Home environment and severe asthma in adolescence: a population based case-control study

David P Strachan, Iain M Carey

Abstract

***Objective*—To investigate the effects of the home environment on the risk of severe asthma during adolescence.**

***Design*—A questionnaire based case-control study drawn from a cross sectional survey of allergic diseases among secondary school pupils in Sheffield in 1991.**

***Subjects*—763 children whose parents had reported that over the previous 12 months they had suffered either 12 or more wheezing attacks or a speech limiting attack of wheeze. A further 763 children were frequency matched for age and school class to act as controls. Analysis was restricted to 486 affected children and 475 others born between 1975 and 1980 who had lived at their present address for more than three years.**

***Results*—Independent associations with severe wheeze were seen for non-feather bedding, especially foam pillows (odds ratio 2·78; 95% confidence interval 1·89 to 4·17), and the ownership of furry pets now (1·51; 1·04 to 2·20) and at birth (1·70; 1·20 to 2·40). These estimates were derived from subjects whose parents denied making changes in the bedroom or avoiding having a pet because of allergy. Parental smoking, use of gas for cooking, age of mattress, and mould growth in the child's bedroom were not significantly associated with wheezing.**

***Conclusions*—Either our study questionnaire failed to detect the avoidance or removal of feather bedding by allergic families or there is some undetermined hazard related to foam pillows. Synthetic bedding and furry pets were both widespread in this population and may represent remediable causes of childhood asthma.**

Introduction

Recent concern about environmental influences on childhood asthma has focused on the possible hazards of outdoor pollutants, particularly those derived from vehicle exhausts, such as nitrogen dioxide and ozone.[1] Less attention has been directed towards the indoor environment, although many people spend upwards of 90% of their time indoors.[2] Certain outdoor pollutants, such as particulates and nitrogen dioxide, may be present at higher concentrations indoors, and domestic allergens such as house dust mites and pet dander (dandruff) are a major source of allergic sensitisation which relate specifically to asthma in children.[3]

Although childhood asthma is common, many cases are relatively mild.[4] Few epidemiological studies have focused on the more severe forms of the disease, which pose a substantial burden on the health services. We present the relation between aspects of the home environment and troublesome asthma, paying particular attention to possible biases arising from avoidance of allergens by allergic families.[5]

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Subjects and methods

A two page questionnaire was circulated at school to the parents of all children in the first to fifth forms (11-16 years old) attending state or private secondary schools in Sheffield in November 1991. Of the 35 schools, 34 participated, and replies were received for 18 203 (79%) of the 23 054 questionnaires issued.

Cases and controls were selected on the basis of responses to previously published questions relating to asthma and wheezing.[6] Children whose parents reported that they suffered either 12 or more wheezing attacks in the past 12 months or an attack of wheeze over the same period that limited speech to only one or two words at a time between breaths were selected as cases. One child with no history of asthma or wheezing at any age and frequency matched for age and school was selected as a control for each case.

A second questionnaire was posted to parents of both groups of children in June 1993. Replies were received for 571/763 children with wheezing (75%) and 568/763 without (74%). Information was collected on household pets, methods of cooking, the child's bedding, dampness or mould, or both, in the child's bedroom, and parental smoking in the house. Respondents were asked two questions specifically about changes to the home environment as a result of asthma or allergy. These asked if they had ever got rid of a pet or decided not to have one because one of the family might be allergic to it, and also if they made any alterations or special arrangements in the child's bedroom because of allergy, asthma, or other chest problems.

Results are presented for 486 cases and 475 controls. The children were born 1975-80 inclusive and had lived at their 1993 address for at least three years. The data were analysed as an unmatched study because cases and controls were frequency matched rather than individually matched. Unadjusted odds ratios were derived from tabulations of the characteristics of the cases and controls: firstly, for all subjects; secondly, restricted to subjects whose parents denied pet avoidance; and, thirdly, restricted to children whose parents denied alterations to the child's bedroom because of asthma or allergy.

Mutually adjusted odds ratios for each indoor environmental risk factor were derived from multiple logistic regression models fitted in the generalised linear interactive modelling system (GLIM).[7] These models included year of birth and sex in addition to environmental characteristics. Interaction terms were fitted to exclude children for whom measures of avoidance of allergens were reported from the assessment of risks associated with pets and bedding while retaining these subjects in the model for assessment of other risk factors.

Results

Among the 18 203 valid responses to the 1991 questionnaires about one child in four had ever wheezed (26·4%; 95% confidence interval 25·8% to 27·1%). The prevalence of wheeze in the past 12 months was 15·7% (15·1% to 16·3%). Severe wheezing was much less common, with a similar annual prevalence of speech limiting wheeze (2·9%; 2·6% to 3·1%) and frequent attacks (12 or more in the past year) (2·3%; 2·1%

to 2·5%), comparable with the results of a recent nationwide survey.[4] The lifetime prevalence of asthma diagnosed by a doctor was 17·7% for the whole study sample, 62·7% for children who had ever wheezed, 92·4% for those with speech limiting wheeze, and 91·7% for the group with 12 or more attacks.

The 486 cases comprised three groups: frequent wheeze only (n=148), speech limiting wheeze only (n=225), and those with both (n=113). These three groups were compared, in turn, with the 475 controls, producing unadjusted odds ratios for indoor environmental factors shown in table I.

Ownership of furry pets and mould in the bedroom were significant risk factors for speech limiting wheeze (odds ratio 1·64 (P<0·05) for ever owning a pet; 2·36 (P<0·05) for damp and mould in bedroom).

TABLE I—*Prevalence of exposure and unadjusted odds ratios for three mutually exclusive case groups in relation to indoor environmental risk factors. Figures are numbers (percentage); odds ratio*

Exposure	Controls (n=475)	Severity of wheezing: Frequent attacks (n=148)	Speech limiting (n=225)	Frequent and speech limiting (n=113)
Housing tenure:				
Owned	382 (81)	127 (86); 1†	174 (78); 1†	85 (76); 1†
Rented	91 (19)	20 (14); 0·66	48 (22); 1·16	27 (24); 1·33
Use of gas cooking:				
None	119 (26)	42 (29); 1†	53 (24); 1†	33 (31); 1†
Hob only	103 (22)	34 (23); 0·94	43 (19); 0·94	23 (21); 0·81
Both oven and hob	243 (52)	70 (48); 0·82	126 (57); 1·16	52 (48); 0·77
Mother smoking now:				
None	382 (80)	120 (81); 1†	169 (75); 1†	75 (66); 1†
1-10 Cigarettes/day	64 (13)	16 (11); 0·80	41 (18); 1·45	25 (22); 1·19
>10 Cigarettes/day	29 (6)	12 (8); 1·32	15 (7); 1·17	13 (12); 2·28*
Father smoking now:				
None	387 (82)	121 (82); 1†	192 (85); 1†	85 (76); 1†
1-10 Cigarettes/day	54 (11)	16 (11); 0·95	23 (10); 0·86	18 (16); 1·52
>10 Cigarettes/day	33 (7)	10 (7); 0·97	10 (4); 0·61	9 (8); 1·24
Bedroom damp and mould:				
None	429 (93)	127 (91); 1†	195 (89); 1†	96 (92); 1†
Damp only	17 (4)	6 (4); 1·19	8 (4); 1·04	0
Damp with mould	14 (3)	7 (5); 1·69	15 (7); 2·36*	8 (8); 2·55*
Type of pillow used:				
Non-feather	299 (64)	125 (85); 1†	188 (84); 1†	101 (90); 1†
Both types	87 (18)	11 (7); 0·30***	23 (10); 0·42***	8 (7); 0·27**
Feather	86 (18)	11 (7); 0·31***	12 (5); 0·22***	3 (3); 0·10***
Type of quilt used:				
Synthetic	387 (82)	135 (92); 1†	186 (83); 1†	103 (93); 1†
Mixed	28 (6)	4 (3); 0·41	19 (8); 1·41	4 (4); 0·53
Feather	55 (12)	8 (5); 0·42*	19 (8); 0·72	4 (4); 0·27**
Age (years) of mattress:				
0-3	172 (37)	54 (37); 1†	89 (41); 1†	37 (34); 1†
4-7	152 (33)	43 (29); 0·90	69 (32); 0·88	37 (34); 1·13
>7	138 (30)	50 (34); 1·15	60 (28); 0·84	36 (33); 1·21
Ownership of furry pets:				
Never	142 (30)	42 (29); 1†	47 (21); 1†	27 (25); 1†
At birth only	35 (7)	9 (6); 0·87	20 (9); 1·73	6 (5); 0·90
Now only	178 (38)	56 (38); 1·06	92 (41); 1·56*	42 (38); 1·24
Both times	114 (24)	40 (27); 1·19	65 (29); 1·72*	35 (32); 1·61

Column totals include subjects with missing data for one or more variables.
†Reference category.
*P<0·05; **P<0·01; ***P<0·001.

TABLE II—*Unadjusted odds ratios for risk factors associated with bedroom before and after restriction to families denying alterations to bedroom. Figures are numbers (percentage); odds ratio (95% confidence interval)*

Exposure	Unrestricted: Controls (n=475)	Unrestricted: Cases (n=486)	Restricted†: Controls (n=463)	Restricted†: Cases (n=365)
Bedroom damp and mould:				
None	429 (93)	418 (90); 1‡	423 (94)	319 (92); 1†
Damp only	17 (4)	14 (3); 0·85 (0·39 to 1·83)	14 (3)	12 (3); 1·14 (0·49 to 2·65)
Damp with mould	14 (3)	30 (6); 2·20* (1·11 to 4·43)	12 (3)	16 (5); 1·77 (0·86 to 2·05)
Type of pillow used:				
Non-feather	299 (63)	414 (86); 1‡	289 (63)	302 (84); 1†
Both	87 (18)	42 (9); 0·35*** (0·23 to 0·53)	85 (18)	35 (10); 0·39*** (0·25 to 0·61)
Feather	86 (18)	26 (5); 0·18*** (0·13 to 0·35)	86 (19)	24 (7); 0·27*** (0·16 to 0·44)
Type of quilt used:				
Synthetic	387 (82)	424 (88); 1‡	375 (82)	318 (88); 1†
Mixed	28 (6)	27 (6); 0·88 (0·49 to 1·56)	28 (6)	19 (5); 0·80 (0·42 to 1·52)
Feather	55 (12)	31 (6); 0·51** (0·32 to 0·83)	55 (12)	26 (7); 0·56* (0·33 to 0·93)
Age (years) of mattress:				
0-3	172 (37)	180 (38); 1‡	167 (37)	130 (36); 1†
4-7	152 (33)	149 (31); 0·94 (0·68 to 1·29)	149 (33)	119 (33); 1·03 (0·73 to 1·45)
>7	138 (30)	146 (31); 1·01 (0·73 to 1·40)	134 (30)	108 (30); 1·04 (0·72 to 1·48)

Column totals include subjects with missing data for one or more variables.
†Excluding children with "alterations" or "special arrangements" in bedroom because of allergy, asthma, or other chest problems.
‡Reference category.
*P<0·05; **P<0·01; ***P<0·001.

The only significant relation with parental smoking was for the category of mothers smoking more than 10 cigarettes a day and frequent and speech limiting wheeze in the child (2·28; P<0·05). Similar sized effects were seen for maternal smoking around the time of the child's birth (not shown). In contrast, the most consistent result across the three groups was a reduction in risk associated with feather pillows, which increased in strength with increasing severity of wheezing (odds ratio 0·31 (P<0·001) for frequent attacks; 0·22 (P<0·001) for speech limiting wheeze; and 0·10 (P<0·001) for both). There were similar, though less clear, reductions in the use of feather quilts by wheezy children.

A possible explanation for the lower proportion of wheezy children using feather bedding would be the previous removal of feather items in response to the child's symptoms. Allergic families might also tend to avoid or remove pets and thereby dilute a positive association of wheezing with pet ownership.

As expected, changes in the bedroom because of asthma, allergy, or chest problems were more commonly reported for cases (24·9% (121)) than for controls (2·5% (12)). When these subjects were excluded from the analysis the decreased risk associated with feather bedding diminished only slightly (odds ratio rising towards unity), and remained significant for feather pillows and for feather quilts (table II).

The families of 144 (29·6%) cases and 46 (9·7%) controls had avoided or removed household pets because of allergy. Exclusion of these subjects from the analyses relating to pet ownership increased the odds ratio for current pet ownership (1·49) but decreased that for past pet ownership (0·92). The effects of owning cats or dogs were broadly similar (table III).

Table IV shows the independent effects of each risk factor as evaluated by multiple logistic regression. Adjustment for other factors altered the protective effect of feather pillows little (odds ratio 0·36 in table IV compared with 0·33 for "feather" and "both" combined in table II), and it remained highly significant (P<0·001). The increased risk associated with ownership of a furry pet was independent of other factors, with significant effects of approximately equal magnitude for pets now (P<0·05) and pets at birth (P<0·01).

After adjustment for other factors in table IV the odds ratios for pet ownership at birth, now, and both times compared with no reported pet ownership were, respectively: 1·30 (95% confidence interval 0·62 to 0·71); 1·35 (0·86 to 2·11), and 2·50 (1·60 to 3·94).

Restriction of the multiple logistic analysis to 102 cases and 142 controls with no parental history of wheeze, asthma, eczema, or hay fever slightly reduced the protective effect of feather pillows (odds ratio 0·41; 0·20 to 0·82), but it remained highly significant. Among these children the increased risk associated with furry pets persisted, albeit not significant at the 5% level (1·94; 0·99 to 3·80).

Discussion

The main strength of our case-control study was the size of the population survey from which it was derived. This permitted systematic ascertainment of a large case group of children with more severe asthma, and selection bias was minimised by selecting a control group from survey respondents.

Limitations of the study are the incomplete response rates (79% in 1991; 77% in 1993) and reliance on a retrospective questionnaire assessment of exposures in the home. On the other hand, special care was taken to deal with the possible biases related to avoidance of allergens.

The most powerful risk factors identified were pet

TABLE III—*Unadjusted odds ratios for pet ownership before and after restriction to families denying avoidance or removal of pet. Figures are numbers (percentage); odds ratio (95% confidence interval)*

Exposure	Unrestricted		Restricted†	
	Controls (n=475)	Cases (n=486)	Controls (n=429)	Cases (n=342)
Ownership of furry pets:				
Never	142 (30)	116 (24); 1†	116 (27)	65 (19); 1†
At birth only	35 (7)	35 (7); 1·22 (0·70 to 2·15)	33 (8)	17 (5); 0·92 (0·45 to 1·86)
Now only	178 (38)	190 (40); 1·31 (0·94 to 1·82)	166 (39)	139 (41); 1·49* (1·01 to 2·22)
Both times	114 (24)	140 (29); 1·50* (1·05 to 2·15)	108 (26)	118 (35); 1·95** (1·28 to 2·97)
Ownership of dogs:				
Never	274 (58)	241 (50); 1†	239 (57)	154 (45); 1†
At birth only	33 (7)	45 (9); 1·55 (0·93 to 2·58)	32 (8)	30 (9); 1·45 (0·82 to 2·58)
Now only	100 (21)	126 (26); 1·43* (1·03 to 1·99)	93 (22)	94 (28); 1·57* (1·09 to 2·56)
Both times	62 (13)	69 (14); 1·27 (0·85 to 1·89)	59 (14)	61 (18); 1·60* (1·04 to 2·47)
Ownership of cats:				
Never	293 (62)	273 (57); 1†	256 (61)	175 (52); 1†
At birth only	28 (6)	39 (8); 1·49 (0·87 to 2·58)	24 (6)	20 (6); 1·22 (0·62 to 2·37)
Now only	97 (21)	91 (19); 1·01 (0·71 to 1·42)	94 (22)	76 (22); 1·18 (0·81 to 1·72)
Both times	51 (11)	78 (16); 1·64* (1·09 to 2·47)	49 (12)	68 (20); 2·03** (1·31 to 3·14)

Column totals include subjects with missing data for one or more variables.
†Excluding families who reported that they "got rid of" or "decided against having" a pet because they thought "one of the family might be allergic to it."
‡Reference category.
*P<0·05; **P<0·01; ***P<0·001.

TABLE IV—*Mutually adjusted odds ratios for indoor environmental risk factors*

Exposure	Odds ratio† (95% confidence interval)
Among all subjects:	
Housing tenure:	
Rented *v* owned	0·92 (0·61 to 1·39)
Use of gas for cooking:	
Any *v* none	0·86 (0·61 to 1·23)
Mother smoking now:	
1-10 Cigarettes/day *v* 0	1·13 (0·73 to 1·74)
>10 Cigarettes/day *v* 0	1·49 (0·80 to 2·77)
Father smoking now:	
1-10 Cigarettes/day *v* 0	0·97 (0·64 to 1·47)
>10 Cigarettes/day *v* 0	0·62 (0·32 to 1·18)
Among subjects with no bedroom alterations‡:	
Mould in bedroom:	
Any *v* none	1·25 (0·67 to 2·31)
Type of pillow used:	
Feather/both *v* non-feather	0·36*** (0·24 to 0·53)
Type of quilt used:	
Feather/both *v* non-feather	0·78 (0·47 to 1·31)
Age (years) of mattress:	
4-7 *v* 0-3	1·10 (0·76 to 1·59)
>7 *v* 0-3	1·17 (0·80 to 1·72)
Among subjects with no pet avoidance/removal§:	
Ownership of furry pets now	
Any *v* none	1·51* (1·04 to 2·20)
Ownership of furry pets at birth:	
Any *v* none	1·70** (1·20 to 2·41)

†Odds ratios derived from model including 441 cases and 429 controls and adjusted for sex, year of birth, and all other factors shown.
‡Terms describing interaction between each bedroom exposure and report of bedroom alterations were fitted in model. Odds ratios shown derived for group with no reported bedroom alterations only.
§Terms describing interaction between each pet exposure and reported pet avoidance or removal were fitted in model. Odds ratios shown derived for group with no pet avoidance or removal only.
*P<0·05; **P<0·01; ***P<0·001.

ownership and non-feather bedding. In contrast, effects of parental smoking, gas cooking, and mould growth were weak and non-significant.

FURRY PET OWNERSHIP

Ownership of furry pets has been suggested as a risk factor for wheeze in many clinical studies,[8-11] but epidemiological studies have generally reported no association or an inverse relation to furry pets,[2 12-14] although a positive association was found in a recent study in Singapore.[15]

These inconsistencies could be due to dilution or reversal of positive associations by the tendency to remove pets from the home after the child (or other family members) have developed allergic complaints.

Brunekreef *et al* reported that 12% of families of Dutch children had removed pets from the home, and 2% had avoided household pets because of allergy.[5] (This compares with 10% of our control families who avoided or removed pets.) The lowest prevalence of pet allergy was found in children who currently (but not previously) had a pet in the home, whereas the highest prevalence was found in families without pets at present who had previously owned some in the past. Kuehr *et al* reported similar findings for skin prick tests, the prevalence of sensitisation to cat dander being significantly raised only in children whose families had owned cats in the past but not among current cat owners.[16]

Our study suggests that exposure to furred pets is an independent risk factor for the more severe forms of wheeze in adolescence. Early pet exposure was no more influential than current exposure after allowance for pet avoidance. Of the control families, 62% reported current ownership of a furry pet, and even among families who said they had avoided or removed a pet because of allergy 14% owned a furry pet both now and at birth. These figures suggest widespread exposure to pet allergens and reluctance even among allergic families to remove all pets from the home. Using the adjusted relative risks for pet ownership at birth, now, and both times (cited in results) and the prevalence of these exposures in the control group (table I) we estimate that current and past ownership of a furry pet accounts for 40% of cases of severe wheeze in our population. Allergy to pet dander provides a biologically plausible mechanism for this relation. Furry household pets are likely to be a widespread but potentially removable cause of the more troublesome forms of childhood asthma.

FEATHER BEDDING

The idea that feather pillows increase the risk of allergic asthma is widely accepted,[17] but remarkably there is no previous epidemiological literature on the subject. Our study suggests a substantially lower risk of troublesome asthma among children using feather bedding relative to those using non-feather materials. At first sight, the most likely explanation for this observation was avoidance or removal of feather bedding by families of an asthmatic child or by allergic parents. The inverse relation of severe asthma to feather pillows, however, remained strong and highly significant even after restriction to non-allergic families

Key messages

- Epidemiological associations between the home environment and asthma may be underestimated by the greater tendency of cases and their families to avoid potential causes of asthma in the home
- The bedroom arrangements of one quarter of teenagers with troublesome asthma in Sheffield had been altered because of the child's allergy or chest problem. One quarter of these families had avoided pets or removed them from the home because of allergy
- Nevertheless, about two thirds of asthmatic children were exposed to furry pets in their home, an exposure which almost doubled their risk of troublesome symptoms
- Alterations to the bedroom commonly entailed use of non-feather bedding, used by 95% of severely wheezy children. Exposure to synthetic pillows was associated with a two to threefold increase in risk of severe wheezing, even after allowance for selective avoidance of allergens by the families of allergic or asthmatic children
- Avoidance of feather bedding is unlikely to benefit children with asthma, and there may be a hitherto unidentified hazard associated with use of synthetic pillows

who denied making changes in the bedroom. This raises the intriguing possibility that non-feather substitutes may pose a greater risk of asthma than any allergens associated with feather bedding.

The single "bedroom alterations" question (on the 1993 questionnaire) may have been insufficient to detect all conscious action by families to ensure that their children do not have feather pillows. Nevertheless, to explain the inverse association of asthma with feather pillows purely on the basis of undetected avoidance it would be necessary to assume that more than half of the families of cases who denied bedroom alterations and who would otherwise have used feather pillows avoided doing so because of their child's chest trouble (table II). This seems unlikely. Further epidemiological studies including more specific inquiries about allergen avoidance are required to confirm the apparent risk associated with non-feather pillows. If this association is causal, however, we estimate that it accounts for 53% of the severe asthma in our population.

Although firm conclusions cannot be drawn from a single study, our results suggest that avoidance of feather bedding is unlikely to benefit children with asthma and raise the possibility that there is a hitherto unidentified hazard associated with synthetic pillows. Volatile organic compounds released in low concentrations close to the breathing zone might increase mucosal permeability to inhaled allergens and thereby offer a speculative explanation for a possible causal link between foam pillows and childhood asthma. This possibility should be investigated by further observational and experimental studies.

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Evidence based purchasing: understanding results of clinical trials and systematic reviews

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Abstract

***Objective*—To assess whether the way in which the results of a randomised controlled trial and a systematic review are presented influences health policy decisions.**

***Design*—A postal questionnaire to all members of a health authority within one regional health authority.**

***Setting*—Anglia and Oxford regional health authorities.**

***Subjects*—182 executive and non-executive members of 13 health authorities, family health services authorities, or health commissions.**

***Main outcome measures*—The average score from all health authority members in terms of their willingness to fund a mammography programme or cardiac rehabilitation programme according to four different ways of presenting the same results of research evidence—namely, as a relative risk reduction, absolute risk reduction, proportion of event free patients, or as the number of patients needed to be treated to prevent an adverse event.**

***Results*—The willingness to fund either programme was significantly influenced by the way in which data were presented. Results of both programmes when expressed as relative risk reductions produced significantly higher scores when compared with other methods ($P < 0.05$). The difference was more extreme for mammography, for which the outcome condition is rarer.**

***Conclusions*—The method of reporting trial results has a considerable influence on the health policy decisions made by health authority members.**

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Introduction

The randomised controlled trial is regarded as the gold standard in the assessment of healthcare interventions.[1] Its explanatory power permits qualitative conclusions about whether a treatment works and a quantitive assessment of the extent to which it works.[2] Purchasing organisations are now being exhorted to make health policy and purchasing decisions in terms of evidence of clinical effectiveness.[3,4] A large proportion of such evidence comes in the form of randomised controlled trials. Research has shown that the way in which the results from controlled trials are expressed has a significant influence on physicians' willingness to prescribe drugs[5-10] and patients' perception of benefit from treatment.[11] Whether or not the framing of the results of controlled trials has an influence on purchasing and health policy decisions has not been examined.

There are at least four ways of reporting outcomes of