Health effects of living near busy roads - and the role of diesel emissions

Bert Brunekreef, PhD

Institute for Risk Assessment Sciences

Environmental and Occupational Health Group

Universiteit Utrecht

What will I talk about??

- The literature….
- Dutch freeway studies
- Dutch mortality cohort study (perhaps…)
- European birth cohort study (unlikely….)

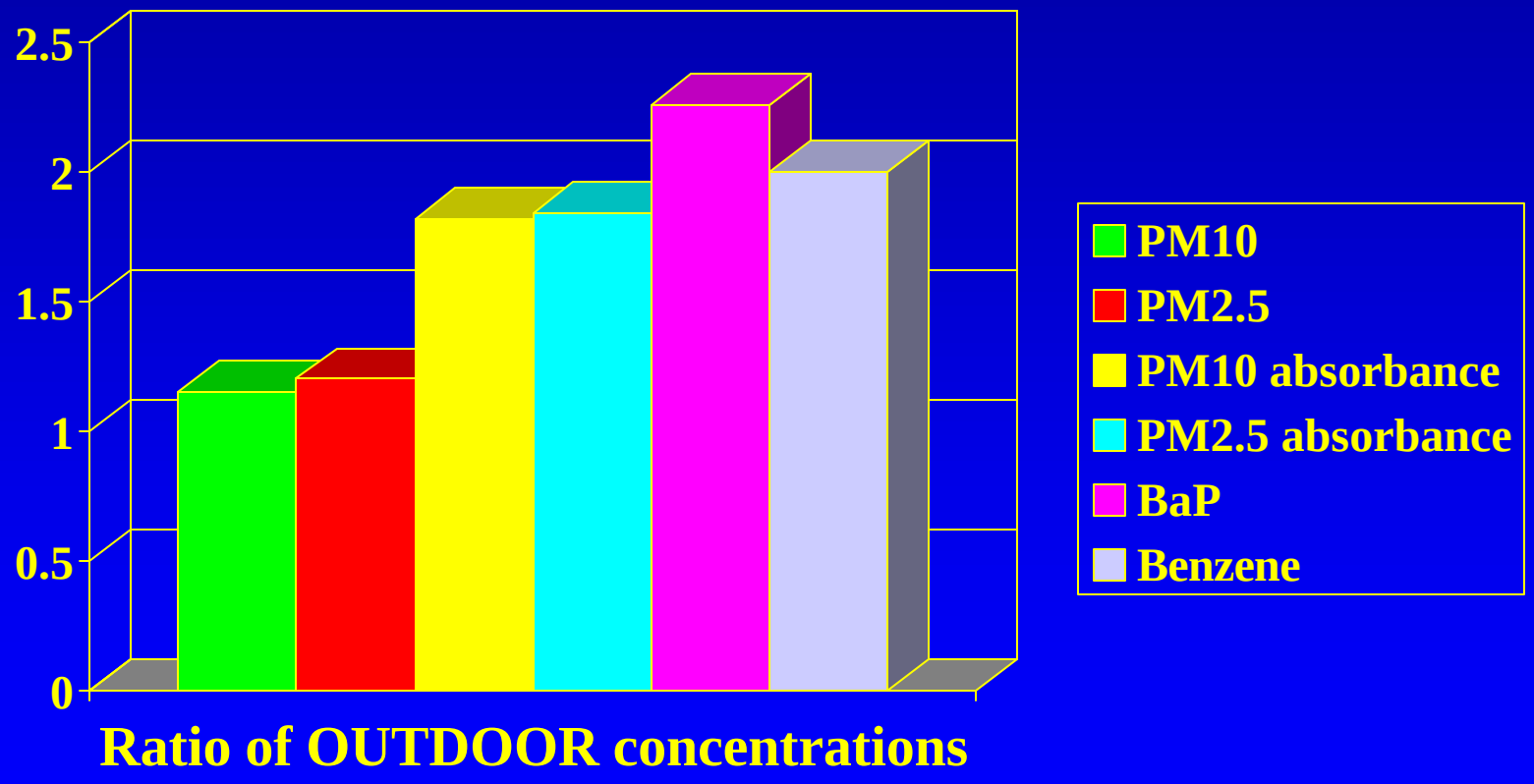
Background...

- Living close to busy roads is associated with increased exposure to traffic-related air pollution
- Several studies suggest that living close to busy roads is associated with impaired health

Traffic-related air pollution:

major vs quiet streets in Amsterdam

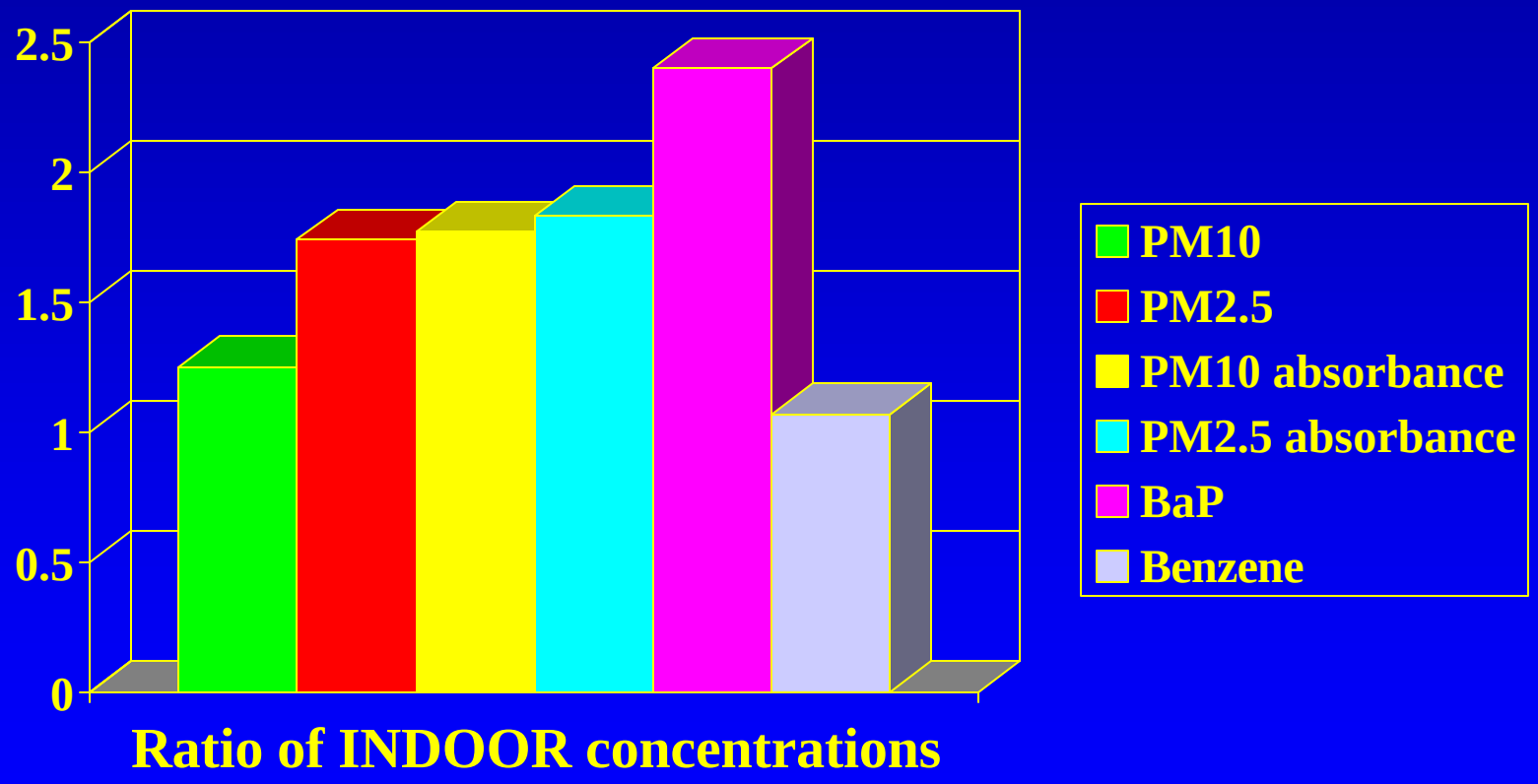
Fischer, Atm Environ 2000;34:3713



Traffic-related air pollution:

major vs quiet streets in Amsterdam

Fischer, Atm Environ 2000;34:3713

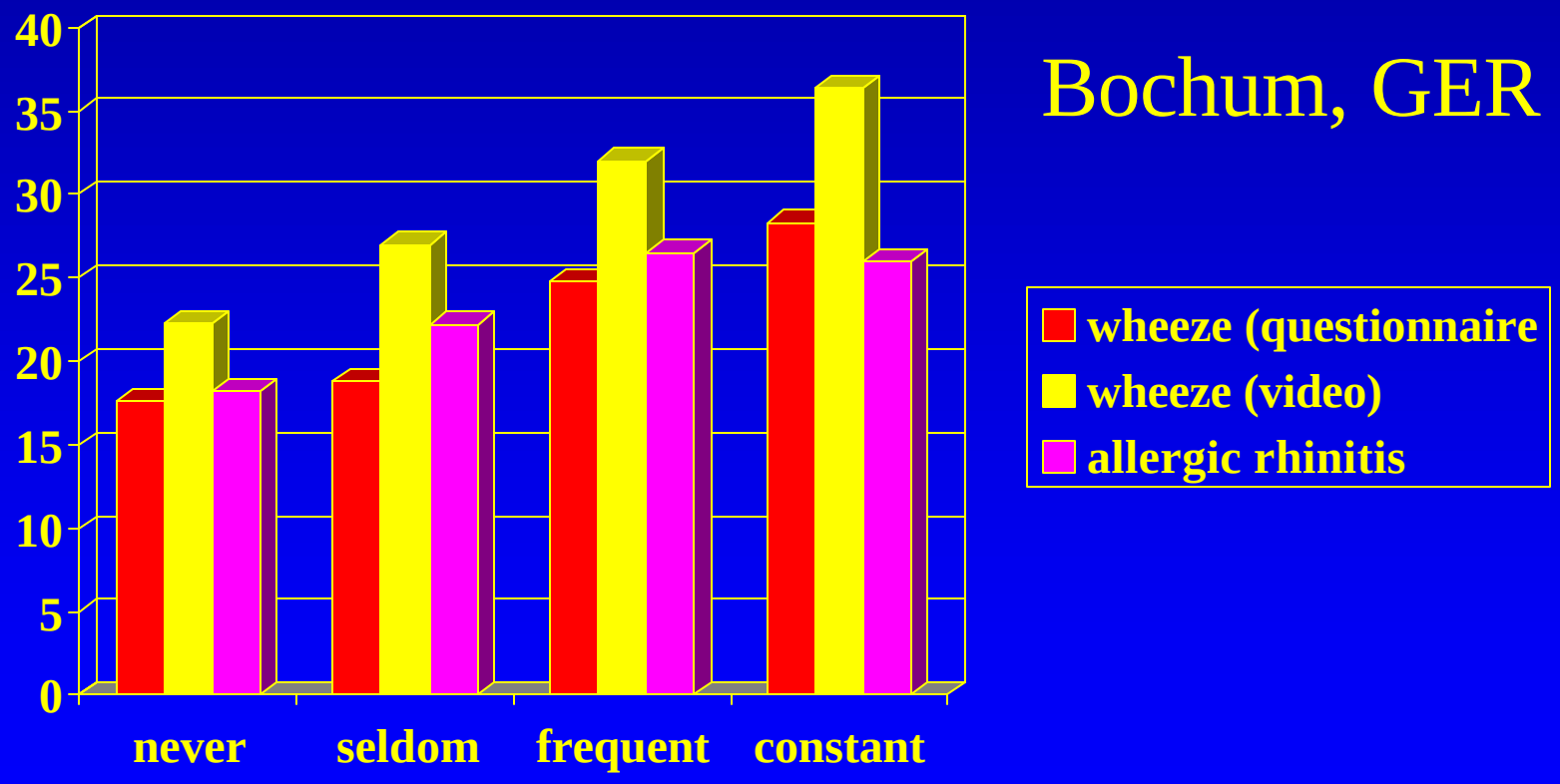


Types of epidemiological studies

- Cross-sectional, questionnaire
- Cross-sectional, questionnaire + objective measures of exposure and/or health
- Case-control
- Cohort
- Intervention (Friedman!)

Cross-sectional, questionnaire:

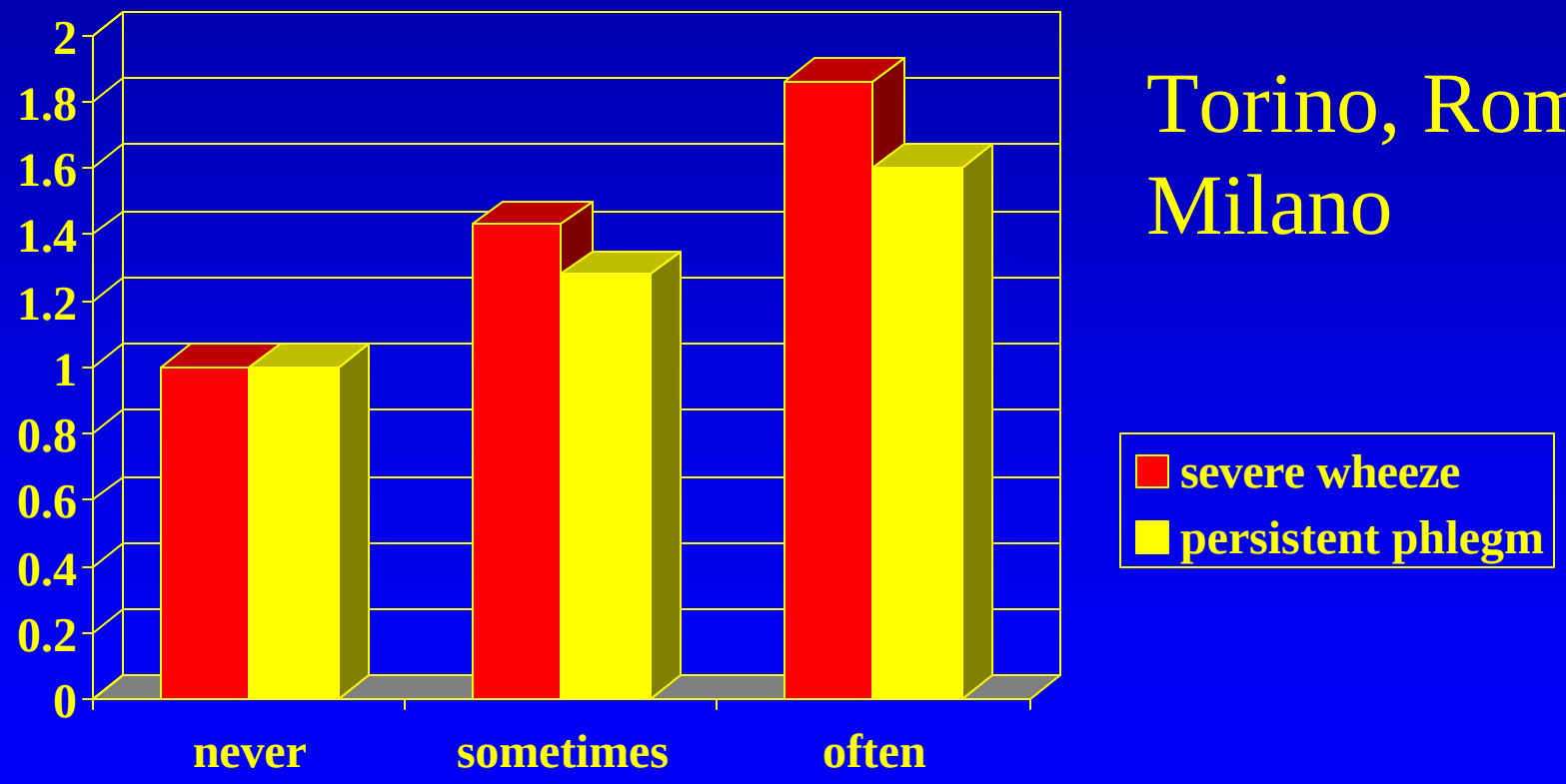
Weiland, Ann Epidemiol 1994;4:243



Frequency of Truck Traffic

Relation of symptoms with lorry transit; exposure validated with measurements and counts

Ciccone, Occup Environ Med 1998;55:771



Torino, Rome, Milano

Frequency of daily lorry transit

Relation of lung function with traffic density in Munich school district

Wjst, BMJ 1993;307:596

% change per 25,000 cars (95% c.i.)

Peak Flow	-.71	(-1.08, -0.31)
MEF25	-0.8	(-1.11, -0.25)

Childhood cancer and traffic density:

Savitz, Scand J Work EH 1989;15:360

Table 2. Dose-response gradient for traffic density and total childhood cancer and leukemias: odds ratios (OR) and 95 % confidence intervals (95 % CI).

Vehicles per day	Referents (N)	Total cases			Leukemias		
		N	OR	95 % CI	N	OR	95 % CI
< 500	238	280	1.0	·	81	1.0	·
500—4999	10	19	1.6	0.7—3.5	4	1.2	0.4—3.9
≥ 5000	14	29	1.8	0.9—3.3	13	2.7	1.3—5.9
500—9999	19	30	1.3	0.7—2.4	9	1.4	0.6—3.2
≥ 10 000	5	18	3.1	1.2—8.0	8	4.7	1.6—13.5

Denver Standard Metropolitan Statistical Area

Childhood cancer and motor vehicle exhaust

Feychting, Scand J Work EH 1998;24:8

Table 3. Relative risk estimates and 95% condifence intervals (95% CI) for childhood cancer for total cancer in relation to exposure to nitrogen dioxide. (RR = risk ratio)

Nitrogen dioxide concentration	Cases	Referents	RR	95% CI
≤ 49 µg/m³	98	399	1	
50—79 µg/m³	36	136	1.9	0.8—4.5
≥ 80 µg/m³	8	15	3.8	1.2—12.1

Children living near power lines in Sweden

Traffic flow and childhood asthma using GIS in San Diego County: *English, EHP 1999;107:761*

Table 6. Crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for two or more medical care visits versus one visit for cases for children 14 years of age and younger.[a]

Traffic flow (cars/day)	*N* 2 or 3 visits	*N* 1 visit	Crude OR (CI)	Adjusted OR[b] (CI)
On nearest street				
1st quintile (ref) (≤ 5,500)	13	896	1.0	1.0
2nd quintile (5,500–9,000)	28	902	2.14 (1.06–4.39)	2.14 (1.10–4.16)
3rd quintile (9,001–13,000)	19	840	1.56 (0.73–3.36)	1.64 (0.81–3.35)
4th quintile (13,001–21,200)	17	875	1.34 (0.61–2.94)	1.37 (0.66–2.84)
5th quintile (> 21,200)	22	872	1.74 (0.83–3.67)	1.85 (0.92–3.71)
90th percentile (> 27,500)	11	434	1.75 (0.72–4.19)	1.86 (0.82–4.18)
95th percentile (> 41,000)	9	215	2.89 (1.07–7.40)	2.91 (1.23–6.91)
99th percentile (> 161,000)	2	43	3.21 (0.34–14.83)[c]	3.58 (0.78–16.44)

Goodness-of-fit statistic for adjusted model = 2.25, $p = 0.94$.

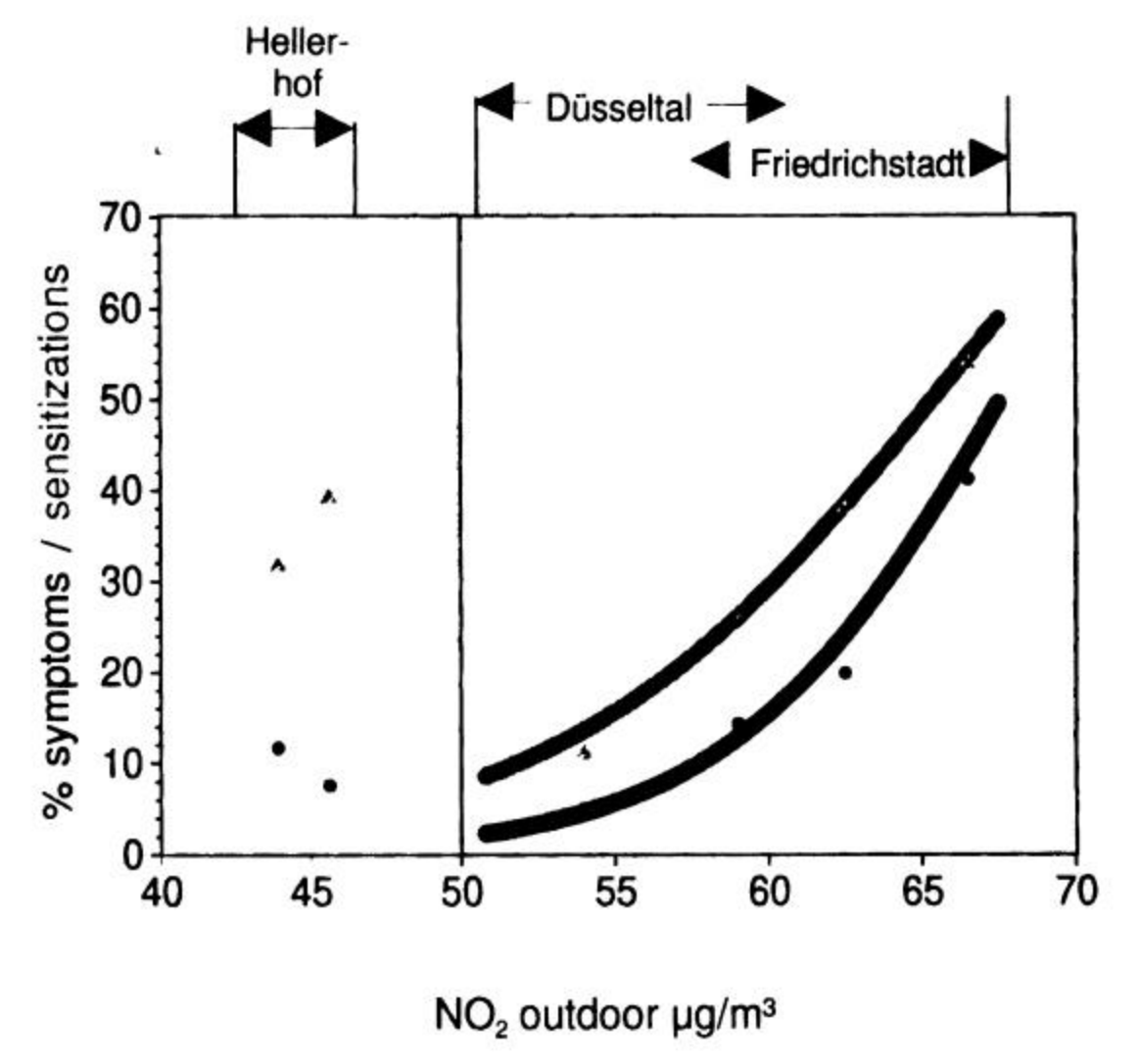
[a]From 1993 California Department of Health Services Medi-Cal paid claims data for San Diego County. [b]Controlling for race (Hispanic, black, other, unknown vs. white). [c]Exact confidence limits.

Allergic rhinitis and cedar pollinosis in Japanese men: ***Sakurai, Prev Med 1998;27:617***

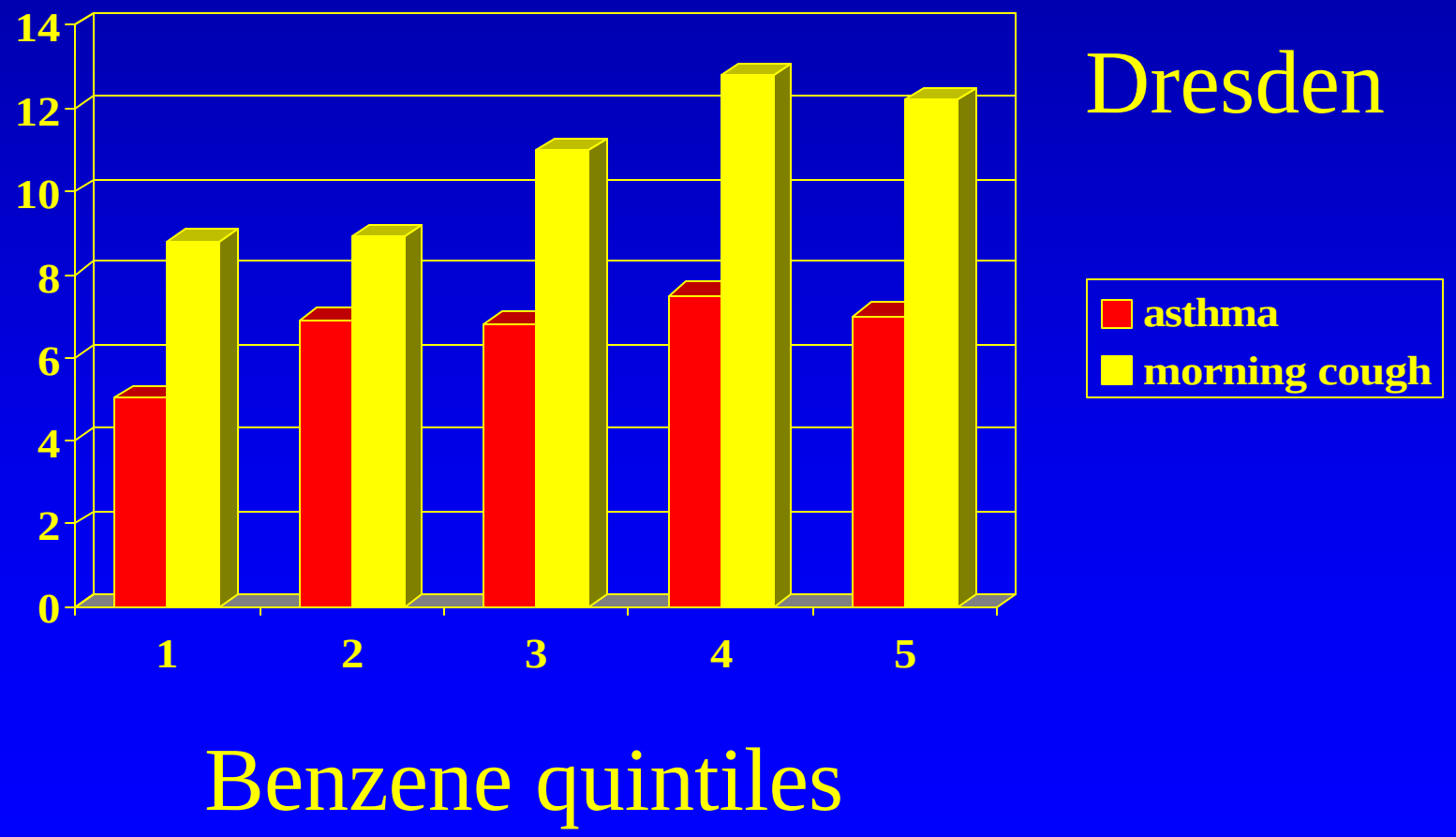
	Odds Ratio for living on main street (95% c.i.)	
Allergic rhinitis	1.38	(1.11, 1.71)
Seasonal rhinitis	1.45	(1.16, 1.80)
Cedar pollinosis	1.53	(1.11, 2.10)

Traffic emissions and atopy in Duesseldorf:

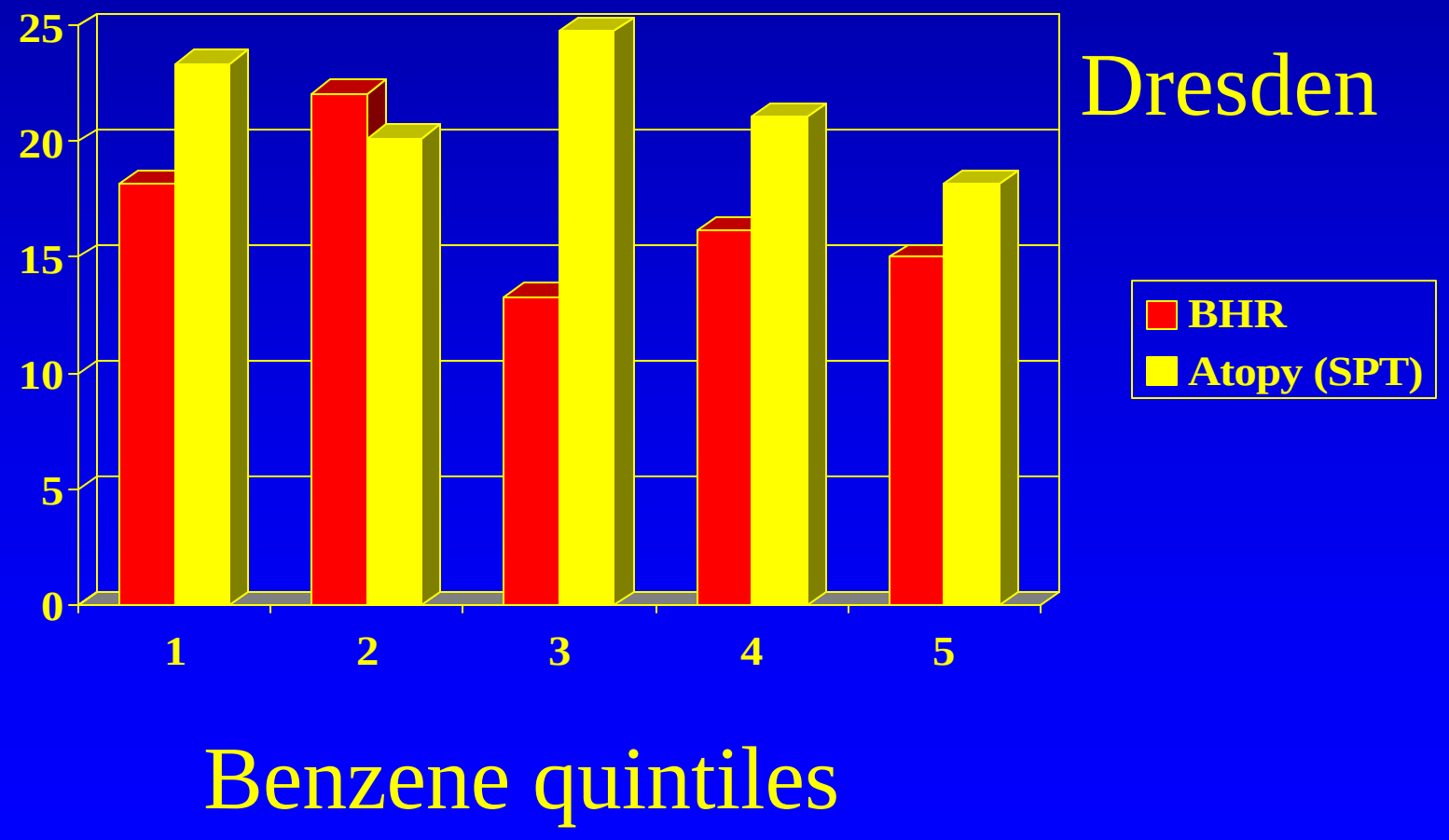
Kraemer, Epidemiology 2000;11:64



Inner city air pollution, respiratory health and atopy. ***Hirsch, ERJ 1999;14:669***



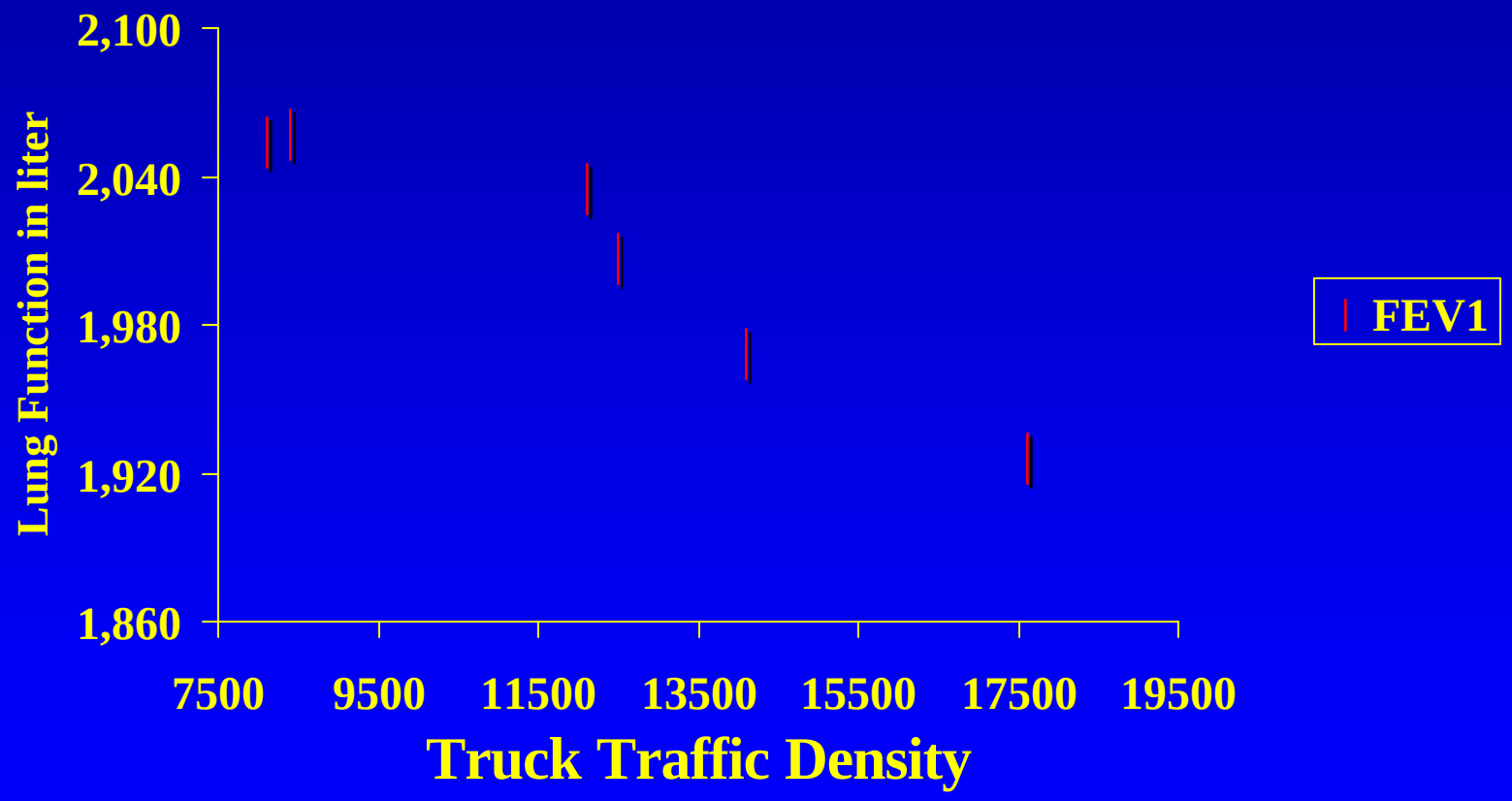
Inner city air pollution, respiratory health and atopy. ***Hirsch, ERJ 1999;14:669***



Dutch freeway studies

- Investigated children living close to freeways
- utilized detailed traffic count data to separate trucks (> 5.1 m) from cars (< 5.1 m)
- 1st study at 6 locations
- 2nd study at 24 locations

Brunekreef, Epidemiology 1997; 8: 298-303



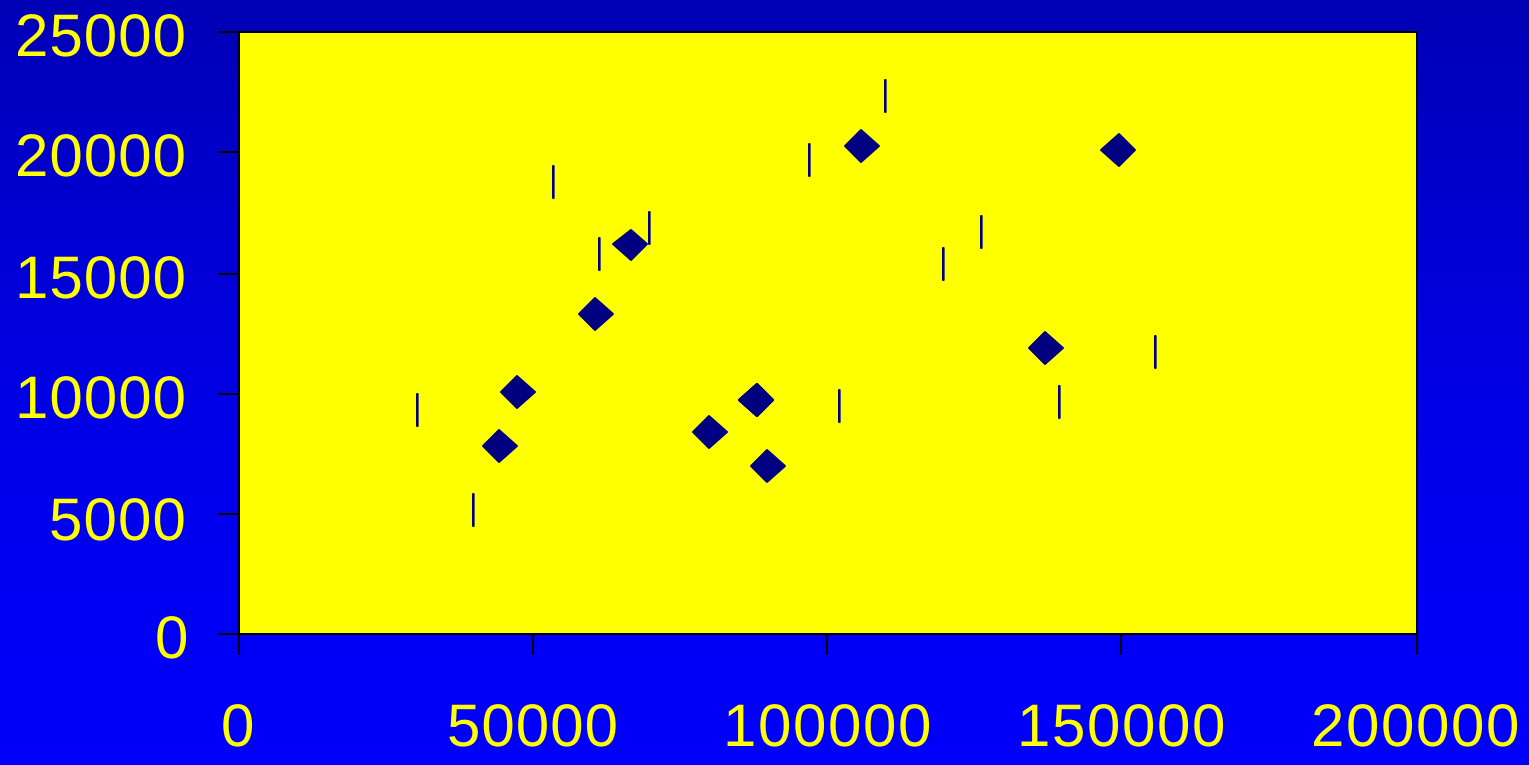
Design of 2nd Dutch Freeway Study

- 24 schools, located near freeways with varying traffic density & composition
- monitoring of PM2.5, BS, NO_2, Benzene indoors and outdoors; EC, PAH and elements (XRF) in selected samples
- measurements conducted May ‘97-June ‘98
- ***Janssen, Atmosf Environ 2001;35:3875***
- ***Rijnders, EHP 2001;109 s3:411***

Distance of school to freeway, and traffic density

- Distance to freeway (m): **209**
  (47 - 377)
- Light (car) traffic/day **89,544**
  (30,399 - 155,656)
- Heavy (truck) traffic/day **13,146**
  (5,190 - 22,326)

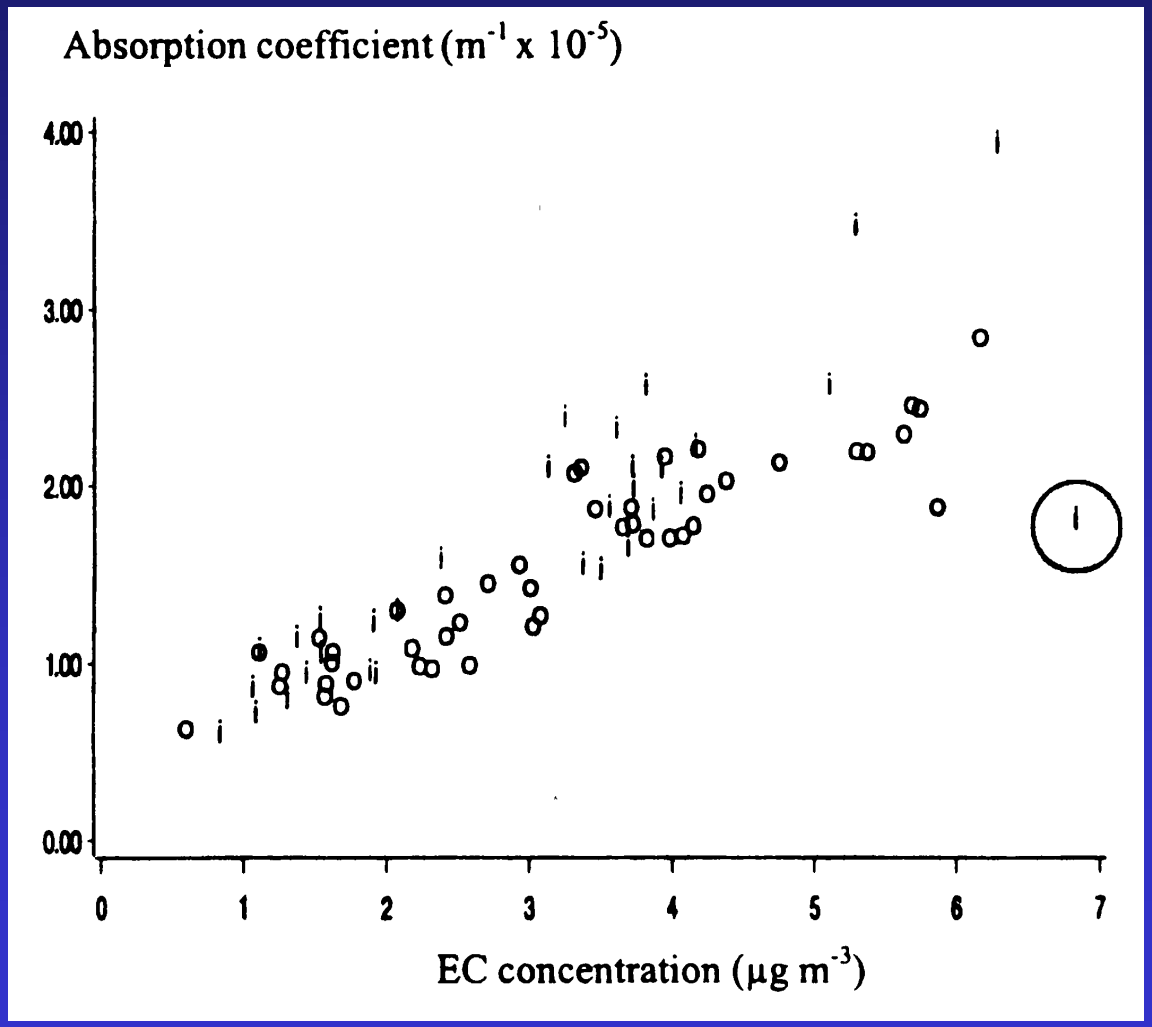
Truck (Y) and car (X) traffic density of freeways near participating schools



Relation between PM2.5 absorbance and EC

O = outdoor
R = 0.92

i = indoor
R = 0.85
R = 0.93 w/o outlier



Association between air pollution outdoors and traffic (β, s.e.)

	Light traffic	Heavy traffic	Log distance
PM2.5	-0.85	***3.37***	***-1.13***
	(0.58)	***(0.90)***	***(0.61)***
Soot	0.02	***1.94***	***-2.50***
	(0.42)	***(0.65)***	***(0.44)***
NO_2	1.12	2.77	-2.78
	(1.60)	(2.49)	(1.68)

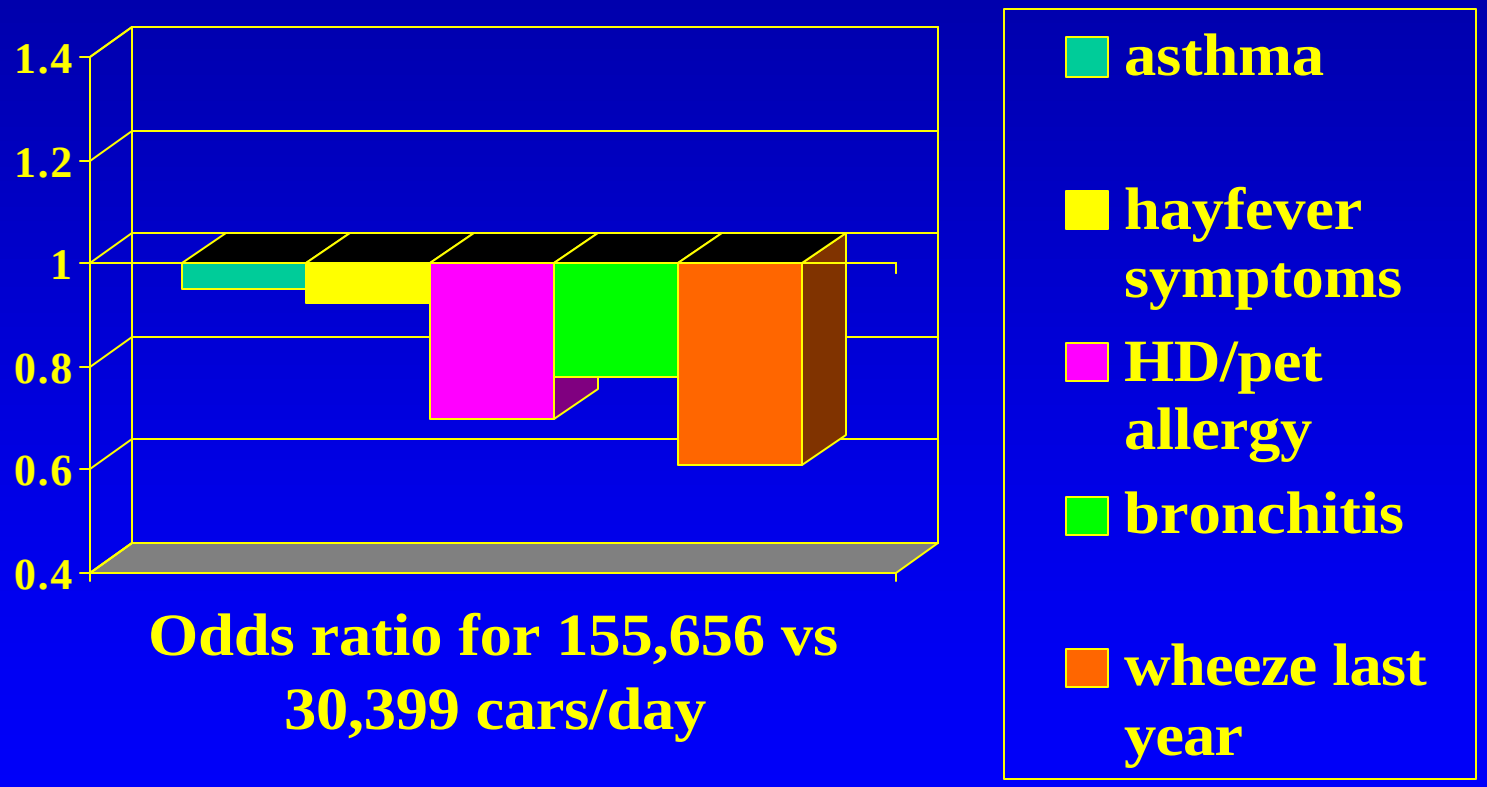
Methods (health)

- Symptoms by ISAAC questionnaire
- Lung function by heated pneumotachometer
- BHR by hypertonic saline challenge
- Sensitisation by SPT (ALK) and total and specific IgE (Pharmacia)

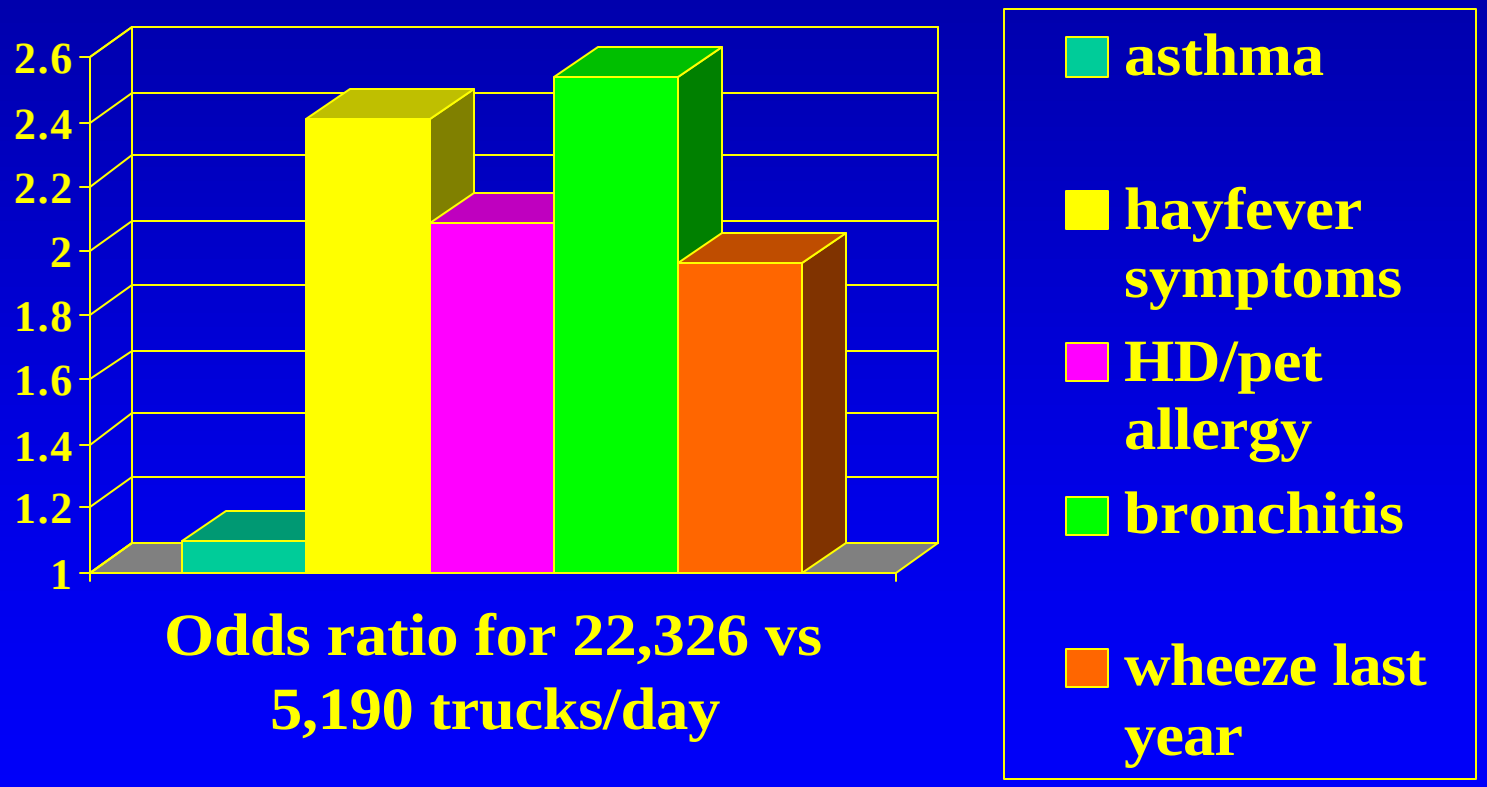
Methods (analysis)

- Density of light and heavy traffic, distance of home and school from freeway, population within 1,000 m from freeway
- Outdoor and indoor PM2.5, Soot, NO_2 and Benzene concentrations
- Associations with symptoms, lung function, BHR, total and specific IgE, SPT

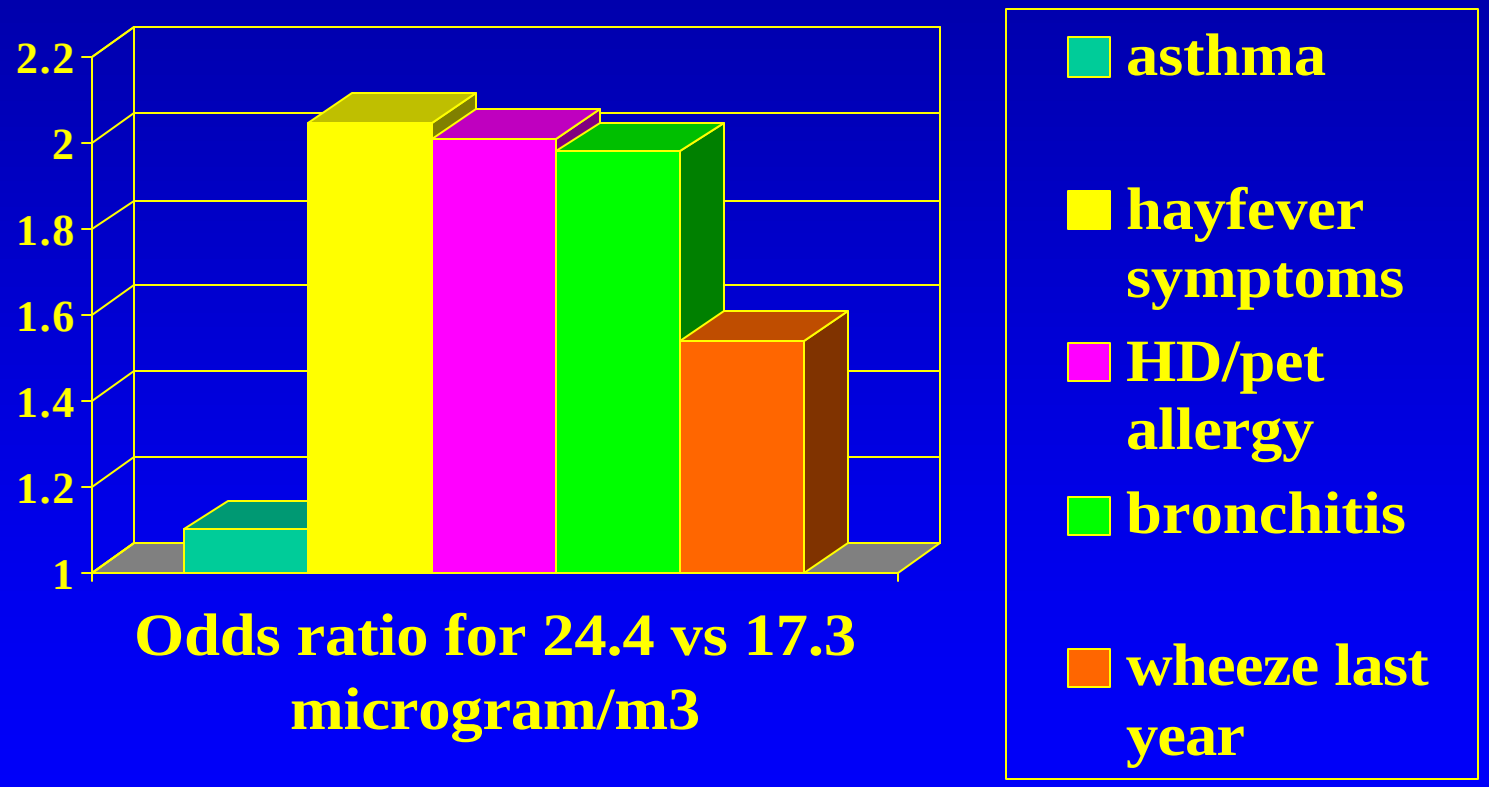
Association between car traffic and symptoms



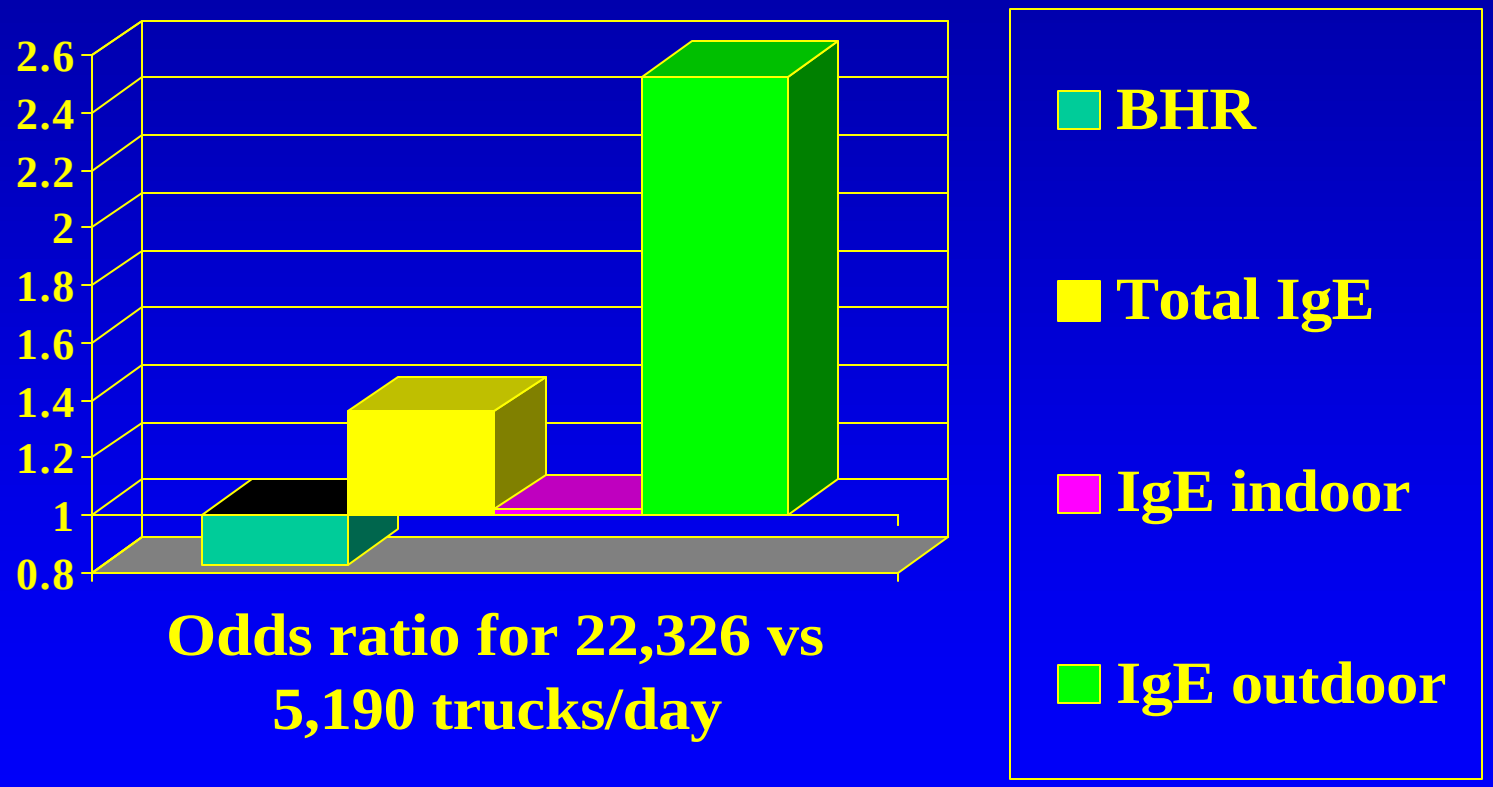
Association between truck traffic and symptoms



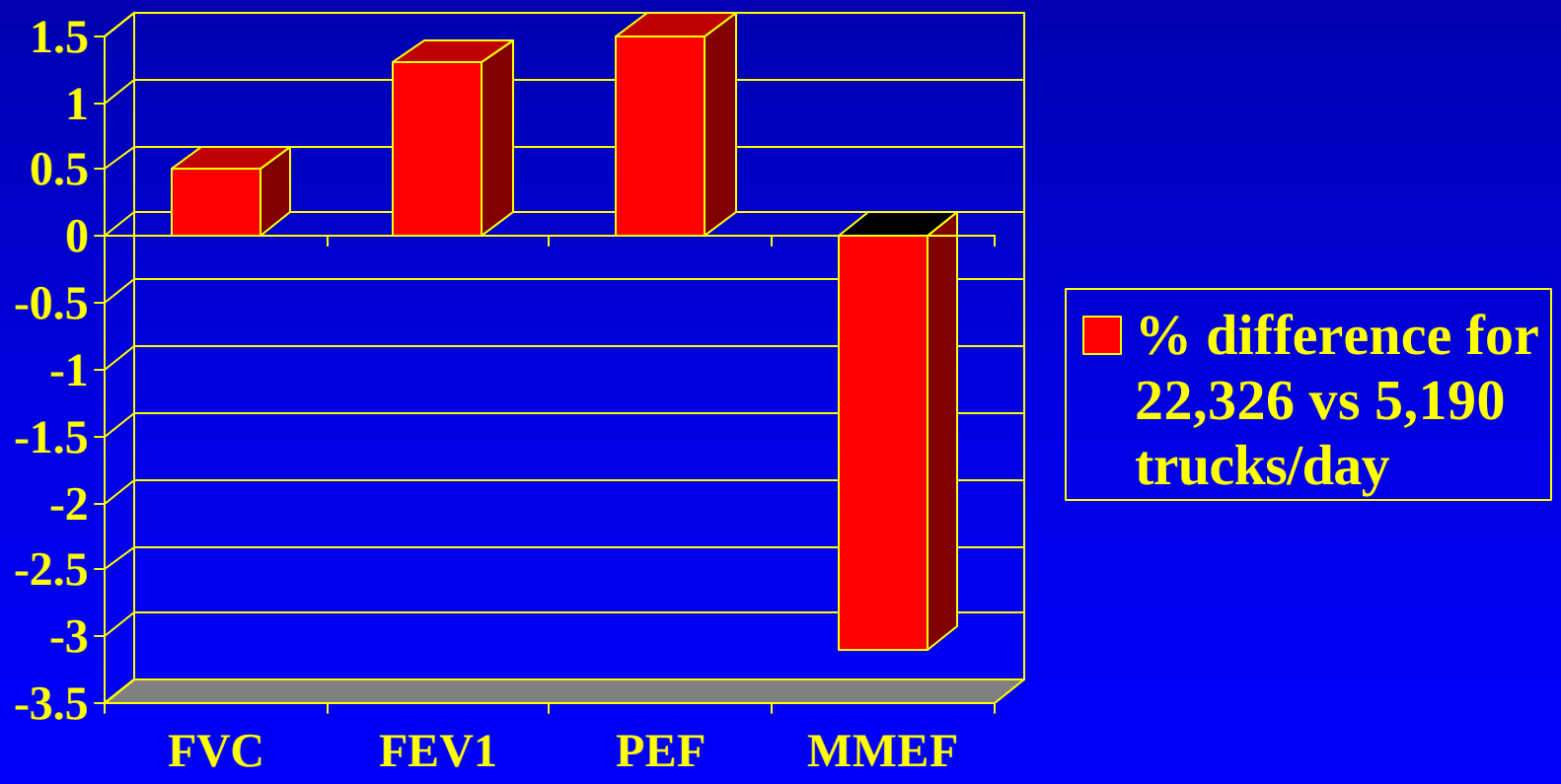
Association between outdoor PM2.5 pollution and symptoms



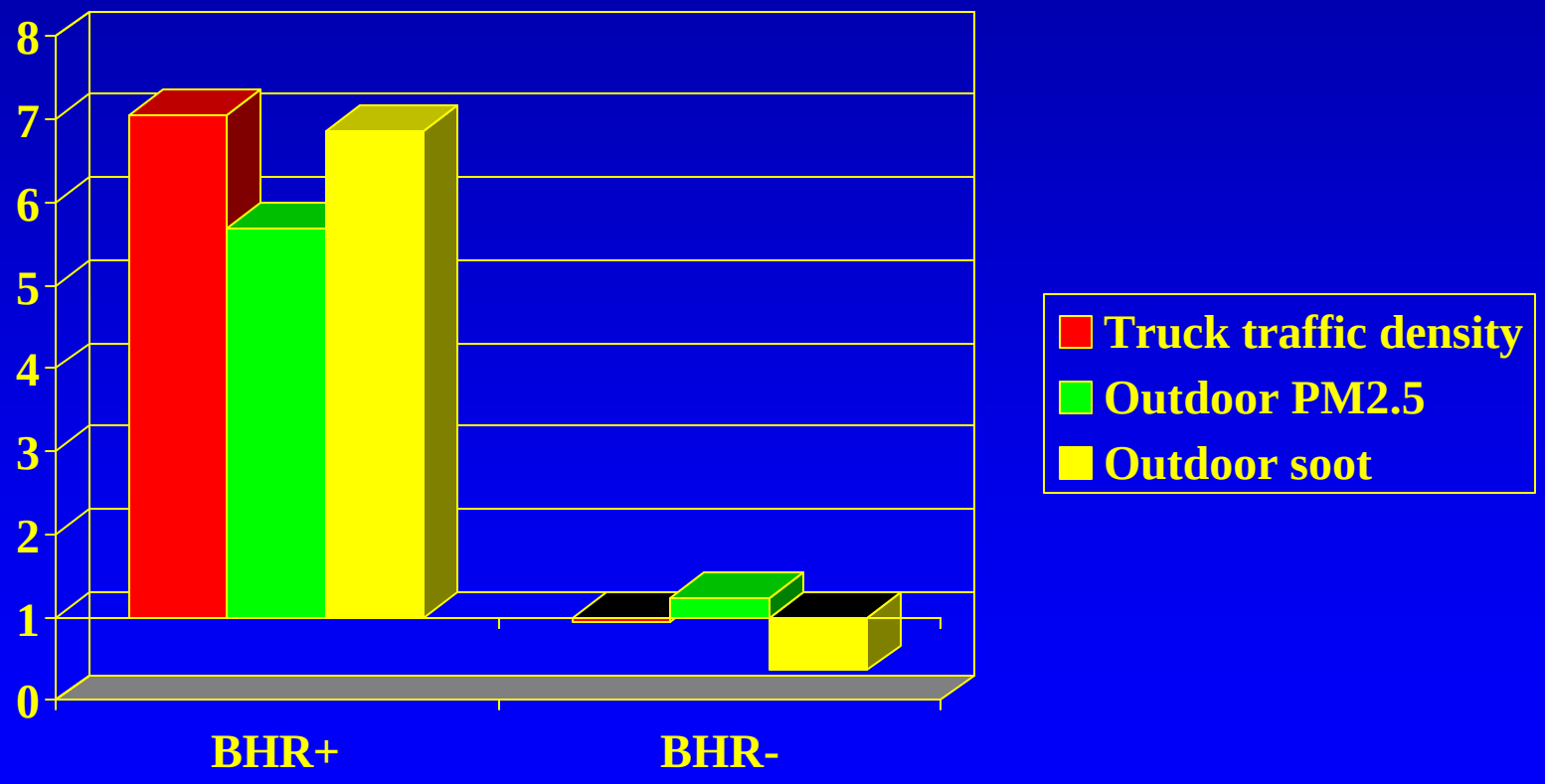
Association between truck traffic and BHR and sensitisation



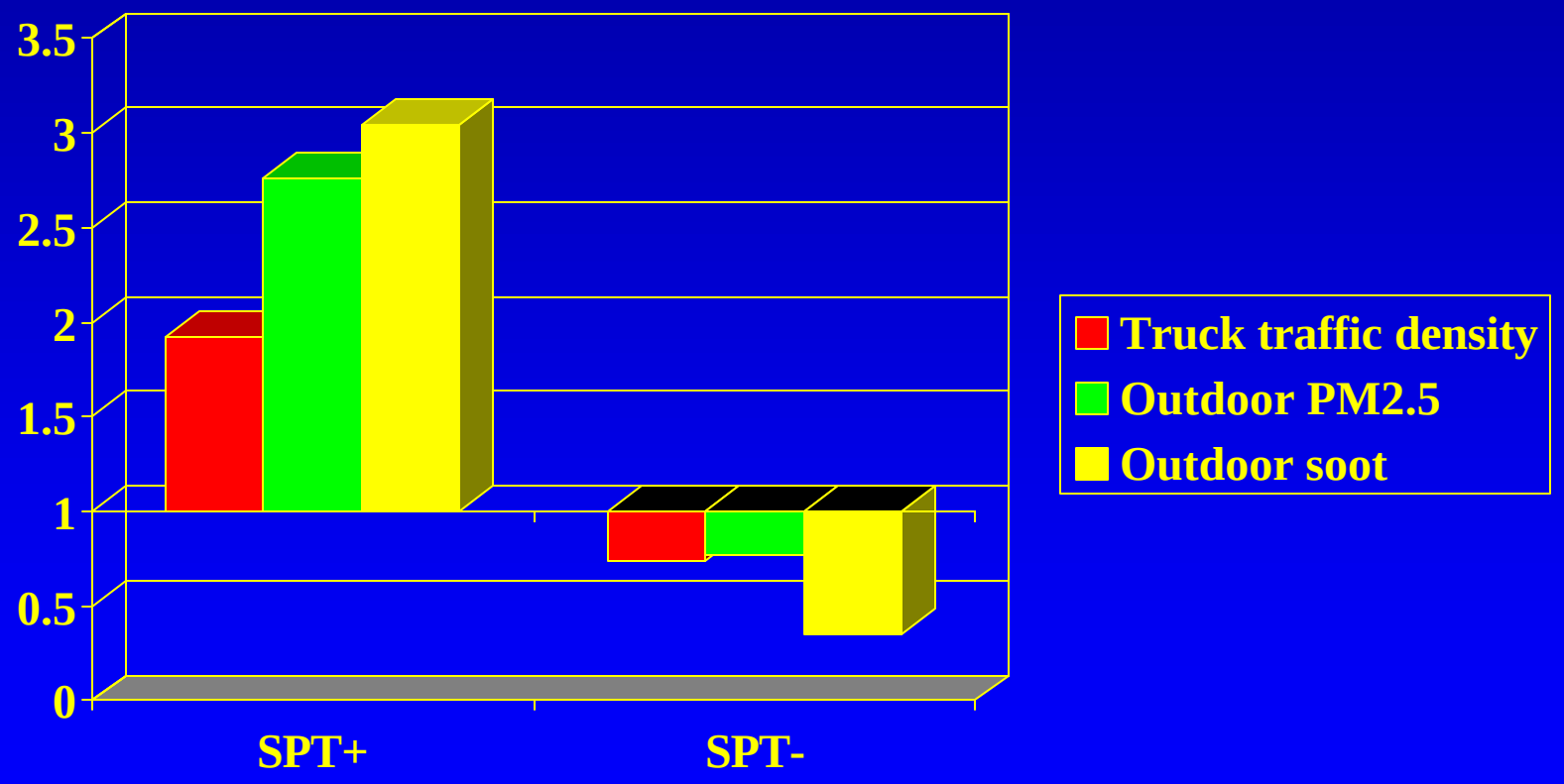
Association between truck traffic and lung function



Odds ratios for ‘Wheeze’ stratified by BHR



Odds ratios for ‘Wheeze’ stratified by SPT for outdoor allergens

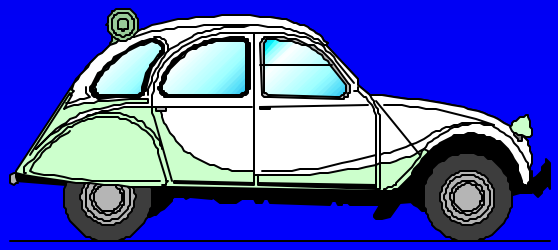


Conclusions 2nd highway study (1)

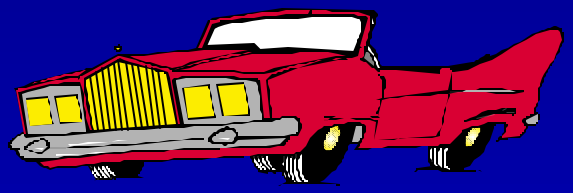
- No relationship between (PM from) truck traffic and BHR, lung function, sensitisation to indoor allergens
- Some relation between (PM from) truck traffic and total IgE and sensitisation to outdoor allergens
- Clear relation between (PM from) truck traffic and wheeze, bronchitis, allergy symptoms

Conclusions 2nd highway study (2)

- Clear relation between (PM from) truck traffic and wheeze in children **<u>with BHR only</u>**
- Clear relation between (PM from) truck traffic and wheeze, allergy symptoms in children **<u>sensitised to indoor and outdoor allergens only</u>**



General Conclusions



- Clear gradient of exposure to traffic-related air pollution near busy roads
- Suggestive evidence of adverse effects on childhood cancer and respiratory symptoms
- Some suggestive evidence of adjuvant role of diesel emissions
- Diesel & gasoline emissions often difficult to disentangle

Future perspectives: Cohort studies

- Follow differentially exposed subjects in time
- NLCS: cohort study on traffic-related air pollution and survival (NL)
- TRAPCA: birth cohort study on traffic-related air pollution and development of allergy and asthma (NL, SE, GE)

NLCS and TRAPCA cohort studies

- Both use GIS to estimate exposure at address level
- NLCS study suggests effect of living near roads on cardiorespiratory mortality
- TRAPCA study has validated GIS exposures by systematic measurements
- www.healtheffects.org/Brussels2001/brunekreef/index.htm
- www.healtheffects.org/Brussels2001/brauer/index.htm

NLCS study

- Existing cohort study: The Netherlands Cohort study on Diet and Cancer (NLCS)
- Started in 1986
- Included about 120,000 50-69 yr old adults
- Spread over the Netherlands, in small towns and large cities

Exposure estimation (1)

- Long-term exposure to outdoor air pollution at the 1986 home address was estimated.
- Traffic related air pollution components NO_2 and Black Smoke.
- Period 1987 - 1990, first years of the cohort study

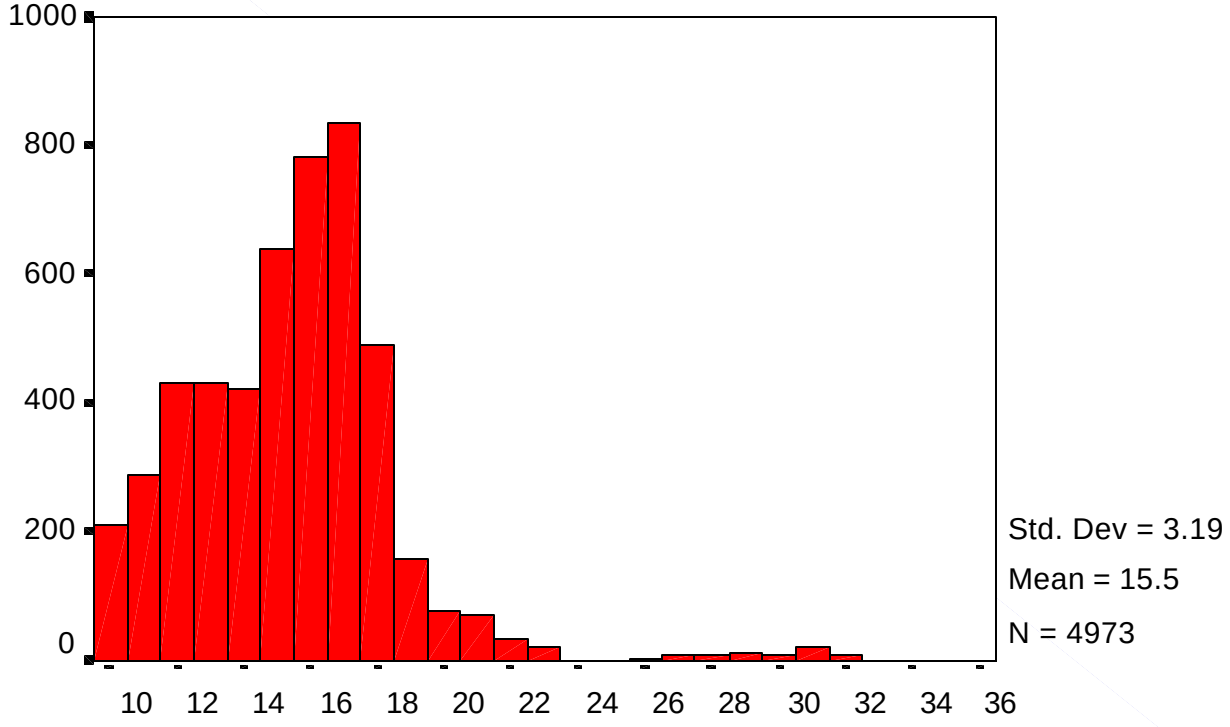
Exposure estimation (2)

- $E = C_{regional} + C_{urban} + C_{road}$

- E = estimated individual exposure
- C_{regio} = regional background
- C_{urban} = city contribution
- C_{road} = contribution from major street

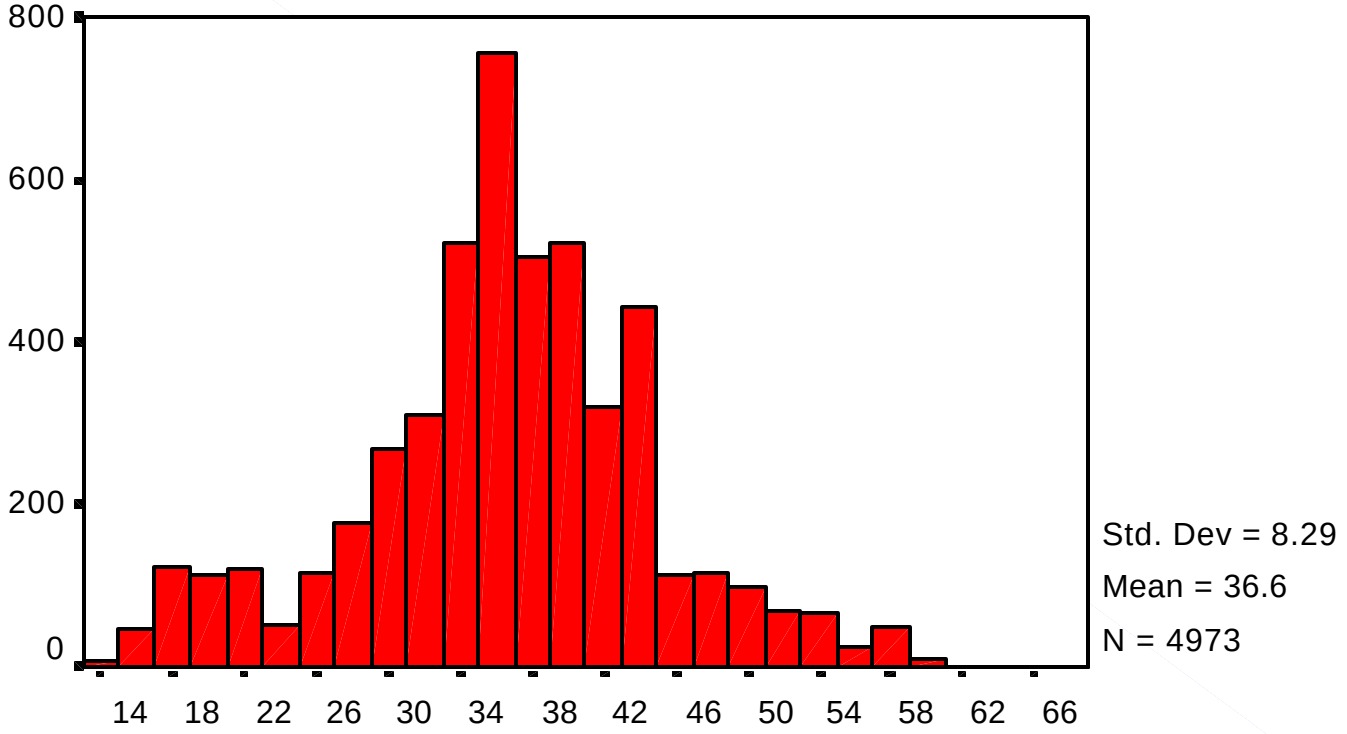
Distribution of Black Smoke exposures (µg/m^3)

regional + urban + local



Distribution of NO_2 exposures ($\mu g/m^3$)

regional + urban + local



Relative risk of cardiopulmonary mortality, adjusted (N = 3,461)

Variable	RR	95%	CI
BS1	1.34	0.68	2.64
ROAD	1.95	1.09	3.51
BS2	1.71	1.10	2.67