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**Geographical patterns in blood lead in
relation to industrial emissions and traffic in
Swedish children, 1978–2007**

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ABSTRACT

Background: Blood lead concentrations (B-Pb) were measured in 3 879 Swedish school children during the period 1978–2007. The objective was to study the effect of the proximity to lead sources based on the children's home and school location.

Methods: The children's home address and school location were geocoded and their proximity to a lead smelter and major roads was calculated using geographical information system (GIS) software. All the statistical analyses were carried out using means of generalized log-linear modelling, with natural-logarithm-transformed B-Pb, adjusted for sex, school year, lead-exposing hobby, country of birth and, in the periods 1988–1994 and 1995–2007, parents' smoking habits.

Results: The GIS analysis revealed that although the emission from the smelter and children's B-Pb levels had decreased considerably since 1978, proximity to the lead smelter continued to affect levels of B-Pb, even in recent years (geometric mean: near smelter: 22.90 $\mu\text{g/l}$; far from smelter 19.75 $\mu\text{g/l}$; $p = 0.001$). The analysis also revealed that proximity to major roads noticeably affected the children's B-Pb levels during the period 1978–1987 (geometric mean near major roads: 44.26 $\mu\text{g/l}$; far from roads: 38.32 $\mu\text{g/l}$; $p = 0.056$), due to the considerable amount of lead in petrol. This effect was, however, not visible after 1987 due to prohibition of lead in petrol.

Conclusion: The results show that proximity to the lead smelter still has an impact on the children's B-Pb levels. This is alarming since it could imply that living or working in the vicinity of a former lead source could pose a threat years after reduction of the emission. The analysis also revealed that urban children exposed to lead from traffic were only affected during the early period, when there were considerable amounts of lead in petrol, and that the prohibition of lead in petrol in later years led to reduced levels of lead in the blood of urban children.

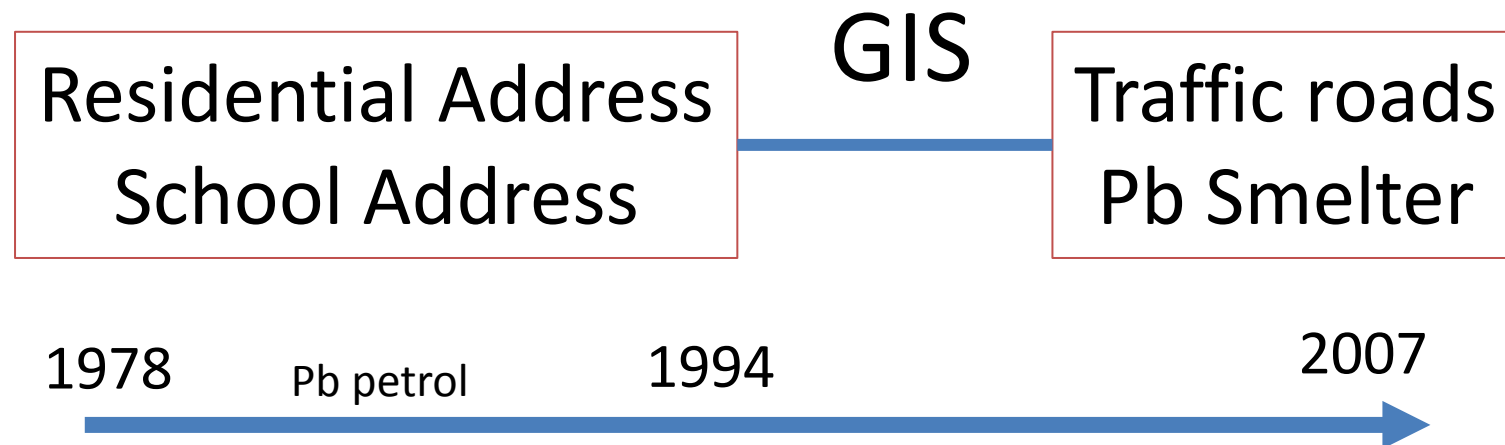
Setting of the study

- Yearly measurements of blood Pb (B-Pb) in two municipalities in Sweden since 1978
- Geometric mean B-Pb decreased from 60 $\mu\text{g/l}$ (1978) to 13 $\mu\text{g/l}$ (2007)



Source of Pb

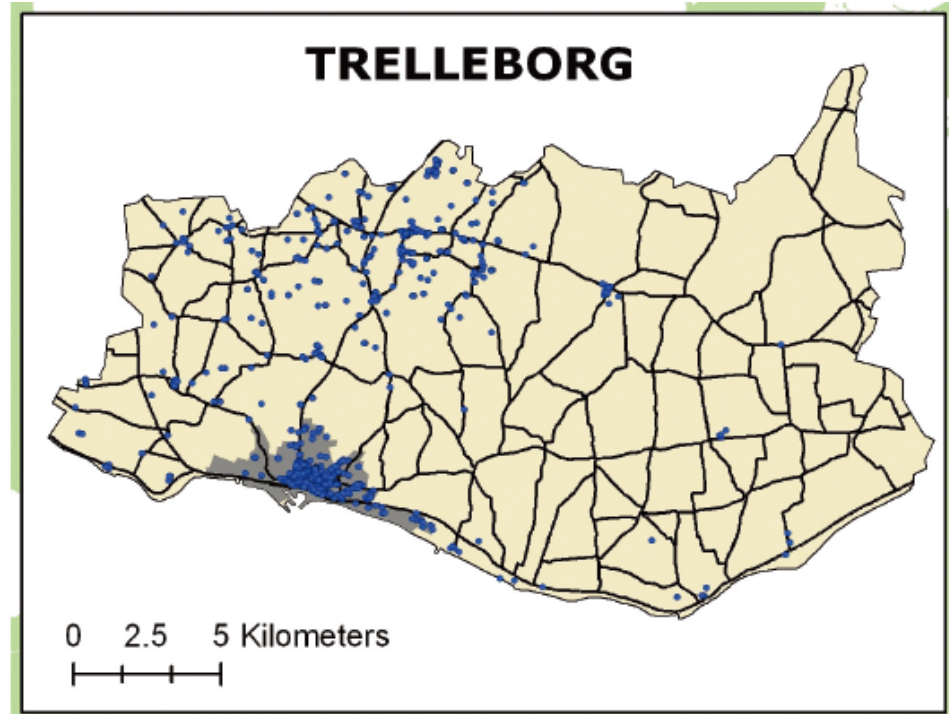
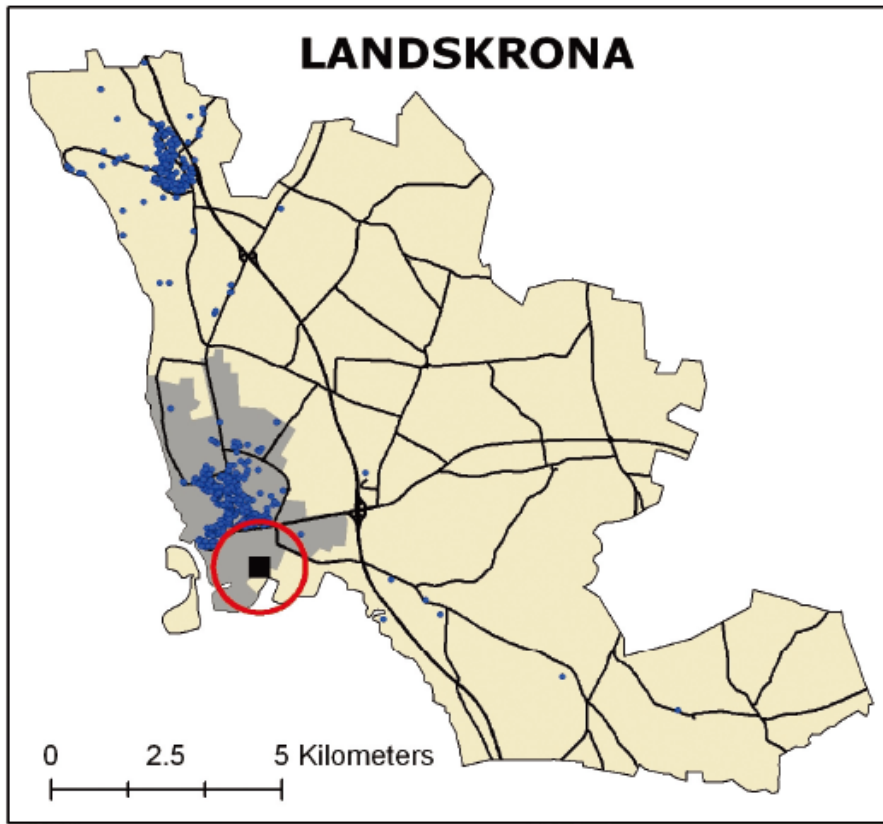
- Leaded house paint (banned in 1926)
- Leaded petrol (banned in 1994)
- Secondary Pb smelter (再生鉛工場) in Landskrona since 1944, not in Trelleborg



Case

Study Sites

Control



- Children 1978-2007
- Smelter
- Major roads
- Area near the smelter
- City
- Municipality

Figure 1. Study location. Map showing the location of the county of Scania, and the municipalities of Landskrona and Trelleborg. The major roads in the municipalities, the location of the lead smelter in Landskrona and the location of the participating children's residences, as well as the area defined as "near the smelter", and city areas from previous studies.

Design

Children of 8-10 years of age, except....

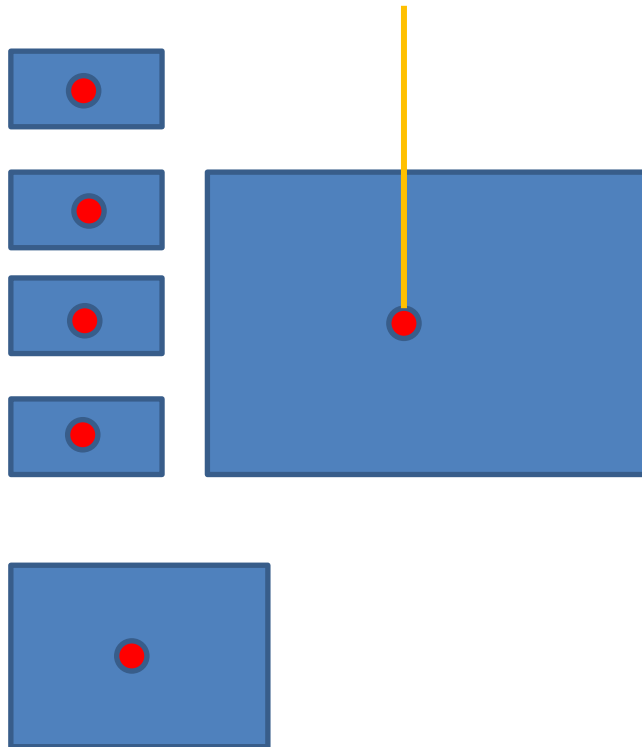
- 1978: Children of 10-17 years of age
- 1986: Children of 3 years of age (n=77)

The target schools (1/3 students close to the smelter, 1/3 urban, 1/3 further away), participation rate =60%

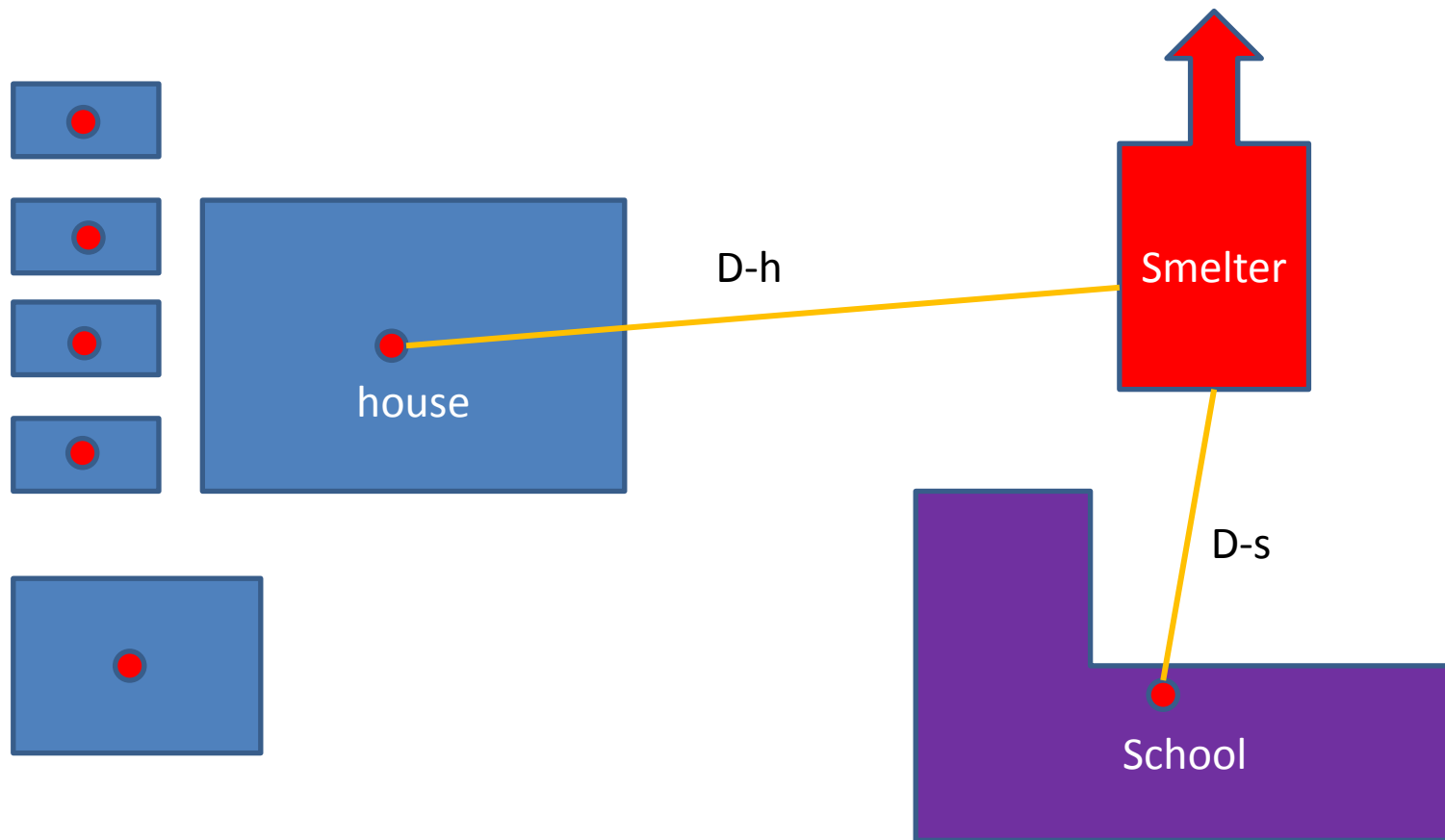
N=4218 blood samples from N=3713 children

who were asked about: hobbies that lead to Pb exposure, parent's smoking habit (1988-2007 only), name of school, school year, country of birth

Geocoding– distance from roads



Geocoding– distance from smelter



$$\text{Time weighted distance} = 0.8 * D-h + 0.2 * D-s$$

Objectives

B-Pb and distance from the smelter

B-Pd and time weighted distance from the smelter

B-Pd and distance from major roads

By three periods:

1978-1987, 1988-1994, and 1995-2007

Table 1-1

Table 1: Background information

	Landskrona			Trelleborg		
	1978–1987	1988–1994	1995–2007	1978–1987	1988–1994	1995–2007
N	979	657	890	652	238	501
Geometric mean B-Pb ($\mu\text{g/l}$)	49.7	30.9	18.4	46.5	28.2	18.2
Range	14.0 – 249.6	11.0 – 122.7	5.7 – 79.8	14.0 – 162.4	10.0 – 68.0	6.1 – 62.0
>50 $\mu\text{g/l}$, N (%)	488 (49.8)	57 (8.7)	15 (1.7)	271 (41.6)	11 (4.6)	2 (0.4)
Sex, N (%)						
Girl	467 (47.7)	355 (54.0)	431 (48.4)	344 (52.8)	115 (48.3)	259 (51.7)
Boy	512 (52.3)	302 (46.0)	459 (51.6)	308 (47.2)	123 (51.7)	242 (48.3)
School year, N (%)						
<i>B-Pb range ($\mu\text{g/l}$)</i>						
Preschool (4–7 years)	77 (7.9) 21 – 84	0 (0.0) ---	0 (0.0) ---	0 (0.0) ---	0 (0.0) ---	0 (0.0) ---
1 st (8 years)	42 (4.3) 24 – 88	140 (21.3) 12 – 73	111 (12.5) 6 – 55	146 (22.4) 14 – 162	29 (12.2) 16 – 68	80 (16.0) 7 – 40
2 nd (9 years)	164 (16.8) 14 – 129	303 (46.1) 11 – 122	352 (39.6) 6 – 72	151 (23.2) 16 – 115	93 (39.1) 10 – 67	175 (34.9) 6 – 49
3 rd (10 years)	150 (15.3) 15 – 102	214 (32.6) 13 – 68	410 (46.1) 6 – 80	137 (21.0) 15 – 124	116 (48.7) 12 – 64	246 (49.1) 8 – 62
Intermediate stage and senior levels (>10 years of age)	546 (55.8) 16 – 250	0 (0.0) ---	17 (1.9) 12 – 68	218 (33.4) 19 – 134	0 (0.0) ---	0 (0.0) ---

Table 1-2

Table 1: Background information

	1978–1987	Landskrona 1988–1994	1995–2007	1978–1987	Trelleborg 1988–1994	1995–2007
N	979	657	890	652	238	501
Smoking parents, N (%)						
Yes (mother/father or both)	6 (0.6)	367 (55.9)	334 (37.5)	66 (10.1)	140 (58.8)	240 (47.9)
No	2 (0.2)	280 (42.6)	376 (42.2)	49 (7.5)	98 (41.2)	261 (52.1)
Missing	971 (99.2)	10 (1.5)	180 (20.2)	537 (82.4)	0 (0.0)	0 (0.0)
Potentially Pb-exposing hobby, N (%)						
Yes	92 (9.4)	126 (19.2)	128 (14.4)	81 (12.4)	57 (23.9)	66 (13.2)
No	887 (90.6)	531 (80.8)	762 (85.6)	571 (87.6)	181 (76.1)	435 (86.8)
Birth country, N (%)						
Nordic countries	936 (95.6)	622 (94.7)	809 (90.9)	623 (95.6)	231 (97.1)	461 (92.0)
All other countries	31 (3.2)	35 (5.3)	79 (8.9)	21 (3.2)	7 (2.9)	40 (8.0)
Missing	12 (1.2)	0 (0.0)	2 (0.2)	8 (1.2)	0 (0.0)	0 (0.0)

Background information for the 3 917 measurements on blood-lead concentrations (B-Pb) in Swedish children, carried out during the period 1978–2007

Landskrona 1978-2007

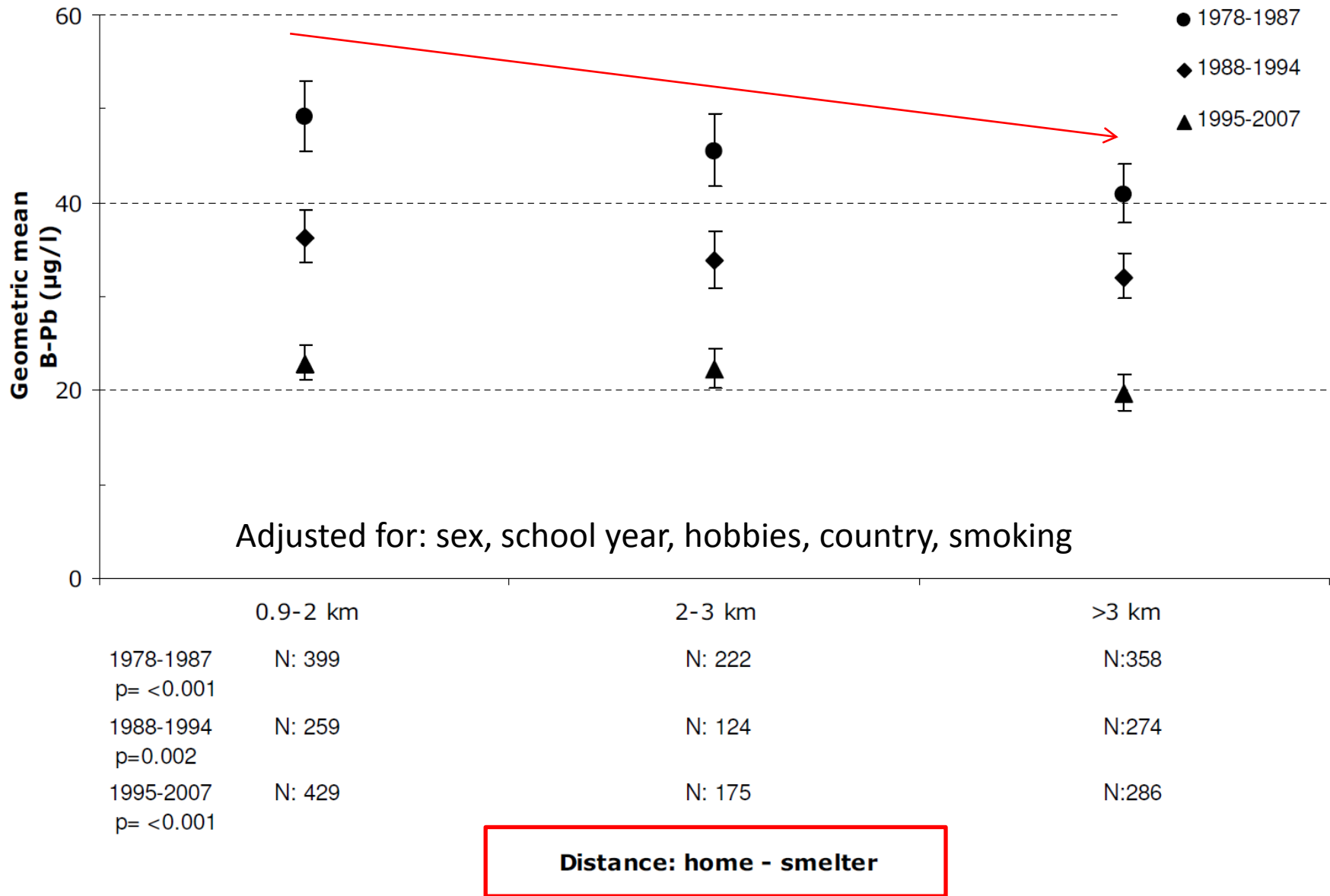


Figure 2

Geometric mean of blood lead based on the distance between the home and the lead smelter. Geometric mean of blood lead levels of children in Landskrona as a function of the distance between their home and the lead smelter. Whisker represents the 95% confidence interval.

Landskrona 1978-2007

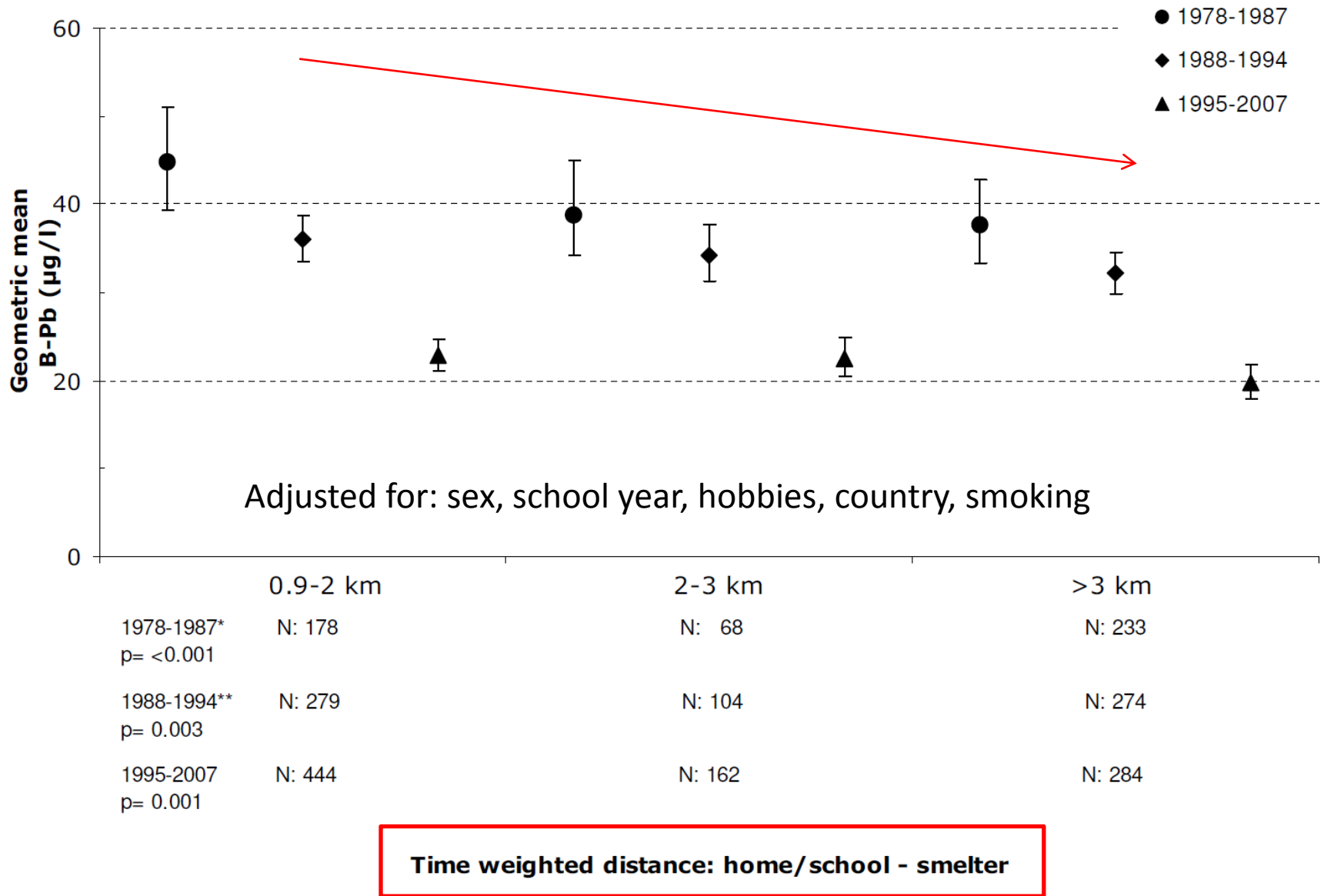


Figure 3

Geometric mean of blood lead based on the time-weighted measure of the home/school and the lead smelter.

Geometric mean of blood lead levels of children in Landskrona as a function of the distance between the time-weighted measure of their home and school and the location of the smelter. Whisker represents the 95% confidence interval.



Landskrona 1978-1987

• Children (n: 979)

Geographical mean: B-Pb ($\mu\text{g/l}$)

○ 14-25 (n:48)

○ 26-50 (n: 443)

○ 51-75 (n: 344)

● 76-100 (n: 116)

● >100 (n:28)

■ Smelter

▭ Landskrona city

▭ Landskrona municipality

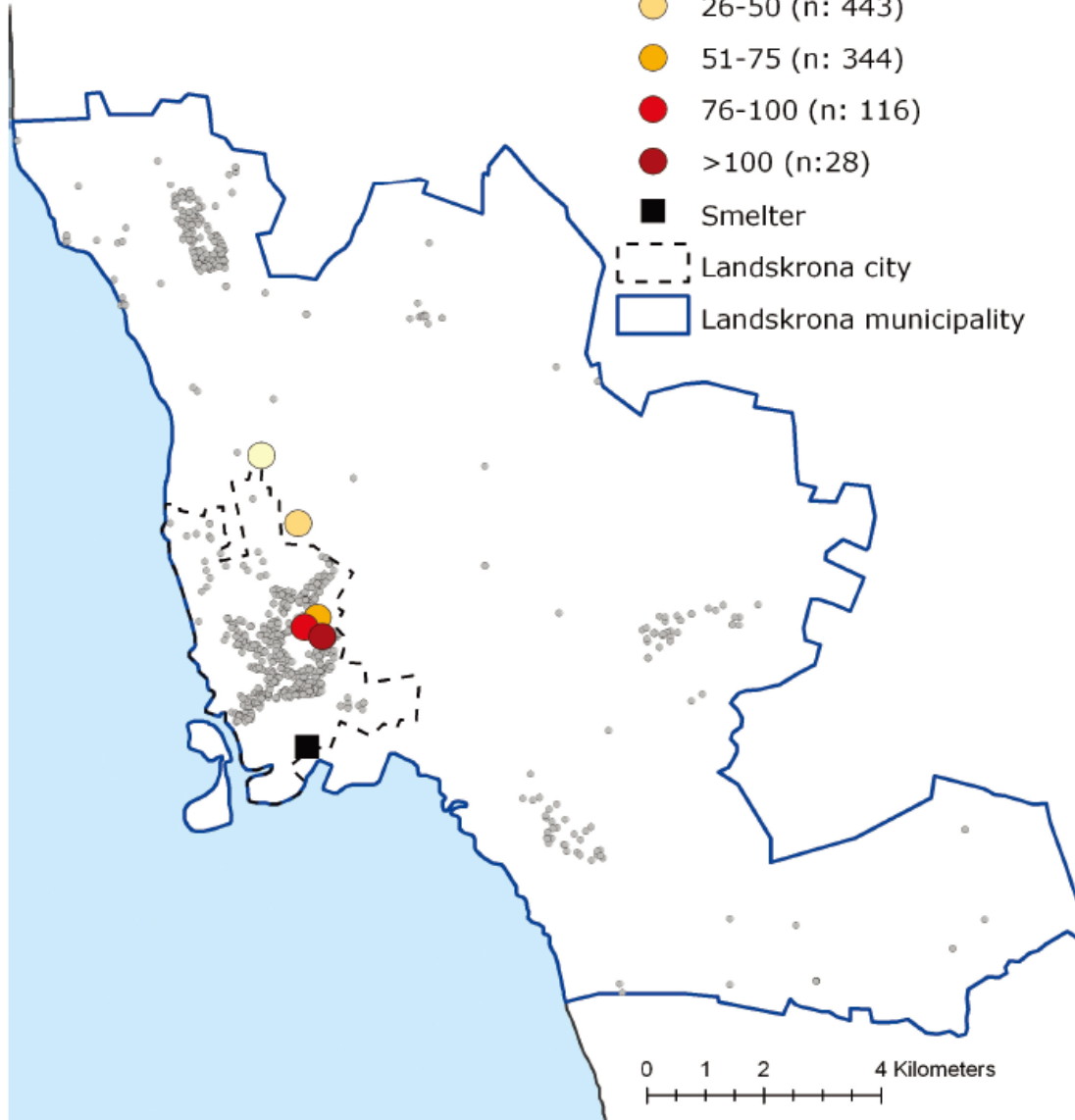


Figure 4. The participating children's homes in Landskrona and the data categorised according to B-Pb level 1978–1987

The location of the participating children's homes in Landskrona and the location of the geographical mean for the children in different B-Pb categories during 1978–1987.



Landskrona 1988-1994

• Children (n: 656)

Geographical mean: B-Pb ($\mu\text{g/l}$)

○ 11-25 (n: 190)

○ 26-50 (n: 410)

○ 51-75 (n: 52)

● 76-100 (n: 4)

■ Smelter

▭ Landskrona city

▭ Landskrona municipality

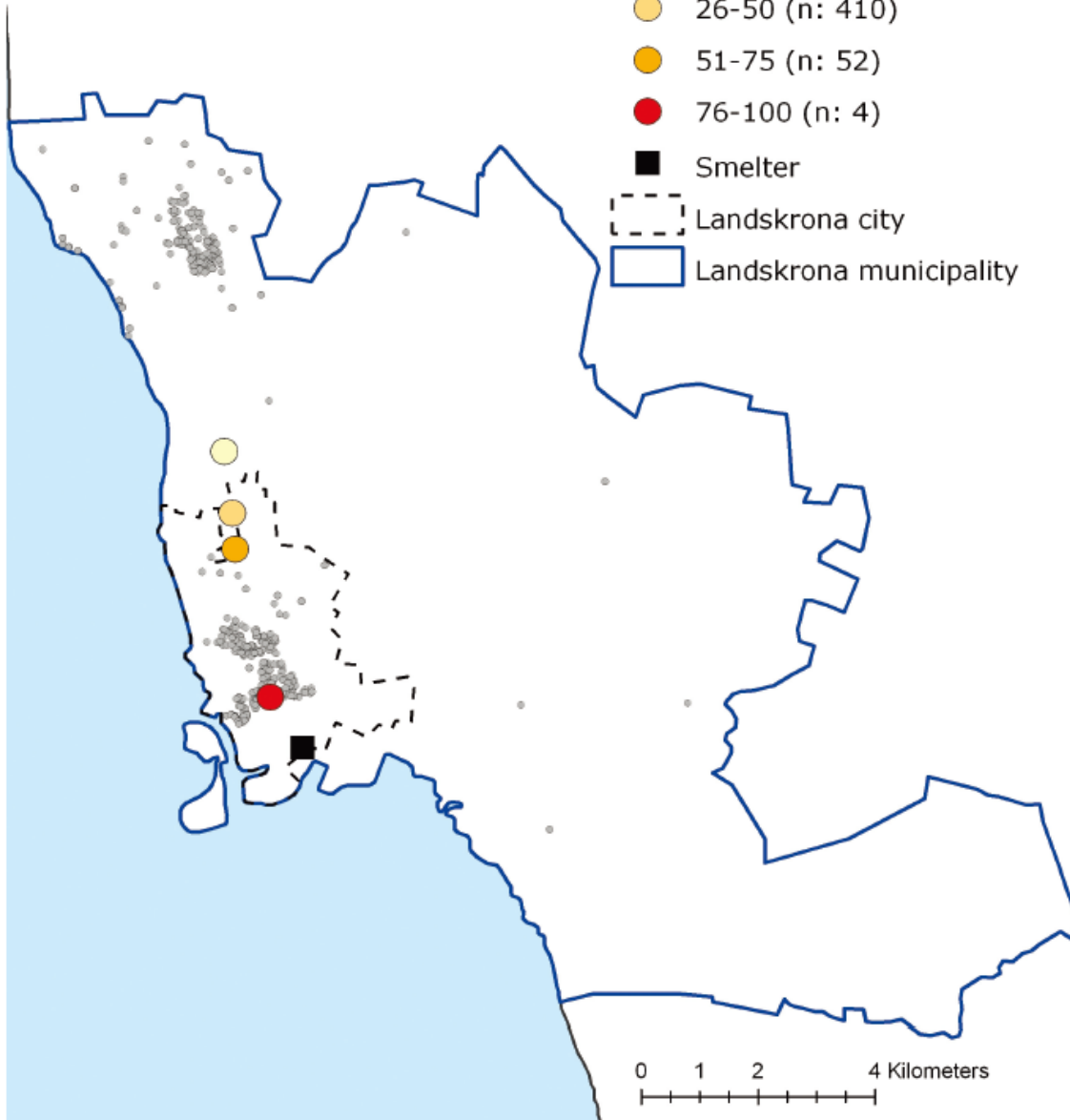


Figure 5.
The participating children's homes in Landskrona and the data categorised according to B-Pb level 1988–1994.

The location of the participating children's homes in Landskrona and the location of the geographical mean for the children in different B-Pb categories during 1988–1994 (one child had a B-Pb level above $>100 \mu\text{g/l}$ ($120 \mu\text{g/l}$), and this child and category were therefore excluded from the analysis).



Landskrona 1995-2007

• Children (n: 889)

Geographical mean: B-Pb ($\mu\text{g/l}$)

● 6-25 (n: 686)

● 26-50 (n: 189)

● 51-75 (n:14)

■ Smelter

▭ Landskrona city

▭ Landskrona municipality

0 1 2 4 Kilometers

Figure 6. The participating children's homes in Landskrona and the data categorised according to B-Pb level 1995-2007.

The location of the participating children's homes in Landskrona and the location of the geographical mean for the children in different B-Pb categories during 1995-2007 (one child had a B-Pb level above $>75 \mu\text{g/l}$ ($80 \mu\text{g/l}$), and this child and category were therefore excluded from the analysis).

Rural Children 1978-1987

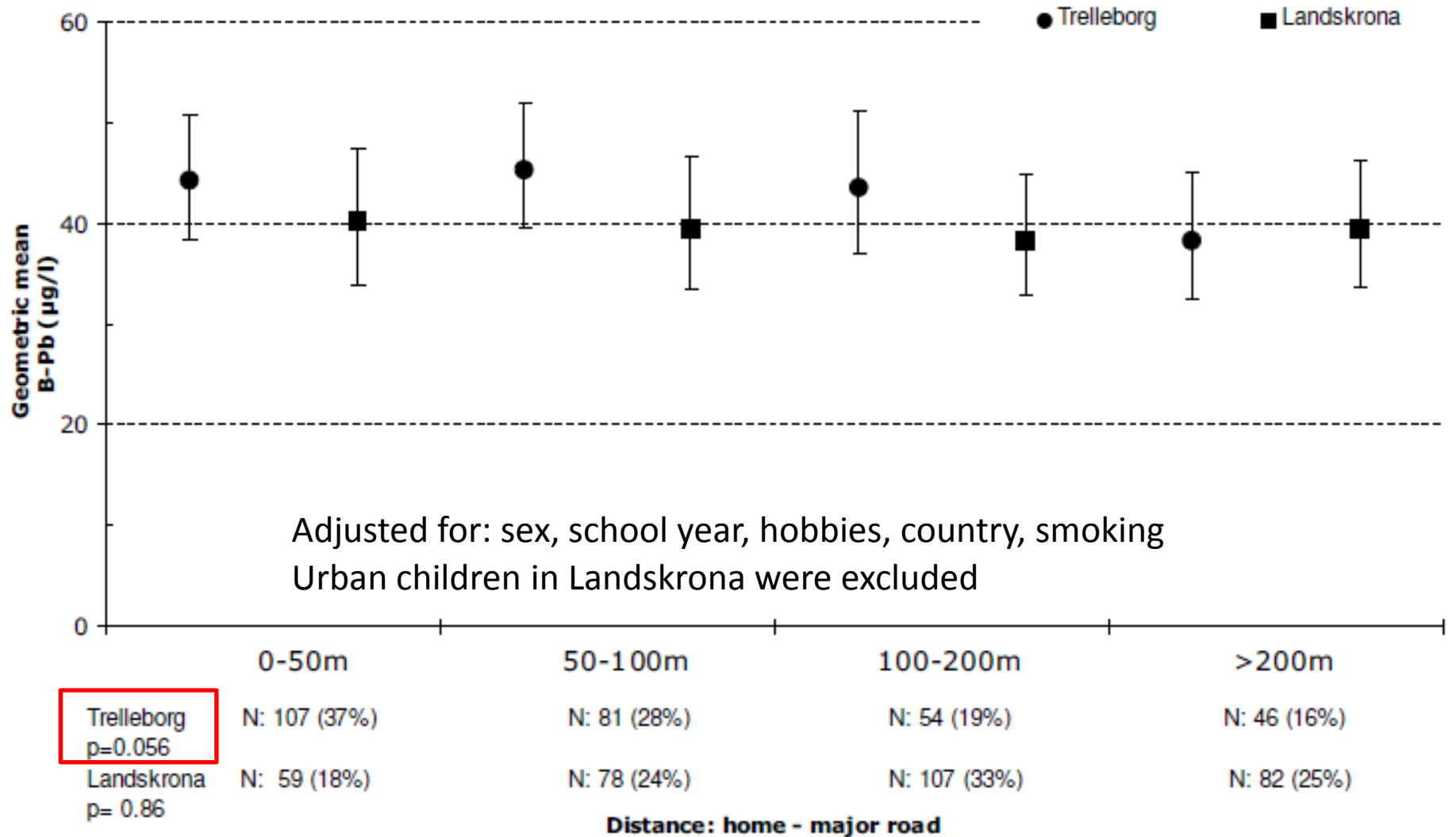


Figure 7
Geometric mean blood lead levels of rural children in Trelleborg and Landskrona. Geometric mean blood lead levels of rural children in Trelleborg and Landskrona from 1978–1987, as a function of the distance between their homes and major roads. Whisker represents the 95% confidence interval.

Discussion

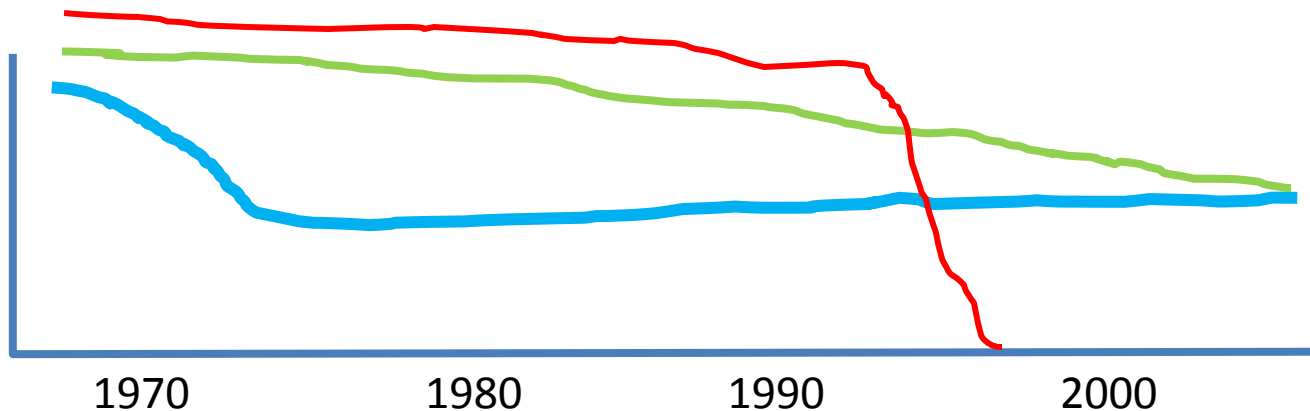
Lead smelter: monitoring of dust deposition ---

Early 1970s: 600 mg/m²

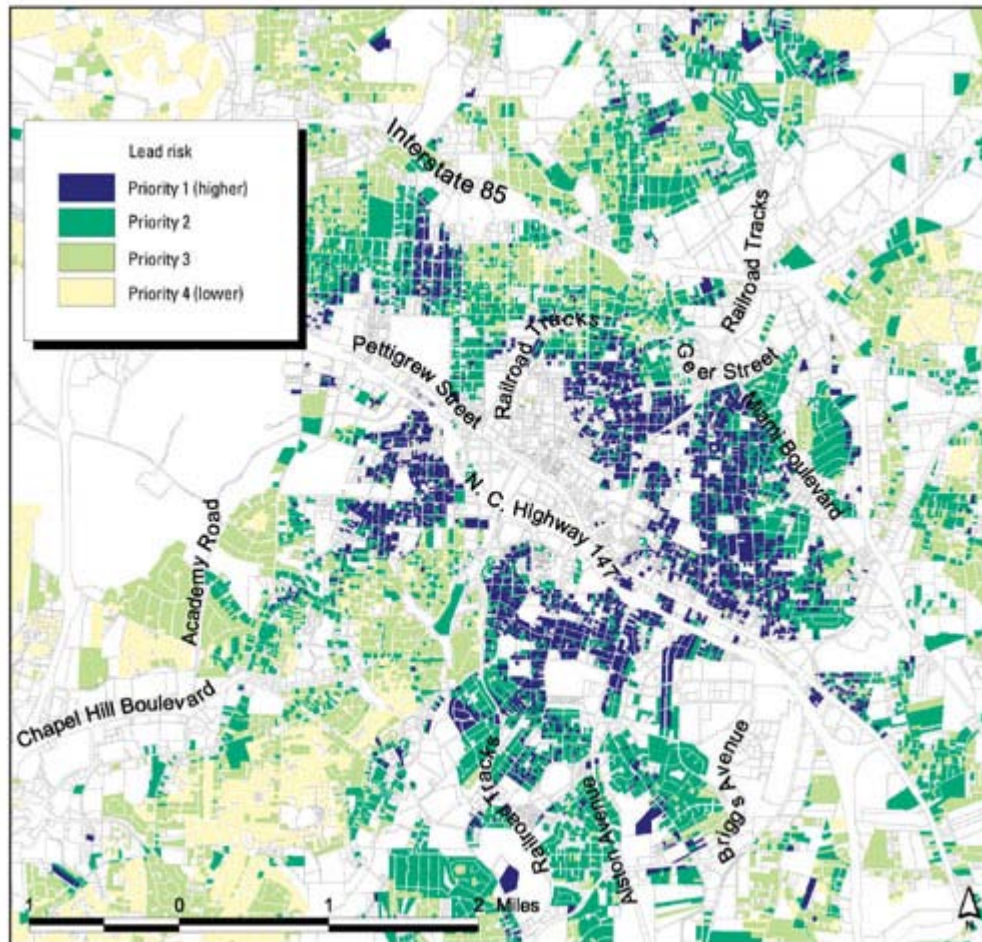
1980s-2007: 200-300 mg/m²

Major roads: No use of Pb petrol since 1994

1978-1987 rural Trelleborg only



Marie Lynn Miranda, Dana C. Dolinoy, and M. Alicia Overstreet (2002) .
Mapping for Prevention: GIS Models for Directing Childhood Lead
Poisoning Prevention Programs *Environ Health Perspect* 110:947-953



Estimated $\ln(\text{BLL})$
= $c + (a * \text{year built})$
+ $(b * \text{median income})$
+ $(c * \text{percent African American})$

$R^2=0.79$

Risk map