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SOCIOECONOMIC CHANGES AND THEIR HEALTH IMPACT ON CHILDREN IN GERMANY AFTER RE-UNIFICATION

Dissertation

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CONTENT

“A man would never undertake great things, could he be amused with small.„
(James Boswell)

1 INTRODUCTION

1.1 Overview of the literature

“Poverty makes you sick. Sickness makes you poor” (Mielck 1998). Since the nineteenth century has been known that there is a relation between social class and health status (Krämer 1997). In Europe, the great majority of studies in the fields of inequalities in health and illness have been conducted in Great Britain and Scadinavia (Helmert 1994). Low childhood socioeconomic status (SES) has been reported to be a risky factor for mortality (Nystrom 1994; Vagero 1994; Davey-Smith 1997; Davey-Smith 2001) primarily resulting from cardiovascular disease (Davey-Smith 1998; Heslop 2001; Frankel 1999), but also from respiratory disease and stroke, and stomach and lung cancer (Davey-Smith 1998).

Data from Germany demostrate that there are important differences in morbidity and mortality by education, occupation and income (Mielck 1994). Most of the studies are based on data from West Germany, but the available studies from Eastern Germany show very similar results. Concerning differences by education, the studies have shown, for example, that the prevalence of less than good health (Mielck 1994), the prevalence of cardiovascular disease and the restrictions of daily activities due to poor health (Kunst 1995) are increasing and that life expectancy (Klein 1996) is decreasing with decreasing educational status. A number of studies have been conducted in Germany which used a combined index of education, occupation and income in order to define different “social strata”. These studies show, for example, that for adults the prevalence less than good health, of myocardial infarction and stroke, of diabetes (Helmert 1994) is increasing with decreasing social stratum, and that a very similar association between social strata and morbidity is found for children as well. (Klocke) There is sufficient empirical information to support the statement that important health inequalities exist in Germany, that mortality and morbidity increase with decreasing social status, in the West as well as in the East. (Mielck 1998) Little is known about the distribution of health parameters in general and atopic diseases in particular in the different social categories in population of the formerly communist countries of Eastern Europe. Studies performed shoutly after the collapse of the communist system revealed that prevalence rates for atopic disease and allergic sensitization in children and young adults in Eastern European countries were substantially lower than those observed in Western Europe.

It has been potulated that factors associated with Western lifestyle may be responsible for the differences in these ethnically similar populations. (Heinrich 1998)

In recognition of the importance of social inequalities in health, the World Health Organization (WHO) has set a special goal of reducing these inequalities in its global program 'Health for all in the Year 2000. (WHO 1985).

1.2 Measures of socioeconomic status (SES)

Socioeconomic status (SES) reflects an individual's position within a social system of hierarchy. (Adler 1994) The most common measures of SES include income, education, or occupation. However, measures of SES can vary substantially. Income is the most widely used indicator of a family's financial resources, but other measures include car or home ownership, house crowding, and welfare status. Each of the SES indicators, although interrelated, taps different aspects of a person's social position. For example, income relates to the resources or spending power a family has accumulated, occupation relates to a person's prestige in society, and education relates to a person's skill in acquiring economic resources and knowledge about health. (Winkleby 1992) Education is the most stable of these measures, whereas income is probably the most fluctuating. (Williams 1995)

People are unequal. Some have a more advantaged position in society than others. These differences between people can be usually portrayed as a social stratification system. People occupy a position in that system according to their (partner's) job, their educational achievement, and their income level or standard of living. These three socioeconomic factors are generally regarded as the core indicators of the people's position in the social stratification system. That position is usually referred to as socioeconomic status (SES). The term social class could be applied when occupation is used as the core indicator; it refers to groups of people with a similar position in the labor market. (Kunst 1997)

1.3 Relationship between SES and health in children

To determine the nature of the relationship between SES and health in children, we searched through the Medline database and used the ancestry method to identify that included health outcomes among individuals ranging in age from 0 to 18 years of age. Our Medline search used the following search terms for SES: socioeconomic status, social class, education, occupation, income, and poverty. The following terms were searched for health: health, disease, mortality, and morbidity.

When mortality rates are broken down by specific causes, similar relationships with SES are found. Children from lower SES backgrounds are more likely to die from chronic conditions such as asthma and other respiratory disorders. (Vagero 1989) Low SES also is associated with increased mortality rates from less common chronic conditions such as cancers, and heart disease. (Nelson 1992)

Across all chronic conditions, low SES children are more functionally impaired than high SES children. Children's degree of limitation from chronic health conditions and school absences increases in a monotonic fashion with decreasing family income in the United States. (Aber 1997) A higher percentage of U.S. children living in poverty have severe chronic conditions and have to be hospitalized because of these conditions. (Newacheck 1994)

With respect to specific chronic conditions, there is evidence from an US study (Crain 1994) for an SES effect. Education, income, and occupation-based measures of SES are all negatively associated with increased prevalence of asthma, wheezing, and chronic night coughing, with some studies documenting a monotonic effect. Lower SES, whether defined by income or occupation, is also associated in a monotonic fashion with asthma severity outcomes, such as hospitalizations and frequent, limiting asthma attacks, which was repoted in New York city. (Claudio 1999)

Poor children suffer from higher prevalence rates of other chronic conditions as well. Increased number of vision and hearing disorder has been associated with lower average neighborhood income and greater crowding in the house. (Dutton 1985) Low family income

is also associated in a monotonic fashion with higher blood lead levels in children. (Egbuonu 1982)

With respect to acute childhood conditions, families living in more crowded houses are more likely to have infants with infectious disease. Poor children have higher rates of rheumatic fever, and parasitic disease than no poor children. In addition, children from poor families miss more days of school and spend more days in bed as a result of these acute illnesses. Children from lower social classes also report more school absences as a result of upper respiratory or ear infections. Low SES, whether defined by education, income, or occupation, also is associated with higher injury rates.

As family income decreases, U.S. children are less likely to be seen by a doctor and more likely to be seen in emergency department and hospitalized, with patterns revealing a monotonic effect. (Aber 1997; Egbuonu 1982) For each $10,000 decrease in median household income, there is a 9% increase in emergency pediatric intensive care unit admissions. (Chen 2002) Although this in part reflects more severe health problems among low SES children, it also reflects access to and decisions about health care, whereby low SES families are less likely to have health insurance, less likely to have regular contact with a physician, and more likely to seek care in emergency rooms.(Chen 2002)

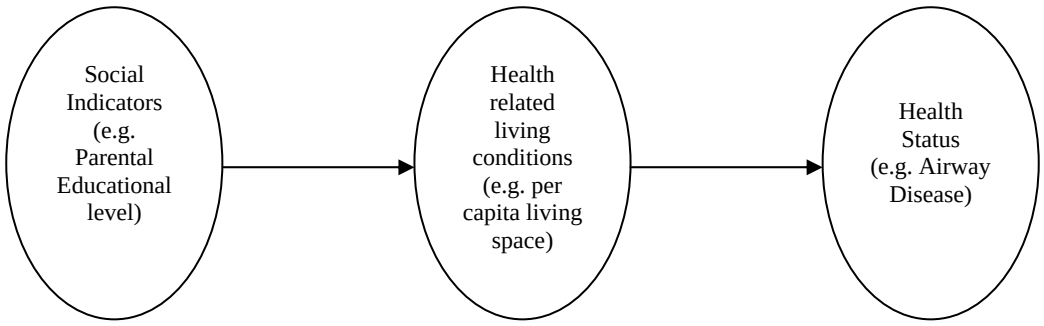
SES also affects health behaviors. Low SES is associated with increased rates of cigarette smoking, greater exposure to tobacco smoke, and more sedentary lifestyle. Although there are substantial data supporting the association of lower SES with increasing health problems, this relationship has not been uniformly documented. In fact, reverse associations of SES and health have been found for a few childhood health problems. Several studies outside the USA have found that prevalence rates of asthma are higher among children whose parents have higher SES. (Chen 2002)

More recently, differences in health outcomes by socioeconomic position have been recognized as a persisting, and perhaps even increasing public health problem. In a number of longitudinal studies, important SES indicators, such as income and education, have been shown to be inversely associated with various mortality outcomes, including premature mortality, cardiovascular mortality, and death from all causes. (Lantz 1998)

With a few notable exception the pattern of distribution can be described as an inverse relationship between SES and health: the higher the SES the lower the risk of morbidity and mortality form chronic disease. (Siegrist 1995). Thus, the question is not why people at the bottom of society have worse health than others but why social differentials in chronic disease are spread across the whole society. The large bulk of empirical evidence so far is derived from economically advanced western societies. These observations underscore the relevance of the problem in terms of international public health. SES is associated with environmental quality and environmental quality affects health.

Therefore, it can be hypothesised that there is a causal pathway from social status via living conditions to health status which can at least partly explain the association between SES and health outcome (Figure 1).

Figure1: **Relationship between social indicators, individual living conditions and health status of 6-year-old children in Germany between 1991 and 2000**



2 QUESTIONS

To obtain more insight into the relationship between socioeconomic status (SES) and health status of a population in Germany, the present study was set up. The purpose of this study was to examine social class differences in relation with health status of 6-year-old children by using the SES indicator-parental education and by comparision between East and West Germany after re-unification.

Specifically, the following issues were addressed:

1. What kind of relationship exists between SES and health status in the population under study?
2. How do individual living conditions influence the relationship between SES and health status in this population?
3. And how about the time trend of changing from 1991 to 2000?

It was hypothesized that:

1. Lower SES parnetal respondents would report less good health status than higher SES respondents. These status differences were hypothesized to explain in part the ability of SES to predict the prevalence and at “risk” of lifestyle.
2. When individual living condition variables were included into the study, the associations between SES and health status would be changed in a way partly explaining the associations.

The findings are important for two reasons:

First, they will contribute to the existing empirical literatures in this area. Although a number of studies have been published elsewhere, research on this subject, specially of children is much more scarce in Germany.

Second, if certain groups have poor health status for social or economic reasons, health policy should address these issues.

3 METHODS

3.1 SAWO Study

The data for our study are derived from an environmental epidemiological study, namely **S**chul**a**nfängerstudie in **W**est- und **O**stdeutschland (SAWO), organized by the Medical Institute for Environmental Hygiene, Duesseldorf, and the District Hygiene Institute of Magdeburg. The purpose of this study was to investigate the health outcomes of school beginners influenced by air pollution from 1991 to 2000. (Krämer 1999) In both parts of Germany, large industrialized cities (in East Germany: Leipzig, Halle, Merseburg, Magdeburg; in West Germany: Duisburg, Essen, Köln) as well as small rural towns (in East Germany: Salzwedel, Gardelegen, Osterburg, Klötze; in West Germany: Borken) were included as study areas.

Figure 2 Map of Germany (East and West) with the locations of SAWO study regions

3.2 Data collection

Leipzig is one of the largest cities in Saxony with about 492,000 inhabitants. The specific study area (South-West Leipzig) was characterized by old dilapidated housing close to small-scale industry. Halle is an industrialized city in Saxony-Anhalt with 238,000 inhabitants. Magdeburg, with about 236,000 inhabitants, is the capital of Saxony-Anhalt. The rural areas used as reference in the environmental study are the small towns Salzwedel, Gardelegen, Osterburg and Klötze in the Altmark in East Germany.

The areas in Nordrein-Westfalen were suggested by the clean-air plans (Luftreinhaltepläne) of that state. They are parts of Duisburg (with about 501,000 inhabitants), Essen (with about 585,000 inhabitants), Gelsenkirchen (with about 270,000 inhabitants), Dortmund (with about 588,000 inhabitants) which are industrialized cities in the Ruhr area and Boken which is a small district capital north of the Ruhr area.

Since 1991 cross-sectional investigations have been repeated every year until 2000 in East Germany and every third year in West Germany. During the ten-year period, altogether 33,442 6-year-old children, 24,624 from East Germany (response 83%) and 8,818 from West Germany (response 71%), participated in the environmental study. All boys and girls entering the elementary school from 1991 to 2000 and living in the geographically defined areas of Germany were eligible to participate. A letter was mailed to the parents asking for participation of the child and for completion of a questionnaire at home, to be checked by a physician on the day of the medical examination immediately following the health check-up compulsory for all first graders. Written consent of the parents of the examined children was requested. 99.2% of the children in the study (51.2% boys and 48.8% girls) had the German nationality. The ethical committee of the Medical Association of Saxony-Anhalt approved the study.

4 PUPLICATIONS

The results of the study are present in three papers.

4.1 Changes in social inequality with respect to health-related living conditions of 6-year-old children in East Germany after re-unification.

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Research article

Changes in social inequality with respect to health-related living conditions of 6-year-old children in East Germany after re-unification

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Abstract

Background: Since Germany re-unified in 1990, substantial social and economic changes have happened in East Germany, the former socialist German Democratic Republic (GDR). The aim of this study was to investigate the influence of these socio-economic changes in East Germany on the association between social status, measured by parental educational level, and health-related living conditions of children during the ten-year period after re-unification.

Methods: In total, 25,864 6-year-old school beginner children (51.2% male and 48.8% female) participated in cross-sectional studies which have been repeated every year from 1991 to 2000 in East Germany. Parental educational level as a social indicator was the independent variable. Dependent variables included not employed parents, small living space and health-related living conditions (e. g. damp housing, single oven heating and living at busy road). The relationships were described by odds ratios using logistic regression.

Results: A large overall effect of parental educational level on health-related living conditions was observed. The time trends showed that the situation regarding small living space, damp housing conditions and single oven heating improved from 1991 to 2000, while regarding not employed parents (1996–2000) and living at busy road (1991–2000) did not, but even deteriorated. 6-year old children with low parental educational level, who lived at the time of re-unification, were often under damp housing conditions and with single oven heating at homes. Nevertheless, this social inequality has almost vanished ten years later. In contrast, we found an increasing gap between low and high parental educational level with respect to the proportion of parents who were not employed (22%: 4% gain), or lived under cramped housing conditions (22%: 37% reduction), or close to a busy road (7% gain: 2% reduction).

Conclusion: The social inequalities which already existed under the socialist system in East Germany persisted in the system of social market economy between 1991 and 2000. 6-year-old children from families with the lowest social status were living under the worst domestic conditions (e. g. living at busy road, having damp housing conditions, single oven heating and small living space) and for some conditions (e. g. living at busy road and having small living space) the gap betweenlow and high social status was even bigger in 2000 than in 1991.

Background

At the turn of the 21st century, social inequalities in health continue to be a key public health problem in advanced societies, including European countries [1]. With regard to mortality, mean difference in life expectancy between those at the top and at the bottom of a society, as defined by education, income and employment status, are anywhere from 4 to 10 years [1]. In recognition of the importance of social inequalities in health, the World Health Organization (WHO) has set a special goal of reducing these inequalities in its global program 'Health for all in the Year 2000' [2,3]. Improved living conditions have contributed to better health and a decrease in death rates across all classes in developed countries [4]. Ecological studies suggest that living areas which are highly contaminated with air pollutants are over-proportionately inhabited by people of lower socioeconomic status [5]. Studies done immediately after the German re-unification [5,6] demonstrated that social inequalities in health-related living conditions already existed under the social system in East Germany. In both parts of Germany children of the lower class were more likely to live at busy streets and were therefore exposed to a greater degree to traffic-related air pollution and a higher noise level [5]. Dwellings of people of lower social class were more likely to be located near industrial areas, and there was less room per person in the houses [5]. Gas was used more frequently for cooking and warm water supply, and finally the dwellings were more frequently heated with individual coal-burning stoves than upper class dwellings [5].

After Germany re-unified in 1990, dramatic social, economic and environmental changes happened during the first decade in East Germany, the former socialist GDR. The aim of this study was to test the hypothesis that the changes in East Germany had influenced social inequality in health-related living conditions of 6-year-old children during the ten-year period starting a few months after the German re-unification in 1990. This investigation has not been done before.

Methods

Study areas

The data for our study are derived from an environmental epidemiological study, organized by the Medical Institute for Environmental Hygiene Duesseldorf and the District Hygiene Institute of Magdeburg. The purpose of this study was to investigate the health outcomes of school beginners influenced by air pollution from 1991 to 2000 [7]. The study was conducted in the cities of Leipzig, Halle, Magdeburg, and several small rural towns. Leipzig is one of the largest cities (with about 492,000 inhabitants) in Saxony. The specific study area (South-West Leipzig) is characterized by old dilapidated housing close to small-scale industry. Halle is an industrialized city in Saxony-Anhalt with 238,000 inhabitants. Magdeburg, with about 236,000 inhabitants, is the capital of Saxony-Anhalt. The rural areas used as reference in the environmental study are the small towns Salzwedel, Gardelegen, Osterburg and Kloetze in the Altmark.

Study design and data collection

Since 1991 cross-sectional investigations have been repeated every year until 2000 in East Germany. All boys and girls entering the elementary school from 1991 to 2000 and living in the geographically defined areas of East Germany were eligible to participate. A letter was mailed to the parents asking for participation of the child and for completion of a questionnaire at home. Written consent of the parents of the examined children was requested. During the ten-year period, altogether 25,864 6-year-old children (response 83%) participated in the environmental study. 99.2% of the children in the study (51.2% boys and 48.8% girls) had the German nationality. Every third year the questionnaire investigation was extended to cover the whole city area of Halle, Magdeburg and Salzwedel.

Measures

Parental educational level

The main social indicator for this study is the parental educational level. Parental respondents reported their education and the education of their current partner if applicable. These responses served as the basis for calculating the educational level of the most highly educated parent of a child. Parental educational level was classified into three categories by the highest school grade (years) completed by either the mother or the father as follows: less than 10 years = 'low'; 10 years = 'middle'; more than 10 years = 'high' [8].

Parental employment status

Parental employment status was classified into two categories: mother and/or father 'in paid employment' (including full-time and part-time jobs) and 'not in paid employment' (including those parents who were not in the paid labour force, i.e. the income of the child's household was not based on regular paid labour). In the following, we will shortly refer to 'not in paid employment' as 'not employed'. The data on employment of both mother and father were only available from 1996 to 2000 for this study, because the information on employment status was not asked for before 1996.

Living space

We have also asked for the number of persons living in the children's homes and for the dimensions of the homes. The questions were "How many people are living in the child's home?" and "How many square meters is the child's home?" Per capita living space was defined by

square meter/per person. We divided per capita living space into two groups: < 20 m^2 ('small living space') and ≥ 20 m^2.

Health-related living conditions

The questionnaire included living conditions which were considered as relevant for children's' health. Parents were asked about the type of heating in the home, whether the house could be described as damp and how far the next street with heavy traffic was. Here, 'damp housing condition', 'single oven heating' (single room heating with coke, gas, oil) and 'living at busy road' (distance to traffic street < 50 m) [9] are considered as being unfavourable health-related living conditions.

Region

The distribution of the socio-economic status and, similar, of the educational level is different between big cities and rural areas. Therefore, we introduced in the analysis of this study a variable which distinguished urban from rural area as potential confounder. The urban area included the cities Leipzig, Halle and Magdeburg; while the rural area included the small rural towns Salzwedel, Gardlegen, Kloetze and Osterburg.

Statistical analyses

The data were analysed with the SAS statistical software, Version 8.2 [10]. The time course of variables was described by the included graphics. Cross tables were used to show relationships between social variables, regions and educational levels; a chi-square test was used to test associations. Multiple logistic regression analyses were conducted to evaluate the influence of educational level, region and time as independent variables on the health-related living conditions as dependent variables. As to determine an increase or decrease of the difference between lower and higher social status with respect to the dependent variable, the interaction of time and educational level was modelled too:

$$\log\left(\frac{p}{1-p}\right) = c + b_1 * M + b_2 * L + b_3 * T + b_4 * M * T + b_5 * L * T + b_6 * R,$$

where p is the probability for the health-related living condition present; M and L are equal 1 if the educational level is 'middle' or 'low', respectively, else 0; T (0,1,2,...,9) represents the year of observation; R is equal 1 for urban area else 0. The estimated model parameters b_i were presented as adjusted odds ratios together with their corresponding 95% confidence intervals to indicate the impact of the specified independent variable on the particular health-related living condition adjusted for all other independent variables of the regression model. The 'high' parental educational level served as reference category for both the 'low' and 'middle' parental educational level. The influence of the urban area environment was compared to the rural environment. The odds ratio for the factor time refers to a one-year increment. The significance of the interaction term was indicated by the two significance levels $p < 0.05$ and $p < 0.01$, respectively.

Results

Descriptive analyses

Table 1 shows the sample size and the distribution of parental educational level by study region from 1991 to 2000. Figures 1, 2, 3, 4, 5, 6 present the time courses of the frequencies of parental social indicators and health-related living conditions of 6-year-old children in East Germany from 1991 to 2000.

More than 90% of children's parents in the study sample (Figure 1) received 10 or more years of school education. A complete reverse of proportions of high to middle educational level can be seen since 1997.

We found a rising rate of parents not being in paid employment at all parental educational levels (Figure 2). Despite the very high rate of not employed parents among the low educated parents in 1996, we observe a further increase of 20% until 2000 for this group.

In general, the percentage of children with homes of small living space was decreasing for all parental educational levels, but with the highest decreasing rate for the high educational level and the lowest for the low educational level (Figure 3).

The proportion of damp housing conditions had partially increased (Figure 4) until 1996 in East Germany, but thereafter, reconstruction measures of homes around that time might be responsible for the slight decline of the frequency of damp housing conditions. The difference decreased by about 10% when comparing low educational level to high educational level during the study period.

A very clear improvement of the situation regarding single oven heating systems at children's homes was found (Figure 5) and the related differences in parental educational levels extremely decreased by about 30% when comparing low educational level with high educational level over time.

A slight increase of the proportion of children living closer than 50 m to traffic street could be observed (Figure 6) for low and middle parental educational levels, whereas for high parental educational level after a slight increase during the first five years the proportion reached in 2000 nearly the same level as in 1991. The difference increased

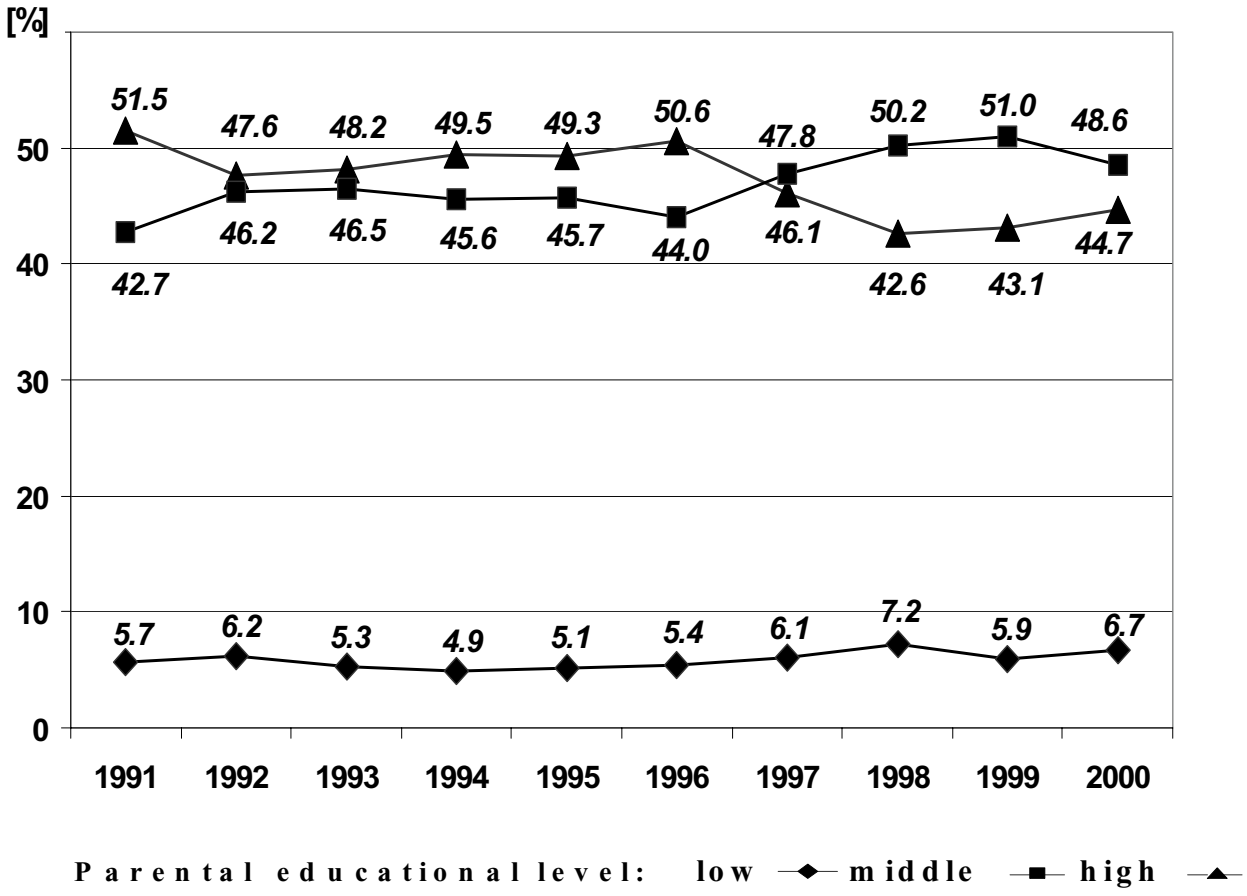

Figure 1
Time courses of sample distribution of parental educational level classified by the highest school grade completed by either mother or father of 6-year-old children in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10);

by about 10% when comparing low educational level with high educational level during the study period.

Table 2 shows a slight shift of parental education to the lower levels in rural regions compared to urban areas. Explanations for this difference between rural and urban areas could be, first, the fact that the educational level is lower in rural regions compared to larger cities or, second, the consequence of different migration after re-unification or, third, the result of a different response behaviour. Table 2 also demonstrates that the health-related living conditions were consistently better in rural areas compared to urban areas. The strongly significant differences between the three parental educational levels with respect to not employed and unfavourable health-related living conditions over the whole study period are clearly demonstrated in Table 3.

Logistic regression analyses

In Table 4, odds ratios, estimated by logistic regression and, therefore, mutually adjusted for the independent variables of the regression model, quantify the association between the health-related living conditions of the 6-year old children and their determinants parental educational level, time and region, respectively. Differences of change over time between the three educational levels are documented by strata-specific odds ratios, and their significance is indicated by the significance level of the respective interaction term of the regression model. The odds ratios were all significantly greater 1 for not

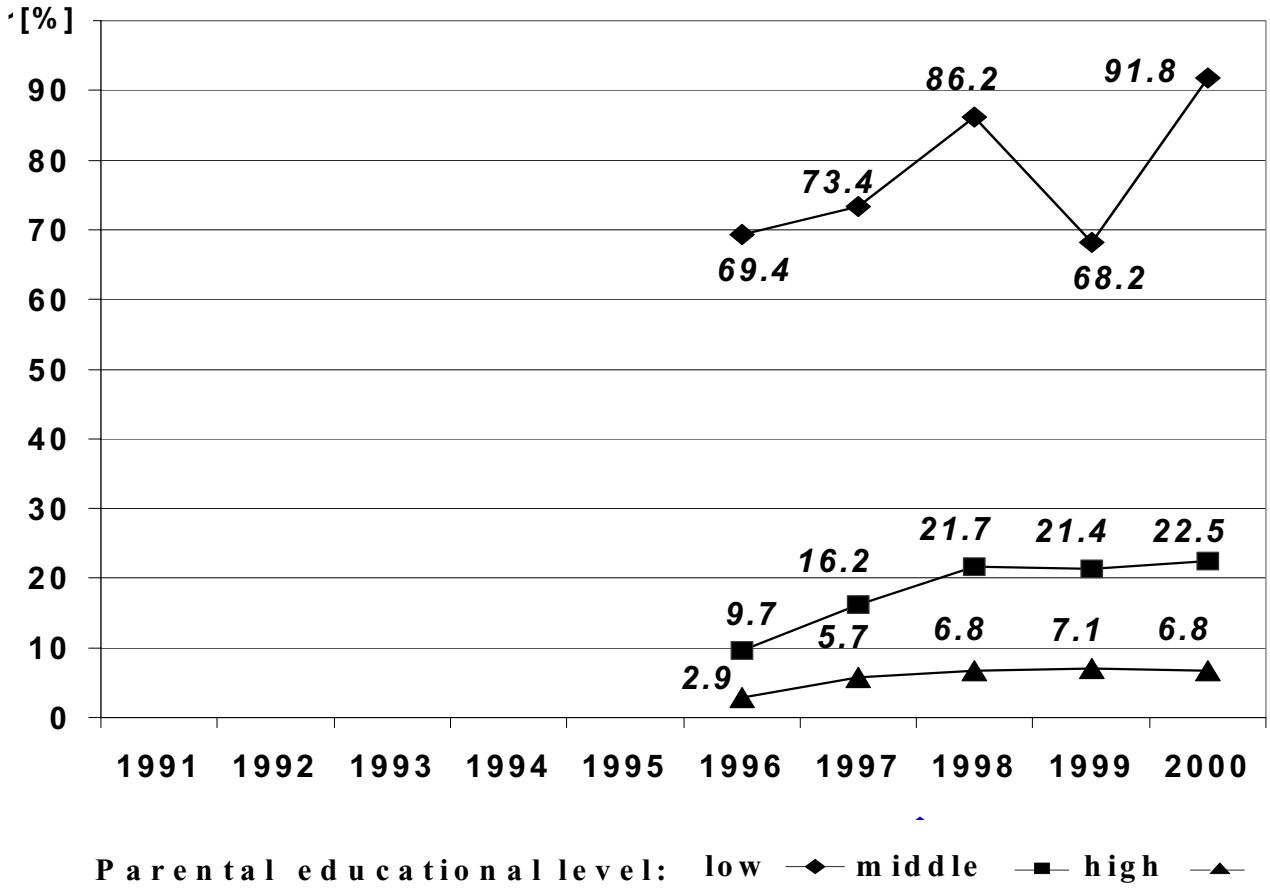

Figure 2
Time courses of prevalence of mother and father not in paid employment of 6-year-old children by parental educational level in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10);

employed, small living space, damp housing conditions, single oven heating and living at busy road when comparing low and middle educational levels to high educational level in accordance with the results in Table 3.

The odds for not employed increased by 34% for low educational level and by 20% for middle educational level compared to 16% for high educational level per year. Despite the clear difference in change over time, the interaction terms were not significant. The odds for small living space decreased by about 10% for low and middle educational levels compared to 15% for high educational level per year. The differences in change over time were significant in favour for the higher educational level. The odds for damp housing conditions slightly, but significantly decreased over time for low and middle educational levels, but not for high educational level. The prevalence of single oven heating strongly decreased for all three educational levels over time, but the low educational level showed the strongest decline of prevalence. Living at busy road slightly, but significantly increased for low and middle educational levels compared to high educational level over time.

If comparing urban areas to rural areas, the adjusted odds for not employed, small living space, damp housing conditions, single oven heating at child's home and living at busy road, respectively, were significantly higher in urban areas.

Discussion

The present study provides new important information on the details of changing social inequality with respect to health-related living conditions of 6-year-old children in

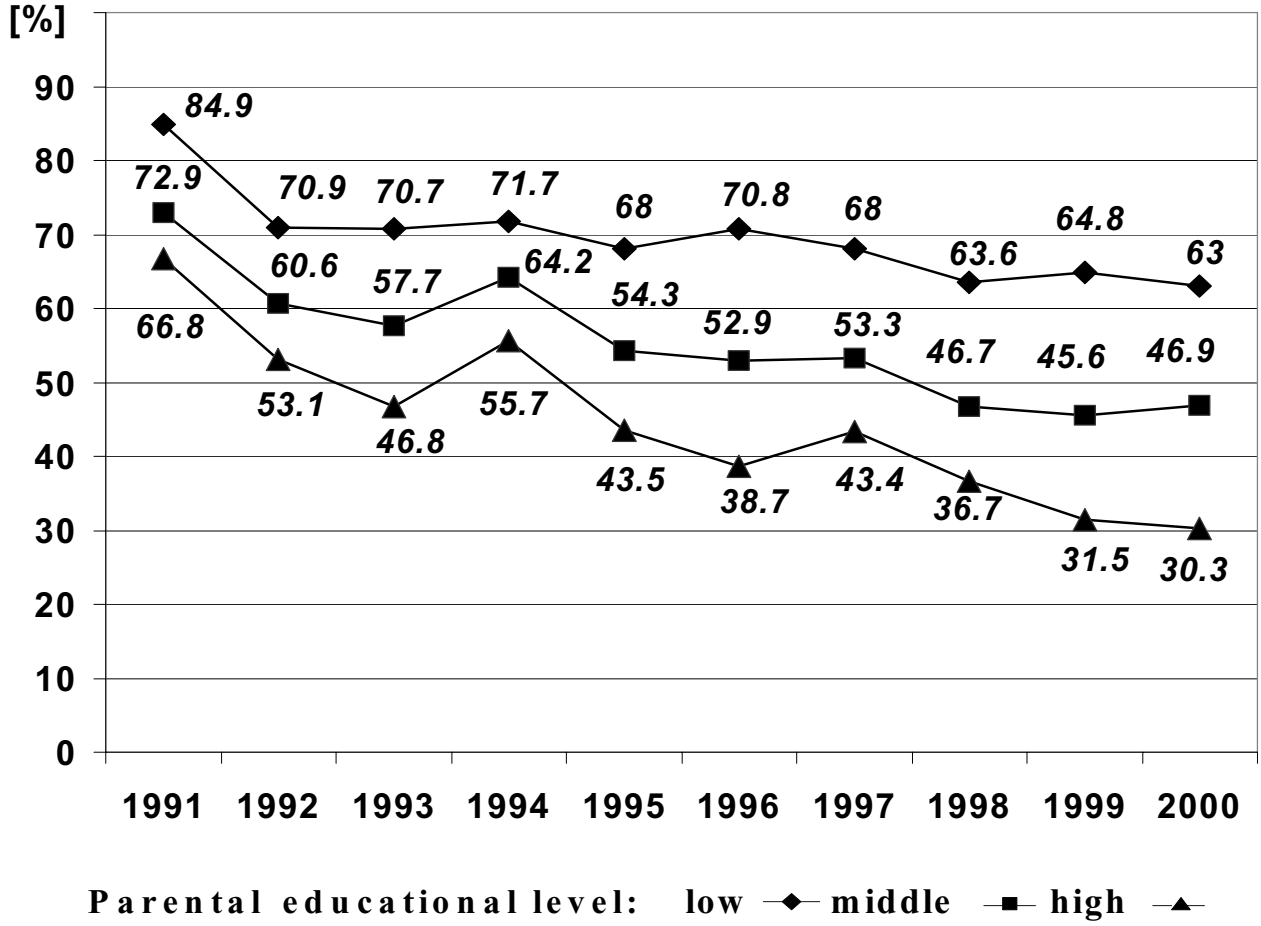

Figure 3
Time courses of prevalence of 6-year-old children's home with small living space (per-capita less than 20 m^2) by parental educational level in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10);

the former socialist country, East Germany, on its transition to social market economy. The data reveals that the parental educational level as a main social indicator was consistently and significantly linked to parental employment status, living space and health-related living conditions during the whole study from 1991 to 2000 (Table 3, Figure 1, 2, 3, 4, 5, 6). The time courses of the two social indicators, employment status (both parents not in paid employment) and living space (per capita living space less than 20 m^2), respectively, developed unfavourably and less favourably, respectively, for the two lower educational levels. For the health-related living condition 'living at busy road' (distance less than 50 m), we also observed an increasing, almost doubling gap between different social status to the disadvantage of children with low educated parents. The proportions of children living under damp housing conditions or being exposed at home to single oven heating were significantly different between the educational levels at the time of re-unification, but, fortunately, nearly identical after 10 years.

The East German society of the former socialist GDR was regarded as characterized by a relatively uniform distribution of resources and living conditions. The standard of living was higher than that in other communist countries, and a comprehensive social insurance system covered medical, disability, unemployment, and other expenses [11]. Education was free and compulsory through 10th grade [11], the economic structure was similar to that in the Soviet Union [11], with state ownership and

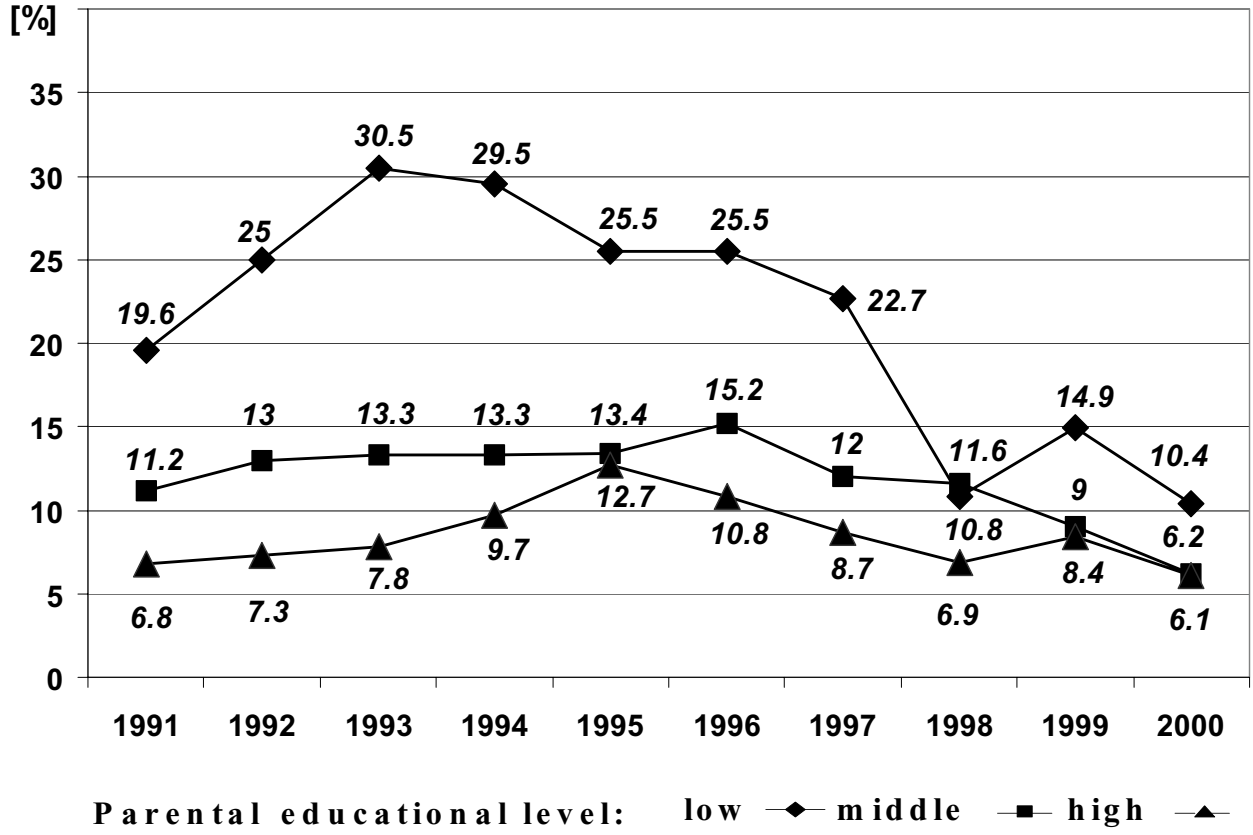

Figure 4
Time courses of prevalence of 6-year-old children's living under damp housing condition by parental educational level in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10);

centralized control [11], income differences between social groups were relatively small, basic health care was equally accessible to all groups of the society [8]. Although living conditions and access to consumer goods in former socialist countries were much more uniform than in the West, disparities between social groups did exist, as shown by our study. The health-related variables of our study were damp housing conditions, single oven heating and living at busy road. Several large epidemiological studies have identified damp living conditions as a major risk factor for respiratory symptoms in children [12]. There are only few publications on health inequalities in GDR and it is difficult to assess whether health inequalities do have different reasons in East Germany [13]. Although equality was a major political goal in the GDR there have been health inequalities comparable to those in Western European countries [13].

Conditions after re-unification were not easy for the East German labour force as the difficulties of adjustment to the Western system caused many hardships, including unemployment [14]. By 1991, a massive decline in employment with a loss of about 3.5 million jobs (35% of the labour force) by the end of 1992; unemployment rose from almost zero at the beginning of 1990 to 15.4% of the labour force in 1992 [15]. In our study (Table 4), odds for parents not in paid employment increased in the average per year by 34% for 'low' educated parents, by 20% for 'middle' and by 16% for 'high'. Since 1989, about 1.7 million East Germans left for the West, the birth rate fell by about 60% in the period from 1989 to 1994, and the number of marriages and divorces declined sharply [16]. In 1991 (Figure 1), about 50% of the parents had an educational level of more than 10 years of school, but, after 1996, this proportion dropped to 40% and the

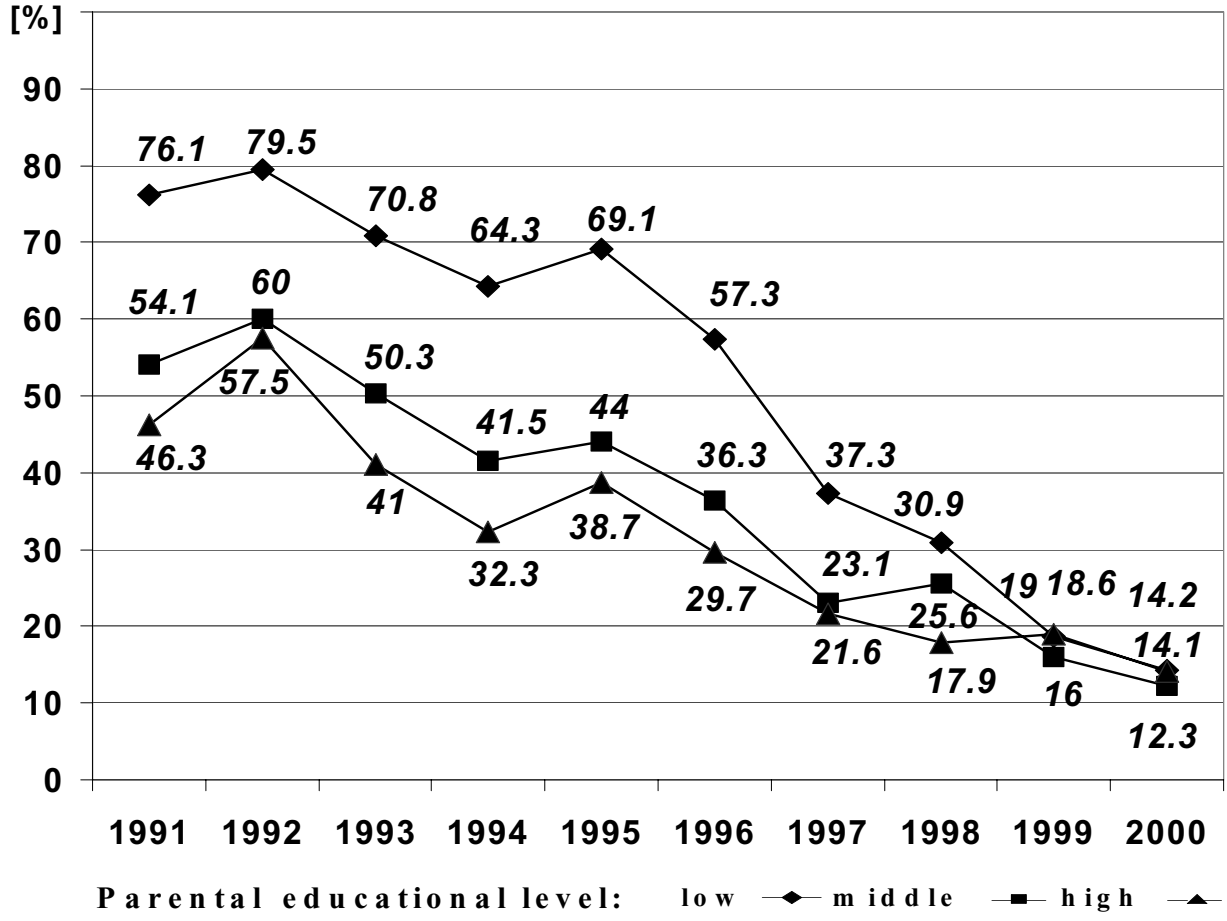

Figure 5
Time courses of prevalence of 6-year-old children's home with single oven heating system by parental educational level in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10);

proportion of parents with 10 years school education raised to 50%. 1997 is the first study year where children born after the German re-unification have been investigated. Although the size of the investigation areas were not changed during the time course of the study, the number of investigated children decreased from 4047 children in 1991 to 2960 in 1997. This massive decrease can only partly be explained by the 10 percent decrease in response rate (93% in 1991 and 83% in 1997), but mostly by the massive decline in birth rates and migration to other areas. 1997 is the same year when the percentage of middle educated parents outnumbered the percentage of highly educated parents for the first time. This means that the decrease in numbers due to declining birth rates and migration was steeper to children with highly educated parents than for children with middle educated parents. This observation has also been made by other groups [personal communication]. Around the year 1994, we observed an increase of 'small living space' which was caused by the different composition of the surveys between 1993 and 1995. While the survey in 1993 had a proportion of 47% of school beginners in rural areas, the survey in 1994 showed just a fraction of 19%, whereas this fraction increased again to 38% in the survey 1995 (see Table 1).

The cross-sectional design of our study could only identify associations between social status and health-related

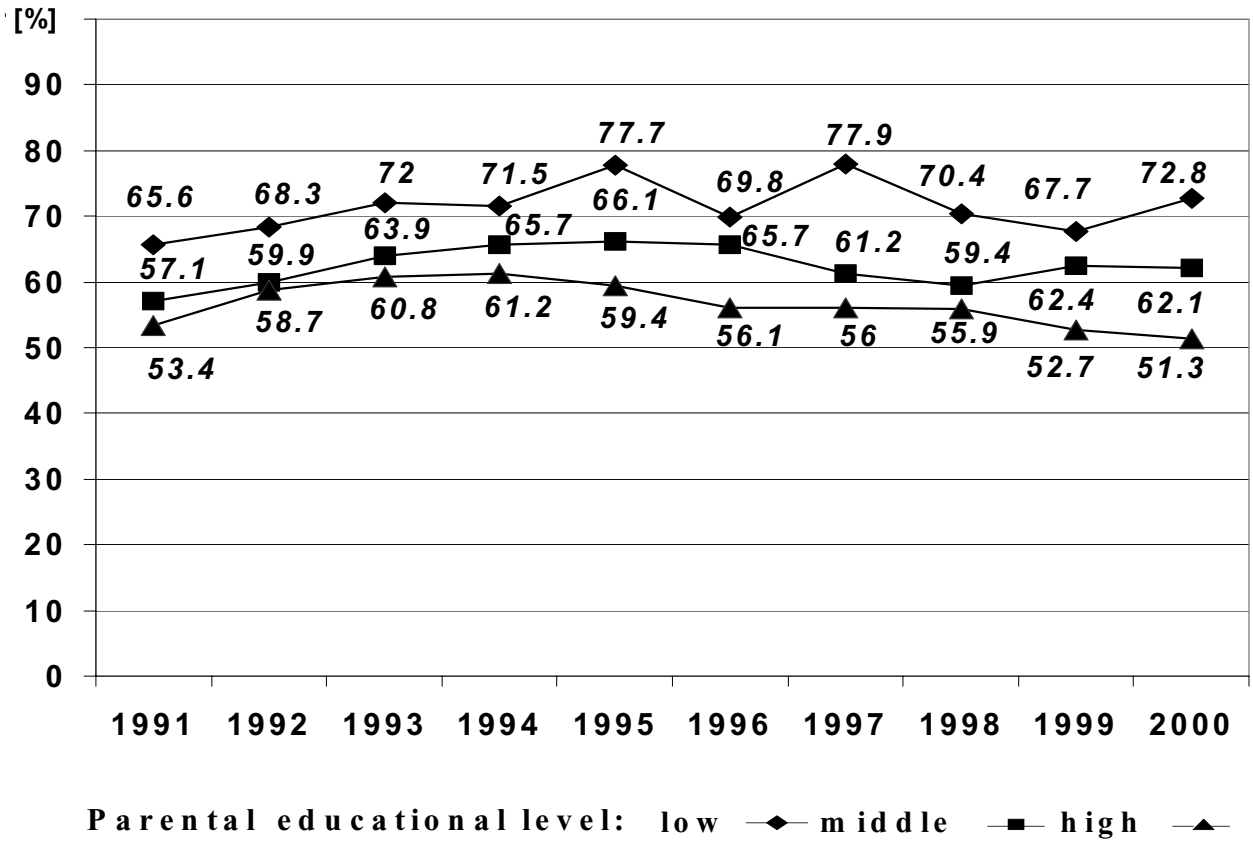

Figure 6
Time courses of prevalence of 6-year-old children living at busy road (distance closer than 50 m to a traffic street) by parental educational level in East Germany from 1991 to 2000 ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10).

Table 1: Distribution of parental education ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10) of 6-year-old children in East Germany (1991–2000), by study region and year

Year	Urban[a]				Rural[b]				Total(n)
	Urban (n)	Low (%)	Middle (%)	High (%)	Rural (n)	Low (%)	Middle (%)	High (%)	
1991	3125	5.2	41.4	53.4	922	7.7	47.2	45.1	4047
1992	1225	7.2	42.9	50.0	924	5.0	50.5	44.5	2149
1993	983	6.0	43.3	50.7	878	4.6	50.1	45.3	1861
1994	3814	4.9	43.4	51.8	901	5.2	54.8	40.0	4715
1995	1223	5.6	42.0	52.3	746	4.2	51.6	44.2	1969
1996	1097	5.0	41.1	53.9	688	6.0	48.6	45.5	1785
1997	2390	6.2	46.9	46.9	570	5.8	51.6	42.6	2960
1998	891	6.7	50.1	43.2	325	8.6	50.5	40.9	1216
1999	842	5.6	50.4	44.1	359	6.7	52.4	41.0	1201
2000	1837	6.8	47.6	45.6	339	6.5	53.7	39.8	2176

[a] Leipzig, Halle and Magdeburg; [b] Salzwedel, Gardelegen, Osterburg and Kloetze.

Table 2: Distribution of parental education, parental employment status, small living space and health-related living conditions of 6-year-old children in East Germany (1991–2000), by study region

	Total	*Urban*[a]		*Rural*[b]		*p-value*[c]
	n	*n*	%	*n*	%	*c*
Parental educational level (highest school grade):						
Low (less than grade 10)	1380	997	5.7	383	5.8	
Middle (grade 10)	11113	7730	44.4	3383	50.9	<.0001
High (more than grade 10)	11586	8700	50.0	2886	43.4	
Mother and father not in paid employment	738	599	14.6	139	10.2	<.0001
Small living space (per-capita < 20 m^2)	13570	10133	56.9	3437	50.5	<.0001
Damp housing condition	2617	2115	12.1	502	7.5	<.0001
Single oven heating at child's home	8617	6725	40.4	1892	29.5	<.0001
Living at busy road (distance < 50 m to traffic)	14482	10812	62.0	3670	55.3	<.0001

[a] Leipzig, Halle and Magdeburg; [b] Salzwedel, Gardelegen, Osterburg and Kloetze; [c] p-value of chi-square test

Table 3: Distribution of parental employment status, small living space and health-related living conditions of 6-year-old children in East Germany (1991–2000), by parental educational level

		Parental educational level						
	Total	Low[a]		Middle[b]		High[c]		p-valued
		n	%	n	%	n	%	
Mother and father not in paid employment	730	157	78.5	408	17.9	165	5.64	<.0001
Small living space (per-capita < 20 m^2)	13163	982	71.2	6514	58.6	5667	48.9	<.0001
Damp housing condition	2581	295	22.0	1306	11.9	980	8.5	<.0001
Single oven heating at child's home	8472	682	56.0	3993	38.6	3797	34.2	<.0001
Living at busy road (< 50 m to traffic)	14238	921	71.3	6785	62.3	6532	56.9	<.0001

[a] Low: less than school grade 10, [b] middle: grade 10, [c] high: more than grade 10; [d]p-value of chi-square test

Table 4: Adjusted § odds ratios (OR) with 95% confidence intervals (95% CI) of parental employment status and health-related living conditions of 6-year-old children in East Germany (1991–2000) for the determinants parental educational level, time and region, by means of logistic regression analysis

Independent variables	Dependent variables – OR (95%CI)				
	Mother and father not in paid employment	Small living space (per-capita < 20 m^2)	Damp housing condition	Single oven heating at child's home	Living at busy road (< 50 m to traffic)
	N = 5406	N = 24079	N = 23778	N = 22660	N = 23662
Parental educational level high (reference)	1.00	1.00	1.00	1.00	1.00
Parental educational level middle	2.89 (1.13–7.39)	1.34 (1.22–1.47)	1.82 (1.58–2.11)	1.55 (1.41–1.70)	1.15 (1.05–1.26)
Parental educational level low	24.82 (3.90–158.10)	2.22 (1.78–2.76)	4.28 (3.38–5.41)	4.83 (3.83–6.10)	1.57 (1.27–1.94)
Time (parental educational level high)	1.16 (1.04–1.29)	0.85 (0.84–0.86)	1.00 (0.98–1.03)	0.82 (0.80–0.83)	0.98 (0.97–1.00)
Time (parental educational level middle)	1.20 (1.13–1.29)	0.89** (0.88–0.90)	0.95** (0.91–1.00)	0.78** (0.77–0.79)	1.01** (0.99–1.02)
Time (parental educational level low)	1.34 (1.09–1.71)	0.90** (0.87–0.94)	0.92** (0.88–0.96)	0.71** (0.23–0.74)	1.03* (0.90–1.18)
Region rural area[a] (reference)	1.00	1.00	1.00	1.00	1.00
Region urban area[b]	1.55 (1.25–1.93)	1.43 (1.35–1.51)	1.78 (1.61–1.97)	1.90 (1.78–2.04)	1.35 (1.27–1.43)

§ Adjusted for all other factors included in the model and give in the Table.
[a] Region rural area: Salzwedel, Gardlegen, Osterburg and Kloetze; [b] urban area: Leipzig, Halle and Magdeburg,
* p-value for interaction term of the regression model: $p < 0.05$
** p-value for interaction term of the regression model: $p < 0.01$

living conditions, but could not provide the evidence of a causal relation by itself. For instance, the causal chain from a low parental educational level over low income to a cheap or unfavourable (with respect to children's health) home could not be explored. Two further limitations of this study need to be discussed. First, in the analyses presented in this paper we have considered social status differences by using parental educational level (of the most highly educated parent) for classifying children. The information about household income and occupational status of parents had not been asked in this environmental study. But an expert committee in Germany also recommended using educational level as a measure for social status in epidemiological and social medical studies [17]. Education is an important determinant of individuals' work and economic circumstances, which are themselves linked to health through specific work conditions and levels of consumption [18], related to health outcomes through its influence on lifestyle behaviours (e.g. exercise, diet), problem-solving capacities and values (e.g., importance of preventive health behaviours) [19]. Education as 'year of education completed', is a core variable in the MONICA project [13]. Nevertheless, the choice of a single indicator of parents' socioeconomic status may be subject to debate [20]. The educational level paralleled factors which are considered to be characteristic of modern domestic comfort, such as central heating, and was inversely related to the degree of crowding in the home. The second limitation was that the environmental study from which the data for this study were derived focused on airway diseases and atopic manifestations and, therefore, the selection of living conditions of the 6-year old children was restricted to their relevance for these health outcomes. Other equally important health-relevant living conditions were missing in our study, such as nutrition or access to health services.

Conclusion

The results of our repeated cross-sectional studies in East Germany are in agreement with the well known fact of a strong association between parental educational level and health-related living conditions of children. Furthermore, we observed that the domestic situations of small living space, damp housing condition and single oven heating system improved from 1991 to 2000; while parental employment status (1996–2000) and living at busy road (1991–2000) did not improve, but even deteriorated. Our basic hypothesis that the changes in East Germany had influenced social inequality was confirmed. We found decreased social inequality for single oven heating and damp housing condition; while increased social inequality was seen for parental employment status, small living space and living at busy road. These findings lead to the conclusion that the lower social class is often, but not always the looser of large socio-economic changes as happened in East Germany. The "winning" effect seems to be bound on strong general improvements, such as the replacement of single oven heating by central heating.

A further level of investigation may be to ask how these social differences in health-related living conditions modify the association between exposure to environmental pollution and health. We know little about the effect modification of social inequality on environmental hazards or about the impact of social inequality on environment-related disease. In future, a closer co-operation between environmental-epidemiological and socio-epidemiological research would be needed.

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

XDP wrote the paper and performed the statistical analysis. UK coordinated the epidemiological cross-sectional studies in East Germany. UR designed the study, assisted the statistical analysis and helped to draft the manuscript. All authors reviewed the final version of the manuscript.

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4.2 Time trends in exposure to environmental tobacco smoke and parental educational level for 6-year-old children in Germany.

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ORIGINAL ARTICLE

Time trends in exposure to environmental tobacco smoke and parental educational level for 6-year-old children in Germany

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Abstract The aim of the study was to investigate the association between exposure to environmental tobacco smoke of 6-year-old children and parental educational level in Germany under the changing socioeconomic conditions after reunification. Logistic regression was used to examine the relationship between tobacco smoke exposure of children (current environmental tobacco smoke, maternal smoking during pregnancy, environmental tobacco smoke during the first 3 years of the child's life) and the determinants parental educational level, time and region. In Germany, the risk of environmental tobacco smoke exposure among 6-year-old children was strongly associated with parental educational level (odds ratio: ≥2 'low'/'middle' versus 'high' parental educational level). In West Germany, environmental tobacco smoke exposure generally exhibited a decreasing trend of about 20%. In contrast, in East Germany the environmental tobacco smoke exposure was only decreasing for children of parents with higher education. The gap between low and high parental educational level with respect to current children's tobacco smoke exposure has increased from 1991 to 2000 in East Germany. A considerable fresh increase of maternal smoking during pregnancy could be observed around 1991 in both parts of Germany. In East Germany, the transition from a socialist economic system to a market economy after reunification might in part explain the increased gap of tobacco smoke exposure between children of parents with lower and higher educational levels.

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Keywords Environmental tobacco smoke exposure of children · Smoking during pregnancy · Parental educational level · East and West Germany

Introduction

Environmental tobacco smoke, the most common indoor air pollutant, is a serious public health problem (Ponsonby et al. 1996). Children appear to be particularly vulnerable to environmental tobacco smoke (Brenner and Mielck 1993). For example, development of childhood asthma and eczema, impairment of airway diseases, low birth weight and sudden infant death are all negatively associated with environmental tobacco smoke exposure (Krämer et al. 2004; Hovell et al. 2002; Romero Palacios 2004; Anderson 1999). The effect of maternal smoking during pregnancy on children's birth weight has been recognized since 1957 (DiFranza and Aligne 2004). Socioeconomic status and school education, as an indicator in particular, have been strongly associated with current smoking (Novotny et al. 1988). The transition in Central and Eastern Europe including East Germany in the late 1980s has brought significant political, social and economical changes and, possibly as consequences, changes in public health (Nolte et al. 2000). In this context, one can argue that these social and economic changes could negatively influence the smoking behaviour in the population among other health determinants and, in consequence, an increased prevalence of smoking could implicate an impairment of the health status of the population. Therefore, a detailed picture of smoking behaviour during the mentioned period of transition can contribute to a better understanding of changes in public health. In a large environmental epidemiological study on 6-year-old children in East and West Germany

after reunification from 1991 to 2000, we investigated children's exposure to tobacco smoke and other environmental health determinants. Here, we report on the association of children's environmental tobacco smoke exposure with the educational level of their parents and its time trend and compare the results between East and West Germany.

Methods

The data were derived from an environmental epidemiological study which investigated the influence of ambient air pollution on health outcomes of school beginners and compared the results between East and West Germany from 1991 to 2000 after reunification (Sugiri et al. 2006; Krämer et al. 1999). In both parts of Germany, large industrialized cities (in East Germany: Leipzig, Halle, Merseburg, Magdeburg; in West Germany: Duisburg, Essen, Köln) as well as small rural towns (in East Germany: Salzwedel, Gardelegen, Osterburg, Klötze; in West Germany: Borken) were included as study areas. In the course of this study, cross-sectional investigations have been repeated every year in East Germany and every 3rd year in West Germany. All boys and girls entering the elementary school in the investigation years and living in the geographically defined study areas were eligible to participate. A letter was mailed to the parents asking for participation of the child and for completion of a questionnaire at home. Written consent of the parents of the examined children was requested individually. An average response rate of 83% in East Germany and of 71% in West Germany was achieved. The lowest response rate of 60% was obtained in 2000 in the city of Duisburg.

Parental respondents reported in the questionnaire their educational level and the educational level of their current living partner if applicable. Parental educational level of the child was then defined by the highest school grade (years) received by either parent or partner and classified as 'low' (less than 10), 'middle' (equal to 10) and 'high' (more than 10) (Jöckel et al. 1998). The child's exposure to environmental tobacco smoke was assessed according to the above-mentioned self-assessed parental questionnaire. Tobacco smoke exposure in utero (maternal smoking during pregnancy) was defined as present if the answer to the question "Did the child's mother smoke during pregnancy?" was "yes". Postnatal exposure (domestic tobacco smoke during the first 3 years) was assumed if the question "Did anybody smoke in the dwelling in which the child lived during the first 3 years of life?" was positively answered, and, accordingly, current exposure (current domestic tobacco smoke) in the case of a positive answer to the question "Does anybody smoke in the dwelling in which the child is now living?" These three exposure variables were considered as dichotomous variables.

Separately for East and West Germany, a multiple logistic regression analysis was conducted to evaluate the influence of parental educational level, time and region (urban or rural) as independent variables on the children's environmental tobacco smoke exposure as dependent variables. The covariate 'region' needed to be included as potential confounder. To model potential interaction between time of observation and parental education, the time was nested within the three parental educational levels:

$$\log\left(\frac{p}{1-p}\right) = c + b_1{*}M + b_2{*}L + b_3{*}R + b_4{*}H{*}T + b_5{*}M{*}T + b_6{*}L{*}T$$

Here, p is the probability for the environmental tobacco smoke exposure; H, M and L are equal to 1 if the parental educational level is 'high', 'middle' or 'low', respectively, otherwise 0; T represents the time as continuous variable using a 9-year interval as adequate unit; R is equal to 1 for urban areas and 0 for rural areas. We used adjusted odds ratios and the corresponding 95% confidence intervals to indicate the association between independent and dependent variables. For the calculations, the SAS statistical software, Version 8.2, was used. (SAS 2000).

Results

A total of 33,039 children (51% boys and 49% girls) at the mean age of 6.3±0.4 years participated in this study. Complete information of parental educational level was known for 31,452 (80.6%) children. The mothers' mean age at the child's birth was 25.3±4.4 years in East Germany and 27.8±5.1 years in West Germany. In Table 1, a detailed description of the distribution, including missing information, of the parental education level and the children's tobacco smoke exposure is given. Information on school education of the parents was provided much more reluctantly in West Germany (12.4% missing) than in East Germany (2.2% missing). Furthermore, a significant difference in parental education existed between East and West Germany with respect to the 'low' educational level (5.7 versus 24.7%), whereas a less significant difference was found for the 'high' educational level (48.1 versus 32.0%). The reason for that were the differences of the educational systems between the two parts of Germany before reunification. For a comparison of the smoking behaviour between East and West Germany with respect to educational level, these differences of distribution in consequence of different educational systems have to be considered. Slight differences in the educational distribution also exist between the rural

Table 1 Distribution, including missing information, of the parental educational level ('high': more than 10 years of school, 'middle': 10 years of school, 'low': less than 10 years of school) and tobacco smoke exposure (current domestic tobacco smoke, maternal smoking during pregnancy and domestic tobacco smoke during the first 3 years of the child's life) in a study population of 6-year-old children from East and West Germany with a total sample size of 33,039 children

N (% excluding missing)

	East Germany			West Germany		
	Total	Urban[a]	Rural[b]	Total	Urban[c]	Rural[d]
Parental educational level						
High	11,586 (48.1)	8,700 (49.9)	2,886 (43.4)	2,360 (32.0)	1,874 (30.5)	486 (39.5)
Middle	11,113 (46.2)	7,730 (44.4)	3,383 (50.9)	3,191 (43.3)	2,637 (42.9)	554 (45.0)
Low	1,380 (5.7)	997 (5.7)	383 (5.8)	1,822 (24.7)	1,631 (26.6)	191 (15.5)
Missing[e]	545 (2.2)	397 (2.2)	148 (2.2)	1042 (12.4)	803 (11.6)	239 (16.3)
Current domestic tobacco smoke						
Yes	10,114 (44.1)	7,496 (45.1)	2,618 (41.4)	4,125 (53.4)	3,615 (57.3)	510 (35.8)
No	12,848 (55.9)	9,136 (54.9)	3,712 (58.6)	3,603 (46.6)	2,688 (42.7)	915 (24.2)
Missing[e]	1662 (6.8)	1192 (6.7)	470 (6.9)	687 (8.2)	642 (9.2)	45 (3.1)
Maternal smoking during pregnancy						
Yes	2,230 (9.3)	1,749 (10.1)	481 (7.2)	2,118 (25.7)	1,954 (28.7)	164 (11.5)
No	21,678 (90.7)	15,526 (89.9)	6,152 (92.8)	6,113 (74.3)	4,851 (71.3)	1,262 (88.5)
Missing[e]	716 (2.9)	549 (3.1)	167 (2.5)	184 (2.2)	140 (2.0)	44 (3.0)
Domestic tobacco smoke during first 3 years						
Yes	6,687 (27.9)	5,117 (29.4)	1,570 (23.7)	3,814 (46.3)	3,346 (49.2)	468 (32.5)
No	17,326 (72.1)	12,275 (70.6)	5,051 (76.3)	4,424 (53.7)	3,452 (50.8)	972 (67.5)
Missing[e]	611 (2.5)	432 (2.4)	179 (2.6)	177 (2.1)	147 (2.1)	30 (2.0)

[a]Leipzig, Halle, Merseburg and Magdeburg
[b]Salzwedel, Gardelegen, Osterburg and Klötze
[c]Duisburg, Essen and Köln
[d]Borken
[e]Percentage of missing referring to total sample size

and urban regions which are different in East and West Germany. Children in urban regions were more exposed to environmental tobacco smoke than in rural regions and this difference was more pronounced in West than in East Germany.

Figures 1, 2 and 3 present the observed time courses of tobacco smoke exposure prevalence among the 6-year-old children of the study group by parental educational level ('low': less than grade 10, 'middle': grade 10, 'high': more than grade 10) in East Germany for every year and in West Germany for every 3rd year from 1991 till 2000. For current domestic tobacco smoke in East Germany (Fig. 1, above), a slight decrease of the prevalence could be observed for 'high' and 'middle' parental educational level, whereas for 'low' parental educational level, the prevalence in 2000 reached the same level as in 1991 after a slight increase during the first 5 years. The difference increased by about 25% when comparing 'high' parental educational level to 'low' parental educational level during the study period. In West Germany (Fig. 1, below), the prevalence of current domestic tobacco smoke decreased to about 25% for 'high' parental educational level, but only a half of that for 'low' parental educational level for the years between 1991 and 2000. The difference increased by about 15% when comparing 'low' parental educational level to 'high' parental educational level over time. For maternal smoking during pregnancy in East Germany (Fig. 2, above), a slight average increase of the prevalence could be observed for 'low' parental educational level. A striking change from a slightly decreasing to an increasing trend of maternal smoking occurred at the time of pregnancy shortly after reunification in 1990 for the 'high' and 'middle' educational levels. The difference increased by about 6% when comparing 'low' parental educational level to 'high' parental educational level during the study period. In West Germany (Fig. 2, below), we could see a decrease of the prevalence of maternal smoking during pregnancy until 1991 (year of pregnancy), but thereafter an increase of about 10% for the three educational levels. For domestic tobacco smoke during the first 3 years after birth in East Germany (Fig. 3, above), we found a slightly decreasing prevalence in all three parental educational levels. The differences between 'low'

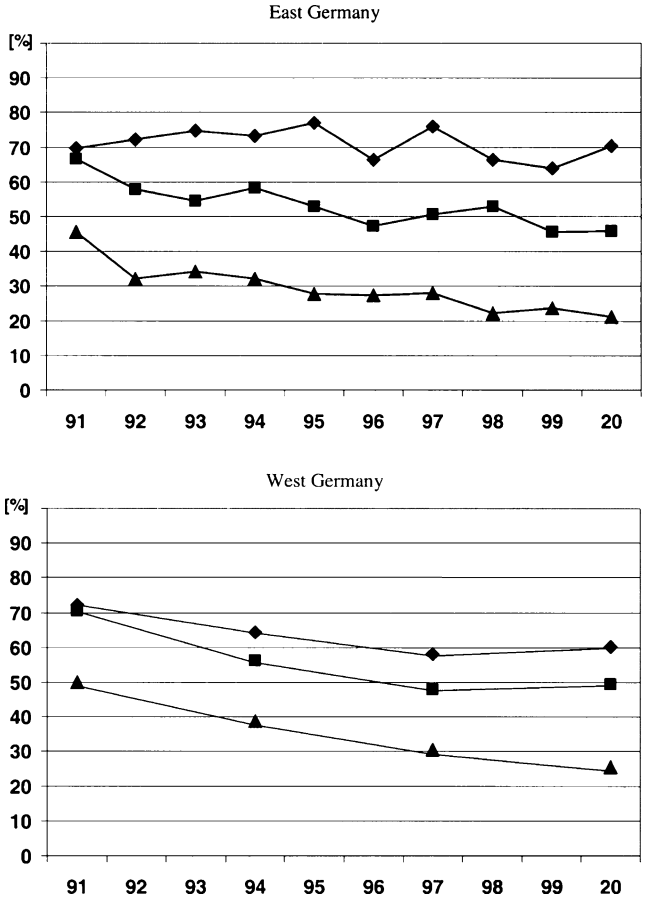

Fig. 1 Time courses of prevalence of current domestic tobacco smoke among 6-year-old children by parental educational level (*rhombuses*='low', less than 10 years of school; *squares*='middle', 10 years of school; *triangles*='high', more than 10 years of school) in East and West Germany from 1991 to 2000

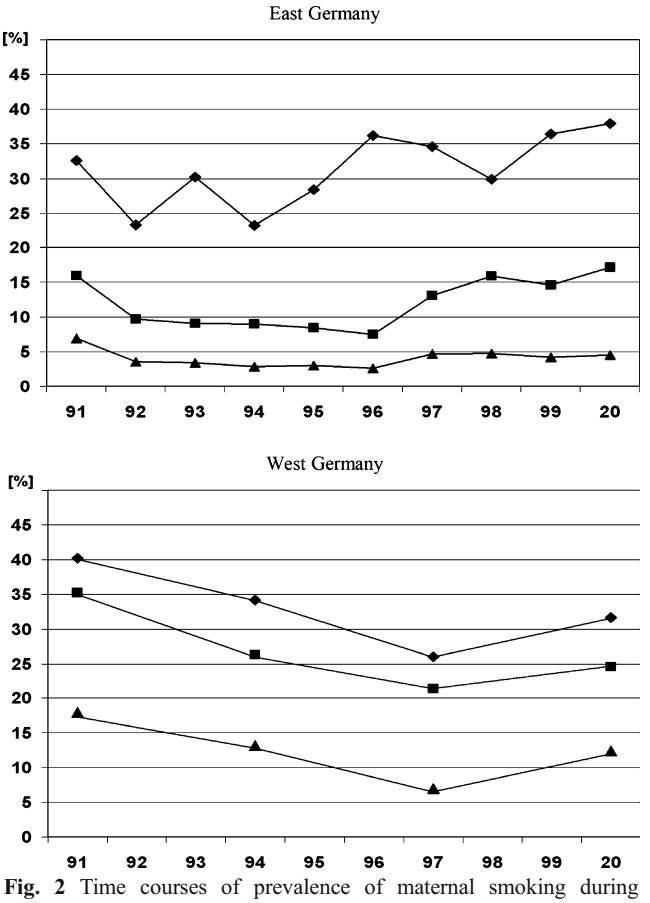

Fig. 2 Time courses of prevalence of maternal smoking during pregnancy among 6-year-old children by parental educational level (*rhombuses*='low', less than 10 years of school; *squares*='middle', 10 years of school; *triangles*='high', more than 10 years of school) in East and West Germany from 1991 to 2000

and 'high' educational levels increased by about 10%. In West Germany (Fig. 3, below), the prevalence of domestic tobacco smoke during the first 3 years decreased to about 20% for all three parental educational levels.

In Table 2, the results of the logistic regression modelling, using the above-mentioned regression formula, provide adjusted odds ratios with 95% confidence intervals to assess differences between educational levels and between regions and changes over time for the prevalence of children's tobacco smoke exposure. For both parts of Germany, a significant overall effect of parental educational level on children's tobacco smoke exposure could be estimated. Children whose parents had 'low' or 'middle' educational levels were about twice as often exposed as children of parents with 'high' educational level. The differences were highest for maternal smoking during pregnancy, e.g. the prevalence of maternal smoking during pregnancy for low parental educational level was up to 7 times the value compared to the high parental educational level in East Germany (Table 2). While the overall effect of parental education was similar between East and West Germany, time trends were different in the two parts of Germany (Table 2). In West Germany, tobacco smoke exposure of 6-year-old children exhibited a significantly decreasing linear trend for all three exposure categories and parental educational levels, amounting to odds ratios from 0.33 to 0.59 during the study time from 1991 to 2000. Generally, the decreasing trend was the lowest for the 'low' educational level and the greatest for the 'high' educational level. In East Germany, a significantly decreasing trend of all three exposure categories was only observed for the 'high' educational level. For the 'low' educational level in East Germany, no linear significantly decreasing time trend was estimated. Furthermore in East Germany, the time trend of maternal smoking during pregnancy obviously diverged from the generally decreasing trend of parental smoking behaviour in East and West Germany as maternal smoking during pregnancy significantly increased for 'low' and 'middle' educational levels. In both parts of Germany, children's tobacco smoke exposure was up to 2 times higher in urban areas in comparison to rural areas (Table 2).

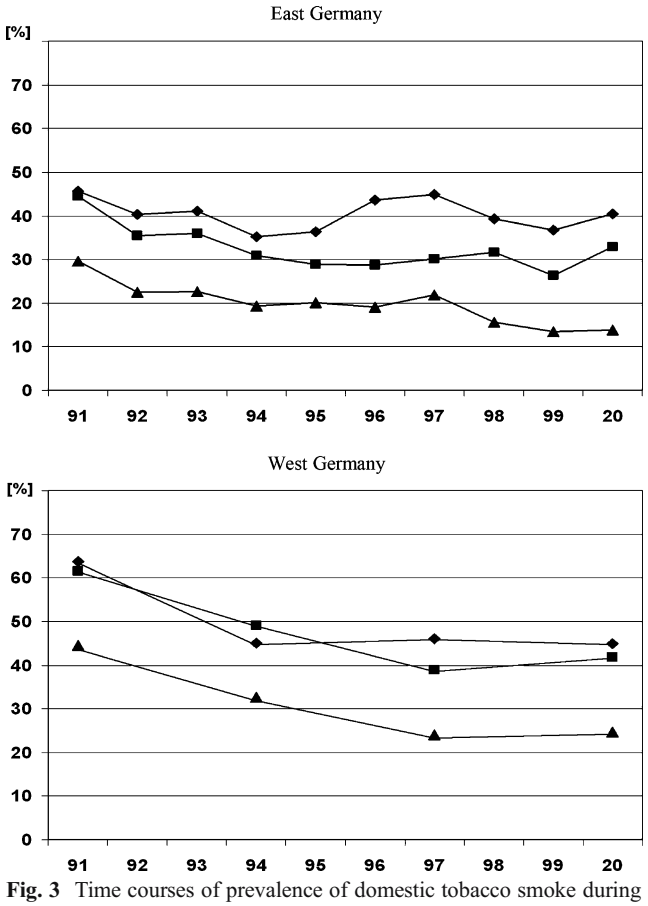

Fig. 3 Time courses of prevalence of domestic tobacco smoke during first 3 years of the child's life among 6-year-old children by parental educational level (*rhombuses*='low', less than 10 years of school; *squares*='middle', 10 years of school; *triangles*='high', more than 10 years of school) in East and West Germany from 1991 to 2000

Discussion

This study confirmed the well-known fact that smoking behaviour is strongly associated with the educational levels and, consequently, that the risk of tobacco smoke exposure among children is largely determined by the different parental educational levels (Barbeau et al. 2004; Helmert et al. 1995). The risk ratio of 6-year-old children of current exposure to tobacco smoke and of prenatal smoking exposure in Germany was well above 2 (odds ratio >2) in comparing lower and higher parental educational levels. For women at the age of 30–40 years in Germany in 1995, Helmert et al. observed an odds ratio of 2.2 for smoking prevalence comparing lowest (<10 years of school) with highest (>10 years of school) educational level (Helmert et al. 2001). With the exception of the lowest educational level in East Germany, we saw in both parts of Germany a significantly decreasing trend of environmental tobacco smoke exposure at the homes of children which amounted to a decreasing rate of 2–3% per year roughly. Declining smoking rates in both sexes have been observed in Switzerland during the same observational period (Kuntsche and Gmel 2005).

Maternal smoking during pregnancy is of a high public health concern. Possibly due to a very close medical supervision of pregnant women in the former socialistic German Democratic Republic (GRD, East Germany before reunification), smoking prevalence among pregnant women was lower in East Germany than in West Germany until 1990. Unfortunately, the prevalence of maternal smoking during pregnancy increased after 1990 in East Germany. Dramatic changes in the health care system in East Germany after reunification causing the closing of many public policlinics could be a possible reason for this new trend. Otherwise in West Germany at the same time, smoking prevalence among pregnant women was slightly increasing again after a considerable decrease during the 6 years before. The gap of maternal smoking prevalence was about 20–30% between low and high educational levels. In 2000 in Sweden, Fossum et al. observed a 13% prevalence of smoking pregnant women which is comparable to the total prevalence in East Germany, but about one-half as high as in West Germany (Fossum et al. 2004). In 1980, smoking during pregnancy was reported for about 30% of all women giving birth in the USA, in 1990 18.4% and in 2002 11.4% (CDC et al. 2004; Frankowski and Secker-Walker 1989). This is equivalent to an odds ratio of 0.54 for a 9-year trend which is in agreement with the respective odds ratios of 0.52 for West Germany (Table 2).

In West Germany, the prevalence of domestic tobacco smoke during the first 3 years of a child's life was only slightly lower than the domestic tobacco smoke exposure at the age of 6. Parents in West Germany reported an average prevalence of 37% between 1997 and 2000. In 2002, 36% of Dutch infants (0–1 year of age) were exposed to environmental tobacco smoke which is similar to the observation in our study (Hofhuis et al. 2003). In East Germany, an average prevalence of 25% for domestic tobacco smoke during the first 3 years was reported between 1997 to 2000 and, therefore, it corresponded to the lower smoking prevalence of the pregnant mothers in East Germany in comparison to West Germany.

The logistic regression analysis of the exposure time course (Table 2) clearly revealed the significantly increasing gap of children's tobacco smoke exposure between social groups over time in East Germany. For example, for current tobacco smoke exposure, the prevalence difference between 'low' and 'high' educational levels increased from 25 to 50%. In West Germany, this time course pattern was only weakly expressed, and the gap between 'low' and 'high' educational levels, for example, increased from 20 to 35%. Social deprivation, as measured by indicators such as poor housing, low income, lone parenthood, unemployment or homelessness, is associated with high rates of smoking and very low rates of quitting (Anderson 1999). In East Germany, the transition from a socialist economic system to a market

Table 2 Association of tobacco smoke exposure of children in East Germany (1991–2000) and West Germany (1991, 1994, 1997 and 2000) at the age of 6 years, during their first 3 years of life and during pregnancy with parental educational level, time and region (urban or rural). Adjusted odds ratios with 95% confidence intervals (95% CI) by means of logistic regression analysis

	East Germany			West Germany		
	Current domestic tobacco smoke	Maternal smoking during pregnancy	Domestic tobacco smoke during first 3 years	Current domestic tobacco smoke	Maternal smoking during pregnancy	Domestic tobacco smoke during first 3 years
Sample size (% yes)	22,610 (44)	23,673 (9)	23,666 (28)	6,805 (55)	7,281 (26)	7,289 (47)
Odds ratio (95% CI)						
Parental educational level high (reference)	1	1	1	1	1	1
Parental educational level middle	2.51 (2.28–2.77)	2.48 (2.08–2.97)	1.77 (1.60–1.95)	2.21 (1.89–2.59)	2.41 (2.03–2.87)	1.93 (1.67–2.24)
Parental educational level low	4.02 (3.21–5.02)	7.58 (5.91–9.71)	2.00 (1.64–2.43)	2.32 (1.92–2.79)	2.85 (2.36–3.44)	1.98 (1.68–2.34)
Region rural area (reference)	1	1	1	1	1	1
Region urban area	1.30 (1.22–1.39)	1.55 (1.39–1.72)	1.44 (1.35–1.54)	2.09 (1.83–2.39)	2.70 (2.24–3.25)	1.78 (1.56–2.03)
Time[a] (parental educational level high)	0.36 (0.32–0.42)	0.69 (0.51–0.92)	0.91 (0.90–0.93)	0.33 (0.26–0.41)	0.52 (0.38–0.72)	0.37 (0.29–0.46)
Time[a] (parental educational level middle)	0.46* (0.41–0.53)	1.26** (1.05–1.51)	0.94** (0.92–0.95)	0.40 (0.33–0.47)	0.59 (0.49–0.71)	0.43 (0.36–0.51)
Time[a] (parental educational level low)	0.85** (0.59–1.24)	1.44** (1.01–2.06)	0.98** (0.95–1.02)	0.58** (0.46–0.74)	0.67 (0.53–0.85)	0.47 (0.38–0.59)

*$p<0.05$ for test of inequality to the odds ratio of the stratum 'time (parental educational level high)'

**$p<0.01$ for test of inequality to the odds ratio of the stratum 'time (parental educational level high)'

[a]Unit: 9 years (2000 versus 1991)

economy created a high socioeconomic pressure on the population. For instance, this change caused an unemployment rate which was completely unknown in the former GRD. Obviously, this socioeconomic transition had the most negative impact on the less educated portion of the population in East Germany, especially exemplified by the unemployment burden (du Prel et al. 2005). This might in part explain our observation that the gap between low and high parental educational level with respect to current children's tobacco smoke exposure was greater in 2000 in comparison to 1991 in East Germany. A similar explanation might hold for the increasing gap of current tobacco smoke exposure between 'low' and 'high' levels of education in West Germany, but with a smaller implication, as the unemployment rate also increased considerably in West Germany after reunification.

Environmental tobacco smoke exposure was considered a confounder of indoor air exposure among others for the epidemiological study on ambient air exposure the data of which was used for this investigation. Hence, a major limitation of this study was the assessment of the children's tobacco smoke exposure by parental questionnaire with three simple questions only. No further quantification or support by objective measure such as cotinine level were available. However, it could be assumed that parental self-assessment rather underestimates the prevalence of the children's tobacco smoke exposure (Krämer et al. 2004). A second limitation was the questionable comparability between the different educational systems in East and West Germany. Especially, the two parental educational classes of 'low' and 'middle' level were not directly comparable between the two parts of Germany. In East Germany, the small group of 'low' parental educational level (5.7% of the East German study group) obviously represented an extremely low educational level which could be considered a specific subgroup of the group of 'low' educational level in West Germany (24.7% of the West German study group). To some extent, this could explain the larger gap of exposure prevalence between 'low' and 'middle' educational level in East Germany in comparison to West Germany.

Conclusion

Our findings led us to the following three conclusions. First, environmental tobacco smoke exposure of children is strongly determined by their parents' educational levels. The risk ratio of exposure comparing the lowest with the highest educational level can even exceed a value of 7. Therefore, preventive measures should focus especially on parents with lower educational level. Second, as the negative consequences of socioeconomic changes, like the transition from a socialist to a market economy in East

Germany, have the strongest impact on the part of the population with a low educational level, an already existing gap between parents with 'low' and 'high' education increases with respect to environmental tobacco smoke exposure of their children. Third, although our results indicated a decreasing trend of environmental tobacco smoke exposure at children's homes, comparable to the findings in the literature, strikingly, we observed a considerable fresh increase of maternal smoking during pregnancy around 1991 in both parts of Germany. In East Germany, this could possibly be explained by changes in health care of pregnant women. For West Germany, a satisfying explanation could not be provided. Therefore, further investigation is needed.

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Conflict of interest statement The authors certify that there are no relevant commercial associations that might pose a conflict of interest.

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4.3 Preschool children's health and its association with parental education and individual living conditions in East and West Germany.

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Preschool Children's Health and its Association with Parental Education and Individual Living Conditions in East and West Germany.

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Abstract

Background: Social inequalities in health are one of the key public health problems also in Germany. Since 1990 substantial social and economic changes occurred in East Germany and it is not clear whether these are reflected in changes in social inequalities in health. The aim of this study was to explore associations between health indicators and parental education in preschool children from East and West Germany during a time of socioeconomic and environmental changes and to search for potential causes of these associations within the individual living conditions of these children.

Methods: All boys and girls entering elementary school and living in predefined areas of East and West Germany were invited to participate in a series of cross-sectional investigations between 1991 and 2000. Data of 28,888 German children with information on parental education were included in the analysis. Information about educational status, individual living conditions, symptoms and diagnoses of infectious diseases and allergies were taken from questionnaire. At the day of investigation, atopic eczema was diagnosed by dermatologists, blood was taken for the determination of allergen-specific immunoglobulin E, height and weight was measured and lung function tests were done in a subgroup. Regression analysis was used (1st step) to determine the association between educational status of the parents and health indicators and (2nd step) to investigate whether this association could be explained by individual living conditions.

Results: Average response was 83% in East Germany and 71% in West Germany. Different pattern of results emerged: Symptoms and diseases diagnosed by a physician were reported more frequent by parents with higher education. Individual living conditions could not explain these differences. “Damp housing conditions” were less prevalent in families with

higher educational background and this explained part of the differences in the unspecific symptoms “frequent cough” and “sneezing” between the educational groups. Furthermore, “heating with fossil fuels or cooking with gas” which was more prevalent in less educated families in East Germany was a protecting factor against sensitization with pollen and partly explained differences between social groups. “Maternal smoking during pregnancy” was more frequent reported by less educated parents and increased in this group over time. Maternal smoking could explain differences in child’s birth weight between educational groups and partly differences in child’s lung function.

Conclusion: The lower prevalence of symptoms and diseases ever diagnosed by a physician in children of less educated parents might be partly due to underreporting. The influence of maternal smoking especially in the less educated group is of concern. Special programs should be developed addressing this group of mothers to reduce the risk of maternal smoking on children’s health and, thereby, reducing social inequality in children’s health.

Introduction

Social inequalities in health are a growing public health concern [1]. Globally and historically, socioeconomic status is among the most important health determinants throughout life [2]. Equity in health is one of the main aims of the WHO program on health policy "Health for all" [3]. However, important social health inequalities exist all over the world and also exist in Germany. In West as well as in East Germany, mortality and morbidity increases with decreasing social status [4].

Exposure to environmental pollutants may be different in different social groups and can add another burden to groups already at higher risk of disease and may even have disparate impacts [5,6]. For instance several factors that might be expected to vary with socioeconomic status have been reported to modify lung function, these include area of residence, outdoor air pollution, type of heating or cooking fuel used, crowding and maternal smoking during pregnancy [7].

Young children seem to be particularly vulnerable to the effects of poverty which might be associated with low socioeconomic status. Poverty is associated with higher risk of death in infancy and childhood, chronic childhood illness, many acute illness, birth weight, obesity and mental health problems [8-12]. Poorer health in poor children is generally explained by the parents' low level of education and negative health behaviors and by the higher frequency of neonatal health problems [13].

In contrast, atopic diseases and allergic sensitization in both children and adults have been reported to occur more frequently in higher than in lower socioeconomic groups in eastern and western industrialized countries [14-16]. Children, whose parents have a high education

suffer more frequently than other children do from allergies, the relationship holds true in West Germany as well as in East Germany [17]. Mielck [18] reviewed 24 studies on the association between childhood asthma and socioeconomic status and found that the studies did not reveal a clear picture; positive associations were as frequent as negative ones, and most studies showed no association at all. The choice of socioeconomic status indicator may make a difference to the measured degree of socioeconomic inequality in health [19].

After the German re-unification, tremendous social and economic changes have taken place in few years during the 1990s in East Germany, the former socialist German Democratic Republic. This might serve as a time-lapse picture for future developments in other Eastern European countries of transient societies. We already described that the social gap in health related living conditions of 6 year old children in East Germany increased between 1991 and 2000 [20,21]. That was especially true for "living near busy roads" and "maternal smoking". Studies about the relationship between the prevalence and trends of childhood diseases, health related living conditions and parental education comparing East and West Germany are not available so far.

In this study, we systematically describe associations between health indicators and parental educational level in 6 year old children investigated between 1991 and 2000. Beside questionnaire based information, we also use "objectively" measured variables to define health indicators. Parental education is no direct cause of disease. Therefore, the main aim of this study was to analyze, whether the associations between parental education and health indicators could be explained by differences in the individual living conditions, which may then be considered as underlying causes.

Material and methods

Study population

The study data was collected within a large study in East and West Germany investigating the health effects of the changing environmental and socioeconomic conditions after re-unification in school beginners (6-year-old) between 1991 and 2000. Details of the study design were presented elsewhere [22-24]. In brief, all boys and girls entering the elementary school between 1991 and 2000 (in West Germany in 1991, 1994, 1997 and 2000 only) and living in geographically preselected areas of East and West Germany were eligible to participate. Rural areas without heavy industrial impact were located in Salzwedel, Gardelegen, Osterburg and Kloetze in East Germany and in Borken and Borken District in West Germany. Urban areas with industrial impact and strong traffic burden were selected in Halle, Leipzig and Magdeburg in East Germany and in Duisburg, Essen and Cologne in West Germany. A letter was mailed to the parents inviting the child to participate in the study and for completion of a standardised questionnaire at home. On the day of investigation, the questionnaire was checked by a physician and subsequently completed by the parents. In the investigation years 1991, 1994, 1997 and 2000 and in a portion of the preselected areas, the children were asked to undergo a dematological examination and to donate a blood sample, and, furthermore, with the exception of the areas in East Germany in the year 2000, a subgroup of about every second child was asked to take a lung function test. The overall response rate to participate by answering the questionnaire was 83% and 71% in East and West Germany, respectively. The response rates for participation in a dermatological examination, donation of a blood sample and testing the lung function were 84%, 73% and 73%, respectively, in East Germany and 88%, 69% and 69% in West Germany. Written informed consent of the parents of the participating children was obtained. The ethical committee of the Medical Association of Saxony-Anhalt approved the study.

Parental education

Information about school education of the parents was taken from the questionnaire. Considering the different schooling systems of East and West Germany before re-unification, a suitable measure of the parental educational level was chosen by classifying the school education into the two categories of no more than 10 years school and more than 10 years school. The parent or partner with the highest school grade defined the parental educational level of the child. For an unambiguous classification of the parental education, we only included children whose mother or father was of German nationality.

Individual living conditions

In the questionnaire, the parents were asked to provide information on the child's living conditions which were considered relevant for the child's health. Altogether, six individual living conditions were investigated: The question for the number of sisters or brothers of the child resulted in the family condition "single child". The per capita living space of the child's home could be defined by using the two questions "How many people are living in the child's home?" and "How many square meters is the child's home?". The living space was considered small if it was below 20 m^2 per person ("small living space"). If single oven heating with fossil fuel or cooking with gas existed then "unfavourable indoor air" in the child's home was assumed. Affirmation of the question "Would you characterise your home as damp?" indicated a "damp housing condition". "Maternal smoking during pregnancy"was highly correlated with current maternal smoking and was considered as an indication of the child's exposure to environmental tobacco smoke throughout life. Traffic exposure of the children was determined by the distance of the children's home to the nearest busy road, and "living near a busy road" was stated if the distance was less than 50 m.

Health status variables

Altogether, 14 variables describing the health status of the child were investigated in this study. Six health indicators representing a range of infectious and atopic diseases and symptoms were selected from the questionnaire data, namely "bronchitis ever diagnosed by a physician", "more than 4 colds during the last 12 months", "frequent cough without cold", "sneeze attacks during the last 12 months", "allergy ever diagnosed by a physician" and "eczema ever diagnosed by physician". "Birth weight" of the child was also provided by questionnaire. Seven further indicators were determined independent from the questionnaire: On the day of investigation, a physician examined the child's skin and decided on the diagnosis of an atopic eczema ("atopic eczema on the day of investigation"). Atopic sensitisation was tested by determining specific immunoglobulin-E (IgE) antibodies against common allergens in the blood serum of the child by an enzyme immuno assay (Radio Allergo Sorbent Test [RAST], Pharmacia & Upjohn, Uppsala, Sweden). Based on the results of the RAST, participants were classified as having "specific IgE grass pollen positive" or "specific IgE house dust mite positive" if the specific IgE concentrations against grass pollen and house dust mite, respectively, were greater than 0.35 kU/l. Body height and weight were measured on the day of examination and "body height" used as a general measure of physical development. A body mass index (BMI = body weight/(body height)^2 [kg/m^2]) greater than 19 kg/m^2 provided an indication of "overweight" Using a body plethysmograph for a sub-group of the participants, "airway resistance" and "total lung capacity" were available as indicators of lung function. To correct for body height and gender, total lung capacity were provided as percent predicted ("total lung capacity % predicted").

Statistical Analysis

Raw prevalence or mean values respectively of all health indicators and living conditions were described in groups defined by "urban/rural living", "year of investigation" and

"parental education". Chi-square test and F-test were applied to the comparison of distributions of dichotomous and continuous variables, respectively, between groups. The Cochran-Armitage test was used to test for a trend in the proportions of a dichotomous variable across the years of investigation. For a continuous variable, the significance of the regression coefficient of a linear regression to the year of investigation was tested by the t-test.

A two-step process of multiple regression analysis was applied to reveal, in the first step, associations between parental education as independent variable and health status variables as dependent variables and to examine, in the second step, the explanatory potency of the living conditions as further independent variables for the associations between education and health status which was observed in the first step. As the educational systems in East and West Germany featured many differences before the re-unification the two-step regression analysis was performed separately for East and West Germany. For dichotomous outcome variables, we used logistic regression, and the linear multiple regression approach was used for continuous outcome variables. In the year of investigation, urban or rural residence and gender were associated with the variables of health status, living conditions and parental education level, respectively. These three co-variables were included into all the regression models as potential confounders. Interaction terms between the year of investigation and the parental educational level were incorporated and the results of a stratified analysis are presented, if the interaction was statistically significant ($p < 0.05$). Parental educational level was the independent variable in the first step regression model besides the three co-variables year of investigation, urban/rural residence and gender. For the second step, the regression model of the first step was expanded by the six living conditions as further independent variables. Only children with complete information regarding all dependent and independent variables were included in the analysis. The regression results with respect to the association

between educational level and health status variables were presented in the case of logistic regression as adjusted odds ratios and in the case of linear regression as adjusted means ratios, both together with 95% confidence intervals. The adjusted means ratio (MR) was calculated as the ratio of the expected adjusted change of the dependent variable Δy by a unit-increase of the respective independent variable and the sample mean $\bar{y}$ plus unity: $MR = 1 + \Delta y / \bar{y}$. The statistical analysis was performed by using the SAS statistical software package, Version 9.01 (SAS Institute, Cary, NC).

Results

Information on parental education was available for 28,888 children with German nationality, comprising 90.4% of all participating children. In Table 1, the study size in terms of year of investigation, urban/rural residence and East and West Germany is presented in more detail. The median age of the children was 6.3 years with a range from 5.6 to 7.1 years, and the proportion of girls was 49.2%.

The distributions of parental education, living condition and health status variables are described in terms of prevalence, mean and standard deviation, respectively, for East Germany (Table 2) and West Germany (Table 3) separately. The prevalence of parents with lower school education was in West Germany 65.2% and in East Germany 51.9%. Table 2 and 3 clearly demonstrates the large prevalence differences of the living conditions between East and West Germany. Unfavourable indoor conditions with respect to heating and cooking and dampness were more frequent reported in the East than in the West, but with respect to environmental tobacco smoke exposure as assessed by maternal smoking during pregnancy, the conditions were worse in West Germany. A single child was more common in East than in West Germany. Living space was smaller in East Germany. Differences in health status variables between East and West existed, but were not as obvious as in the living conditions.

Furthermore in Tables 2 and 3, the influence of urbanisation (urban or rural residence) and time (year of investigation) on the study variables was documented. In general, living conditions were more favourable at a rural than an urban residence in both parts of Germany. The same relation was true for the health indicators with the exception of sensitization and lung function. For all living conditions in East Germany, we observed highly significant time trends: The number of single children and those living near a busy road increased the latter

peaking in the mid-nineties, small living place, unfavourable indoor air and damp housing conditions decreased, the latter also with a peak in the mid-nineties. This was already described and discussed in more detail elsewhere [20]. Time trends in health indicators were heterogeneous: The prevalence of frequent cough and eczema at the day of observation decreased whereas sneeze attacks, ever diagnosed eczema, overweight, height, birth weight and total lung capacity increased. In West Germany, changes over time of living conditions and health variables were present, but to a lesser degree compared to East Germany (Table 3).

With the exception of "unfavourable indoor air" in West Germany, all living conditions were significantly ($p<0.1$) associated with parental educational level (Table 4): Less educated parents had more frequent a single child, they lived more frequent in a small or damp living place, heated with coal or gas and lived near a busy road. The higher prevalence of maternal smoking in families with lower education of the parents was most striking. This also was described and discussed in more detail elsewhere[21].

In Table 4, the crude associations between health status variables and the parental education are presented too. Parents with higher educational level more frequent reported symptoms and diseases with the exception of frequent cough than parents with lower level. Also sensitization against grass pollen and house dust mite was more frequently observed among children with parents of higher education. Overweight, small height and low birth weight however were in both parts of Germany significantly more frequent in children of less educated parents.

As can be seen from table 5 and 6 most health indicators were influenced by living conditions: Single children had more frequent allergies and symptoms of allergies, were more frequent sensitized (significant only for grass pollen sensitization in West Germany), were more frequent overweight, were taller and their birth weights were lower; heating with coal or

cooking with gas was associated with more colds and less eczema and sensitization, which was significant in East Germany; dampness in the flat was unfavourable for nearly all health indicators and this was especially pronounced for cough, sneezing and (in East Germany) sensitizations against house dust mites. Maternal smoking had the most pronounced and highly significant effect on children's birth-weights, frequent cough and specific air way resistance.

The focus of this study was to find out whether specific living conditions might be partially causal for the association between educational level and health status. Therefore, we applied the two-step statistical regression modelling. The results of this regression analysis are presented in Tables 5 and 6 for East and West Germany, respectively. The crude associations of the parental education with the children's health status, as presented in Table 4, were essentially confirmed by the odds ratios and means ratios adjusted for gender, residence and time trend at the first step of the regression analysis (Table 5 and 6). In the second step, the regression model of the first step was augmented by the six living conditions as independent variables. Comparing the adjusted measures of association between parental education and health status of the second step with the respective measures of the first step, one can value to which extent the living conditions could explain the educational influence on the children's health. The results of these analyses were heterogeneous, and we could roughly identify four different patterns:

(i) *Influence of parental education but no change after adjusting for living conditions:* Higher educated parents reported diseases ever diagnosed by a physician and number of colds significantly more frequent than less educated parents. The odds ratios describing these associations did not change or only marginally change when adjusting for living conditions. The results were very similar in East and in West Germany, but with the one exception in East

Germany that the association between parental education and ever diagnosed allergy was stronger in 1991 than in 2000. This is mainly due to more reports of higher educated parents in 1991 than in the years after. Overweight was more frequently observed for children with less educated parents than with higher educated. This association did not change after adjusting for the influential factor "single child" in East Germany, but in West Germany.

(ii) *Marginal influence of parental education with change after adjusting for living conditions:* The odds ratio for the association of frequent cough and sneezing with lower parental education was reduced after inclusion of living condition factors mainly due to the strong influence of damp housing conditions. After adjusting, the odds ratio indicates more positive reports in the higher educated group. These results were also very similar in both East and West Germany.

(iii) *Influence of parental education and explanation by living conditions:* The association of positive specific IgE sensitization with high parental educational level in East Germany could partly be explained by living condition factors. This is due mainly by the association with "unfavourable indoor air". The lower birth weight of children from less educated families could be explained by the two factors "single child" and "small living space" and the higher prevalence of maternal smoking during pregnancy in the group with less educational level. This latter influence was stronger in West Germany and in East Germany in the year 2000 than in East Germany 1991. The differences in mean of airway resistance between the educational groups also was reduced after inclusion of lifestyle factors. This also was mainly due to maternal smoking, and again this effect was stronger in West Germany than in East Germany 1991.

(iv) *No association with parental education*: This was true for the total lung capacity (% predicted). After adjusting for living conditions, there was no additional effect of educational level.

Discussion

In this study we observed strong associations between parental education and health indicators of children. Higher educated parents reported more diagnoses and symptoms than less educated. Children of higher educated parents were also more frequent sensitized against grass pollen or house dust mites, but had higher birth-weights, lower air way resistance and were less overweight at the age of six. Taking individual living conditions of the children into account, we searched for possible explanations of the observed differences between social groups. Because of the heterogeneity of the effects, we propose different mechanisms driving the associations between parental education and health indicators:

Under- or over-reporting in certain educational groups might be of concern. As in most of the population-based studies examining the relationship of socioeconomic status to childhood disease, we used parental reporting to assess the respiratory outcomes [25]. Differences in reporting behavior among parents of different social classes may bias such associations. A combined analysis of questionnaire based information from studies done in children from Eastern and Western Europe and North America also revealed that diagnoses of allergies were more frequent reported in groups with higher educated parents and this was true for Eastern and Western countries [16]. Under-reporting or access to healthcare might explain a decreased prevalence of the diagnoses with low parental education. Furthermore, the higher prevalence of bronchitis, allergy and eczema in children with high parental education could also be explained in part by differences in the perception of severity of diseases. Highly educated parents might take medical advice in mild cases of bronchitis whereas parents with a low level of education take medical advice in more severe cases only [16]. Therefore, part of the difference in diagnoses and symptoms of children with differently educated parents found in our study might be due to over-reporting of higher educated parents or under-reporting of less

educated parents. However, the extent of this bias is difficult to assess. A comparison between "eczema at the day of investigation" which was determined independently from reporting and "eczema ever diagnosed" was already done with data from this study and demonstrated that under-reporting of less educated parents was most likely [26]. Higher educated parents from East Germany reported allergy ever diagnosed by a physician more frequent in 1991 than in 2000 which was not true for less educated parents. This may hint to over-reporting of higher educated parents shortly after the re-unification when an allergy diagnosis perhaps became "fashionable".

None of the *living conditions* included in our evaluation could explain the social differences in reporting of doctor-diagnosed diseases. This does not necessarily mean that these differences are completely due to over-reporting and do not exist. Several studies conducted in different European countries already reported higher prevalence of eczema, hay fever and sensitization to inhalant allergens among children, adolescents and adults of the most advantaged socioeconomic group [14,16,27,28]. Factors related to "hygiene" are known to modify factors for allergic diseases and might be differently distributed between social groups. For instance, living as a single child in a family is related to "hygiene" (less infection in early age) and is a strong known determinant of allergic disease and sensitization. This latter could again be demonstrated in our study. However, in this study a single child was more frequently observed in families with low educated parents. Therefore this factor could not explain lower prevalence of allergies and sensitizations in low educated families. Other factors not measured might be responsible for the differences. The following lifestyle factors, however, could be identified which drove social differences in several health indicators.

To live as a single child in a family was not only a risk factor for allergies, but also a risk factor for overweight in both parts of Germany. In West Germany, this could partly be explained by the higher prevalence of overweight in children with less educated parents.

Living in damp housing conditions was a risk factor for sneezing and frequent cough and partly explained the prevalence of these symptoms in families with lower educational background because this condition was more frequent in these families. After adjusting for these conditions the odds ratio for social differences demonstrated higher reporting in higher educated families which might again be due to over-reporting or due to the fact that these symptoms could as well be symptoms of allergic disease. Similar results were gained from the combined analysis of questionnaire based information from studies done in children from Eastern and Western Europe and North America [16]. Here nocturnal cough and wheezing was more prevalent in groups with low educated parents in Eastern countries and more prevalent in groups with highly educated parents in Western countries where these symptoms were related to allergic diseases.

Heating with fossil fuels or cooking with gas which was more prevalent in less educated families in East Germany was a protecting factor against sensitization with pollen and partly explained differences in pollen sensitization between social groups. A protective effect of indoor heating with fossil fuels was already demonstrated for Bavarian families. [29], but remained largely unexplained.

Maternal smoking during pregnancy was more prevalent in groups with lower parental education. Maternal smoking during pregnancy was also the strongest identified risk factor for low birth weight of the child. This factor mainly explains the lower birth weight of children from less educated parents. Interestingly this factor only became relevant in East

Germany for children born after the re-unification (significant interaction between year of investigation and educational level). This is due to the fact that the prevalence of "smoking in pregnancy" increased in East Germany in the less educated groups in contrast to other groups [21]. It is a well-known fact that smoking during pregnancy leads to a low birth weight of the child [30]. Maternal smoking also partly explained the higher mean airway resistance of children from less educated parents.

In conclusion, no single individual living condition of the children could be identified explaining the associations between parental education and children's health indicators. Different mechanisms may be involved including under-reporting of diagnoses and ranging from poor housing conditions (dampness) to - most important - unhealthy parental lifestyle (maternal smoking). Studies comparing reporting behaviour of different social groups are missing, but urgently needed in order to properly interpret results gained in regions with different social backgrounds. The increasing gap in early life health conditions between social groups induced by maternal smoking during pregnancy is of special concern. This is a factor potentially preventable and prevention programs have been successfully applied [30]. Programs which reach less educated mothers are needed.

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

UR proposed the idea for the article. XDP wrote the first draft, supervised by UR. HO coordinated the study in East Germany. HB and JR were responsible for the evaluation of allergy related variables. UK was main investigator of the study in East and West Germany and together with UR edited subsequent drafts. TS commented on the draft. All authors reviewed the final version of the manuscript.

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Table 1. Study population of 6-year-old children in East and West Germany by year of cross-section, sample sizes of participants of German nationality with complete information on parental education and portions of these participants with specific investigations (in parentheses).

Year	*Sample size (percentage with RAST, dermatological investigation and lung function test)*				
	East Germany		*West Germany*		*Total*
	Urban [a]	Rural [b]	Urban [c]	Rural [d]	
1991	3108 (32.4 ; 9.1 ; 24.3)	916 (40.9 ; 0.0 ; 25.7)	2554 (16.9 ; 20.9 ; 5.4)	359 (58.5 ; 68.8 ; 20.1)	6937 (29.2 ; 15.3 ; 17.2)
1992	1225	924	--[e]	--[e]	2149
1993	973	873	--[e]	--[e]	1846
1994	3331 (24.6 ; 17.2 ; 8.5)	890 (33.3 ; 31.7 ; 26.7)	396 (70.5 ; 37.1 ; 45.5)	265 (79.6 ; 87.7 ; 44.2)	4882 (32.9 ; 25.2 ; 16.8)
1995	1061	714	--[e]	--[e]	1775
1996	965	667	--[e]	--[e]	1632
1997	2095 (16.9 ; 16.5 ; 10.5)	561 (36.4 ; 47.1 ; 28.9)	356 (64.0 ; 82.9 ; 31.5)	429 (53.1 ; 58.3 ; 11.0)	3441 (28.1 ; 33.6 ; 15.7)
1998	862	321	--[e]	--[e]	1183
1999	826	356	--[e]	--[e]	1182
2000	1662 (17.0 ; 16.2 ; 0.0)	336 (29.5 ;38.4 ; 0.0)	1540 (12.3 ; 15.8 ; 13.1)	323 (41.2 ; 52.9 ; 44.6)	3861 (18.2 ; 21.1 ; 8.9)
Total	16108 (15.3 ; 9.1 ; 7.8)	6558 (14.9 ; 10.3 ; 9.5)	4846 (22.2 ; 25.2 ; 13.0)	1376 (56.8 ; 65.3 ; 27.6)	28888 (18.3 ; 14.8 ; 10.0)

[a] Leipzig, Halle and Magdeburg; [b] Salzwedel, Gardelegen, Osterburg and Kloetze;

[c] Duisburg, Essen, and Cologne; [d] Borken; [e] no investigation

Table 2: Prevalences and mean values, respectively, of the study variables by residence and year of investigation of 6-year-old children in East Germany

Study variables	*Total*	*Residence*			*Year of investigation*										
		Urban[a]	Rural[b]		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
	Prev.[%]	Prevalence [%]		p[c]	Prevalence [%]										P[d]
Low parental educational level	51.9	49.9	56.7	<0.001	48.6	52.4	50.1	50.2	50.9	49.7	53.8	58.0	57.1	54.7	<0.001
Single child	38.2	41.5	30.3	<0.001	30.9	30.2	33.6	38.5	39.5	41.7	46.6	45.4	41.2	44.7	<0.001
Small living space	46.3	48.1	41.8	<0.001	58.7	49.3	46.2	53.4	42.6	38.6	43.2	36.8	33.2	32.1	<0.001
Unfavourable indoor air	50.8	53.8	43.5	<0.001	62.5	73.7	61.5	50.6	58.7	47.3	37.1	36.6	31.7	27.2	<0.001
Damp housing condition	10.5	11.7	7.6	<0.001	9.4	11.0	11.4	11.6	13.3	13.5	10.2	9.8	9.1	6.0	0.001
Maternal smoking during pregnancy	9.2	10.1	7.3	<0.001	12.2	7.6	7.5	6.3	7.0	6.4	10.7	12.1	11.5	12.4	0.004
Living near a busy road	57.7	59.8	52.6	<0.001	55.6	59.8	62.8	63.0	63.3	30.4	59.6	58.8	58.6	57.1	0.013
Bronchtis ever diagnosed	48.1	49.7	44.3	<0.001	56.0	50.3	47.2	50.6	44.9	45.0	44.9	43.6	44.0	39.4	<0.001
More than 4 colds in last 12 months	13.1	14.7	9.1	<0.001	16.1	14.2	11.6	13.4	9.8	11.1	11.7	12.0	14.6	12.7	<0.001
Frequent cough	6.4	7.3	4.2	<0.001	10.0	7.4	6.2	6.0	6.4	4.7	4.9	4.5	5.3	4.5	<0.001
Sneeze attacks in the last 12 months	5.0	5.7	3.2	<0.001	4.8	2.9	3.0	4.4	4.0	4.2	6.7	6.6	6.5	7.7	<0.001
Allergy ever diagnosed	9.3	9.6	8.5	0.014	11.5	8.4	9.2	7.7	7.4	8.9	9.0	9.7	9.4	10.8	0.417
Eczema ever diagnosed	16.9	16.1	15.4	0.198	14.7	12.1	13.8	15.0	15.0	16.4	18.0	18.1	20.9	20.0	<0.001
Atopic eczema, day of investigation	11.7	12.4	10.1	0.113	17.7	--[g]	--[g]	12.5	--[g]	--[g]	11.2	--[g]	--[g]	6.5	<0.001
Specific IgE grass pollen positive	11.3	10.9	12.2	0.265	11.7	--[g]	--[g]	10.8	--[g]	--[g]	10.5	--[g]	--[g]	12.1	0.824
Specific IgE house dust mite positive	9.8	9.6	10.4	0.487	10.1	--[g]	--[g]	9.2	--[g]	--[g]	9.7	--[g]	--[g]	10.8	0.825
Overweight BMI > 19 kg/m²	5.6	5.5	5.8	0.392	3.5	3.9	5.2	5.7	5.8	6.1	7.0	7.6	6.3	8.0	<0.001
	Mean ± Std.	Mean ± Standard dev.		P[e]	Mean ± Standard deviation										P[f]
Body height [cm]	120.1 ±5.5	119.9 ±5.5	120.6 ±5.5	<0.001	119.5 ±5.4	119.7 ±5.4	120.0 ±5.8	120.5 ±5.4	120.0 ±5.6	120.5 ±5.3	120.4 ±5.6	120.3 ±5.7	120.4 ±5.8	120.0 ±5.5	<0.001
Birth weight [10•g]	333 ±54	331 ±54	336 ±54	<0.001	327 ±51	331 ±59	333 ±53	332 ±54	334 ±56	335 ±52	332 ±53	336 ±52	336 ±56	340 ±55	<0.001
Airway resistance [10•kPa•s/l]	6.67 ±1.64	6.64 ±1.59	6.71 ±1.73	0.407	6.76 ±1.74	--[g]	--[g]	6.52 ±1.56	--[g]	--[g]	6.63 ±1.44	--[g]	--[g]	--[g]	0.066
Total lung capacity % predicted	104 ±11	102 ±10	105.5 ±11	<0.001	101 ±10	--[g]	--[g]	106 ±10	--[g]	--[g]	107 ±11	--[g]	--g	--[g]	<0.001

[a] Leipzig, Halle and Magdeburg; [b] Salzwedel, Gardelegen, Osterburg and Kloetze; [c] Chi-square test; [d] Trend test [e] F-Test; [f] t-Test, [g] not investigated

Table 3: Prevalences and mean values, respectively, of the study variables by residence and year of investigation of 6-year-old children in West Germany

Study variables	*Total*	*Residence*			*Year of investigation*				
		Urban[a]	Rural[b]		1991	1994	1997	2000	
	Prev.[%]	Prevalence [%]		p-value[c]	Prevalence [%]				p-value[d]
Low parental educational level	65.2	66.5	60.6	<0.001	63.4	47.5	67.3	73.5	<0.001
Single child	27.2	31.1	13.3	<0.001	28.8	22.1	19.6	29.6	0.690
Small living space	29.0	33.8	12.1	<0.001	33.8	22.5	20.6	27.4	<0.001
Unfavourable indoor air	16.2	16.3	16.0	0.809	19.2	23.0	15.8	9.4	<0.001
Damp housing condition	5.3	6.2	2.3	<0.001	5.9	3.9	4.6	5.2	0.223
Maternal smoking during pregnancy	28.7	33.6	11.4	<0.001	34.8	25.2	19.4	24.3	<0.001
Living near a busy road	50.9	54.6	38.1	<0.001	48.5	57.5	50.6	52.4	0.017
Bronchtis ever diagnosed	45.5	45.0	47.2	0.163	44.9	52.3	51.2	41.5	0.117
More than 4 colds in last 12 months	14.7	15.5	11.9	0.001	15.7	13.2	15.1	13.4	0.041
Frequent cough	7.8	8.4	5.7	0.001	8.9	6.8	8.5	6.1	0.001
Sneeze attacks in the last 12 months	5.8	6.4	3.6	<0.001	4.9	--f	6.2	7.1	0.002
Allergy ever diagnosed	14.0	14.1	14.0	0.902	15.8	13.5	12.4	12.1	<0.001
Eczema ever diagnosed	13.4	13.6	12.6	0.341	10.7	16.3	15.7	15.5	<0.001
Atopic eczema, day of investigation	7.9	7.0	9.2	0.057	10.9	9.0	5.5	4.6	<0.001
Specific IgE grass pollen positive	10.8	11.2	10.2	0.513	9.8	12.2	10.6	10.6	0.782
Specific IgE house dust mite positive	13.0	13.0	13.1	0.965	11.7	14.3	10.8	16.2	0.194
Overweight BMI > 19 kg/m²	7.5	8.3	4.7	<0.001	5.7	5.1	6.5	11.8	<0.001
	Mean ± Std	Mean ± standard dev.		p-value[e]	Mean ± standard deviation				p-value[f]
Body height [cm]	120.4±5.6	120.0±5.6	121.5±5.4	<0.001	120.6±5.6	120.9±5.4	120.7±5.2	119.6±5.7	<0.001
Birth weight [10•g]	337±59	333±58	348±61	<0.001	334±60	338±56	343±54	337±58	0.019
Airway resistance [10•kPa•s/l]	6.30±15.0	6.39±1.49	6.15±1.50	0.015	5.83±1.53	6.23±1.58	6.96±1.51	6.35±1.27	<0.001
Total lung capacity % predicted	105±11	105±10	104±11	0.204	103±11	105±9	105±9	107±11	<0.001

[a] Duisburg, Essen, and Cologne; [b] Borken; [c] Chi-square test; [d] Trend test; [e] F-test; [f] t-Test

Table 4: Prevalences and mean values, respectively, of the study variables by parental educational level of 6-year-old children in East and West Germany

Study variables	*East Germany*			*West Germany*		
	Parental education			*Parental education*		
	Low[a]	High[b]		Low[a]	High[b]	
	Prevalence [%]		p-value[c]	Prevalence [%]		p-value[c]
Single child	38.8	37.6	0.064	28.4	24.9	0.003
Small living space	51.7	40.8	<0.001	35.4	17.1	<0.001
Unfavourable indoor air	52.3	49.2	<0.001	16.3	16.1	0.817
Damp housing condition	12.7	8.2	<0.001	6.4	3.3	<0.001
Maternal smoking during pregnancy	13.9	4.2	<0.001	36.3	14.5	<0.001
Living near a busy road	60.6	54.5	<0.001	55.0	43.2	<0.001
Bronchtis ever diagnosed	43.7	52.8	<0.001	41.9	52.3	<0.001
More than 4 colds in last 12 months	12.0	14.3	0.001	13.9	16.1	0.020
Frequent cough	6.6	6.3	0.407	8.0	7.4	0.366
Sneeze attacks in the last 12 months	4.5	5.4	0.003	5.8	5.9	0.912
Allergy ever diagnosed	7.8	10.9	<0.001	12.2	17.4	<0.001
Eczema ever diagnosed	12.9	19.1	<0.001	11.2	17.4	<0.001
Atopic eczema, day of investigation	11.1	12.3	0.399	7.0	9.3	0.057
Specific IgE grass pollen positive	9.7	12.8	0.004	10.1	11.7	0.247
Specific IgE house dust mite positive	8.5	11.1	0.010	12.0	14.0	0.128
Overweight BMI > 19 kg/m²	6.6	4.6	<0.001	8.9	4.9	<0.001
	Mean ± standard dev.		p-value[d]	Mean ± standard dev.		p-value[d]
Body height [cm]	119.7±5.6	120.6±5.4	<0.001	120.2±5.7	120.6±	0.014
Birth weight [10•g]	330±53	336±53	<0.001	334±60	342±57	<0.001
Airway resistance [10•kPa•s/l]	6.71±1.6	6.61±1.62	0.156	6.41±1.53	6.14±1.45	<0.005
Total lung capacity % predicted	103±11	104±10	0.166	105±11	105±10	0.416

[a] ≤ 10 year scholl; [b] > 10 year school; [c] Chi-square test; [d] F-test

Table 5: Association of parental educational level and living conditions with health status indicators of 6-year-old children in East Germany from 1999 to 2000:

Health status indicator		*Parental education*		*Living condition*					
	Sample size	Low parental educational level 1st step *	Low parental educational level 2nd step **	Single child	Small living space	Unfavourble indoor air	Damp housing condition	Maternal smoking during pregnancy	Living near a busy road
	Prevalence [%]	Adjusted odds ratio (95% confidence interval) – bold type if significant ($p < 0.05$)							
Bronchtis	19878	**0.71**	**0.69**	0.96	0.98	1.02	**1.25**	1.03	**1.11**
ever diagnosed	48.4	**(0.67-0.75)**	**(0.65-0.74)**	(0.91-1.03)	(0.92-1.04)	(0.96-1.09)	**(1.13-1.37)**	(0.93-1.14)	**(1.04-1.17)**
More than 4 colds	20059	**0.83**	**0.80**	1.00	0.99	**1.13**	**1.41**	1.13	**1.11**
in the last 12 months	13.1	**(0.77-0.91)**	**(0.73-0.87))**	(0.91-1.10)	(0.91-1.08)	**(1.03-1.23)**	**(1.25-1.60)**	(0.98-1.30)	**(1.02-1.21)**
Frequent cough	20567	1.09	1.01	0.98	0.97	0.98	**1.67**	**1.34**	**1.27**
	6.3	(0.98-1.22)	(0.90-1.14)	(0.86-1.11)	(0.85-1.09)	(0.86-1.11)	**(1.41-1.96)**	**(1.12-1.60)**	**(1.12-1.43)**
Sneeze attacks	20123	**0.84**	**0.78**	**1.32**	1.12	0.92	**1.52**	1.11	**1.33**
in the last 12 months	5.0	**(0.74-0.95)**	**(0.69-0.89)**	**(1.15-1.52)**	(0.97-1.29)	(0.80-1.06)	**(1.26-1.83)**	(0.90-1.38)	**(1.16-1.52)**
Allergy	20071	**0.61 (0.52-0.71)§a**	**0.60 (0.51-0.70)§a**	**1.15**	1.00	1.07	1.09	0.97	1.11
ever diagnosed	9.4	0.86 (0.70-1.04)§b	0.85 (0.69-1.04)§b	**(1.04-1.28)**	(0.91-1.11)	(0.96-1.18)	(0.93-1.28)	(0.82-1.16)	(1.01-1.22)
Eczema	19783	**0.61**	**0.63**	1.00	0.92	**0.90**	**1.15**	**0.80**	1.04
ever diagnosed	16.2	**(0.57-0.66)**	**(0.58-0.68)**	(0.92-1.09)	(0.85-1.00)	**(0.83-0.98)**	**(1.01-1.31)**	**(0.69-0.93)**	(0.96-1.12)
Atopic eczema on the	2021	0.90	0.92	1.20	1.13	0.74	1.44	0.68	0.92
day of investigation	11.8	(0.68-1.18)	(0.69-1.21)	(0.89-1.61)	(0.84-1.52)	(0.54-1.01)	(0.97-2.14)	(0.39-1.17)	(0.69-1.22)
Specific IgE grass	3204	**0.75**	0.81	1.04	0.91	**0.70**	1.03	0.67	1.00
pollen positive	11.6	**(0.60-0.94)**	(0.65-1.02)	(0.82-1.32)	(0.72-1.16)	**(0.54-0.90)**	(0.73-1.43)	(0.43-1.03)	(0.79-1.25)
Specific IgE house dust	3196	**0.74**	**0.75**	1.08	0.99	0.96	**1.51**	**0.62**	1.04
mite positive	10.0	**(0.59-0.94)**	**(0.59-0.96)**	(0.84-1.40)	(0.77-1.28)	(0.73-1.27)	**(1.10-2.08)**	**(0.39-0.99)**	(0.81-1.32)
Overweight	20547	**1.45**	**1.44**	**1.26**	1.13	0.89	0.87	1.06	0.94
BMI > 19 kg/m²	5.4	**(1.28-1.64)**	**(1.27-1.63)**	**(1.10-1.43)**	(0.99-1.29)	(0.78-1.02)	(0.70-1.08)	(0.87-1.31)	(0.83-1.07)
	Mean	Adjusted means ratio (95% confidence interval) – bold type if significant ($p < 0.05$)							
Body height [cm]	19087	**0.992**	**0.994**	**1.007**	**0.997**	0.998	**0.996**	**0.990**	**0.998**
	120.2	**(0.991-0.994)**	**(0.993-0.995)**	**(1.005-1.008)**	**(0.996-0.998)**	(0.997-1.000)	**(0.993-0.998)**	**(0.988-0.993)**	**(0.996-0.999)**
Birth weight [g]	20500	**0.981**	**0.982 (0.975-0.990)§a**	**0.985**	**0.990**	0.996	0.995	**0.953**	0.998
	3331	**(0.977-0.986)**	0.995 (0.986-1.004)§b	**(0.980-0.990)**	**(0.985-0.995)**	(0.991-1.00)	(0.988-1.003)	**(0.945-0.961)**	(0.994-1.003)
Airway resistance	1728	1.012	1.009	0.994	1.006	1.009	0.995	1.020	1.006
[kPa•s/l]	0.665	(0.989-1.035)	(0.985-1.032)	(0.969-1.019)	(0.981-1.030)	(0.980-1.038)	(0.961-1.030)	(0.981-1.059)	(0.981-1.030)
Total lung capacity	1356	0.991	0.991	1.005	1.001	0.988	1.007	0.996	1.008
% predicted	103.8	(0.980-1.002)	(0.980-1.002)	(0.994-1.017)	(0.989-1.013)	(0.975-1.001)	(0.991-1.023)	(0.977-1.016)	(0.996-1.019)

* adjusted for gender, time and residence only; ** same as '*' but additionally adjusted for the six living conditions; § Interaction between time and parental education; a 1991; b 2000

Table 6: Association of parental educational level and living conditions with health status indicators of 6-year-old children in West Germany from 1999 to 2000:

Health status indicator		*Parental education*		*Living condition*					
	Sample size	Low parental educational level 1st step *	Low parental educational level 2nd step **	Single child	Small living space	Unfavourable indoor air	Damp housing condition	Maternal smoking during pregnancy	Living near a busy road
	Prevalence [%]	Adjusted odds ratio (95% confidence interval) – bold type if significant ($p < 0.05$)							
Bronchtis ever diagnosed	5757 45.9	**0.67** **(0.60-0.74)**	**0.68** **(0.60-0.76)**	0.93 (0.82-1.06)	**0.86** **(0.75-0.98)**	1.15 (1.00-1.32)	**1.30** **(1.03-1.65)**	1.01 (0.89-1.14)	1.01 (0.91-1.12)
More than 4 colds in the last 12 months	5768 14.8	**0.83** **(0.72-0.97)**	**0.84** **(0.72-0.99)**	1.19 (1.00-1.41)	0.95 (0.79-1.14)	0.96 (0.79-1.18)	**1.62** **(1.21-2.17)**	**0.83** **(0.70-0.99)**	1.11 (0.96-1.29)
Frequent cough	5892 7.9	1.12 (0.91-1.37)	0.98 (0.79-1.22)	1.13 (0.89-1.42)	1.16 (0.92-1.46)	0.88 (0.68-1.15)	**2.60** **(1.90-3.55)**	1.16 (0.93-1.43)	**1.25** **(1.02-1.52)**
Sneeze attacks in the last 12 months	5200 5.6	0.94 (0.73-1.20)	0.85 (0.65-1.11)	**1.56** **(1.18-2.05)**	1.16 (0.86-1.56)	1.21 (0.88-1.66)	**2.25** **(1.52-3.33)**	1.00 (0.76-1.32)	1.11 (0.87-1.42)
Allergy ever diagnosed	5831 14.2	**0.68** **(0.59-0.79)**	**0.69** **(0.59-0.81)**	1.14 (0.95-1.36)	1.00 (0.83-1.20)	0.97 (0.79-1.19)	1.20 (0.87-1.66)	0.93 (0.78-1.11)	0.95 (0.81-1.10)
Eczema ever diagnosed	5716 13.4	**0.56** **(0.48-0.66)**	**0.59** **0.50-0.70)**	**0.80** **(0.66-0.97)**	0.88 (0.72-1.07)	1.07 (0.87-1.32)	1.10 (0.77-1.57)	0.85 (0.71-1.03)	1.07 (0.92-1.25)
Atopic eczema on the day of investigation	2052 8.0	0.84 (0.61-1.16)	0.85 (0.61-1.19)	0.92 (0.61-1.40)	0.86 (0.55-1.33)	0.94 (0.62-1.43)	0.71 (0.28-1.82)	0.96 (0.64-1.46)	1.21 (0.87-1.69)
Specific IgE grass pollen positive	1807 10.8	0.84 (0.62-1.13)	0.84 (0.61-1.16)	**1.78** **(1.25-2.54)**	1.22 (0.82-1.80)	0.84 (0.55-1.27)	0.56 (0.22-1.42)	0.82 (0.55-1.21)	1.09 (0.80-1.48)
Specific IgE house dust mite positive	1781 13.0	**0.75** **(0.57-1.00)**	**0.72** **(0.53-0.97)**	1.22 (0.86-1.73)	1.19 (0.83-1.71)	1.14 (0.79-1.63)	1.18 (0.60-2.30)	0.92 (0.64-1.32)	1.19 (0.89-1.58)
Overweight BMI > 19 kg/m²	5783 7.4	**1.83** **(1.44-2.31)**	**1.67** **(1.31-2.14)**	**1.33** **(1.05-1.68)**	1.15 (0.90-1.46)	1.12 (0.86-1.47)	1.26 (0.85-1.86)	1.20 (0.96-1.50)	1.03 (0.84-1.26)
	Mean	Adjusted means ratio (95% confidence interval) – bold type if significant ($p < 0.05$)							
Body height [cm]	5784 120.4	0.998 (0.996-1.001)	1.000 (0.998-1.003)	**1.004** **(1.001-1.006)**	0.998 (0.995-1.000)	0.999 (0.996-1.003)	1.003 (0.998-1.008)	**0.992** **(0.989-0.994)**	1.001 (0.998-1.003)
Birth weight [g]	5812 3371	**0.982** **(0.972-0.991)**	1.000 (0.990-1.009)	**0.973** **(0.962-0.983)**	**0.982** **(0.971-0.993)**	0.999 (0.988-1.011)	1.018 (0.999-1.037)	**0.935** **(0.925-0.945)**	0.994 (0.985-1.003)
Airway resistance [kPa•s/l]	983 0.630	1.030 (0.999-1.060)	1.015 (0.983-1.047)	0.993 (0.956-1.030)	1.017 (0.980-1.054)	1.022 (0.985-1.059)	0.942 (0.869-1.015)	**1.051** **(1.015-1.088)**	1.018 (0.988-1.048)
Total lung capacity % predicted	787 105.1	1.003 (0.988-1.017)	1.006 (0.991-1.021)	1.017 (0.999-1.035)	0.986 (0.968-1.003)	0.993 (0.976-1.011)	1.026 (0.989-1.063)	0.995 (0.977-1.012)	0.993 (0.978-1.007)

Mutually adjusted odds ratios and means ratios with 95% confidence intervals by means of a two step multiple logistic and linear regression analysis.
* adjusted for gender, time and residence only; ** same as '*' but additionally adjusted for the six living conditions

5 DISCUSSION

5.1 The association between socioeconomic factors and health

People are unequal. Some have a more advantaged position in society than others. These differences between people can be usually portrayed as a social stratification system. People occupy a position in that system according to their (partner's) job, their educational achievement, and their income level or standard of living. (Kunst 1997)

Children grow up as members of the overall society. (Palfrey 1994) As developing beings, they depend on the society around them to shape the context, relationships, and opportunities of their lives. Children as part of families, systems, and populations, their experience is determined and molded by what is happening in society at large. In a world that itself is developing and changing, emergent secular trends, technologic advances, and sociopolitical realities all have profound effects on the environment around families and children. To define children's health service needs, we must understand these influences.

Child health is determined by many factors: physical predisposition, nutrition, nurturance, environmental conditions, and the confluence of a whole range of biopsychosocial determinants. The interconnectedness of health and environmental influences has been well articulated by Sameroff and Chandler (Sameroff and Chandler 1975) in their now widely accepted "transactional model." Examining the causes of negative birth outcomes, they developed the notion of a "continuum of care taking casualty," establishing a link between biologic vulnerability and external forces that either foster or hinder the growth of the human organism. Emmy Werner's (Werner and Smith 1977) classic study "The Children of Kauai" demonstrated that children from low socioeconomic backgrounds fared much worse than children of higher SES when confronted with identical perinatal events. Werner's findings have been replicated in many subsequent investigations, and it is now well accepted that ultimate perinatal outcome is the result of the interplay of biologic and no biologic factors.

Many routes lead from low SES to bad health. A simple causal pathway seems to be that the higher lung cancer mortality of low class people is explained by their higher tobacco consumption. Why people in lower classes smoke more? Due to failure to recognize the

health hazards of smoking, as a way of coping with their higher levels of daily stress, and/or due to attitudes and social norms that are more conducive to smoking?

Education of parents is an important influencing factor for most health outcome variables in children. Contrary to the well known fact that upper classes are more healthy, allergies are less frequent in the lower socioeconomic classes. Education has to be included as a confounding variable in the statistical analysis to prevent misleading interpretations. This has been shown for neuropsychological and allergological variables. As the education of parents can not be a cause of a disease by itself, a striking association should always lead to a search for underlying causes. This has successfully been done for the lung function data and should be done for the allergological data as well. The influence of parental education on the health outcome variables is even more pronounced in East Germany than in West Germany. Purely economic reasons can not lead to these differences.

5.2 Protecting children from passive smoking

Air pollution is one of the causal risk factors between SES and disease. For example, high levels of air pollution may contribute to the higher morbidity and mortality rates that are usually found among residents of deprived urban districts. Increased exposure to air pollution is one of the many factors that might contribute to the poorer health of lower socioeconomic groups. It is likely that lower socioeconomic groups not only are exposed to higher levels of air pollution, but in addition have an increased risk of developing symptoms and disease when exposed to a certain level of air pollution.

Environmental tobacco smoke (ETS) is one of the most common indoor air pollutants (Krämer 2004) and associated with many adverse prenatal and postnatal conditions during childhood. Children are more likely to suffer from ETS-related health effects than adults, and the home is the most important site of such exposure.

Maternal smoking during pregnancy is of a high public health concern. Possibly due to a very close medical supervision of pregnant women in the former socialistic German Democratic Republic (GRD, East Germany before re-unification), smoking prevalence among pregnant women was lower in East Germany than in West Germany until 1990. Unfortunately, the

prevalence of maternal smoking during pregnancy increased after 1990 in East Germany. Dramatic changes in the health care system in East Germany after the re-unification causing the closing of many public policlinics could be a possible reason for this new trend. Otherwise in West Germany at the same time, smoking prevalence among pregnant women was slightly increasing again after a considerable decrease during the six years before. The gap of maternal smoking prevalence was about 20-30% between low and high educational level.

Extensive epidemiological literature documents an association between exposure to ETS and increased lower respiratory illness (bronchitis, pneumonia and their symptoms) in infancy and early childhood. In a quantitative overview of 38 studies on respiratory outcomes, Strachan and Cook revealed pooled odds ratios of 1.57 for smoking by either parent and 1.72 for maternal smoking. (Strachan 1997) The authors conclude that there is a causal relationship between parental smoking and acute lower respiratory illness, at least in the first 2 years of life. The results of a large population-based study from Italy support the hypothesis that ETS may act as an adjuvant factor in determining persistent bronchial hyperactivity and asthma in genetically predisposed children, whereas in no predisposed individuals parental smoking could be an irrigative cofactor provoking wheezing attracts. (Agabiti 1999)

The world Health Report 2002 gave an estimation of 4.9 million tobacco-related deaths (8.8% of all deaths) for the year 2000. (Kuntsche 2005) Projections by Peto et al. (1994) indicated even about 10 Million annually by the year 2020 to 2030. The course of smoking prevalence varies across countries, however, as well as in men and women and socioeconomic groups within countries. In some northern European countries, for example, women smoke as much as men. (Mackay 2002) Smoking cessation is more likely to increase among high socioeconomic groups than among those of lower status. (Barbeau 2004)

5.3 Socioeconomic differences in health

The distribution of health status, with respect to infectious and atopic diseases and symptoms of 6-year-old children with regard to their parental education presented a varied picture. The relationship between indicators of social inequality, exposure to pollutants and selected environmental related diseases is not straightforward. With regard to living conditions and

exterior air pollutants, the lower class is more highly exposed, while the upper class suffers from more exposure to interior pollutants such as allergens.

Most of the population-based studies examining the relationship of socioeconomic status to childhood disease have used parental reporting to assess the respiratory outcomes (Ernst 1995). Differences in reporting behavior among parents of different social classes may bias such associations. Under-reporting or access to healthcare might explain a decreased prevalence of the diagnoses with low parental education (Gehring 2006). Several studies conducted in Western European countries reported higher prevalence of eczema, hay fever and sensitization to inhalant allergens among children, adolescents and adults of the most advantaged socioeconomic group (Williams 1994; Schafer 2000; Wright 1994). Severity of disease could also (in part) explain the higher prevalence of bronchitis, allergy and eczema in children with high parental education in other countries; highly educated parents might take medical advice in mild cases of bronchitis whereas parents with a low level of education take medical advice in more severe cases only. (WHO 2004; Gehring 2006)

Moreover, people with low socioeconomic status are more likely to live in more highly polluted area and/or to be more susceptible to the health effects of air pollution because of compromised health due to material deprivation and psycho-social stress (Gehring 2006). A number of hypotheses have been proposed as potential partial explanations for between-country and within-country disparities in prevalence on asthma, eczema and allergies including differences in “hygiene”, cigarette smoking (Krämer 2004), indoor pollutants (Sharif 2003; Spengler 2004), traffic pollution (Ferguson 2004), and obesity (Langnäse 2002; Langnäse 2003; Koziel 2000; Adams 2004; Veugelers 2005), but it is unclear which lifestyle or environmental factors account for the association between socioeconomic status and prevalence of allergies. The present study adjusted for a set of explanatory variables, but the associations remained.

East-West differences of unfavorable indoor condition were more reported in East while maternal smoking during pregnancy was worse in West Germany. Urban-rural differences were also observed for better living condition of rural area than urban area. Before 1990, the information about health effects of air pollution was not available in East Germany. This might be the reason for the higher response in East than in West Germany (Krämer 1997). Over the time, a decreasing trend of air pollution existed when comparing between East and

West Germany from 1991 to 2000. Understanding how social forces such as socioeconomic status exert their effects and create differential states of health remains a critical challenge to researchers in public health (Goodman 1999). The relationship between socioeconomic status and child health also has developmental implications, the SES and health relationship may change with age: that is, SES may have stronger effects during certain period of childhood than others. (Chen 2002)

The use of different socioeconomic indicators to assess the extent of the association between socioeconomic status and health status usually depends on the availability of the data. This is the reason why the most common index used in the UK is occupational level while educational level is used in the USA. (von Mutius 1994) Educational attainment is a commonly used although imprecise, measure of socioeconomic status. (Woodruff 2003) The social inequalities resulting in differences in health outcomes existed not only in Western European countries, but also in former socialist countries with a relatively uniform distribution of resources. (Gehring 2006)

The available data concerning class-specific differences in the exposure to living condition, as well as the infectious, atopic diseases and symptoms, are not at present sufficient to explain the apparently demonstrable health inequality. The information obtained in this study through self-reporting only assesses the prevalence and not the severity or chronic disease. The used questionnaire is an epidemiological instrument and not a diagnostic interview. Although it is tempting to continue to seek a single strand in the “web of causation” to explain the effects of socioeconomic gradients on health, a better focus might be on “two spiders”, one biologic and one social, spinning a joint web of societal factors on health (Goodman 1999). The translation of social factors into biologic and pathologic processes is a thorny and complex process that may involve different mechanisms and have different effects at distinct stages in life and that may act differentially for specific disease states.

Environmental and sociopolitical decisions should not be based entirely on available empirically derived information (Heinrich 1997). These observations may guide the public health policy in the efficient intervention of children’s health and social issues early in life.

6 CONCLUSIONS

A large overall effect of parental education on health-related living conditions was observed.

Social inequalities existed under the socialist system in East Germany as indicated by the results of the cross-sectional study in 1991.

Children from families with the lowest social status were living under the worst domestic conditions (e. g. living at busy road, having damp housing conditions, single oven heating and small living space).

The gap between low and high social status for some conditions (e. g. living at busy road and having small living space) was bigger in 2000 than in 1991.

The risk of environmental tobacco smoke exposure among children was strongly associated with parental education (OR≥2 ‘low’/’middle’ versus ‘high’).

In West Germany, environmental tobacco smoke exposure generally exhibited a decreasing trend of about 20%.

In East Germany, the environmental tobacco smoke exposure was only decreasing for children with higher educated parents.

The gap between low and high parental education with respect to current children’s tobacco smoke exposure has increased from 1991 to 2000 in East Germany.

A considerable fresh increase of maternal smoking during pregnancy could be observed around 1991 in both parts of Germany.

The reporting of diagnoses (bronchitis, allergy and eczema) was strongly influenced by the parental education without significant changes of the odds ratios.

The association of symptoms of airway irritations (frequent cough, sneeze attacks) with parental education changed after adjusting for the living conditions in a way of explaining the causal pathway in part.

Sensitization and atopic eczema were less prevalent among children with lower than higher educated parents independently of adjusting for living conditions.

The unfavorable association of overweight, body height and birth weight with educational level could be partly explained by living condition.

The children’s lung function was not associated with their parent’s education. With the exception of total lung capacity and atopic eczema at the day of investigation, all health indicators were influenced by at least one of the living conditions.

7 SUMMARY

Social inequality is a major influencing factor in public health, particularly also in Western countries. The aim of this study was to explore associations between health indicators and social status, indicated by parental education in a population of 6-year-old children under different socio-economic and environmental conditions in Germany after re-unification, and to search for potential causes of these associations within the individual living conditions of the children.

In total, for 28,888 school beginners (49% girls) who participated in cross-sectional studies conducted between 1991 and 2000 for both East and West Germany, parental education was provided as an indicator of social status. Medical diagnoses and symptoms of respiratory diseases and allergies as well as individual living conditions (traffic exposure, environmental tobacco smoke etc.) were assessed by parental questionnaire. In subgroups, sensitisation against grass pollen and house dust was measured in serum, atopic eczema was diagnosed by a physician at the day of investigation, body height and weight were measured, and lung function tested by means of bodyplethysmography.

Social inequalities obviously existed not only in West Germany, but also under the socialist system in East Germany as demonstrated by the cross-section in 1991. Children from families with the lowest social status were living under the worst domestic conditions. The gap between low and high social status was bigger in 2000 than in 1991 while the living conditions had improved in general.

The risk of child's exposure to environmental tobacco smoke (ETS) was twice as high for the lower status (less than 10 years of parental education) compared to the higher status with 10 and more years of parental education. In West Germany, ETS exposure generally exhibited a decreasing trend. In East Germany however, the ETS exposure was only decreasing for children with higher educated parents. The gap between low and high parental education with respect to current children's tobacco smoke exposure has increased from 1991 to 2000 in East Germany. An initial decrease of the frequency of maternal smoking during pregnancy was reversed to a considerable fresh increase right after reunification in both parts of Germany.

Underreporting of parents with lower educational level was obviously responsible for the considerably lower frequencies of reported diagnoses (bronchitis, allergy and eczema) and respective symptoms of their children. Sensitisation against house dust mites was observed to a lesser extent (20%) in the lower educational level in East as well as in West Germany. Overweight children were found 45 per cent more frequently in East Germany and 80 per cent more frequently in West Germany. Indicators of the lung function were not associated with social status.

Detailed regression analyses resulted in no clear indication for at least partial explanation of detected social differences in health indicator by differences in children's living conditions, although the living conditions themselves showed significant associations with several health indicators. One exception was overweight, which could partially be explained by a single child condition.

The results of this study clearly indicate the large research needs to reveal the complex causes of social difference in children's health.

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Socioeconomic changes and their health impact on children in Germany after re-unification

(Sozioökonomische Änderungen und ihre Auswirkungen auf die Gesundheit von Kindern in Deutschland nach der Wiedervereinigung)

Xianming Freifrau von du Prel

Soziale Ungleichheit ist ein bedeutender Einflussfaktor in Public Health, insbesondere auch in westlichen Ländern. Ziel dieser Untersuchung war es, Zusammenhänge zwischen Gesundheitsindikatoren und dem Sozialstatus, definiert durch die elterliche Schulbildung, bei 6jahre alten Kindern in Deutschland unter den sich ändernden sozioökonomischen Bedingungen nach der Wiedervereinigung und im Vergleich zwischen Ost- und Westdeutschland zu untersuchen und dabei mögliche Ursachen dieser Assoziationen in den individuellen Lebensbedingungen der Kinder aufzudecken. Für insgesamt 28.888 Schulanfänger (49% Mädchen), die an einer Serie von Querschnittstudien zwischen 1991 und 2000 sowohl in West- wie auch in Ostdeutschland teilnahmen, war die elterliche Schulbildung als Sozialstatusindikator bekannt. Angaben zu ärztlichen Diagnosen und Symptomen von Atemwegserkrankungen und Allergien sowie zu Lebensumständen (Kfz-Belastung, Wohnqualität, Passivrauchen, Einzelkind usw.) wurden per Elternfragebogen erhoben. Jeweils für Teilkollektive wurden Sensibilisierungen gegenüber Gräserpollen und Hausstaub im Serum bestimmt (RAST), eine ärztliche Hautbegutachtung zur Feststellung eines atopischen Ekzems durchgeführt, Körpergröße und –gewicht gemessen und die Lungenfunktion im Ganzkörperplethysmographen getestet. Soziale Ungleichheiten existierten offensichtlich nicht nur in Westdeutschland sondern auch im ehemaligen sozialistischen System in Ostdeutschland, wie die Untersuchungen 1991 reflektieren. Kinder aus Familien mit niedrigem Sozialstatus lebten unter den ungünstigsten häuslichen Bedingungen. Der Unterschied zwischen niedrigem und hohem Status war in Ostdeutschland im Jahre 2000 größer als unmittelbar nach der Wiedervereinigung, obwohl die Lebensumstände sich insgesamt überwiegend verbessert hatten. Das Risiko einer Passivrauchexposition war für das untere Sozialniveau (weniger als 10 Jahre Schulbildung) doppelt so hoch wie für das höhere (mindestens 10 Jahre Schulbildung). In Westdeutschland war allgemein eine Abnahme der Passivrauchexposition zu beobachten. Hingegen in Ostdeutschland war dieser Trend nur bei den Kindern mit Eltern höherer Schulbildung zu erkennen, weshalb sich der Sozialschichtunterschied in der Passivrauchexposition der Kinder in Ostdeutschland von 1991 bis 2000 noch vergrößert hatte. Ein anfänglicher Rückgang der Häufigkeit des Rauchens der Mütter in der Schwangerschaft kehrte sich sowohl in Ost- wie auch in Westdeutschland kurz nach der Wende in einen Anstieg um. Die erheblich geringeren Häufigkeiten der Angaben von Diagnosen zu Bronchitis, Allergien und Ekzemen sowie auch von entsprechenden Symptomen bei der niedrigeren Bildungsschicht waren offensichtlich durch ein unterschiedliches Berichtsverhalten der Eltern („underreporting“ der Eltern mit geringerer Schulbildung) bedingt. Sensibilisierungen gegenüber Hausstaubmilben waren sowohl in Ost- wie in Westdeutschland etwa 25% weniger in der unteren Bildungsschicht beobachtet worden. Übergewichtigkeit der Kinder war in Ostdeutschland zu 45% und in Westdeutschland zu 80% häufiger in der unteren Sozialschicht festzustellen gewesen. Die Lungenfunktionsindikatoren waren nicht mit dem Sozialstatus assoziiert. Detaillierte regressionsanalytische Untersuchungen ergaben keine klaren Anhaltpunkte für eine zumindest teilweise Erklärung der gefunden Sozialschichtunterschiede in den Gesundheitsindikatoren durch die Unterschiede in den Lebensumständen der Kinder, die selbst einen durchaus signifikanten Einfluß bei einzelnen Indikatoren zeigten. Eine Ausnahme bildete lediglich das Übergewicht, das durch eine Einzelkindsituation zumindest teilweise erklärbar war. Die Ergebnisse dieser Untersuchung machen deutlich, dass nach wie vor großer Forschungsbedarf besteht, die vielschichtigen Ursachen der sozialen Unterschiede in der Gesundheit gerade auch bei Kindern aufzudecken.

Düsseldorf, 8. September 2006

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