Health Effects of High Level Exposure to Traditional Pollutants in East Germany—Review and Ongoing Research

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In East Germany ambient air pollution is characterized by high concentrations of sulfur dioxide (SO\textsubscript{2}) and suspended particulates (SP). Since acidity and sulfate flow are surprisingly low, oxidation of SO\textsubscript{2} seems to be incomplete and neutralization seems to play an important role. Few studies on health effects of air pollution in the former German Democratic Republic have been performed. They showed an increased prevalence in polluted areas of respiratory symptoms, lung function decrement, mild anemia, nonspecific stimulation of the immune system and, retardation of skeletal maturation of children. Since the German unification in 1990, several large-scale studies have been started. Short-term effects of air pollution on daily mortality have been investigated in Erfurt retrospectively for 1980 to 1989. Logarithmic exposure-effect curves have been found for both SO\textsubscript{2} and SP. The number of deaths increased by about 10\% with SO\textsubscript{2} and by more than 20\% with SP if the 95th percentile of the pollutant is compared to the 5th percentile. The logarithmic shape shows that the increase of ambient concentrations at the beginning of the heating season in fall is more important than further increases in concentrations later in winter. A second study on short-term effects was conducted using daily peak flow measurements and respiratory symptoms in 270 patients with asthma and other obstructive airway diseases in East Germany and the Czech Republic between 1990 and 1992. From regression analysis it follows that an increase by 500 mg/m\textsuperscript{3} of SO\textsubscript{2} leads to a mean decrease of the average patient’s peak flow below 2\%. Three cross-sectional studies are in progress to compare the existing respiratory health status in East and West Germany. They consider about 9000 adults (20–44 years of age), 9000 school children (9–11 years of age) and 10,000 preschool children (age 6). Analysis is ongoing. Preliminary analyses show that respiratory symptoms like bronchitis, tonsillitis, recurrent colds, and chronic cough are reported more often in East than in West Germany. In contrast, prevalence of asthma, wheezing, hayfever, bronchial hyperresponsiveness and positive skin tests for common allergies is higher in West Germany. Total IgE (but not specific IgE) is clearly elevated in East Germany. To summarise the results, respiratory symptoms, lung function decrement and daily mortality are compatible with a possible influence of the "classical pollutants" SO\textsubscript{2} and SP. For asthma prevalence and atopic reactions other risk factors seem to be more relevant. Total IgE in East Germany seems to be related to crowded homes and may reflect specific chains of reinforcement. It should be of interest to follow the rapidly changing composition of ambient air (less SO\textsubscript{2} and particulates and more NO\textsubscript{x} and other automobile emissions) as well as improved insulation of homes to observe their effects on the health status of the East German population in the future. — Environ Health Perspect 103(Suppl 2):29-35 (1995)

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We present an overview of health effects of air pollution in East Germany based on ongoing and recently performed studies in the former German Democratic Republic (GDR; Figure 1). The overview is restricted to investigations addressing respiratory symptoms or diseases, lung function measurements, hematologic and immunologic parameters, and skin tests. Additionally, analyses of daily mortality and morbidity are included, since these also may show acute effects of "traditional pollutants" such as sulfur dioxide and particulates.

**Ambient Air Pollution in East Germany**

Ambient air pollution in East Germany is mainly characterized by high concentrations of suspended particulates (SP) and even higher concentrations of sulfur dioxide (SO\textsubscript{2}). Emission of SO\textsubscript{2} is caused to a large extent by the burning of brown coal with a high content of sulfur for heating and energy production. Compared to that in West Germany, the emission density of SO\textsubscript{2} in the former GDR was four times higher. The most polluted parts of the country are industrialized areas like the Triangle Leipzig, Halle, Bitterfeld but also cities like Erfurt and Weimar, where domestic heating plus unfavorable geography lead to frequent smog episodes.

For illustration, data on ambient air pollution are presented for Erfurt (Figure 2, Table 1). Erfurt is a city of 217,000 inhabitants, situated in a valley with frequent inversions. In the 1980s Erfurt had extremely high levels of air pollution caused by the fuel changeover to sulfur-rich brown coal as a consequence of the oil crisis. About 30 to 40\% of the homes are supplied by heat distributed by pipes to individual homes from a central power plant; the rest are supplied by single-room heating. The heating plants are close to the center of the city. From 1986 on, coal with lower sulfur content was used increasingly, resulting in reduced emissions of SO\textsubscript{2}. This was reinforced by mild winters. From 1990 on, a considerable part of heating was changed to natural gas, and the shutdown of many industries further reduced emissions. Parallel to this development, the composition of ambient pollution...
began to change because of the increase in automobile traffic.

Table 1 shows the situation for the years 1988 to 1992. Compared to the Ruhr area, which is the most polluted part of West Germany, SO$_2$ and SP levels were very high in Erfurt before 1990 and were reduced to less than 50% by 1992. In 1991 measurements of SO$_2$, SO$_2$$^2-$, H$,^+$, and PM$_{10}$ were performed (Table 2). Data from North America are available for the same period. Although SO$_2$ and PM$_{10}$ are higher in Erfurt, SO$_2$$^2-$ is comparable and H$^+$ is clearly lower compared to measurements obtained from the North American east coast.

Review of Epidemiologic Studies of the Effects of Air Pollution in the Former GDR

In the former GDR environmental pollution and its potential health risks were suppressed. This explains why only a few environmental studies exist. Since 1983 authors of publications were not allowed to mention the areas where the studies took place or to publish the concentrations of pollutants. Furthermore, many of the studies have limitations in epidemiologic design such that relevant factors may not have been controlled in the analysis.

The most extensive investigations took place from 1968 to 1988 in Bitterfeld, a highly industrialized and polluted area 150 km southwest of Berlin. In 1968 and 1969, 851 school children from this area were compared to 799 school children from control areas in Berlin and by the Baltic Sea, presumably areas with lower air pollution. Most of the spirometric lung function variables were worse in the polluted area (4).

In 1980 to 1983 a cohort comparison study was performed with school children 7 to 10 years of age from Bitterfeld and Rostock. The study started with 194 and 452 children, respectively (second grade), in 1980 and 1981 and was completed by 159 and 316 of these children, respectively (fourth grade), in 1982 and 1983. The children from Bitterfeld showed problems with foreign bodies in the eyes and an increased prevalence of conjunctivitis, both clearly caused by the extreme pollution by dust and large particles. Also rhinitis, cough, tonsillitis, and bronchitis occurred more frequently in Bitterfeld, suggesting chronic irritation of the airways. In a physical examination 80% of the children from Rostock had normal conjunctivae compared to only 10% from Bitterfeld. Similar results were found for tonsils and lymph nodes. In spirometric lung function tests, lower values for FEV$\text{I}$ and FVC were found in Bitterfeld. Hematologic and immunologic tests showed a reduced number of red blood cells (as well as hematocrit), a higher rate of phagocytosis, and more peripheral polymorphic granulocytes, which may be interpreted as an unspecific stimulation of the immune system. Enlarged titer of complements C3c and C4 and higher concentrations of IgA, IgG, and IgM point in the same direction (2,3).

In 1968 and 1978 to 1988 the skeletal maturation of 10-year-old boys from Bitterfeld was compared to those of control children (4,5). A retardation by 10 months was observed in 1968. Skeletal maturation improved parallel to the improvement of air quality but still was retarded by five months in the children investigated in 1988.

Forty-three children from an industrialized area (the place is not revealed but it is probably Bitterfeld) experienced holidays for 4 weeks in clean air. A detailed physical examination, spirometry, hematologic, and immunologic tests were performed at the

### Table 1. Sulfur dioxide (SO$_2$) and suspended particulates (SP) in Erfurt, East Germany, before and after German unification in 1990.

| Year | Erfurt | Ruhr$^a$ area |
|------|--------|--------------|
| 1988 | 217    | 33           |
| 1989 | 208    | 118          |
| 1990 | 90     | 151          |
| 1991 | 87     | 428          |
| 1992 | 62     | 151          |

$^a$For comparison, data from Essen, Ruhr area, West Germany. Data from Spix et al. (17) and Lahmann (34).

### Table 2. Comparison of SO$_2$ acid aerosols, and PM$_{10}$ in Erfurt and on the North American east and west coasts in 1991.$^b$

| Location | East Germany | North American west coast | North American east coast |
|----------|-------------|---------------------------|----------------------------|
| Erfurt   | 62.7        | 0.7                       | 26.9                       |
| Germany  | 9.7         | 0.6                       | 7.0                        |
| PM$_{10}$ | 8.9         | 7.4                       | 30.9                       |
| H$_2$SO$_4$ | 0.4        | 0.4                       | 1.5                        |
| PM$_{10}$ | 64.3        | 15.4                      | 34.4                       |

$^b$Data from Guttschmidt et al. (17) and Guttschmidt et al. (18). $^b$February to September 1991. $^b$January to December 1991.
beginning and end of the holidays. Lung function improved, the number of red cells increased, and in general a significant recovery was seen. The authors proposed to use this type of holiday as prophylaxis for children from polluted places (6, 7).

In the district of Halle, which includes Bitterfeld, 18,000 children between 5 and 18 years participated in a study of airway diseases (8). In Bitterfeld the prevalence of respiratory symptoms was twice as high as in cleaner areas. The prevalence decreased as the children aged, but this reduction was less clear in the highly polluted areas.

In Leipzig, environmental influences on total mortality and on the number of patients delivered by ambulance to hospitals have been investigated for 1981 to 1986 (9). After adjustment for season, both parameters showed a significant adverse influence of SO2.

A study in Rostock in 1987 dealt with irritants in homes (10). The investigation included 130 school children who had NO2 and formaldehyde measured in their bedrooms, schools, and kindergartens as well as in the ambient air. Older houses had higher concentrations of formaldehyde than newer buildings; the NO2 concentrations were comparable. Formic acid in urine, hematologic and immunologic parameters as well as lung function and clinical investigations showed no clear dependence, on levels of the pollutants.

Air Pollution and Daily Mortality

After unification of the two German states in 1990, it became possible to investigate in more detail the relationship between ambient air pollution and mortality in the past (measurements exist since the 1970s but from 1983 on were treated as secret). From the local health administration in Erfurt daily mortality and weekly case counts during influenza epidemics were made available for the years 1980 to 1989. Measurements of SO2, suspended particulates, and meteorologic data were provided by the Institute of Hygiene in Erfurt (11, 12). Poisson regression was used for the statistical analysis.

The best fit was found to be a logarithmic dependence of daily mortality of SO2 with a delay of two days and of suspended particulates on the same day. After adjustment for the other influences such as influenza epidemics and weather, mortality increases by about 10% between the 95th percentile and the 5th percentile of SO2 and by more than 20% over the same range of SP (Figure 3).

From the analysis of mortality data, it is known that smog episodes do not affect all individuals in the same way. Subjects already in poor health have a much higher risk of dying than others due to this additional stress. Therefore, typically one observes a decrease in numbers of deaths 1 to 2 weeks after an increase of mortality during a smog episode (13), showing that there is a limited pool of individuals at high risk dying somewhat earlier. This is called a "harvesting effect." We analyzed our data for this effect and found that the increase of mortality due to the same concentration of pollutant was smaller during periods when more people than usual had died on the days before. This indicates that the pool of high-risk individuals was depleted (Figure 4). This harvesting effect was even clearer for SP than for SO2.

The harvesting effect may explain the logarithmic dependence of mortality on SO2 and suspended particulates with the beginning of the heating season ambient air pollution moves from moderate concentrations in summer to high concentrations in fall. This leads to an increase in mortality and a reduction of the group of highly susceptible persons. From fall to winter the concentration of pollutants increases further from high to very high, but mortality only increases moderately because the pool of susceptibles is permanently depleted due to continuous stress. High pollution during fall and winter keeps this pool small, so that smog episodes in winter cannot show further effects on daily mortality counts. In spring, the pool of susceptibles recovers. In contrast, in areas with lower air pollution like West Germany, the pool of susceptibles is higher during winter. A smog episode can thus lead to a high increase in mortality.

This concept is supported by separate analysis each month, as reported by Spix et al. (11). The excess mortality is much higher in September and October and in April and May (about 2% per 100 mg/m3 SO2) than in December and January (10.4% per 100 mg/m3 SO2, calculated from Spix et al. (11)) and reported in Table 3 here. It may explain not only the logarithmic exposure–effect curve but also the surprising observation that during the smog episode in January 1985 an effect on mortality was observed in West Germany (13) but not in Erfurt (11, 12). In West Germany (Ruhr area, Köln, Düsseldorf) the daily average of SO2 increased from ca. 50 to ca. 800 mg/m3, followed by an increase in mortality of 8%. In Erfurt, however, with an increase from ca. 1000 to 2900 mg/m3, no observable alteration of mortality occurred.

Effects on Daily Peak-flow and Respiratory Illness

A prospective longitudinal study was carried out to investigate short-term effects of air pollution on children and adults with chronic airway diseases in two cities of the former GDR (Erfurt and Weimar) and in the Czech Republic (Sokolov).

| Table 3. Current studies on short-term effects of pollution in East Germany |
|---------------------------------------------------------------|
| Spix, Heinrich, Wichmann 1980–1989: daily mortality in Erfurt. |
| Logarithmically shaped dependence on SP (more important) and SO2. |
| Stronger influence in fall and spring compared to winter (harvesting effect?) |
| Luttmann, Goldstein, Spengler, Heinrich, Wichmann 1990–1992: daily peak flow, symptoms in asthmatics in Erfurt, Weimar, Sokolov. |
| Only small decrease of peak flow and increase of symptoms with SP and SO2. |
Data collection began in September 1990 and lasted until June 1992. A total of 110 adults between ages 40 and 70 with asthma or other obstructive airway diseases and 160 children with asthma between 6 and 13 years of age were included in the study (14,15).

They completed diaries in which they recorded the readings of their miniwirright peak-flow meter two or three times a day each before and 10 min after medication intake. In addition, detailed questions about medication intake and daily symptoms—which included cough, phlegm, and breathing problems—were entered into the diary.

Ambient air pollutants and meteorologic parameters were measured at local monitoring stations for the entire study period. Additionally, measuring stations were set up in Erfurt and Sokolov to measure PM10, H+, and SO42-. This was done in cooperation with the Harvard School of Public Health (16–18).

Each individual time series was analyzed in a linear regression with respect to influences such as medication, previous day's condition, meteorologic parameters, and air pollution measurements. The individual parameters were then pooled. In a preliminary analysis the data were separated for the two winter periods in Erfurt, Weimar, and Sokolov and broken down by adults and children. An increase of 500 mg/m3 of SO2 leads to a mean decrease of the patient's peak-flow below 2% (15).

Comparison between East and West Germany

Epidemiologic studies comparing the health status in East and West Germany have been performed by three working groups and have addressed respiratory illness, lung function, asthma, and allergic reactions.

As part of the EC Respiratory Health Survey, Hamburg and Erfurt have been compared (19,20). In either city a screening questionnaire on respiratory symptoms was mailed to 4500 (Hamburg) and 4950 (Erfurt) randomly selected subjects between the ages of 20 and 44. The investigations started in October 1991 with a first mailing, two reminding letters, phone calls, and home visits to nonresponders. As of October 1992, response rates of 80% in Hamburg and 73% in Erfurt were obtained. Table 4 shows that the prevalence of asthma and nasal allergies is lower in Erfurt than in Hamburg. This result, however, may be influenced by differences in diagnostic practices of physicians in East and West Germany. Comparing prevalences of symptoms is more appropriate, showing all asthma-specific symptoms to be less frequent in Erfurt. In the second stage of the study, the relationship between variables will be analyzed using more detailed questionnaires as well as objective measures of lung function and of atopic status.

In 1991, a study with 4376 6-year-old children was performed in Leipzig, Halle, Magdeburg, and rural parts of East Germany. The information from questionnaires was compared to that from 5574 children who participated in 1988 in a similar study in Köln, Düsseldorf and a control area in West Germany (21). Higher prevalences of chronic cough, recurrent cold, tonsillitis, and bronchitis, and slightly lower prevalences for asthma and hay fever were observed in East Germany than in West Germany. The comparison between polluted and control areas was less consistent, indicating more respiratory symptoms and asthma in the polluted parts within both East and West Germany.

The same study from East Germany was compared with a further investigation of 1530 children that took place 1991 in the Ruhr area (Duisburg, Essen) and a control area in West Germany. For a total of 2054 children, data on allergic sensitization and IgE formation have been collected (22). Sensitization against common allergens, as determined in sera by RAST, in total showed no difference between East and West German children, whereas sensitization as measured by skin-prick testing was lower in East Germany (22). In contrast, total IgE in East Germany was 2.5 times higher than in West Germany. The more detailed analysis of the latter observation showed a strong influence of parent-reported worm infections and of number of persons per dwelling. Furthermore, multiple regression analysis revealed a positive association between elevated total IgE levels and the air pollutants SO2 and dust fall (22).

In 1991, 1429 children ages 9 to 11 participated in a study in Leipzig. The results are compared with those of a similar study on 7445 children that took place in 1989 to 1990 in München (23). Main outcome measures were prevalence of asthma and allergic disorders and bronchial hyperresponsiveness assessed by cold air inhalation challenge. Prevalence of asthma, bronchial hyperresponsiveness, and positive skin-prick testing was slightly lower, hay fever was clearly lower and wheezing was slightly higher in Leipzig compared to München. On the other hand, bronchitis was higher in Leipzig (23).

Discussion

Traditional air pollutants such as sulfur dioxide and suspended particulates played an important role in East Germany. Due to the use of brown coal with high sulfur content, the former GDR had the highest SO2 emission per person in the world (24). Therefore, in several cities with unfavorable geographic and meteorologic conditions, extremely high SO2 peaks occurred during smog episodes. These extreme conditions have changed significantly since the end of the 1980s for several reasons and the situation is approaching that in West Germany.

Data for acid aerosols, PM10, and H+ were collected at two sites in Erfurt and Sokolov from October 1990 to June 1992 (17,18). Low sulfate concentrations and acidity were measured, which is surprising considering the high SO2 concentrations. Obviously the SO2 oxidation to SO42- was incomplete, adsorption from SO2 on solid soot particles, SO2 deposition, the short time between emission, and sampling or the inhibition or absence of catalytic heavy metals have contributed to the reduced

| Symptoms                                    | Hamburg | Erfurt |
|---------------------------------------------|---------|--------|
| n = 4500                                    |         |        |
| Wheezing, whistling                         | 20.7    | 13.7   |
| Breathlessness with wheezing                | 8.0     | 5.1    |
| Wheezing, whistling without cold            | 13.2    | 7.4    |
| Woke up with chest tightness                | 9.6     | 9.2    |
| Woke up because of shortness of breath      | 5.0     | 4.4    |
| Woke up because of attacks of coughing      | 26.7    | 20.1   |
| Asthma attack                               | 3.0     | 1.3    |
| Current medication for asthma               | 3.4     | 1.6    |
| Nasal allergies, hay fever                  | 22.8    | 13.2   |

*These results are from a local analysis of data collected for the European Community Respiratory Health Survey.

*Prevalence within the last year. Any final international comparison may use a different form of analysis.

Table 4. Comparison of respiratory symptoms in Hamburg, West Germany, and Erfurt, East Germany, as part of the EC Respiratory Health Survey (17,20).
local oxidation rate. The acidity was most likely neutralized by ammonia (18).

Health effects of air pollution have been observed in several studies in the former GDR, although only a limited number of environmental studies are available. In agreement with studies from the 1960s and 1970s in western Europe (25), increased prevalence of respiratory symptoms and lung function decrements were observed, together with parameters that showed mild anemia, unspecific immunologic stimulation, and retardation in parameters of the development of children (Table 5).

After German unification, it became possible to perform larger epidemiologic studies on health effects of air pollution in East Germany (26–28). Short-term effects of SO2 and particulates could be investigated in detail using recent data on daily mortality in Erfurt (11,12). The data show a clear and significant increase of mortality on days with high pollution. Furthermore, they indicate that the beginning of the heating season in the fall may be more relevant than high concentrations later in the winter. Particulate matter seems to be a better indicator for air pollution effects on mortality than SO2, as found in other studies (29,30). However, the effects are smaller than expected.

Short-term effects on daily morbidity have been investigated for children and adults with asthma or other obstructive airway diseases in Erfurt, Weimar (East Germany), and Sokolov (Czech Republic). On average, only a small decrease in peak flow values and an increase of daily symptoms with increasing concentrations of SO2 and SP occurred. This is in agreement with similar investigations from Leipzig and Magdeburg in East Germany (31), while during two very mild winters in West Germany (Düsseldorf, the Ruhr area, and a control area), no effects of SP and SO2 could be observed (32). In an earlier study on short-term effects of acute respiratory illness in five West German communities, an increase of daily cases of group syndrome was associated with SP and NO2 but not with SO2 (33).

On the basis of three large cross-sectional studies with approximately 9000 adults (20–44 years of age) in Erfurt and Hamburg, 9000 school children (9–11 years of age) in Leipzig and München, and about 10,000 preschool children (6 years of age) in several polluted and control places, a comparison of the prevalence of respiratory symptoms and allergic disorders between East and West Germany was carried out (19–23). For respiratory symptoms like bronchitis, tonsillitis, recurrent cold, and chronic cough, higher prevalences were observed in East Germany (Table 6). This finding is consistent with the information from western Europe and the United States, where 20 to 30 years ago comparable concentrations of SO2 and SP occurred (25,35). In the Harvard study of six cities, a correlation between particulates, bronchitis, and chronic cough also has been reported (36).

On the other hand, prevalence of asthma and wheezing is not higher but lower in East Germany. This information, based on questionnaires, is supported by lung-function measurements after cold-air challenge shows slightly lower levels of bronchial hyperresponsiveness in East Germany. From other studies there is also no indication of strong influences of SO2 and SP on asthma prevalence. In 21,000 preschool children of five West German cities, no correlation between SO2, SP, and asthma prevalence was found (37), as in the six-city study (36). In contrast, an association between automobile exhausts and asthma prevalence (37,38) or bronchial hyperresponsiveness (39,40) has been described. Ambient concentrations of automobile exhausts are higher in West Germany than in East Germany and within East Germany

### Table 5. Review of air pollution epidemiology in the former GDR

| Condition | Description | Study |
|-----------|-------------|-------|
| Bronchitis | Chronic cough | Thielebeule, Hülse, Peich, 1968, 1970–1988, 1991: Children in Bitterfeld vs Rostock, Wismar |
| Tonsillitis | Recurrent cold |  
| Asthma | Slightly higher |  
|惠气 | Slightly lower |  
| Wheezing | Clearly lower |  
| Hay Fever | Lower |  
| Bronchial hyperresponsiveness | Slightly lower |  
| Positive skin test | Slightly lower |  
| Positive RAST | Equal |  
| Total IgE | Clearly higher |  

### Table 6. Comparison of respiratory and allergic symptoms in East and West Germany—interim summary of current studies.

| Symptom | Prevalence in East vs West Germany | Age group | Source |
|---------|-----------------------------------|-----------|--------|
| Bronchitis, chronic cough | Higher | School children | von Mutius et al. (23)f |
| Tonsillitis, recurrent cold | Higher | Preschool children | Krämer et al. (21)f |
| Asthma | Clearly lower | Adults | Nowack et al. (19)f |
| | Slightly lower | School children | Nowack et al. (19)f |
| | Slightly lower | Preschool children | Krämer et al. (21)f |
| | Equal | Preschool children | Behrendt et al. (22)f |
|惠气 | Clearly lower | Adults | Nowack et al. (19)f |
| | Slightly higher | School children | von Mutius et al. (23)f |
| Hay Fever | Lower | Adults | Nowack et al. (19)f |
| | Clearly lower | School children | von Mutius et al. (23)f |
| | Slightly lower | Preschool children | Krämer et al. (21)f |
| Bronchial hyperresponsiveness | Slightly lower | School children | von Mutius et al. (23)f |
| Positive skin test | Slightly lower | School children | von Mutius et al. (23)f |
| | Slightly lower | Preschool children | Behrendt et al. (22)f |
| Positive RAST | Equal | Preschool children | Behrendt et al. (22)f |

*Preschool children (6 years of age): 4376 from Leipzig, Halle, Magdeburg, Salzwedel, Gardelegen, Osterburg, East Germany, investigated in February and March 1991 and 5574 children from Düsseldorf, Dormagen, Leverkusen, Köln-Zentrum, Köln-Süd, Borken, West Germany, investigated from April to July 1988 (only questionnaires analyzed). *Preschool children (6 years of age): 1876 children from Leipzig, Halle, Magdeburg, Salzwedel, Gardelegen, Osterburg, East Germany, investigated in February and March 1991 and 1530 children from Duisburg, Essen, Borken, West Germany, investigated in April and May 1991. *School children (9–11 years of age): 1429 children from Leipzig, East Germany, investigated from January to June 1991 and 7445 children from München, West Germany, investigated from September 1989 to July 1990. *1050 adults from Erfurt, East Germany, investigated from September 1991 to November 1992 and 4500 adults from Hamburg, West Germany, investigated from September 1991 to November 1992 (only questionnaires analyzed). The numbers represent the invited subjects; the response rate for questionnaires in all studies was between 73 and 91%.
higher in the big cities. However, it seems unlikely that the higher prevalence of asthma and asthma symptoms, the allergic sensitization, and hyperresponsiveness all are due to automobile exhausts. Other conditions related to western lifestyle also have to be considered, as already has been proposed (23).

The high concentrations of total IgE in the serum of children from East Germany seem to be caused at least in part by parasitic reinficentions. These could be influenced by the public child care system in the former GDR and by crowded homes (22). A further cause for the high total IgE might be common colds and infectious diseases in early childhood.

With respect to the future development in East Germany, one may expect that the primary emission of SO₂ and particulates due to heavy metal industry, power plants, and domestic heating will remain higher than in West Germany for a couple of years. However, they have already decreased due to structural changes and will decrease further. On the other hand, one may expect an increase of pollutants due to automobile traffic in East Germany, as NOₓ and hydrocarbons, since the number of cars is increasing. Secondary formation of ozone may also play a more important role.

Important changes can be expected in the indoor environment as well. Due to better insulation of homes because of energy conservation measures, an increase of the concentrations of all pollutants emitted in the home is likely. On the other hand, pollutants coming from outside into the home may be reduced. How these changes will influence the health status of the population in the future needs to be explored.

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