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Relation of indoor heating with asthma, allergic sensitisation, and bronchial responsiveness: survey of children in South Bavaria

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Abstract

Objective—To investigate the relation between different types of heating and the prevalence of atopic diseases, skin test reactivity, and bronchial hyperresponsiveness.

Design—Cross sectional survey among school-children aged 9-11 years. Skin prick tests, pulmonary function tests, and bronchial challenge in the children and self completion of a written questionnaire by the children's parents.

Subjects—1958 children in a rural area in southern Bavaria, Germany.

Main outcome measures—Prevalence of asthma, hay fever, and atopic dermatitis as determined by parents' answers to a questionnaire; the atopic status of the child assessed by skin prick tests; and bronchial responsiveness to cold air challenge in the children.

Results—After possible confounders were controlled for, the risk of developing hay fever (odds ratio=0.57; 95% confidence interval 0.34 to 0.98), atopy defined as at least one positive reaction to a panel of common aeroallergens (0.67; 0.49 to 0.93), sensitisation to pollen (0.60; 0.41 to 0.87), and of bronchial hyperresponsiveness (0.55; 0.34-0.90) was significantly lower in children living in homes where coal or wood was used for heating than in children living in homes with other heating systems.

Conclusions—Factors directly or indirectly related to the heating systems used in rural Bavarian homes decrease the susceptibility of children to becoming atopic and to developing bronchial hyperresponsiveness.

Introduction

It has been estimated that adults spend most of their time indoors,¹ where they could be exposed not only to passive smoking but to emissions from stoves used for heating and cooking. Though conflicting evidence exists about adverse effects of gas fuelled stoves on respiratory health,² coal and wood combustion have been reported to increase the risk of upper and lower respiratory tract infections.³⁻⁶

As little is known about the effects of different heating systems on the development of atopic sensitisation and related diseases, we aimed to investigate the relation between atopic diseases and indoor heating systems. We studied a rural population in southern Bavaria with a high proportion of households using coal or wood stoves for heating or cooking.

Methods

Sixty three primary schools were selected in a rural area in southern Bavaria that is characterised by little traffic (fewer than 10 000 cars passing the main street per day) and no industry. All 1958 schoolchildren attending the fourth grade of these schools were invited to participate in a cross sectional survey on asthma and allergies from September 1989 to July 1990.

The study was approved by the ethics committee of the Bavarian Medical Association, and informed consent was obtained from the parents.

QUESTIONNAIRE

A self administered questionnaire was distributed through the schools to the parents. Details of the questions used have been given elsewhere.^{7,8} Prevalences of diseases and symptoms, the number of siblings and other persons in the household, the parents' education, the number of cigarettes smoked at home, and dampness and the presence of pets in the home were assessed.

Children whose parents reported either asthma or recurrent "asthmatic" or "spastic" bronchitis were classified as having asthma. Hay fever and atopic dermatitis were defined as parents' report of a doctor's diagnosis of hay fever and the presence of atopic dermatitis, respectively. Children with one or more first degree relatives with asthma, hay fever, or eczema were defined as having a positive family history of atopy. Parents were also asked about the energy source used for heating and cooking, and about the presence of a central heating system.

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Table 1—Prevalence of atopic diseases, pneumonia in the first year of life, and skin test reactivity in children living in homes with different heating sources in rural south Bavaria. Values are percentages (numbers)

	Central heating	Coal or wood	Other sources
Asthma	7.7 (47/610)	4.8 (30/622)*	5.2 (12/230)
Current asthma	4.8 (29/610)	2.9 (18/622)	2.6 (6/230)
Hay fever	7.8 (48/617)	4.2 (28/662)*	8.8 (20/227)
Atopic dermatitis	19.9 (119/599)	17.1 (108/633)	15.4 (35/228)
Pneumonia in first year of life	1.3 (8/635)	2.4 (16/672)	1.7 (4/239)
Atopy	24.0 (132/549)	15.3 (91/593)**	26.0 (56/215)
Sensitisation:			
Mites	6.4 (35/549)	5.1 (30/593)	7.9 (17/215)
Cats	3.6 (20/549)	2.0 (12/593)	4.7 (10/215)
Dogs	1.8 (10/549)	1.3 (8/593)	2.3 (5/215)
Pollen	18.8 (103/549)	10.5 (62/593)***	21.4 (46/215)

*P<0.05, **P<0.001, ***P<0.0001 when comparing children living in homes with coal or wood burning stoves and children living in homes with a central heating system; χ^2 statistic was used to estimate statistical significance.

Table 2—Pulmonary function and prevalence of bronchial hyperresponsiveness in children living in homes with different heating sources in rural south Bavaria

	Central heating (n=560)†	Coal or wood (n=581)†	Other source (n=217)†
Mean (SD) forced vital capacity	100.8 (10.7)	100.1 (10.9)	101.2 (10.4)
Mean (SD) forced expiratory volume in 1 second	101.2 (10.2)	101.2 (10.2)	101.6 (10.6)
Mean (SD) maximum expiratory flow at 50% of vital capacity	104.2 (22.0)	105.3 (22.2)	105.0 (22.1)
Prevalence (%) of bronchial hyperresponsiveness‡	11.3 (57/506)	5.7 (31/545)*	8.4 (17/203)

*P=0.001.

†Number of children undergoing baseline pulmonary function testing. Analysis of variance with multiple comparison procedures (Student-Newman-Keuls test, Scheffé test) was used to estimate statistical significance. No significant difference between groups was seen.

‡Numbers are given for children undergoing cold air challenge. Chi-square statistic was used to estimate statistical significance.

Table 3—Characteristics of children living in homes with different sources of heat. Values are percentages (numbers)

	Source of heat			P value (χ^2 test)
	Central heating	Coal or wood	Other	
Socioeconomic status:				
Low	39.3 (223/568)	63.7 (395/620)	43.4 (92/212)	<0.0001
Middle	45.4 (258/568)	28.5 (177/620)	44.8 (95/212)	
High	15.3 (87/568)	7.7 (48/620)	11.8 (25/212)	
Number of siblings:				
0	14.4 (93/645)	5.7 (39/685)	11.0 (27/245)	<0.0001
1	49.9 (322/645)	43.8 (300/685)	51.4 (126/245)	
2	26.4 (170/645)	29.2 (200/685)	27.3 (67/245)	
3	7.4 (48/645)	13.9 (95/685)	9.0 (22/245)	
>4	1.9 (12/645)	7.4 (51/685)	1.2 (3/245)	
Number of adults:				
1	7.2 (45/627)	3.0 (20/665)	10.3 (24/234)	<0.0001
2	83.4 (523/627)	74.0 (492/665)	78.6 (184/234)	
>3	9.4 (59/627)	23.0 (153/665)	11.1 (26/234)	
Passive smoking (cigarettes/day):				
0	68.8 (444/645)	72.9 (499/684)	66.9 (164/245)	0.01
1-10	18.3 (118/645)	18.7 (128/684)	17.1 (42/245)	
11-20	9.9 (64/645)	6.6 (45/684)	14.3 (35/245)	
>20	2.9 (19/645)	1.7 (12/684)	1.6 (4/245)	
Cat at home	32.0 (208/649)	47.3 (323/683)	35.1 (85/242)	<0.0001
Dog at home	15.1 (98/649)	19.5 (133/683)	14.9 (36/242)	0.07
Dampness	7.2 (46/641)	11.9 (80/670)	11.7 (28/239)	0.009

SKIN PRICK AND PULMONARY FUNCTION TESTS

The sensitivity to six aeroallergens (*Dermatophagoides pteronyssinus*, grass, birch and hazel pollen, cat and dog dander) was assessed by skin prick tests using a multi-test device (Stallerkit, Stallergènes, France).⁷ A child was considered sensitised to a specific allergen if a wheal reaction of 3 mm or more to this allergen was present, after the reaction to the negative control was subtracted.

Details of pulmonary function tests and bronchial challenge have been given elsewhere.⁹ The cold air challenge consisted of four minutes of isocapnic hyperventilation (that is, 22 × the forced expiratory volume in 1 second per minute) of dry, cold air (−15°C, measured at the mouthpiece). Bronchial hyperresponsiveness was defined as a drop in forced expiratory volume in 1 second of at least 9%.

Results

Parents of 1714 (87.5%) of the 1958 children returned the questionnaire. Only children of German nationality (1635; 95.4%) were included in the analysis, since health care access, diagnostic labelling, and management may differ considerably in children of different origins. Of the eligible German children for whom the questionnaire was returned, skin prick tests were obtained in 85.3% (1395). In addition, 78.7% (1287) of children underwent pulmonary function testing and cold air challenge.

Central heating was installed in 41.1% (650) of households, whereas wood or coal stoves were used by 43.5% (688) families. The remaining 15.5% of the rural population used gas or oil stoves for heating or cooking (n=245). The prevalence of asthma, hay fever, atopy, and bronchial hyperresponsiveness was significantly lower in children whose homes were heated by coal or wood than in children living with a central heating system (tables 1 and 2).

When different types of sensitisation were considered, the greatest difference was found for sensitivity to pollen. No difference in the prevalence of atopic dermatitis (table 1), chronic cough (data not shown), and mean values of baseline pulmonary function (table 2) were seen between groups. Conversely, the prevalence of pneumonia in the child's first year of life was slightly higher in children with coal or wood heating than in children living in homes with a central heating system (table 1).

Families using coal or wood either for heating or cooking were of lower socioeconomic status, had more children and adult family members, and had more often a cat or dog at home than families living in homes with a central heating system (table 3). However, when adjustment was made for these potential confounders, the risk of developing atopy, a specific sensitisation to pollen, hay fever, and bronchial hyperresponsiveness remained significantly lower when coal or wood was used as an energy source than for homes with other heating systems (table 4).

Discussion

The results of this analysis suggest that factors directly or indirectly related to the use of coal and wood stoves either for heating or cooking interfere with the production of specific IgE antibodies to allergens, the development of hay fever and asthma, and the manifestation of bronchial hyperresponsiveness in exposed children. Although variations in the labelling of respiratory and allergic symptoms probably exist among socioeconomic classes, it is unlikely that differential reporting could explain the findings, since skin test reactivity and bronchial hyperresponsiveness showed an even stronger association than self reports.

The epidemiological evidence on the health effects of wood smoke is derived from studies in developing countries and the United States. An increased risk of pneumonia, bronchiolitis, and wheezing bronchitis and an increased incidence of more severe respiratory illness was shown for infants and young preschool children exposed to wood burning stoves in the home.^{3-5 10 11} Such exposure may thus increase the risk of early childhood infections of the upper and lower respiratory tract. Previous reports have pointed towards a protective role

Table 4—Odds ratios of developing asthma, hay fever, atopic sensitisation, or bronchial hyperresponsiveness when living in homes where coal or wood are used for heating as compared to homes with other heating systems

	No of children	Crude odds ratio (95% confidence interval)	P value	No of children	Adjusted odds ratio (95% confidence interval)*	P value
Asthma	1486	0.88 (0.75 to 1.03)	0.14	1237	0.79 (0.47 to 1.32)	0.4
Hay fever	1534	0.77 (0.67 to 0.88)	0.002	1270	0.57 (0.34 to 0.98)	0.04
Atopy	1382	0.80 (0.72 to 0.89)	<0.0001	1144	0.67 (0.49 to 0.93)	0.02
Sensitisation to pollen	1382	0.76 (0.69 to 0.85)	<0.0001	1144	0.60 (0.41 to 0.87)	0.01
Sensitisation to mites	1382	0.89 (0.75 to 1.06)	0.23	1144	0.84 (0.49 to 1.42)	0.5
Bronchial hyperresponsiveness	1273	0.79 (0.69 to 0.91)	0.004	1058	0.55 (0.34 to 0.90)	0.02

*All logistic regression models to compute adjusted odds ratios controlled for socioeconomic status, number of adults living in the household, number of siblings, family history of atopic diseases, passive smoking, dampness, and presence of a cat or dog in the home.

of early childhood exposure to infectious diseases for the development of atopic sensitisation and hay fever¹²; thus exposure to home wood or coal combustion in the home may be linked to the reduced prevalence of atopy, hay fever, asthma, and bronchial hyperresponsiveness found in this study.

Bedrooms in houses heated with coal or wood may be cooler, since not all rooms are heated regularly, and the use of heating appliances with a chimney or flue may induce ventilation. Both these factors may reduce the growth of dust mites¹³ and thus affect the development of sensitisation, asthma, and bronchial hyperresponsiveness.¹⁴ However, in children exposed to heating systems using coal or wood, skin test reactivity to pollen was less prevalent, in relation to children with other types of heating, than was sensitisation to mites.

An alternative explanation is that the use of home wood or coal burning stoves may be a surrogate of a more traditional lifestyle in these homes. Although we did not obtain information on the occupation of the parents, it seems reasonable to assume that most of these large families with a short period of school education and animals in the house were farmers. If this assumption is correct, the finding of a stronger protective effect on the sensitisation to pollen as compared to other allergens is of interest, since children in these environments may be more exposed to pollen when playing outdoors or in barns where hay for feeding cattle is kept. High exposure to allergens may thus contribute to the development of tolerance in these children, as has been shown in animal experiments.¹⁵ Alternatively, a genetic selection bias may have arisen over generations, resulting from inability to work as a farmer when suffering from hay fever or seasonal asthma.

To our knowledge, only one recent survey has investigated the effects of indoor wood or coal heating on the development of atopic diseases. These authors observed a reduced prevalence of asthma, current wheeze, and hay fever but not of eczema in preschool children aged 4–5 years in Southern Australia.¹⁶ Indirect evidence for the effects of wood or coal burning comes from studies performed in eastern European countries, where coal

was used for heating in most households¹⁷ or as energy source for power stations.¹⁸ As in this survey, the prevalence of atopic sensitisation to a panel of common aero-allergens and of hay fever, asthma, and bronchial hyperresponsiveness, but not of atopic dermatitis, was decreased in schoolchildren living in East Germany and Poland in comparison to western Germany or Sweden, where coal is no longer an important energy source.^{7, 18} Whether similar factors are important in explaining the findings in east European urban populations and in Australian and south Bavarian rural populations remains to be shown. Within Western societies, rural populations using wood or coal for heating may have retained a more traditional life style than the rest of the population, and this way of living may compare with living conditions that are still existing in eastern Europe.

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Conflict of interest: None.

Key messages

- Little is known about the effects of different heating systems on the development of atopic sensitisation and related diseases
- This study shows that in a rural population children of families using wood or coal for heating and cooking had a significant lower prevalence of hay fever, atopy, and bronchial hyperresponsiveness than children living in homes with other heating systems
- Factors directly related to home wood or coal combustion may explain these findings
- Alternatively, using coal and wood burning stoves indoors may be related to a more traditional life style with unknown protective factors that have been lost in families using other sources of energy such as gas, oil, or a central heating system

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