National Research Center for Environment and Health/Technical University Munich, Germany. Submitted July 24, 1998; final version accepted July 20, 1999.

Address correspondence to: Ursula Krämer, Medical Institute of Environmental Hygiene at the Heinrich-Heine University, Auf'm Hennekamp 50, D-40225 Düsseldorf, Germany.

This study was financed by the Ministry of the Environment of North Rhine Westphalia Grant VB 8819.

Abstract

Traffic emissions are a major source of air pollution in Western industrialized countries. To investigate the association between traffic-related air pollution and parameters of atopy, we studied 317 children 9 years of age living near major roads in two urban areas and one suburban area of a city in West Germany. Atopic sensitization was analyzed by skin-prick testing and determination of allergen-specific serum immunoglobulin E. Parents recorded allergic symptoms in a symptom diary, and physicians assessed allergic diseases. Personal NO₂ exposure and NO₂ concentrations in front of each child's home were measured. Outdoor NO₂ was a good predictor for traffic exposure but a poor predictor for NO₂ exposure at the personal level. Atopy was found to be related to outdoor NO₂ (odds ratio for the association between symptoms of allergic rhinitis and outdoor NO₂ = 1.81; 95% confidence interval = 1.02–3.21) but

not to personal NO₂ (odds ratio for the association between symptoms of allergic rhinitis and personal NO₂ = 0.99; 95% confidence interval = 0.55–1.79). When the analysis was restricted to urban areas, we found that hay fever, symptoms of allergic rhinitis, wheezing, sensitization against pollen, house dust mites or cats, and milk or eggs were associated with outdoor NO₂. The results indicate that traffic-related air pollution leads to increased prevalence of atopic sensitizations, allergic symptoms, and diseases.

In recent years, several epidemiologic studies have investigated the association between traffic-related air pollution and respiratory diseases and symptoms in children 1–16 and adults. 8,17–19

Exposure characterization has included self-reported traffic density, 14,15,18 self-reported distance from a busy street, 5,6 measurement of distance to the road, 1–3,18 measurement of traffic density, 1,2,4,8,16 and measurement of particles and/or nitrogen dioxide (NO₂) at a child's school 1,2 or home 10,11 address.

Studies relating personal measurements of traffic-related air pollution to health effects are still not available.

Five out of the six studies conducted 2,10,12–15 showed an association between traffic-related exposure and wheezing. For other allergy-related symptoms and for atopic manifestation, the results are less clear. Two studies with an identical design 14,15 found an association between self-reported truck traffic and self-reported symptoms of allergic rhinitis. Two studies reported an association with asthma, 3,12 whereas four did not. 2,4,5,16 In two studies, atopy was more prevalent when exposure to traffic pollution was low 2,11 than when it was high. A study conducted in Germany 20,21 found more sensitization and symptoms among residents near major roads than away from major roads, and another conducted in Japan 8 showed a higher rate of cedar

pollinosis among individuals living in regions with cedar trees and heavy traffic compared with those living in regions with heavy traffic or cedar trees alone. There is additional evidence from human exposure studies using either controlled chamber protocols or nasal provocation tests that traffic-related air pollution increases the allergic immune response in an established allergy. This response was shown for NO₂^{22–26} at concentrations of about 200–400 µg/m³. Only very high concentrations of NO₂ (2,000 µg/m³) have a direct inflammatory effect in humans.²⁷ Diesel exhaust particles enhance nasal cytokine secretion in human.^{28,29} In mice, diesel exhaust particles have been shown to express adjuvant activity for allergen-specific immunoglobulin E (IgE) production.³⁰ An alternate explanation for an effect of traffic-related air pollution on allergic immune responses is the modulation of allergen release from pollen by the pollutants.³¹

We investigated the health effects of traffic pollution on children living in urban and suburban areas by measuring individual outdoor NO₂ and personal NO₂ to control exposure conditions precisely. In this article, we describe the effects of these exposures on physician-diagnosed allergies, allergic symptoms ascertained from symptom diaries, sensitizations ascertained by skin-prick tests (SPTs), and determinations of allergen-specific IgE antibodies (radioallergosorbent tests; RASTs).

Subjects and Methods[↑]

Study Locations[↑]

We conducted the study in Düsseldorf, a city located in the highly industrialized Rhine-Ruhr region of Germany. The city has approximately 570,000 inhabitants, a population density of 2,650 inhabitants per km², and 550 automobiles per 1,000 inhabitants. Three areas were chosen; two were urban (Friedrichstadt and Düsselthal), with a traffic density of up to 50,000 cars per 24 hours in front of the children's homes. The other area was suburban (Hellerhof), with a lower traffic density ([Table 1](#)).

TABLE 1. Description of Study Sites and Exposure to Traffic-Related Air Pollution

	Friedrichstadt (Urban)	Düsseldal (Urban)	Hellerhof (Suburban)
N	130	104	821
Traffic in front of residential building			
Automobiles per 24 hours	<2,000-80,914	<2,000-46,191	<2,000-~2,000
Trucks per 24 hours	<70-2,100	<70-2,000	<70-~70
NO ₂ (µg/m ³)			
Outdoors in front of residential building*			
Mean	41.7	36.8	41.4
Minimum-Maximum	37.5-47.5	30.5-42.1	43.2-46.5
Personal†			
Mean	36.7	34.3	33.0
Minimum-Maximum	14.0-70.0	11.0-44.0	10.0-36.0
Personal (calculated)			
Mean	38.2	36.3	31.7
Minimum-Maximum	18.2-49.9	15.3-41.6	11.1-40.9

*Values from two-dimensional interpolation.

†Sixty-five children in Friedrichstadt, 49 in Düsseldorf, and 70 in Hellerhof had personal monitors.

[\[Help with image viewing\]](#)[\[Email Jumpstart To Image\]](#)

Table 1. Description of Study Sites and Exposure to Traffic-Related Air Pollution* Values from two-dimensional interpolation.† Sixty-five children in Friedrichstadt, 49 in Düsseldorf, and 70 in Hellerhof had personal monitors.

Population📍

The children asked to participate in this study included all 844 children born in 1986/1987 who were living near major roads in the above-mentioned areas. Early in 1996, we sent parents an informed consent form, a basic questionnaire, and detailed information explaining the study procedure. The study plan required a high level of cooperation from both the parents and their children. Out of 844 families, 317 responded, and the number could not be enhanced either by telephone contact or personal visit. The response rates in the three investigational areas were 49.3% (Hellerhof), 38.4% (Friedrichstadt), and 30.1% (Düsseldorf). We asked the nonrespondents to complete a short, self-administered questionnaire with questions on diagnoses and covariates. One hundred sixty-seven families responded to this questionnaire.

A medical examination took place in one school in each of the study areas in the spring of 1996. There, the basic questionnaire was checked by a study researcher.

Mean residential time was 7.9 years in Friedrichstadt, 7.8 years in Düsseldorf, and 8.0

years in Hellerhof, with no difference between the three areas. Of the 317 children taking part in the medical examination, 306 had lived a minimum of 2 years at their address. The data from these children were included in the analysis.

Air Pollution Assessment

NO₂ was measured by Palmes tubes throughout the study. Exposure time was 1 week per exposure period. The following three different methods were used to assess exposure to NO₂.

1. Outdoor NO₂ was simultaneously measured at 158 sampling points in the three selected areas with a spatial resolution of 150–200 meters. To estimate annual mean levels of NO₂, measurements were taken in four different months: March 1996, June 1996, September 1996, and January 1997.

We used the outdoor measurement data to produce two-dimensional profiles by an interpolating algorithm. Using these profiles, it was possible to ascribe an interpolated outdoor NO₂ value to each child's home. Six out of 306 children lived more than 200 meters outside the areas with measurement points. No NO₂ values were assigned to these children.

2. Personal monitoring assessed exposure directly. In March and September 1996, 191 children agreed to wear NO₂ personal air samplers on a chain for 1 week, with parental permission. This monitoring allowed us to estimate total personal NO₂ intake during this period.

3. As an indirect method of individual exposure assessment, we used a microenvironmental model. We measured NO₂ in four relevant microenvironments: the interior of the homes of the 306 children, the interior of three classrooms at each

participating school, the exterior of the children's homes, and the outside area by the main roads. Measurements were taken simultaneously during March and September 1996 in each of these microenvironments. To achieve a better exposure estimation, we asked children to keep a diary and record their individual stay in these microenvironments on an hourly basis during 14 days in March and September 1996. We calculated the total personal NO₂ exposure index by adding the NO₂ concentrations measured in the microenvironments weighted by the period of time the children spent in these microenvironments.

In addition to NO₂ measurements as indicators for traffic exposure, we also ascertained traffic density. We used data from the Düsseldorf Board of Works that recorded weekday counts per 24 hours of automobiles and trucks for main roads in 1993. From this information, we constructed a personal traffic density index to characterize the traffic load in front of the children's homes. This index was 0 if the child lived in suburban Hellerhof, and in the urban areas the value was 1. If more than 2,000 but fewer than 25,000 cars passed, the number 1 was added to the index, and 2 was added if more than 25,000 passed.

History of Diagnoses Made by a Child's Physician

In autumn 1996, one physician administered a standardized questionnaire to the parents of 249 children while the children performed a lung function test done in the schools. He inquired after the child's lifetime history of diagnosed illnesses. Questions analyzed in this study included the following: "Has a physician ever diagnosed bronchial asthma in your child?" and "Has a physician ever diagnosed hay fever in your child?"

For the remaining 57 children, we used the answers to the same questions obtained

from the basic questionnaires completed at the time of physical examination in the spring of 1996.

Eczema and Determination of Atopic Sensitization📌

Two trained physicians from the Department of Dermatology and Allergology, Technical University Munich, who were blinded to the children's street addresses and exposure statuses, diagnosed atopic eczema according to standardized criteria [5,6](#) on the day of the basic examination. These same physicians administered a SPT on the volar aspect of the forearm. They read results after 15 minutes and assessed as positive a wheel 2 mm or greater in diameter. They assessed sensitivity to eight common allergens by this test [birch pollen, grass pollen, mugwort pollen, cat epithelium, house dust mite, alternaria, egg, and milk]. Histamine was used as a positive control, and saline was used as a negative control. We set the values of children with a positive saline control or no reactions at all (including positive controls) to missing. Specific IgE antibodies against birch pollen, grass pollen, mugwort pollen, cat epithelium, house dust mite, egg, and milk were determined by enzyme immunoassay using the CAP-RAST system (Pharmacia, Uppsala, Sweden). Identical charges of allergens were used throughout the study. Serum was available from 246 of the 306 children. A sensitization was defined as positive if the concentration of specific IgE antibodies was >0.34 kilounits per liter. A child was said to be sensitized against pollen if RAST or SPT yielded positive results for aeroallergens from birch pollen, grass pollen, or mugwort pollen. Sensitizations against the indoor allergens, cat epithelium and house dust mite, and against food allergens from egg or milk were also analyzed in the same way.

Symptom Diary📌

The children's parents were asked to observe 13 symptoms and manifestations of

airway diseases and allergies from March 18, 1996, to March 10, 1997, and to record weekly entries in symptom diaries. Every second or third month (five times per year), parents returned one section of the diary. 67% completed more than 80% of weekly entries (57% in Friedrichstadt, 67% in Düsseldorf, and 76% in Hellerhof) and were included in the analysis. We defined the following as symptoms of atopic diseases: attacks of sneezing or running, stuffy, itchy nose, together with itchy/watery eyes (allergic rhinitis), wheezing (bronchial asthma), and itchy skin rash (eczema).

We defined binary variables as positive if the symptom was present for a minimum of 1 week.

Potential Confounders

Information about potential confounders was collected via questionnaire. We queried as to the following: birth (calculating the age in years); number of older and younger siblings; level of education for each parent (the higher level was chosen to characterize that of the family); nationality of the parents (the family was defined as German if one parent was German); age of the house; and current exposure to smoking at home, dampness in the home, heating with fossil fuels, gas usage without ventilation, wall-to-wall carpeting, and animals in the home.

Statistical Analysis

We conducted logistic regression analyses. Changes of 10 $\mu\text{g}/\text{m}^3$ in the NO_2 values were taken as exposure units. The core model included gender, education of the parents, and presence of older siblings as fixed covariates. We added each of the remaining potential confounding variables separately to the core model and included it into a final model if the odds ratios (ORs) for the NO_2 associations changed by at least 10%.

Results

Air Pollution Exposure

The outdoor NO₂ mean was highest in Friedrichstadt, one of the urban areas ([Table 1](#)). Düsseldorf had a lower mean value, with an overlapping range with Friedrichstadt. The values in Hellerhof were low, with no overlapping with the urban areas.

The mean values of personal NO₂ were below 50% of outdoor NO₂ values, and the correlation between both was only marginal. [Pearson correlation for all areas, 0.37 (N = 281); for urban areas, 0.06 (N = 182)]. There was a better correlation between outdoor NO₂ and the index characterizing the amount of traffic in front of the child's home [Pearson correlation, 0.70 (N = 294)]. The measured and calculated personal mean values were similar. The Pearson correlation between both of these values was 0.71 (N = 177). Therefore, in the following analysis, we used the calculated NO₂ value that was available for 284 children to characterize personal exposure.

Participation

The short questionnaire was answered by 167 of the 527 nonrespondents. We found no important differences between this group and the respondents for all potentially confounding variables. The percentages of positive answers for “ever-diagnosed bronchial asthma” (7.3% as compared with 6.9%) and “ever-diagnosed hay fever” (9.6% as compared with 10.2%) were very similar. Only for “ever-diagnosed eczema,” positive answers were given by 25.8% of the respondents and 13.9% of the nonrespondents. This difference was especially pronounced in the suburban area, Hellerhof (28.4% of the respondents vs 10.5% of the nonrespondents). Ever-diagnosed eczema was not included in the analysis. We also compared self-reported allergy prevalence between respondents and nonrespondents in three equidistant NO₂

outdoor exposure strata (50–<56, 56–<62, and 62–<68) of the urban area. In the group of respondents, the proportions indicating ever having hay fever were 5.3% (N = 38), 8.3% (N = 120), and 18.6% (N = 43) in the three strata, compared with 5.3% (N = 19), 9.2% (N = 87), and 14.3% (N = 14) among the nonrespondents; for bronchial asthma the respective numbers were 2.6% (N = 39), 6.7% (N = 120), and 4.7% (N = 43) in the respondent group and 5.0% (N = 20), 7.9% (N = 87), and 7.1% (N = 14) in the nonrespondent group.

Description of Allergy-Related Variables and Potential Confounders

[Table 2](#) provides an overview of the percentage of atopic children expressed as either being sensitized, diseased, or symptomatic for a minimum of 1 week. Percentages or mean values for potentially confounding variables in the three areas are summarized in [Table 3](#).

TABLE 2. Proportion of Children with Atopic Symptoms

Characteristic	Percentage
Ever diagnosed by a physician (N = 306)	
Hay fever	11.4
Bronchial asthma	8.2
Eczema at the day of examination (N = 303)	11.6
At least 1 week with symptoms (N = 205)	
Rhinitis and itchy and reddened eyes	13.7
Wheezing	10.2
Itchy skin	26.3
Sensitization (SPT or RAST) against (N = 232)	
Pollen (birch, grass, mugwort)	30.6
House dust mites or cats	26.3
Milk or eggs	18.1

SPT = skin-prick test; RAST = radioallergosorbent test.

Table 2. Proportion of Children with Atopic Symptoms SPT = skin-prick test; RAST = radioallergosorbent test.

[\[Help with image viewing\]](#)

[\[Email Jumpstart To Image\]](#)

TABLE 3. Characteristics and Living Conditions among Children According to Urban and Suburban Residence

Characteristic	Friedrichshagen (Urban)	Düsseldorfer (Urban)	Hellerhof (Suburban)	Total
Gender (% boys)	46.0	46.1	51.9	46.7
Age (years)	9.2 (0.60)	9.1 (0.61)	9.2 (0.52)	9.1 (0.58)
Parental education*	12.0	12.3	11.3	11.5
German nationality	96.0	91.2	97.0	91.4
Smoking in the home	46.0	47.1	16.0	30.7
Living in damp home	13.3	7.0	6.0	8.7
Unvented gas use	5.0	8.8	0.0	4.6
Heating with fossil fuels†	46.0	12.4	6.6	28.4
Residential house built before 1960	88.9	83.8	0.0	58.6
Wall-to-wall carpeting	65.0	91.2	88.0	81.4
Older brothers or sisters (% only)	43.4	47.1	57.4	49.3
Contact with dogs	31.0	25.5	57.4	34.6
Contact with cats	32.0	36.5	25.3	27.9

Data are given as percentage (Urban, Düsseldorf or mean, Hellerhof). Numbers in parentheses are standard deviations.
* Percentage with >10 years of schooling.
† Predominantly gas heat.

[\[Help with image viewing\]](#)
[\[Email Jumpstart To Image\]](#)

Table 3. Characteristics and Living Conditions among Children According to Urban and Suburban ResidenceData are given as percentage (where indicated) or mean. Numbers in parentheses are standard deviations.* Percentage with >10 years of schooling.† Predominantly gas heat.

Exposure and Potential Confounders

The personal NO₂ values were higher if the children lived in homes with a smoker. Personal NO₂ values were also higher if fossil fuels (mostly gas) were used for heating. Higher outdoor NO₂ values were found to be associated with a lower parental educational level, with non-German nationality, living in older houses, and having children older than the participant. With one exception, these associations vanished when the suburban area was excluded and the analysis was restricted to urban areas alone. The association with education remained even for the urban areas alone; parents with a better education lived in less polluted parts.

Exposure and Allergy-Related Variables

The results for the core model are given in [Table 4](#).

TABLE 4. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)

	Urban				Urban and Suburban			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Hay fever ever	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Current wheezing or shortness of breath	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Current wheezing or shortness of breath and rhinitis	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Hay fever	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Hay fever and rhinitis	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Hay fever and rhinitis and asthma	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Hay fever and rhinitis and asthma and eczema	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17
Hay fever and rhinitis and asthma and eczema and allergic rhinitis	1.2	1.05-1.34	1.1	0.95-1.27	1.0	0.85-1.17	1.0	0.85-1.17

* Adjusted for age, sex, parental education, and German nationality.
† Data not available for Hellerhof.

[\[Help with image viewing\]](#)
[\[Email Jumpstart To Image\]](#)

Table 4. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)* Adjusted for older siblings, gender, and education of parents.† Additionally adjusted for physician who investigated the skin.

For urban and suburban areas, allergy symptoms were associated with outdoor NO₂ values but not with confirmed diagnoses or sensitization. When counting symptoms occurring during the pollen season (April 15 through August 15) only, the OR for allergic rhinitis changed from 1.81 to 3.09 [95% confidence interval (CI) = 1.38–6.92]. By including the age of the residential house as a covariate, the OR for the association between outdoor NO₂ values and nearly all outcome variables in the combined (urban and suburban) analysis increased by more than 10% for the following: hay fever (OR = 1.28; 95% CI = 0.63–2.59), asthma (OR = 0.88; 95% CI = 0.34–2.28), eczema (OR = 0.35; 95% CI = 0.12–1.02), symptoms of allergic rhinitis (OR = 2.36; 95% CI = 1.06–5.22), wheezing (OR = 2.68; 95% CI = 1.16–6.19), symptoms of eczema (OR = 1.39; 95% CI = 0.68–2.81), sensitization against pollen (OR = 1.98; 95% CI = 1.07–3.66), sensitization against indoor allergens (OR = 1.62; 95% CI = 0.86–3.03), and sensitization against food (OR = 2.71; 95% CI = 1.38–5.32). From this analysis, we cannot evaluate whether age of the residential house is a real confounder or is merely an indicator characterizing urban and suburban areas. The results of the core model and the results from restricting the analysis to the more homogeneous urban areas alone are presented in [Table 4](#).

When we added nationality as a covariate in the model describing the association between outdoor NO₂ values and hay fever and eczema in urban areas, the OR changed by more than 10%. For hay fever, the mode of heating also changed the effect estimates. According to the chosen change-in-estimate criterion, all the above-mentioned variables were included within a final model. The OR for hay fever changed to 4.08 (95% CI = 0.94–17.72), and the OR for eczema changed to 0.62 (95% CI = 0.14–2.66).

For the urban areas alone, the diagnosis of hay fever, its symptoms and wheezing, as

well as allergic sensitizations, were related to the NO₂ outdoor levels. The relation between outdoor NO₂ levels, symptoms of allergic rhinitis, and sensitizations against pollen, are depicted in Figure 1. In the urban areas there was a monotonous increase in the adjusted percentages for groups of children with increasing exposure.

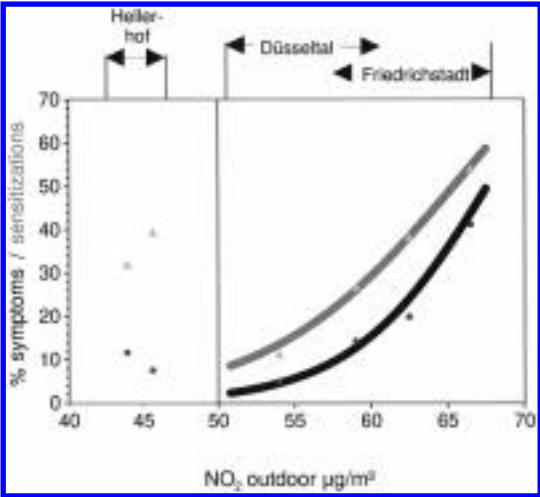


FIGURE 1 Association between exposure to traffic-related outdoor NO₂ levels and atopic sensitization against pollen allergens (gray line; triangles) as well as symptoms of allergic rhinitis (black line; dots) in 306 children 9 years of age. Adjusted percentages in equidistant exposure groups and regression line for the urban areas.

[\[Help with image viewing\]](#)
[\[Email Jumpstart To Image\]](#)

Table 5 demonstrates that the observed effect is most pronounced for girls, whereas for boys, high estimates only occur with rhinitis, wheezing, and sensitization to milk or eggs.

	NO ₂ Outdoor				NO ₂ Personal			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
All symptoms	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Rhinitis	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Sensitization	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Wheezing	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Atopy	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Food allergy	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Drug allergy	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Other	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69
Overall	1.45	1.05-2.00	1.22	0.88-1.69	1.45	1.05-2.00	1.22	0.88-1.69

Table 5. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂ in the Urban Areas Stratified by Gender; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)* Adjusted for older siblings, gender, and education of parents.† Additionally adjusted for physician who investigated the skin.

[\[Help with image viewing\]](#)
[\[Email Jumpstart To Image\]](#)

Higher estimates for the association between NO₂ personal exposure and allergy-

related symptoms occur for eczema, rhinitis, and itchy and reddened eyes and itchy skin for girls but not for boys.

In the suburban area alone there is nearly no variation in outdoor NO₂ values ([Table 1](#)), and the number of symptomatic children is fairly small (14 for hay fever, 11 for bronchial asthma, for instance). Therefore, the effect estimates for the association between allergy-related symptoms and outdoor NO₂ in the suburban area are imprecise and are not given here.

Discussion

We questioned whether selection bias could explain the results. A survey of the nonrespondents revealed only minor differences in the frequency of potentially confounding variables and diagnosis of hay fever, as well as bronchial asthma between the participating and nonparticipating groups. We could not detect systematic differences in the association between outdoor NO₂ and the prevalence of allergic diseases in the urban areas, either. In addition, NO₂ outdoor concentrations were very similar for the respondents and the nonrespondents in the three areas. Therefore, response bias is unlikely to be a factor.

With respect to physician-diagnosed eczema, children in the participating group were less healthy than those who did not participate, which could be explained by parents' advance knowledge of the scheduled skin examination. Because this effect was most prominent in the suburban area, we also performed the analysis for the urban areas alone. In urban areas, this difference in participation was not related to NO₂ outdoor exposure.

Another source of bias could be that not all children who participated in the medical

examination gave blood for determination of allergen-specific IgE levels. We do not consider this bias to be of importance, because we found no association between outdoor NO₂ values, personal NO₂ values, and the absence of blood specimens. For example, the OR for the association of missing blood specimens with outdoor NO₂ in the urban areas was 0.93 (95% CI = 0.36–2.39).

A third source of bias could be that only 67% of children had completed more than 80% of weekly entries in the symptom diary. There is a possible association between missing values in the diary and NO₂ outdoor values in the urban areas (OR = 1.82; 95% CI = 0.82–4.00). This association was found because highly educated parents lived in the less polluted areas and made diary entries more precisely. To test whether this differential participation might bias the effect seen for symptoms, we calculated the adjusted OR between the diagnosis of hay fever and outdoor NO₂ in the urban areas for those without a symptom diary (OR = 6.97; 95% CI = 0.23–208.4) and for those with a complete diary (OR = 3.19; 95% CI = 0.72–14.11). Therefore, a bias resulting in incorrect high values does not seem plausible.

Observer bias seems unlikely to be a factor, as well. Doctor diagnosis and SPT sensitizations were assessed blindly with respect to exposure status. The association between outdoor NO₂ exposure in the urban area and sensitization against pollen allergens was 4.96 [4.13 (1.38–12.40) for SPT and 5.49 (1.51–20.00) for RAST]. Bias that might be associated with the children's street address is very unlikely for the RAST, because the samples were analyzed in a randomized sequence.

The prevalence of allergy-related variables found in our study was similar to those found in Munich in children of similar age. [16,32](#) The prevalence in Munich was (our values in parentheses) 8.1% (8.2%) for lifetime asthma, 10.5% (11.4%) for lifetime

hay fever, 12.7% (13.4) for SPT birch pollen, 21.3% (23.6%) for SPT grass pollen, and 10.3% (15.3%) for SPT house dust mite.

The outdoor NO₂ concentrations found in our study were rather high. Raaschou-Nielson *et al*, [33](#) for example, found a front door median value of 34 µg/m³ for children in Copenhagen. The reason for this difference may be that the study was designed for traffic-related exposures and the children who were invited to participate lived near major roads. Therefore, the mean values of approximately 60 µg/m³ in the urban areas do not represent the average NO₂ concentration in urban Düsseldorf. The Copenhagen study found a personal median of 15 µg/m³. [33](#) The indoor/outdoor ratio is less than 0.5 in this study, as well as in our study. We found that outdoor NO₂ values were poor predictors for the personal exposure of the children. [34](#)

In our study, we did not find a strong association between personal NO₂ exposure and atopy. This finding is consistent with the observation that personal NO₂ exposure concentrations were lower than those where effects have been seen. [25–29,35](#) Possibly, a mean NO₂ exposure of 20–30 µg/m³ is not causally related to atopy. The association seen between atopy and outdoor NO₂, which was a good proxy for traffic-related exposure, could be explained in part by high peak outdoor exposures with NO₂ (half-hour values of up to 257 µg/m³), [35](#) which occur mostly during the morning rush hour when children are on their way to school, or by exposure with traffic-related substances other than NO₂. At the same high peak NO₂ exposure observed in urban areas, a fairly high level of soot (8 µg/m³) was also found. [35](#) Studies in the Netherlands [1,2](#) and in Germany [14,15](#) reported the highest association of health indicators with measurements of truck density, which is related to soot concentrations.

The predominance of the effects in girls is quite fascinating. Girls show strong

associations of most outcome measures with outdoor NO₂ and some positive associations with personal NO₂. Others have found similar results. [1,2,9,10](#) The reason is still unclear. One can speculate that elicitation of symptoms in girls is less strictly genetically fixed than in boys, and therefore girls are more likely to be affected by the environment.

Association between traffic-related air pollution and allergological parameters was more pronounced when the analysis was restricted to urban areas. As is shown in [Figure 1](#), there is a monotonous dose-response relation in urban areas, whereas sensitization is high in the suburban area given this relation. Symptoms of hay fever show a more monotonous relation over all areas (OR = 3.09). Different factors might influence prevalence of sensitization and symptoms (for example, age of the residential house).

In this study, we demonstrated that there is an association between atopy in 9-year-old children and traffic-related air pollution that is not reflected by the association between atopy and mean personal NO₂ exposure of the children.

Acknowledgments

We thank Sandra Schläfke (Düsseldorf) for organizing the field work and the basic statistical evaluation of the study; Gerhard Andreas Wiesmüller (Düsseldorf) for administering the interviews; Sönke Thomsen and Kerstin Boeck (Munich) for performing the skin examinations and administering the skin-prick test; and Dorothea Sugiri for analyzing the nonresponders. We especially thank all of the participating children and parents for their patience. Additionally, we thank Bert Brunekreef (Wageningen) and Erika von Mutius (Munich) and their respective teams for fruitful discussions. We also thank Karin Konrad (Düsseldorf) for typing the manuscript and Karin Wörman (Witten) for language corrections.

References

1. Brunekreef B, Janssen NAH, de Hartog J, Marssema H, Knape M, van Vliet P. Air pollution from truck traffic and lung function in children living near motorways. *Epidemiology* 1997; 8:298–303. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)
2. van Vliet P, Knape M, de Hartog J, Janssen N, Marssema H, Brunekreef B. Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. *Environ Res* 1997; 74:122–132. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)
3. Edwards J, Walters S, Griffiths RK. Hospital admissions for asthma in preschool children: relationship to major roads in Birmingham, United Kingdom. *Arch Environ Health* 1994; 49:223–227. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)
4. Luttmann H, Grömping U, Kreienbrock L, Treiber-Klötzer C, Wichmann HE. Kohortenstudie zu Atemwegserkrankungen und Lungenfunktion bei Schulkindern in Südwestdeutschland. Teil 4. Innerstädtische Umwelteinflüsse auf Atemwegserkrankungen in Mannheim. *Zbl Hyg Umweltm* 1994; 196:114–138. [\[Context Link\]](#)
5. Krämer U, Behrendt H, Ring J. Risk factors for allergy: the East-West German experience. In: Ring J, Behrendt H, Vieluf D, eds. *New Trends in Allergy IV*. Berlin: Springer, 1997; 21–24. [\[Context Link\]](#)
6. Krämer U, Schäfer T, Behrendt H, Ring J. The influence of cultural and educational factors on the validity of symptom and diagnosis questions for atopic eczema. *Br J Dermatol* 1998; 139:1040–1046. [Catalogo Biblioteca ISS Buy Now Bibliographic Links](#) [\[Context Link\]](#)
7. Behrendt H, Friedrichs KH, Krämer U, Hitzfeld B, Becker WM, Ring J. The role of indoor and outdoor air pollution in allergic diseases. *Prog Allergy Clin Immunol* 1995; 3:83–89. [\[Context Link\]](#)
8. Ishizaki T, Koizumi K, Ikemori R, Ishiyama Y, Kushibiki E. Studies of prevalence of Japanese cedar pollinosis among the residents in a densely cultivated area. *Ann Allergy* 1987; 58:265–270. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)
9. Oosterlee A, Drijver M, Lebrecht E, Brunekreef B. Chronic respiratory symptoms in children and adults living along streets with high traffic density. *Occup Environ Med* 1996; 53:241–247. [Catalogo Biblioteca ISS Buy Now Bibliographic Links](#) [\[Context Link\]](#)
10. Pershagen G, Rylander E, Norberg S, Erikson M, Nordvall SL. Air pollution involving nitrogen dioxide exposure and wheezing bronchitis in children. *Int J Epidemiol* 1995; 24:1147–1153. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)
11. Schupp A, Kaaden R, Islam MS, Kreienbrock L, Porstmann F, Rosenlehner R, Spix C, Stiller T, Wichmann HE. Einfluss verkehrsabhängiger Immissionen auf die Empfindlichkeit der Atemwege bei Kindern in Duisburg. *Allergologie* 1994; 12:591–597. [\[Context Link\]](#)
12. Studnicka M, Hacke E, Pischinger J, Fangmeyer C, Haschke N, Kuhr J, Urbanek R,

Neumann M, Frischer T. Traffic-related NO₂ and the prevalence of asthma and respiratory symptoms in seven year olds. Eur Respir J 1997; 10:2275–2278. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

13. Waldron G, Pottke B, Dod J. Asthma and the motorways: one district's experience. J Public Health Med 1995; 17:85–89. [\[Context Link\]](#)

14. Weiland SK, Mundt KA, Rückmann A, Keil U. Self-reported wheezing and allergic rhinitis in children and traffic density on street of residence. Ann Epidemiol 1994; 4:243–247. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

15. Duhme H, Weiland SK, Keil U, Kraemer B, Schmid M, Stender M, Chambless L. The association between self-reported symptoms of asthma and allergic rhinitis and self-reported traffic density on street of residents in adolescents. Epidemiology 1996; 7:578–582. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

16. Wjst M, Reitmeir P, Dold S, Wulff A, Nicolai T, Freifrau von Loeffelholz-Colberg E, von Mutius E. Road traffic and adverse effects on respiratory health in children. BMJ 1993; 307:596–600. [Catalogo Biblioteca ISS Full text \(pacchetto Ovid\) Bibliographic Links](#) [\[Context Link\]](#)

17. Nitta H, Sato T, Nakai S, Maeda K, Aoki S, Ono M. Respiratory health associated with exposure to automobile exhaust. I. Results of cross-sectional studies in 1979, 1982, and 1983. Arch Environ Health 1993; 48:53–58. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

18. Nakai S, Nitta H, Maeda K. Respiratory health associated with exposure to automobile exhaust II: personal NO₂ exposure levels according to distance from the roadside. J Expo Anal Environ Epidemiol 1995; 5:125–136. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

19. Nakatsuka H, Watanabe T, Ikeda M, Hisamichi S, Shimizu H, Fujisaku S, Ichirowatari Y, Konno J, Kuroda S, Ida Y, Suda S, Kato K. Comparison of the health effects between indoor and outdoor air pollution in northeastern Japan. Environ Int 1991; 17:51–59. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

20. Ranft U, Mücke HG, Koch T. Measurements of indoor and outdoor air pollutants and health effects in small areas with different vehicular traffic burden. Proceedings, 9th World Clean Air Congress. vol. 5. Health and Ecological Effects, Pittsburgh, PA: Air & Waste Management Assoc, 1992:IU-21B.02. [\[Context Link\]](#)

21. Ranft U, Wiesmüller GA, Dolgner R. The diary as an instrument in air pollution exposure assessment for children. Proceedings, Conference on Environmental Epidemiology in Europe 1995, Bremen, Institute for Prevention Research and Social Medicine, 1996;340–351. [\[Context Link\]](#)

22. Wang JH, Duddle J, Devalia JL, Davies RJ. Nitrogen dioxide increases eosinophil activation in the early-phase response to nasal allergen provocation. Int Arch Allergy Immunol 1995; 107:103–105. [\[Context Link\]](#)

23. Strand V, Rak S, Svartengren M, Bylin G. Nitrogen dioxide exposure enhances asthmatic

reaction to inhaled allergen in subjects with asthma. Am J Respir Crit Care Med 1997; 155:881–887. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

24. Wang JH, Devalia JL, Duddle JM, Hamilton SA, Davies RJ. Effect of six-hour exposure to nitrogen dioxide on early-phase nasal response to allergen challenge in patients with a history of seasonal allergic rhinitis. J Allergy Clin Immunol 1995; 96:669–676. [\[Context Link\]](#)

25. Devalia JL, Rusznak C, Herdman MJ, Trigg CJ, Tarraf H, Davies RJ. Effect of nitrogen dioxide and sulfur dioxide on airway response of mild asthmatic patients to allergen inhalation. Lancet 1994; 344:1668–1671. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

26. Tunnicliffe WS, Burge PS, Ayres JG. Effect of domestic concentrations of nitrogen dioxide on air way responses to inhaled allergen in asthmatic patients. Lancet 1994; 344:1733–1736. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

27. Blomberg A, Krishna M, Bocchino V, Biscione GL, Shute J, Kelly FJ, Frew AJ, Holgate ST, Sandström T. The inflammatory effects of 2 ppm NO₂ on the airways of healthy subjects. Am J Respir Crit Care Med 1997; 156:418–424. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

28. Diaz-Sanchez D, Tsien A, Casillas A, Dotson AR, Saxon A. Enhanced nasal cytokine production in human beings after *in vivo* challenge with diesel exhaust particles. J Allergy Clin Immunol 1996; 98:114–123. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

29. Diaz-Sanchez D. The role of diesel exhaust particles and their associated polyaromatic hydrocarbons in the induction of allergic airway disease. Allergy 1997; 52(suppl 38):52–56. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

30. Takafuji S, Suzuki S, Koizumi K, Tadokoro K, Miyamoto T, Ikemori R, Muranaka M. Diesel-exhaust particulates inoculated by the nasal route have an adjuvant activity for IgE production in mice. J Allergy Clin Immunol 1987; 79:639–645. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

31. Behrendt H, Becker WM, Fritzsche C, Sliwa-Tomszok W, Tomszok J, Friedrichs KH, Ring J. Air pollution and allergy: experimental studies on modulation of allergen release from pollen by air pollutants. Int Arch Allergy Immunol 1997; 113:69–74. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

32. von Mutius E, Martinez FD, Fritzsche C, Nicolai T, Roell G, Thiemann HH. Prevalence of asthma and atopy in two areas of West and East Germany. Am J Respir Crit Care Med 1994; 149:358–364. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

33. Raaschou-Nielsen O, Skov H, Lohse C, Thomsen BL, Olsen JH. Front door concentrations and personal exposures of Danish children to nitrogen dioxide. Environ Health Perspect 1997; 105:964–970. [Catalogo Biblioteca ISS Bibliographic Links](#) [\[Context Link\]](#)

34. World Health Organization. Nitrogen Oxides. 2nd ed. Environmental Health Criteria, No. 188. Geneva: World Health Organization, 1997. [\[Context Link\]](#)

35. Luftbelastung in Düsseldorf, Messbericht 1996. Düsseldorf: Umweltamt der Stadt Düsseldorf, 1997. [\[Context Link\]](#)

Keywords: air pollution; traffic; atopy; child; nitrogen dioxide; living conditions; urban environment; gender

Accession Number: 00001648-200001000-00014

Copyright (c) 2000-2005 [Ovid Technologies, Inc.](#)

Version: rel10.1.0, SourceID 1.11080.2.37

Full Text

Previous Page

Main Search Page

Help

LOGOFF

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

Table 1

TABLE 1. Description of Study Sites and Exposure to Traffic-Related Air Pollution

	Friedrichstadt (Urban)	Düsseltal (Urban)	Hellerhof (Suburban)
N	100	104	102
Traffic in front of residential building			
Automobiles per 24 hours (minimum to maximum)	<2,000–50,914	<2,000–40,351	<2,000–<2,000
Trucks per 24 hours (minimum–maximum)	<70–2,183	<70–2,007	<70–<70
NO ₂ (μg/m ³)			
Outdoors in front of residential building*			
Mean	61.7	56.6	44.4
Minimum–Maximum	57.5–67.5	50.8–60.5	43.0–46.5
Personal†			
Mean	26.7	24.3	22.0
Minimum–maximum	14.0–70.0	11.0–44.0	10.0–36.0
Personal (calculated)			
Mean	28.2	26.3	21.7
Minimum–Maximum	18.2–69.9	15.7–41.6	11.1–40.9

* Values from two-dimensional interpolation.

† Sixty-five children in Friedrichstadt, 49 in Düsselstal, and 70 in Hellerhof had personal monitors.

Table 1. Description of Study Sites and Exposure to Traffic-Related Air Pollution* Values from two-dimensional interpolation.†
Sixty-five children in Friedrichstadt, 49 in Düsseldorf, and 70 in Hellerhof had personal monitors.
From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70

Copyright (c) 2000-2005 [Ovid Technologies, Inc.](#)
Version: rel10.1.0, SourceID 1.11080.2.37

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

Table 2**TABLE 2. Proportion of Children with Atopic Symptoms**

Characteristic	Percentage
Ever diagnosed by a physician (N = 306)	
Hay fever	11.4
Bronchial asthma	8.2
Eczema at the day of examination (N = 303)	11.6
At least 1 week with symptoms (N = 205)	
Rhinitis and itchy and reddened eyes	13.7
Wheezing	10.2
Itchy skin	26.3
Sensitization (SPT or RAST) against (N = 232)	
Pollen (birch, grass, mugwort)	30.6
House dust mites or cats	26.3
Milk or eggs	18.1

SPT = skin-prick test; RAST = radioallergosorbent test.

Table 2. Proportion of Children with Atopic Symptoms SPT = skin-prick test; RAST = radioallergosorbent test.

From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70

Full Text

Previous Page

Main Search Page

Help

LOGOFF

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

Table 3

TABLE 3. Characteristics and Living Conditions among Children According to Urban and Suburban Residence

Characteristic	Friedrichstadt (Urban)	Düsseltal (Urban)	Hellerhof (Suburban)	Total
Gender (% boys)	46.0	46.1	53.9	48.7
Age (years)	9.2 (0.60)	9.1 (0.62)	9.2 (0.52)	9.2 (0.58)
Parental education*	32.0	67.3	51.5	50.3
German nationality	86.0	91.2	97.0	91.4
Smoking in the home	66.0	47.1	39.0	50.7
Living in damp home	13.3	7.0	6.0	8.7
Unvented gas use	5.0	8.8	0.0	4.6
Heating with fossil fuels†	46.0	32.4	6.9	28.4
Residential house built before 1960	84.9	83.8	0.0	54.6
Wall-to-wall carpeting	95.0	91.2	88.0	91.4
Older brothers or sisters (% yes)	43.4	47.1	57.4	49.3
Contact with dogs	11.0	25.5	37.4	24.6
Contact with cats	32.0	26.5	25.3	27.9

Data are given as percentage (where indicated) or mean. Numbers in parentheses are standard deviations.

* Percentage with >10 years of schooling.

† Predominantly gas heat.

Table 3. Characteristics and Living Conditions among Children According to Urban and Suburban ResidenceData are given as percentage (where indicated) or mean. Numbers in parentheses are standard deviations.* Percentage with >10 years of schooling.† Predominantly gas heat.

From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70

Copyright (c) 2000-2005 [Ovid Technologies, Inc.](#)

Version: rel10.1.0, SourceID 1.11080.2.37

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

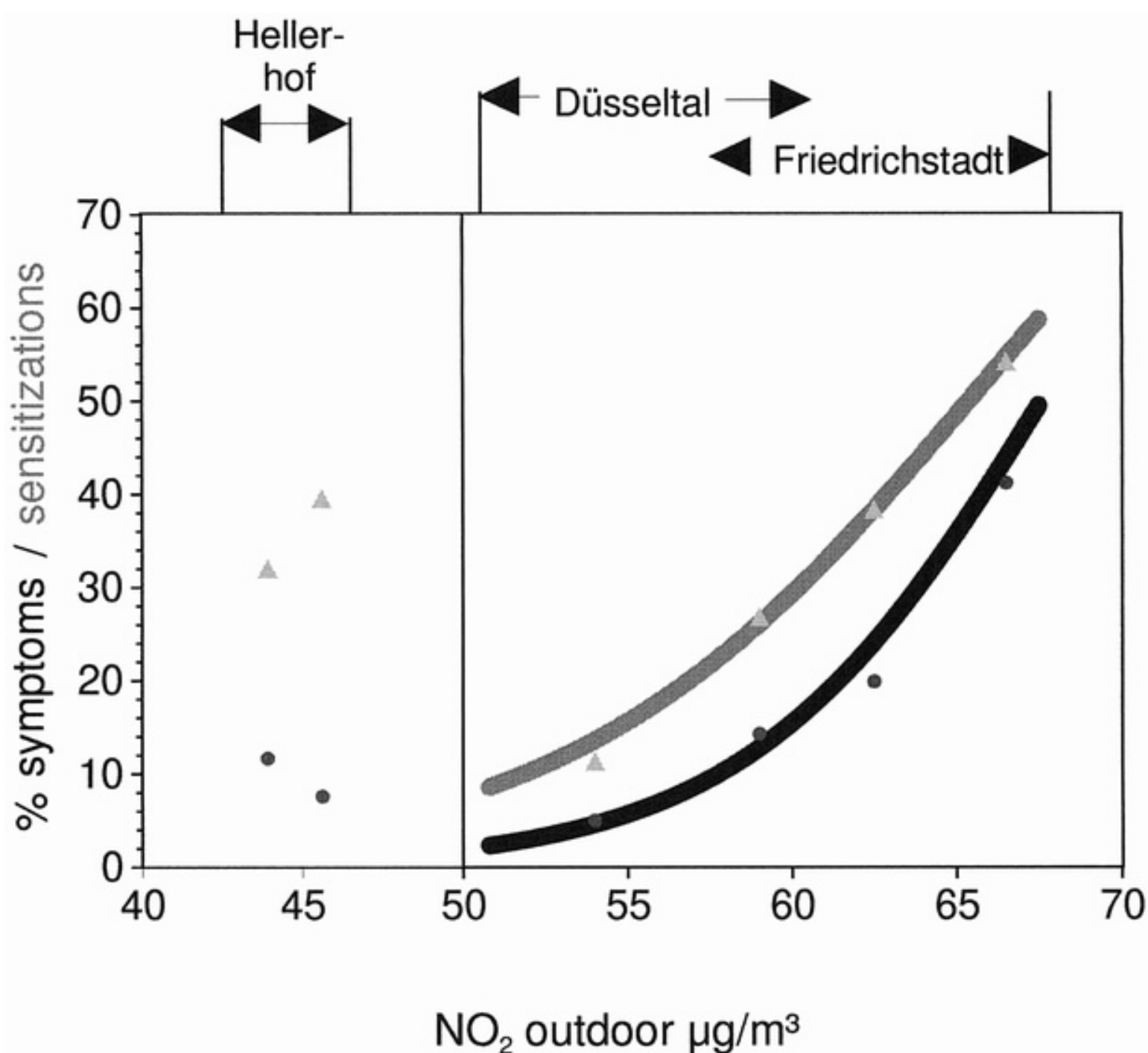
FIGURE 1

FIGURE 1 Association between exposure to traffic-related outdoor NO₂ levels and atopic sensitization against pollen allergens (gray line; triangles) as well as symptoms of allergic rhinitis (black line; dots) in 306 children 9 years of age. Adjusted percentages in equidistant exposure groups and regression line for the urban areas.

From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70

Copyright (c) 2000-2005 [Ovid Technologies, Inc.](#)

Version: rel10.1.0, SourceID 1.11080.2.37

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

Table 5

TABLE 5. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂ in the Urban Areas Stratified by Gender; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)

	NO ₂ Outdoors				NO ₂ Personal			
	Girls (N = 109)		Boys (N = 93)		Girls (N = 109)		Boys (N = 93)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Hay fever ever	46.08	3.42–620.39	0.93	0.14–6.13	0.90	0.22–3.68	1.33	0.63–2.80
Bronchial asthma ever	6.29	0.75–53.08	0.33	0.02–6.11	0.38	0.07–2.27	0.59	0.11–3.09
Eczema at day of investigation†	0.62	0.10–3.96	0.52	0.05–5.74	1.58	0.55–4.57	0.79	0.22–2.93
Rhinitis and itchy and reddened eyes	37.73	3.26–437.28	2.58	0.35–19.06	1.68	0.54–5.25	0.86	0.32–2.31
Wheezing	20.41	1.81–230.62	17.38	0.91–330.72	0.40	0.06–2.51	0.14	0.02–1.20
Itchy skin	6.50	1.32–31.94	0.50	0.08–2.90	2.38	0.89–6.41	0.99	0.45–2.16
Sensitization against								
Pollen	21.28	3.57–126.87	1.05	0.21–5.37	0.78	0.30–2.04	0.99	0.50–1.97
House dust mites or cats	8.24	1.21–56.10	1.89	0.38–9.33	0.84	0.26–2.69	0.81	0.40–1.65
Milk or eggs	4.30	0.64–28.97	4.46	0.68–29.08	1.16	0.34–4.00	1.14	0.55–2.35

* Adjusted for older siblings, gender, and education of parents.

† Additionally adjusted for physician who investigated the skin.

Table 5. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂ in the Urban Areas Stratified by Gender; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)* Adjusted for older siblings, gender, and education of parents.† Additionally adjusted for physician who investigated the skin.

From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70

[\[Get TIFF\]](#)

Tables and charts containing text may be unclear or incomplete when printed. To retrieve the best possible version of an image, use the "Get TIFF" link above. For more information, see Help under "Help with Image Viewing."

Table 4

TABLE 4. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)

	Urban				Urban and Suburban			
	NO ₂ Outdoors		NO ₂ Personal		NO ₂ Outdoors		NO ₂ Personal	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Hay fever ever	4.24	1.01–17.84	1.15	0.61–2.17	0.93	0.57–1.50	0.97	0.56–1.67
Bronchial asthma ever	1.82	0.36–9.36	0.48	0.15–1.50	0.90	0.52–1.57	0.56	0.26–1.24
Eczema on day of investigation†	0.54	0.13–2.29	1.07	0.54–2.12	0.62	0.32–1.19	1.03	0.59–1.81
Rhinitis and itchy and reddened eyes	9.08	2.06–40.11	1.07	0.55–2.09	1.81	1.02–3.21	0.99	0.55–1.79
Wheezing	14.95	2.59–86.35	0.26	0.06–1.06	1.70	0.90–3.19	0.54	0.22–1.31
Itchy skin	1.97	0.65–6.03	1.21	0.71–2.08	1.58	1.02–2.43	1.34	0.86–2.09
Sensitization against								
Pollen	4.96	1.56–15.74	0.91	0.52–1.60	1.05	0.70–1.56	0.84	0.53–1.33
House dust mite or cat	3.51	1.03–11.96	0.85	0.47–1.52	1.19	0.77–1.83	0.72	0.43–1.20
Milk or egg	4.20	1.12–15.72	1.17	0.64–2.13	1.32	0.81–2.17	0.96	0.56–1.63

* Adjusted for older siblings, gender, and education of parents.

† Additionally adjusted for physician who investigated the skin.

Table 4. Association between Allergy-Related Symptoms and Outdoor and Personal (Calculated) Exposure to NO₂; Adjusted* Odds Ratios (OR) with 95% Confidence Intervals (CI)*

Adjusted for older siblings, gender, and education of parents.† Additionally adjusted for physician who investigated the skin.

From: Kramer: Epidemiology, Volume 11(1).January 2000.64-70