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## Social inequality and environmentally-related diseases in Germany: Review of empirical results

### Summary

A literature search was conducted aiming at all empirical studies from Germany till mid 1997 containing data on the association between environmentally-related diseases and the socio-economic status (education, occupation, income, social class) and/or on the association between the exposure to harmful substances and the socio-economic status. With respect to the exposures, a clear picture becomes visible: the concentration of harmful substances in the ambient air as well as indoors is considerably higher with regard to the lower social class as compared with the higher social class. This applies to children as well as to adults and to West Germany as well as to East Germany. However, with respect to environmentally-related diseases, no such clear picture becomes visible. For example, several studies indicate that allergies, atopic eczema and croup occur less frequently in the lower social class than in the higher social class. Malignant tumours (lung cancer, kidney cancer or bladder cancer), however, seem to occur more frequently in the lower social class than in the higher social class. Environmental-epidemiological studies should increasingly integrate socio-epidemiological study approaches and explicitly present their results.

Recently published extensive reviews show consistent associations between socio-economic factors and health in Europe<sup>1</sup>. Irrespective of the individual indicators of social inequality, empirical studies in Germany show similar results: usually, adults with a higher level of education are healthier than adults with a lower level of education, white-collar workers (in German “Angestellte” or “Beamte”) are healthier than blue-collar workers

(in German “Arbeiter”), people with a higher income are healthier than people with a lower income<sup>2</sup>. There are some exceptions, however. Several chronic diseases, such as breast cancer<sup>3</sup>, seem to occur less frequently in the lower social class as compared with the higher social class. Overall though, people with a lower socio-economic status report a worse state of health. This association holds true for both adults and children and exists in

West Germany as well as in East Germany. Until now, the reasons for these health inequalities have largely remained unexplained.

The overall association between social inequality on the one hand and disease and death on the other hand caused us to study in particular the distribution of environmentally-related diseases in relation to the social classes in Germany. A summarizing account of this topic was missing up to now. The results of a literature review were just recently presented in detail in a German monograph<sup>4</sup>. On the basis of this review the present study intends to answer – in an updated version on the basis of the empirical studies published till mid 1997 on the association between socio-economic factors on the one hand and environmentally-related diseases and the exposure to harmful substances on the other hand - the following questions:

- Does the general picture of higher morbidity in the lower social classes also apply to environmentally-related diseases?
- Is the exposure to harmful substances in the environment different with regard to the social classes?

### Definition of environmental pollution and environmentally-related diseases

In this study, the definition of environmental pollutants is based on the restriction of the term “environment” to natural, material factors, i.e. the pollution of the ambient air, water, soil, foodstuff and textiles by chemical and biological materials, particles and physical influences. The current study is limited to those pollutants affecting the general population and the exposure to which is for the most part involuntary. In these cases, there is little possibility for individuals to reduce their exposure through preventive behaviour. Pollutants fitting this description are mostly airborne pollutants whose effects on health have been thoroughly tested. Risk factors primarily depending on individual behaviour, such as cigarette smoking or diet as well as occupational exposures, are not taken into consideration in this study, neither the exposure to pollutants at work.

In order to define environmentally-related diseases, we refer to the list of diseases described in the study “Environment and Health” from 1996<sup>5</sup>. In this study, the term “environmentally” was limited in the same way as described above. Nevertheless, the defined environmentally-related diseases are rather unspecific, caused by a variety of concomitant causes. Furthermore, exposures in occupational and environmental settings might overlap. The reviewed studies did not differentiate between effects of occupational and environmental exposures. Thus, this review has to mostly ignore occupational exposures. The following diagnoses were included: allergies, specific non-allergic respiratory diseases, skin diseases, and specific malignant tumours. The limitation to these diseases was necessary due to insufficient data. Occupational diseases which are related to spe-

cific physical and chemical exposures at work were not considered, although members of the lower social class often experience a higher degree of exposure at work than members of the higher social class.

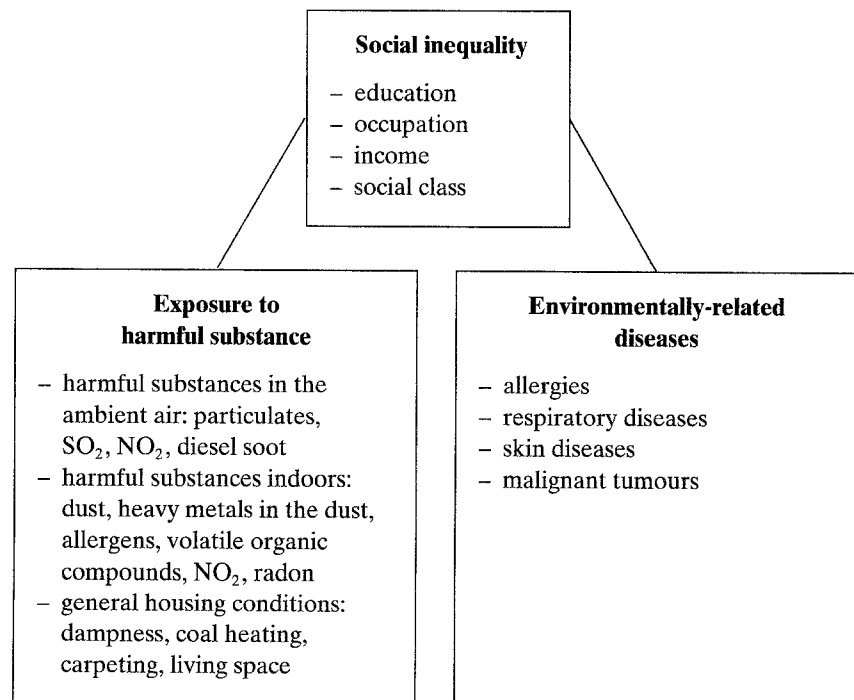
### Definition of social inequality

Social inequality is mostly understood as differences in education, occupational status and income. Expressed in a more precise way, these are characteristics of the vertical social inequality. The addition of the word “vertical” in this context is intended to express the fact that these characteristics enable us to divide the population into a higher and a lower class. Linguistically the hierarchic character of the vertical social inequality is expressed most clearly by the term “social class”. This picture is meant to remind of clearly distinguishable strata.

The three characteristics of the vertical social inequality (i.e. education, occupational status and income), which are frequently also called “socio-economic factors”, are of course interrelated. A higher level of education, for example, often results in the possibility of obtaining a higher income. Although it makes sense to study these three characteristics separately, all three characteristics are often combined in a joint “index of the social class”. However, each characteristic expresses a different aspect of the social status and the association with the state of health is likely to be different for each characteristic as well.

### Methodological approach

In order to study the association between social inequality and environmentally-related diseases, a very simplified model is used to structure the available data (Fig. 1).



**Figure 1.** Structure of the available data for the association between social inequality and environmentally-related diseases.

In contrast to the official statistics, several empirical studies on the influence of harmful substances in the environment on the state of health of the population also took into account the characteristics of social inequality. Unfortunately, some of these studies do not explicitly present the association with social inequality. None of the epidemiological studies explicitly aimed at examining the class-specific effects on environmentally-related diseases. As a consequence, social factors were frequently treated as confounding factors and their effects were not described separately.

This model does not distinguish between the social inequality effect per se and the potential pathophysiologic physical-chemical causes of disease inequality across social classes.

Social inequality and environmentally-related diseases

*Allergies:* The prevalence of allergies is apparently higher in the higher social class than in the lower social class. Numerous studies with children and adults show consistently similar results (Table 1). This association has been demonstrated in West Germany<sup>6</sup> as well as in

East Germany<sup>7</sup>. The higher prevalence of allergies in the higher social class – which is usually determined by a standardised questioning – is furthermore supported by the serological determination of specific IgE-antibodies<sup>6</sup> and skin prick tests<sup>7</sup>. As a consequence, reporting bias can be ruled out as an explanation for the higher prevalence of allergies in the higher social classes.

Several epidemiological studies from Italy, the United Kingdom and the U.S. (NHANES II) also showed a higher prevalence of skin test reactivity in those participants with a higher socio-economic status,

Author(s)	Allergy	Age group	Indicator of social inequality				
			Brief description	Index	Education	Occupation	Income
Krämer, et al. (1997)	several studies	5, 6 years		+			
Wilde, et al. (1996)	Wittbg./Dessau	5, 6 years		+			
Ministerium für Umwelt, Raumordnung und Landwirtschaft des Landes Nordrhein-Westfalen (1990)	Rheinschiene Süd und Mitte	5, 6 years		+			
Heinrich, et al. (1995)	Vorst. Bitterfeld	5–14 years		•			
Heinrich, et al. (1998)	Bitterfeld-Studie	5–14 years		+			
Wichmann, et al. (1991)	Duisburg	10 years		+			
Mütius von (1992)	Allergiestudie München	10 years		•			
Wichmann, et al. (1995)	SW-Deutschland	8–16 years		+			
Hoffmeister, Hüttner (1995)	Survey 90/91, 91/92	25–69 years		+			
Helmert (1994)	Survey 84/86, 87/88	25–69 years	+				
Hoffmeister, Hüttner (1995)	Survey 85–91	25–69 years	+				
Helmert, et al. 1997	DHP 1984–1991	25–69 years					+
Helmert, Shea 1994	DHP 1984–1991	25–69 years	+				
Hoeltz, et al. 1990	DHP 1984	25–69 years		+		+	

Index: Index combining education, occupation and income.  
 + Higher morbidity with higher socio-economic status,  
 - lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status.

**Table 1.** Social inequality and prevalence of allergy.

in children<sup>8</sup> as well as in adults<sup>9,10</sup>. The social inequality of allergic diseases – lower prevalences in the lower social classes – seems to be a common phenomenon. The reasons for these health inequalities have not yet been fully understood. Possibly more prevalent and more severe infections in early life in the lower social class stimulate the immune response. The stimulation of TH1 lymphocytes by infections and the resulting possible inhibition of the expansion of allergen-specific TH2 lymphocytes at a critical time during early childhood could explain these results<sup>11</sup>.

**Asthma:** The results regarding bronchial asthma in children are not consistent (Table 2). This possibly results from combining different severity degrees of asthma. When stratifying asthma according to the degree of its severity, a considerably higher prevalence of severe asthma became visible in the lower social class<sup>12</sup>. Except for the study in the region around Bitterfeld<sup>13</sup> the other studies hardly ever showed a clear association with the socio-economic status. In the only study with adults<sup>14</sup> no indications for an association between social inequality and the prevalence and the degree of severity of bronchial asthma could be found either.

Over the last few decades several studies in Great Britain reported a higher prevalence of asthma in children from the higher social classes<sup>15</sup>. In contrast to that a higher prevalence of asthma in children was found in lower class children within a national sample in the United States<sup>16</sup>. Possibly extreme living and housing conditions in disadvantaged groups contribute to a higher risk for asthma. A review of results from more than 24 studies published since the late 1960s shows no clear pattern<sup>12</sup>. This might be due to different definitions of asthma, different me-

Author(s)	Asthma		
	Brief description	Age group	Education
Wilde, et al. (1996)	Wittenbg./Dessau	5, 6 years	•
Krämer, et al. (1997)	several studies	5, 6 years	•
Wichmann, et al. (1991)	Duisburg	10 years	•
Mutius von (1992)	Allergiestudie München	10 years	•
Mielck, et al. (1996)	Allergiestudie M	10 years	– <sup>a</sup>
Forster, et al. (1992)	Kinderstudie FB	no data	•
Heinrich, et al. (1998)	Bitterfeld-Studie	5–14 years	+
Heinrich, et al. (1995)	Vorst. Bitterfeld	5–14 years	+
Wichmann, et al. (1995)	SW-Deutschland	8–16 years	+
Hoffmeister, Hüttner (1995)	Survey 90/91, 91/92	25–69 years	•

+ Higher morbidity with higher socio-economic status,  
 – lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status,  
<sup>a</sup> severe asthma.

**Table 2.** Social inequality and the prevalence of asthma.

thods of assessing asthma, different age groups, etc.

**Bronchitis:** Several studies report on the association between the socio-economic status and the prevalence of bronchitis (Table 3). However, a uniform tendency of the association between the social status and the prevalence of bronchitis is not discernible in the various studies with children. There are reports on a higher prevalence of bronchitis in children with a higher social status<sup>13,17,18</sup> as well as reports on a lower prevalence of bronchitis in children with a higher social status<sup>19</sup>. With respect to adults the picture is much clearer; in the lower social class the prevalence is apparently considerably higher than in the higher social class. Compared with the higher social class, men from the lower social class report a prevalence increased by the factor 2.1. With respect to women this factor only amounts to 1.4 and is not statistically significant<sup>20,21</sup>. The interpretation of these differences is difficult, as smoking behaviour is

often not controlled for in the analyses.

**Croup:** With a higher school education the morbidity of croup in children apparently increases considerably (Table 4). Although this tendency can be shown in studies it can be proven as statistically significant only in a few of them. In some studies even a continuous gradient between the prevalence of croup in children and the level of school education of the parents can be shown: university degree: 12.8%, grammar school degree: 10.5%, secondary school degree (after the 10th grade): 8.3%, secondary school degree (after the 9th grade): 5.3%<sup>22</sup>.

**Skin diseases:** In all studies the prevalence of skin diseases (atopic eczema) in the higher social class is obviously higher than in the lower social class (Table 5). These differences were once again confirmed by recently published results of a study with children entering school<sup>23</sup>. The results are usually based on a standardized questioning

Author(s)	Chronic bronchitis (adults), obstructive bronchitis (children)					
	Brief description	Age group	Indicators of social inequality			
			Index	Education	Occupation	Income
Wichmann, et al. (1991)	Duisburg	10, 11 years	•			
Wilde, et al. (1996)	Wittenbg./Dessau	5, 6 years	•			
Wichmann, et al. (1990)	Pseudokruppstudie	5, 6 years	•			
Hendel-Kramer, et al. (1992)	Breisgau 87–89	school children	–			
Heinrich, et al. (1995)	Vorstudie Bitterfeld	5–14 years	+			
Wichmann, et al. (1995)	SW-Deutschland	8–16 years	+			
Helmert (1994)	Survey 84/86,87/88	25–69 years	–			
Helmert, et al. (1997)	DHP 1984–1991	25–69 years				–
Helmert, Shea (1994)	DHP 1984–1991	25–69 years	–			
Hoeltz, et al. (1990)	DHP 1984	25–69 years	–		–	

Index: Index combining education, occupation and income.  
 + Higher morbidity with higher socio-economic status,  
 – lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status

**Table 3.** Social inequality and the prevalence of bronchitis.

Author(s)	Croup		
	Brief description	Age group	Education
Wichmann, et al. (1991)	Duisburg	10 years	•
Wilde, et al. (1996)	Wittenbg./Dessau	5, 6 years	•
Wichmann, et al. (1990)	Pseudokruppstudie	5, 6 years	+
Heinrich, et al. (1995)	Vorstudie Bitterfeld	5–14 years	+
Heinrich, et al. (1998)	Bitterfeld-Studie	5–14 years	+

+ Higher morbidity with higher socio-economic status,  
 – lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status.

**Table 4.** Social inequality and the prevalence of croup.

of the parents, but they were confirmed by dermatological examinations<sup>7</sup>. After skin examinations the British Cohort Study also found a higher risk of atopic eczema in children from the higher social class<sup>24</sup>. With respect to adults no data on the class-specific prevalence of skin diseases are available.

**Malignant tumours:** With respect to cancer mortality which is independent from the cancer localization two ecological studies from Bremen and Bochum<sup>25,26</sup> both report a higher cancer mortality in those residential areas with an especially high percentage of persons from the lower social class (Table 6). However, it seems that the social dependency of the cancer mortality is mostly due to the

increased lung cancer mortality in the lower social class. When lung cancer cases are excluded from the analyses, no clear association with socio-economic status remains<sup>25</sup>. For men the ecological mortality study in Bremen reported a clear social class gradient with constantly decreasing standardized mortality rates from the lowest social class to the highest. Women from the higher social class reported the lowest mortality rate as well, however, a continuous trend was not visible<sup>26</sup>. Although the two mortality studies report inverse associations between the membership to a specific social class and the death rate from cancer, no clear associations with respect to the cancer morbidity are discernible from the results of the DHP-study<sup>27</sup>. Social inequality in cancer mortality is above all reflected by the mortality from lung cancer. This mortality is considerably higher in the lower social classes than in the higher social classes<sup>25,26,28,29</sup>. As no significant differences between morbidity and mortality exist for

Author(s)	Skin diseases (atopic eczema)		
	Brief description	Age group	Education
Wilde, et al. (1996)	Wittbg./Dessau	5, 6 years	+
Ministerium für Umwelt, Raumordnung und Land- wirtschaft des Landes Nordrhein-Westfalen (1990)	Rheinschiene Süd und Mitte	5, 6 years	+
Mutius von (1992)	Allergiestudie München	10 years	+
Krämer, et al. (1997)	several studies	5, 6 years	+
Schwartz, et al. (1993)	MORBUS	up to 8 years	+
Heinrich, et al. (1998)	Bitterfeld-Studie	5–14 years	+
Heinrich, et al. (1995)	Vorstudie Bitterfeld	5–14 years	+

+ Higher morbidity with higher socio-economic status,  
 – lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status.

**Table 5.** Social inequality and the prevalence of skin diseases.

Author(s)	Total malignant tumours		
	Brief description	Age group	Index
Stolpe, et al. (1994) <sup>a</sup>	Mortalitätsstudie Bochum	25–74 years	–
Tempel, Witzko (1994) <sup>a</sup>	Mortalitätsstudie Bremen	all age groups	–
Helmert, Shea (1994)	DHP 1984–1988	25–69 years	•
Helmert, et al. (1997)	DHP 1984–1991	25–69 years	•

Index: Index combining education, occupation and income.  
 + Higher morbidity with higher socio-economic status,  
 – lower morbidity with higher socio-economic status,  
 • no clear association with the socio-economic status,  
<sup>a</sup> ecological study.

**Table 6.** Social inequality and total malignant tumours.

this diagnostic group, the higher mortality rates cannot solely be explained by class-specific survival times. On the whole, the descriptive data as well as the mortality analyses from German study regions confirm the results of international studies, which unanimously reported an inverse association between lung cancer and social class<sup>30</sup>.

When evaluating the risk for leukaemia in relation to social class, no uniform tendency can be found

on the basis of the two results published in Germany<sup>26,31</sup>. No consistent results are found in the international epidemiological literature as well. Older ecological studies indicate a positive association between social class and disease risk, whereas more recent analytical studies confirm the increasing risk with decreasing social status which was found in the German case control study<sup>31</sup>.

Two case-control-studies regarding kidney carcinoma and urothelial

carcinoma in Bremen, West Berlin, Leverkusen, Halle/Merseburg and Jena<sup>32</sup> and in the region around the Rhine, the Neckar and the Odenwald<sup>33</sup> report an inverse association between social status and disease risk. Nutrition and occupational factors are discussed as possible explanations for the higher risk in the urban region; environmental factors of influence, however, are not discussed.

No studies for Germany could be found regarding the influence of

the social status on the disease risk for malignant melanoma. However, it can be assumed that the positive associations between the social class and the risk for melanoma found internationally<sup>34</sup> can be applied to German populations as well.

It is remarkable that the social class effect remains largely unchanged after controlling for known risk factors such as smoking or occupational exposures. These results indicate that the social class is a surrogate for independent risk factors for cancer which have not yet been examined. Strains arising from the environment may also belong to the factors of influence not yet examined, however, they have only rarely been taken into consideration in the present studies. Furthermore, social class is also a proxy-measure for exposure to hazards or for exposures to preventive factors. The reviewed empirical studies reflect the exposures to hazards and mostly ignore the exposure to preventive measures.

In summary, the distribution of environmentally-related diseases with regard to the socio-economic status presents a mixed picture (Table 7). On the one hand, certain malignant tumours are found more frequently in the lower social class. On the other hand, some environmentally-related diseases, such as allergies, eczema, croup, occur significantly more frequently in the higher social class, even though we assume that those people experience less exposure to ambient pollutants as compared with people from the lower social class. In addition to factors related to the way of life, indoor factors might play an important role as well.

Social inequality and environmental exposure

In environmental-epidemiological studies the effects of the exposure to harmful substances on health

	Children		Adults	
	West <sup>a</sup>	East <sup>b</sup>	West <sup>a</sup>	East <sup>b</sup>
Allergies	+	+	+	+
Respiratory diseases				
– bronchial asthma (as a whole)	•	+	•	•
– severe asthma	–			
– bronchitis	•	+	–	
– croup	+	+		
Skin diseases (eczema)	+	+		
Malignant tumours				
– total			–	
– lung cancer			–	
– kidney cancer, bladder cancer			–	–
– leukaemia, malignant lymphomas			–	

<sup>a</sup> West Germany, <sup>b</sup> East Germany.  
+ Higher morbidity with higher socio-economic status,  
– lower morbidity with higher socio-economic status,  
• no clear association with the socio-economic status.

Source: Empirical studies from West and East Germany: References listed in tables 1–6.

**Table 7.** Social inequality and environmentally-related diseases.

are the main focus. In this context social factors are sometimes reported on an accompanying basis as potential confounding factors. It is very rare, however, that their effects on the exposure to harmful substances are explicitly presented.

*Harmful substances in the ambient air:* The residential area – in rare cases the daily way to school along busy roads – is often taken as a surrogate for the exposure to harmful substances in the ambient air. Strains arising from the environment impair the health of a person but also a person's well-being and finally the attractiveness of the residential area. In particular in urban centres the land prices and the rent level depend on the local level of pollution. Therefore, persons with a low socio-economic status live more often than other persons along main streets, near industrial sites and more often in regions with a higher concentration

of harmful substances in the outside air<sup>7,35–37</sup>.

Apart from the harmful substances resulting from traffic, the exposure to harmful substances in the ambient air is always analysed by referring to the residential areas. In this context small residential areas are characterized by the concentration of harmful substances as well as by the percentage of residents from different social classes. Therefore, only data derived from ecological study approaches is available with respect to the association between indicators of social inequality and the exposure to harmful substances in the air. Such results are presented below for selected harmful substances in the ambient air.

Studies in the Ruhr region at the beginning of the 1970s showed that in the areas with high concentrations of SO<sub>2</sub> and particulates the percentage of blue-collar workers is considerably higher than in other

	School education of the parents				p-value
	8th grade	10 <sup>th</sup> –12 <sup>th</sup> grade	Degree from a technical college	Degree from a university	
<b>Children</b>					
n	28	244	153	63	
dust fall(mg/m <sup>2</sup> xd)	10.7	9.1	8.2	8.4	0.037
Pb (µg/m <sup>2</sup> xd)	1.8	1.2	1.1	0.9	0.001
Cd (µg/m <sup>2</sup> xd)	0.042	0.024	0.020	0.018	< 0.001
As (µg/m <sup>2</sup> xd)	0.042	0.024	0.021	0.018	< 0.001

Source: Hoting 1996.

**Table 8.** Geometric means for dust, lead, cadmium and arsenic deposits in relation to school education<sup>40</sup>.

areas<sup>35</sup>. This association was also confirmed for children in Hamburg<sup>36</sup>. The percentage of children from the lower social class entering school was higher in the residential areas with a higher concentration of harmful substances in the air as well. A higher strain on the children from the lower social class due to harmful substances in the air resulting from traffic in general – and in particular from nitrogen dioxide<sup>36–38</sup> can be assumed.

In the literature no results from German studies can be found with respect to the association between the exposure to diesel soot and social class. However, it can be assumed that the higher exposure to non-specific harmful substances resulting from traffic in the lower social classes also applies to the exposure to diesel soot. A summary of the class-specific differences in the exposure to harmful substances in the outside air can be seen in Table 10.

**Harmful substances indoors:** Differences between the social classes with respect to the concentration of harmful substances indoors could be a result of the higher concentration of harmful substances in the ambient air. As it can be assumed that persons belonging to a lower social class more often

live in residential areas with a higher concentration of harmful substances in the ambient air, the consequence – when taking into account constant penetration factors – is a higher concentration of harmful substances indoors as well. There is in general only few data available for Germany with regard to harmful substances indoors. Detailed analyses with respect to

the association between the social class and the concentration of harmful substances could not be found.

Results of the first German environmental survey<sup>39</sup> reported higher dust falls as well as a higher concentration of heavy metals in the house dust in the homes of blue-collar workers as compared with the homes of white-collar

	School education of the parents <sup>a</sup>			p-value
	≤ 8th grade	10th grade	12th grade	
	<b>n = 192</b>	<b>n = 1183</b>	<b>n = 1027</b>	
Busy road (> 50 motor vehicles/minute)	21.5 %	14.6 %	8.2 %	< 0.001
Central heating	31.8 %	47.9 %	59.5 %	< 0.001
Gas utilisation	64.5 %	50 %	45.2 %	< 0.001
Home is damp	16.3 %	8.5 %	4.8 %	< 0.001
Carpeting in children's room	44.3 %	64.0 %	68.7 %	< 0.001
Living space > 20 m <sup>2</sup> /Person	27.1 %	42.7 %	48.9 %	< 0.001

<sup>a</sup> Highest school education of father and mother.  
Source: Heinrich, et al. 1997.

**Table 9.** Housing conditions of children in East Germany in relation to the education of the parents (Bitterfeld-Studie).



workers. Indoor measurements in 488 homes in East Germany showed statistically significant higher dust falls and a higher concentration of heavy metals in those homes in which children lived whose parents had completed a lower school education (Table 8)<sup>40</sup>. The higher concentration of heavy metals in the house dust demonstrably leads to a higher corporal exposure from heavy metals<sup>41,42</sup>. An association between the social status and indoor allergens has not been demonstrated by empirical studies in Germany. However, as a result of the different housing con-

ditions of the social classes, differences in the exposure to indoor allergens can be expected. Furthermore, class-specific analyses with respect to volatile organic compounds, NO<sub>2</sub> and radon have not been published. An overview of the association between social inequality and harmful substances indoors can be seen in Table 9. The general living conditions of children, and consequently of adults as well, largely depend on the education of the parents. The homes of children whose parents concluded a lower school education are more frequently located

along busy roads, are more frequently heated by single ovens heated with coal, are more often equipped with gas cookers for cooking and are more frequently described as damp. The children's rooms of these homes are less frequently equipped with carpeting. The living space per person is significantly smaller (Table 9)<sup>7</sup>. Similar associations can also be demonstrated for children just entering school in North-Rhine Westphalia and Saxony-Anhalt<sup>6</sup>. A summary of the class-specific differences in exposures is presented in Table 10.

### Discussion and conclusions

A rather clear picture emerges with respect to the exposure to harmful substances in the ambient air as well as regarding harmful substances indoors: in the lower social class this exposure is considerably higher than in the higher social class. This association can be shown for children as well as for adults and can be found in West Germany as well as in East Germany. No such clear result is found with respect to environmentally-related diseases, though (Table 7). Malignant tumours of selected localisations (lung cancer, kidney cancer or bladder cancer) apparently occur more frequently in the lower social class than in the higher social class. As opposed to that association several studies consistently showed that allergies occur significantly less frequently in the lower social class than in the higher social class. A similar association also seems to exist with respect to eczema and croup. For the interpretation of the association between social inequality and differences in the exposure to harmful substances on the one hand and environmentally-related diseases on the other hand the following conceptionally different perspectives have to be taken into

	Children		Adults	
	West <sup>a</sup>	East <sup>b</sup>	West <sup>a</sup>	East <sup>b,e</sup>
Harmful substances in the ambient air				
– sulphur dioxide <sup>c</sup>	–	–	–	–
– particulates <sup>c</sup>	–	–	–	–
– nitrogendioxide <sup>c,d</sup>	–	–	–	–
– diesel soot <sup>c,d</sup>	–	–	–	–
Harmful substances indoors				
– dust	–	–	–	•
– heavy metals in the dust:				
– lead	–	–	–	•
– cadmium	–	–	–	•
– arsenic	–	–	–	•
Housing conditions				
– close to a busy road	–	–	–	–
– small living space per person	–	–	–	–
– lack of central heating	–	–	–	–
– heating/cooking with gas	–	–	–	–
– damp home	–	–	–	–
– carpeting	+	+	–	–

<sup>a</sup> West Germany.  
<sup>b</sup> East Germany.  
<sup>c</sup> An explicit proof for children is not available. However, as the social status of the children is defined through the parents, the association shown for the parents can be transferred to children as long as the sample surveys for adults include parents with young children.  
<sup>d</sup> Primarily resulting from road traffic.  
<sup>e</sup> Only women between 52 and 58 years.  
+ Higher exposure with higher socio-economic status,  
– lower exposure with higher socio-economic status,  
• no clear association with the socio-economic status.  
Source: Empirical studies from West and East Germany: Jarre 1975; Mielck 1985; Wjst, et al. 1993; Krause, et al. 1991; Hoting 1996; Heinrich, et al. 1998.

**Table 10.** Environmentally-related exposure and social inequality.

account. It can be assumed that persons belonging to the lower social class more frequently stay in regions and rooms with a relatively high concentration of harmful substances than persons belonging to a higher social class. Under an environmental perspective, however, it is important to distinguish between the construct “exposure” to “social class” and the potential pathophysiologic physical-chemical causes of disease inequality across social classes. It can be assumed that the condition of immunity could be different between the social classes. A further level of investigation may be to ask whether the association of environmental agents and health is different across social status, e.g., does air pollution have a stronger impact on socially deprived persons compared to affluent persons, given the same level of exposure. Results of a cross-sectional study in East Germany confirm differences between the social classes with respect to the situation regarding immunity reactions and the health of the respiratory tracts of children<sup>44</sup>. Presumably, frequent infections in early childhood result in a stimulation of the immune system and have a protective effect with respect to infections of the respiratory tracts taking a more serious course. It has been suggested that the stimulation of TH1 lymphocytes by infections and the resulting possible inhibition of the expansion of allergen-specific TH2 lymphocytes at a critical time during early childhood could explain the lower prevalence of allergies in the lower social class<sup>11</sup>. As a consequence it could be speculated that more infections in very early childhood – possibly caused by a higher exposure to environmental pollutants and several other co-factors – could stimulate the immune response and consequently protect against allergies in later life. This speculative interpretation is however not intended to mislead

about the fact that up to now we know little about the extent and the effects on health of the class-specific distribution of environmentally-related exposures and environmentally-related diseases. Furthermore, we know little about the effect modification of social inequality on environmental hazards or about the effect modification of environmental exposures on the impact of social inequality on diseases. In future environmental-epidemiological studies socio-epidemiological study approaches should be increasingly integrated and should be explicitly presented in the analysis. There is a great need for a closer co-operation between environmental epidemiologists and socio-epidemiologists in future research.

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## Zusammenfassung

### **Soziale Ungleichheit und umweltbedingte Erkrankungen in Deutschland: Review empirischer Ergebnisse**

*In einer Literaturrecherche wurden alle empirischen Arbeiten aus der Bundesrepublik bis Mitte 1997 gesucht, in denen Angaben über den Zusammenhang zwischen umweltbedingten Erkrankungen und sozioökonomischem Status (Bildung, Beruf, Einkommen, soziale Schicht) enthalten sind bzw. über den Zusammenhang zwischen Schadstoffexpositionen und sozioökonomischem Status. Bei den Expositionen zeigt sich ein klares Bild: die Schadstoffbelastungen in der Aussenluft und in der Wohnung sind in der unteren sozialen Schicht erheblich grösser als in der oberen, bei Kindern und bei Erwachsenen, sowohl in den alten als auch in den neuen Bundesländern. Bei den umweltbedingten Erkrankungen ergibt sich dagegen kein so klares Ergebnis. So weisen zum Beispiel mehrere Studien darauf hin, dass Allergien, atopisches Ekzem und Pseudokrampf in der unteren sozialen Schicht seltener auftreten als in der oberen. Bösartige Neubildungen (Lungenkrebs, Nieren- oder Blasenkrebs) sind in der unteren sozialen Schicht jedoch offenbar häufiger als in der oberen. Umweltepidemiologische Untersuchungen sollten verstärkt sozioepidemiologische Studienansätze integrieren und deren Ergebnisse explizit darstellen.*

**Résumé**

**Inégalité sociale et maladies liées à l'environnement**

Dans le cadre d'une recherche de littérature on a cherché toutes les études empiriques effectuées en Allemagne jusqu' à la mi-1997, contenant des données soit sur la relation entre les maladies liées à l'environnement et le statut socio-économique (instruction, métier, revenu, couche sociale), soit sur la relation entre les expositions aux polluants et le statut socio-économique. En ce qui concerne les expositions, une image claire apparaît: les concentrations de polluants dans l'air extérieur et dans l'habitation sont nettement plus importantes dans les couches sociales inférieures que dans les supérieures, chez les enfants comme chez les adultes, aussi bien en Allemagne de l'Ouest que dans celle de l'Est. Par contre, en ce qui concerne les maladies liées à l'environnement, l'image obtenue est moins claire. Plusieurs études par exemple indiquent que les allergies, l'eczéma atopique et le pseudo-croup apparaissent plus rarement dans la couche sociale inférieure que dans la supérieure. Les tumeurs malignes (cancer du poumon, cancer du rein ou de la vessie) sont toutefois manifestement plus fréquentes dans la couche sociale inférieure que dans la supérieure. Les études sur l'épidémiologie environnementale devraient intégrer davantage les approches socio-épidémiologiques et en exposer les résultats explicitement.

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