

# Wheeze, cough, atopy, and indoor environment in the Scottish Highlands

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## Abstract

**A questionnaire which included items on wheeze, cough, eczema, hay fever, and indoor environment, including parental smoking habits, pet ownership, heating and cooking methods, home insulation, damp, mould, and years lived in their houses, was given to 1801 children, aged 12 and 14 from the Highland Region in Scotland. Of the 1537 (85%) who replied, 267 (17%) reported current wheeze, 135 (9%) cough for three months in the year, 272 (18%) eczema, and 317 (21%) hay fever. There was no consistent relationship between respiratory symptoms and indoor environment although cough was associated with damp, double glazing, and maternal smoking. The prevalence of wheeze, cough, and atopy was higher in children who had lived in more than one house during their lifetime. These results suggest that increasing mobility of families in recent years may be more important in the aetiology of asthma than exposure to any one individual allergen or pollutant.**

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The rising prevalence of childhood asthma and atopy<sup>1</sup> has major implications for health care in terms of morbidity,<sup>2</sup> service provision, and costs. For example, in the Highland Health Board area the first quarter prescriptions for bronchodilators in all age groups rose by 28% from 17 461 in 1990 to 22 390 in 1995 (figures from pharmaceutical advisors, Highland Health Board).

To date, no satisfactory explanation has been found for the increasing prevalence of wheezing disorders in childhood, which in the Highland Region affect 25% of the paediatric population at some time in their lives.<sup>3</sup> One explanation for this rise may be exposure to outdoor<sup>4</sup> and indoor pollution and/or allergens. Thus, Priftis *et al* showed that the sensitisation rate to common environmental allergens, particularly house dust mite, was significantly higher in coastal regions of Greece than in urban areas, and suggested that this was due to the encouragement of mite growth by the high humidity levels found in coastal areas.<sup>5</sup> In the UK, the combined effects of central heating, insulation, wall to wall carpets, and double glazing have in recent years encouraged the development of just such an environment indoors. There is conflicting evidence with

regard to the role of indoor pollutants such as maternal smoking,<sup>6</sup> method of cooking and heating,<sup>7, 8</sup> and allergens<sup>9, 10</sup> such as dust mites and pet allergens in relation to asthma and wheeze.

The Highland Region of Scotland is a rural area with a large coastline and many inland waters and lochs. Living conditions vary considerably within the region; in particular, there is a greater frequency of open fires burning wood and peat in the more remote areas compared with relatively urban districts. Having demonstrated in a previous study that the prevalence of wheeze is as high in the Scottish Highlands as in urban areas of the UK,<sup>3</sup> and in the absence of major outdoor pollution, we felt that this area was ideally situated for the study of indoor environmental factors which might be related to the prevalence of asthma.

## Subjects and methods

Ethical approval for the study was granted by the Highland Health Board ethical committee.

The respiratory questionnaire used in the previous Highland study<sup>3</sup> was supplemented by additional questions based on those used in studies by Anderson and Forsberg (personal communication), in order to obtain information regarding heating, cooking, and insulation methods within the home.

The main questions were as follows. *Wheeze* was defined by the question: 'Has a wheeze—that is, a whistling noise (high or low pitched)—ever been heard from your child's chest?' *Current wheeze* was defined by the question: 'How many times has it occurred during the last 12 months?' *Cough* was defined by the question: 'dose he/she cough on most days for as much as three months per year?' *Hay fever* and *eczema* were defined by the question: 'Has your child ever suffered from any of the following?'

Following a pilot study on children who did not take part in the main study, 1801 children attending secondary schools throughout the Highland Region were invited to take part. These comprised 876 children aged 14 born between 1 March 1979 and 29 February 1980 (the original cohort studied in 1992),<sup>3</sup> and 925 children aged 12 born between 1 March 1981 and 28 February 1982 (the new cohort). The sampling procedure for subjects was identical with that used in the previous study.<sup>3</sup> Results were analysed using the Statistical Package for Social Sciences (SPSS).

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Table 1 Comparison of prevalence of asthma, wheeze, and atopy in 1992 and 1994. Values in parentheses are percentages

	1992			1994		
	Total (n=1825)	Girls (n=887) (49)	Boys (n=938) (51)	Total (n=1537)	Girls (n=759) (49)	Boys (n=778) (51)
Reported asthma	251 (14)	97 (11)	154 (16)	267 (17)*	123 (16)*	144 (19)
Current wheeze	350 (19)	154 (17)	196 (21)	267 (17)	129 (17)	138 (18)
Eczema	257 (14)	119 (13)	138 (15)	272 (18)*	141 (19)*	131 (17)
Hay fever	351 (19)	151 (17)	200 (21)	317 (21)	143 (19)	174 (22)
Cough	168 (9)	80 (9)	88 (9)	135 (9)	62 (8)	73 (9)

\*For change in prevalence,  $p=0.005$ . Significance of associations for 1994: current wheeze with hay fever,  $\chi^2=113.43$ ,  $df=1$ ,  $p=0.000$ ; current wheeze with eczema,  $\chi^2=48.3$ ,  $df=1$ ,  $p=0.000$ ; current wheeze with cough,  $\chi^2=212.09$ ,  $df=1$ ,  $p=0.000$ ; cough with hay fever,  $\chi^2=18.0$ ,  $df=1$ ,  $p=0.000$ ; cough with eczema,  $\chi^2=29.9$ ,  $df=1$ ,  $p=0.000$ ; cough with asthma,  $\chi^2=199.86$ ,  $df=1$ ,  $p=0.000$ .

Table 2 Smoking attributes of the family in relation to asthma, wheeze, and atopy. Values in parentheses are percentages

	Either parent smokes (n=707) (46)	Mother smokes (n=425) (28)	Antenatal smoking (n=435) (28)	Neither parent smokes (n=796) (52)
Wheeze in last 12 months (n=267) (17)	130 (18)	79 (19)	78 (18)	132 (17)
Reported eczema (n=272) (18)	120 (17)	62 (15)	76 (17.5)	145 (18)
Reported hay fever (n=317) (21)	121 (17)*	66 (15.5)†	62 (14)‡	190 (24)
Cough (n=135) (9)	77 (11)§	55 (13)	43 (10)	57 (7)

\* $\chi^2=10.32$ ,  $df=1$ ,  $p=0.001$ ; † $\chi^2=9.8$ ,  $df=1$ ,  $p=0.0017$ ; ‡ $\chi^2=15.04$ ,  $df=1$ ,  $p=0.0001$ ; § $\chi^2=6.56$ ,  $df=1$ ,  $p=0.01$ ; ||  $\chi^2=12.02$ ,  $df=1$ ,  $p=0.0005$ .

## Results

Questionnaires were returned by 1537 (85%) children, 741 (85%) from the original cohort and 796 (86%) from the new cohort.

### CHANGES IN PREVALENCE OF SYMPTOMS AND ATOPY

Table 1 describes the prevalence of and correlations between respiratory symptoms and reported atopy. As there was no significant difference in the prevalence figures between the two cohorts in 1994, the results are presented in total for 1994. Although there was no significant change in the prevalence of wheeze between 1992 and 1994, there were significant rises in the prevalence of reported asthma ( $p=0.005$ ) and eczema ( $p=0.005$ ), both accounted for by a rise in the prevalence of these diagnoses in girls.

Current wheeze was strongly associated with cough ( $\chi^2=212.09$ ,  $df=1$ ,  $p<0.001$ ). Only 35 (2.3%) of the study population coughed in the absence of current wheeze or reported asthma.

### PET OWNERSHIP

A total of 1101 (72%) children owned one or more pets; 669 (43.5%) owned a dog, 575 (37%) owned a cat, and 329 (21%) owned some other mammal. Of these pet owners, 191 (17%) reported current wheeze, 96 (9%) reported cough, 232 (21%) reported hay fever,

and 188 (17%) reported eczema. The only significant association between respiratory symptoms or reported atopy and pet ownership was between eczema and owning a mammal other than a cat or a dog ( $\chi^2=4.425$ ,  $df=1$ ,  $p=0.035$ ; relative risk=1.30, 95% confidence interval (CI) = 1.02 to 1.66).

### PARENTAL SMOKING

Table 2 presents data on parental smoking. Cough was associated with parental smoking ( $\chi^2=6.56$ ,  $df=1$ ,  $p=0.01$ ), particularly maternal smoking ( $\chi^2=12.02$ ,  $df=1$ ,  $p=0.0005$ ). Parental smoking did not influence the prevalence of current wheeze ( $\chi^2=0.92$ ,  $df=1$ ,  $p=0.337$ ) or eczema ( $\chi^2=0.38$ ,  $df=1$ ,  $p=0.54$ ). There was less risk of hay fever in subjects whose mothers smoked now ( $\chi^2=9.8$ ,  $df=1$ ,  $p=0.0017$ ) or during pregnancy ( $\chi^2=15.04$ ,  $df=1$ ,  $p=0.0001$ ).

### LENGTH OF RESIDENCE AT CURRENT ADDRESS

A total of 551 (36%) had lived five years or less in their current house, 341 (23%) had lived six to nine years in their current house, and 617 (41%) had lived 10 or more years in their current house.

A quarter of the children (380) had lived in one house all their lives, 320 (21%) in two houses, 157 (10%) in three houses, 60 (4%) in four houses, and 32 (2%) in five houses.

Table 3 Asthma, symptoms, and atopy in relation to length of residence and number of houses lived in. Values in parentheses are percentages

	Current wheeze (n=267) (17)	Cough (n=135) (9)	Hay fever (n=317) (21)	Eczema (n=272) (18)
Lived 5 years or less (n=551) (36)	98 (18)	62 (11)	92 (17)	114 (21)
Lived 6–9 years (n=341) (22)	70 (21)	31 (9)	75 (22)	57 (17)
Lived 10 or more years (n=617) (40)	97 (16)	39 (6)	145 (23.5)	99 (16)
One house (n=380) (25)	57 (15)	23 (6)	86 (23)	63 (17)
More than one house (n=1128) (74)	208 (18.5)	109 (10)	227 (20)	207 (18)
Two houses (n=320) (21)	60 (19)	26 (8)	66 (21)	65 (20)
Three houses (n=157) (10)	33 (21)	25 (16)	36 (23)	38 (24)
Four houses (n=60) (4)	7 (12)	9 (15)	18 (30)	12 (20)
Five houses (n=32) (2)	8 (25)	3 (9)	6 (19)	8 (25)
Relative risk of condition for living in more than one house (95% CI)	1.23 (0.94 to 1.61)	1.6 (1.03 to 2.47)	0.89 (0.71 to 1.11)	1.11 (0.86 to 1.43)
Relative risk of condition if lived in house 5 years or less compared to 10 or more years (95% CI)	1.13 (0.88 to 1.46)	1.78 (1.21 to 2.61)	0.71 (0.56 to 0.90)	1.29 (1.01 to 1.64)

CI = confidence interval.

Table 4 Current wheeze, hay fever, and eczema in relation to indoor environment. Values in parentheses are percentages

	Current wheeze (n=267) (17)	Cough (n=135) (9)	Hay fever (n=317) (21)	Eczema (n=272) (18)
<b>Heating</b>				
Gas (n=663) (43)	117 (18)	68 (10)	155 (23)*	118 (18)
Electric (n=837) (54.5)	157 (19)	81 (10)	178 (21)	151 (18)
Coal, peat, wood (n=803) (52)	139 (17)	64 (8)	156 (19)	142 (18)
Central heating (n=1018) (66)	181 (18)	87 (8.5)	223 (22)	194 (19)
Stove/Raeburn (n=236) (15)	37 (16)	15 (6)	38 (16)	34 (14)
Open fire (n=638) (41.5)	111 (17)	55 (9)	125 (20)	112 (17.5)
<b>Cooking method</b>				
Gas (n=382) (25)	57 (15)	32 (8)	73 (19)	56 (15)
Electric (n=1252) (81.5)	224 (18)	110 (9)	261 (21)	229 (18)
Microwave oven (n=1009) (66)	177 (17.5)	98 (10)	214 (21)	173 (17)
Stove/Raeburn (n=173) (11)	27 (16)	10 (6)	29 (17)	23 (13)
Coal, peat, wood (n=60) (4)	9 (15)	5 (8)	12 (20)	9 (15)
<b>Insulation</b>				
Wall to wall carpet (n=1406) (91.5)	250 (18)	122 (9)	293 (21)	252 (18)
Double glazing (n=1012) (66)	177 (17.5)	76 (7.5)†	215 (21)	204 (20)‡
Roof, cavity wall insulation (n=1129) (73)	200 (18)	99 (9)	238 (21)	211 (19)
House within 100 yards of farm/croft (n=486) (32)	95 (19.5)	43 (9)	96 (20)	79 (16)
Damp (n=167) (11)	30 (18)	22 (13)§	42 (25)	25 (15)
Mould (n=109) (7)	20 (18)	16 (15)	24 (22)	20 (18)

\* $\chi^2=5.31$ ,  $df=1$ ,  $p=0.02$ , relative risk 1.26, 95% confidence interval (CI) 1.04 to 1.53; † $\chi^2=5.55$ ,  $df=1$ ,  $p=0.018$ , relative risk 0.675, 95% CI 0.486 to 0.936; ‡ $\chi^2=12.92$ ,  $df=1$ ,  $p=0.00032$ , relative risk 1.59, 95% CI 1.23 to 2.06; § $\chi^2=4.77$ ,  $df=1$ ,  $p=0.029$ , relative risk 1.62, 95% CI 1.06 to 2.48; ||  $\chi^2=5.26$ ,  $df=1$ ,  $p=0.021$ , relative risk 1.78, 95% CI 1.1 to 2.89.

Table 3 gives the relationships with respiratory symptoms and diagnosed atopy.

#### AGE OF HOUSE

The year the house was built correlated with the presence of double glazing ( $r=0.194$ ,  $p<0.001$ ) and with eczema ( $r=0.060$ ,  $p=0.031$ ). There were no significant relationships between the age of the house and respiratory symptoms.

#### HOUSING CONDITIONS—SKYE AND THE MAINLAND

In Skye, where we previously demonstrated an unusually high prevalence of bronchial hyper-reactivity to exercise,<sup>3</sup> 161 (80%) of 201 homes burned coal, wood, or peat in fires (n=111; 55%), stoves (n=38; 19%), or both (n=12; 6%). This compares with mainland Highland Region (n=1336), where 642 (48%) burned coal, wood, or peat, 477 (36%) in open fires and 162 (12%) in stoves.

However, neither the method of heating nor any other environmental factor in the home had any influence on the prevalence of current wheeze (table 4), although hay fever was associated with gas heating ( $\chi^2=5.31$ ,  $df=1$ ,  $p=0.02$ , relative risk 1.26, 95% CI=1.04 to 1.53), and cough with damp ( $\chi^2=4.77$ ,  $df=1$ ,  $p=0.029$ , relative risk 1.62, 95% CI=1.06 to 2.48) and mould ( $\chi^2=5.26$ ,  $df=1$ ,  $p=0.021$ , relative risk 1.78, 95% CI=1.1 to 2.89). Cough was negatively associated with double glazing ( $\chi^2=5.55$ ,  $df=1$ ,  $p=0.018$ ,  $r=-0.0606$ , relative risk 0.675, 95% CI=0.486 to 0.936), and eczema showed a positive association with double glazing ( $\chi^2=12.92$ ,  $df=1$ ,  $p=0.0003$ ,  $r=0.092$ ).

#### Discussion

There is no satisfactory definition or test for wheeze or atopy. Skin prick testing and/or radioallergosorbent tests have been used in population studies, but could not be entertained in the present study for logistic and financial reasons. In common with most epidemiological studies on asthma, we have there-

fore had to rely on symptoms suggestive of asthma, and on parental awareness and/or recollection of the diagnosis of an atopic condition. However, the items included in our questionnaire have been widely used elsewhere, and in order to allow comparison with our previous study in 1992 we repeated the same basic questionnaire.

#### CHANGES IN PREVALENCE OF WHEEZE AND REPORTED DIAGNOSIS OF ASTHMA

The prevalence figures obtained in 1994 were very similar to those obtained in the 1992 study<sup>3</sup> and support the long established association of wheeze and reported asthma with reported hay fever and eczema.<sup>11</sup> The increase in the prevalence of reported asthma between 1992 and 1994 was not matched by a change in the prevalence of current wheeze, suggesting that family doctors are now more ready to offer a diagnosis of asthma to children, particularly girls, with wheeze, rather than a true increase in the prevalence of asthma during the two year interval between the two studies. The close similarity of the figures for the prevalence of respiratory symptoms in the two studies also suggests that the results obtained in 1992 are reliable, supporting our previous conclusion that wheeze is common in the Highlands of Scotland despite the relative lack of air pollution, and our decision on this occasion to examine relationships between symptoms and indoor environment.

#### ECZEMA AND HAY FEVER

In Highland children, the prevalence of eczema is similar to, and the prevalence of hay fever higher than, that reported in Aberdeen children aged 8 to 13 in 1994.<sup>1</sup> Using the same questionnaire as Burr *et al* in their study of 12 year olds,<sup>12</sup> we have shown a higher prevalence of reported eczema in Highland children (18%) than in New Zealand and Wales (both 16%), and South Africa (11%) and lower than in Sweden (22%). For hay fever our prevalence figures are higher than previously reported for Wales (16%) and Sweden (14%) but lower

than for New Zealand (21%) and South Africa (31%).<sup>12</sup>

#### PET OWNERSHIP

Burr *et al* found no correlation between pet ownership and wheezing,<sup>12</sup> a finding supported in the present study. In contrast, Strachan and Carey found that furred pets were an independent risk factor for the more severe forms of wheeze in adolescence.<sup>9</sup>

#### PARENTAL SMOKING

Although numerous studies have shown that maternal smoking, both current and antenatal, is associated with a significantly higher prevalence of wheezing illness in children,<sup>13 14</sup> and it has been suggested that parental smoking may enhance allergic sensitisation in children, especially in boys,<sup>15</sup> a review of the literature by Hood *et al* suggests that there is no consistent association between parental smoking and respiratory symptoms in school aged children.<sup>16</sup>

In the present study cough was significantly increased in children whose mothers smoked currently. Although the prevalence of wheeze was higher in children whose mothers smoked, this did not reach significance. The relevance of cough in relation to asthma is debatable.<sup>17</sup> Although cough is frequently included in respiratory questionnaires as an indicator of occult asthma,<sup>18</sup> cough on its own is non-specific and is an unreliable marker for asthma in epidemiological studies.<sup>19</sup> In the present study, we found a strong association between cough and current wheeze, and few children who had coughed persistently for three months did not also wheeze.

A significant but inexplicable finding was the reduced risk of hay fever in children whose mothers smoked.

#### INDOOR DOMESTIC ENVIRONMENT

Recent evidence from a small study in general practice suggests that children who develop asthma have moved house more frequently before the condition develops than non-asthmatic children.<sup>20</sup> Our population study, although of older subjects who had already developed their symptoms, showed a greater risk for cough in subjects who had lived in their current house for a short time only, having therefore moved house at least one more time than those subjects living all their lives in one house. This evidence is supported by an association between the prevalence of cough, wheeze, and eczema, and the number of houses lived in by the children, although the number of subjects is small for four and five houses.

Burr *et al* showed that there was a significantly higher prevalence of wheeze in infants from atopic families living in homes with open coal fires than in other homes.<sup>21</sup> In contrast, von Mutius *et al* showed that the prevalence of atopy was significantly less in children where coal or wood was used for heating compared with those living in homes with gas or central heating.<sup>22</sup> Infante-Rivard showed that electric heating and heavy maternal smoking were

independent risk factors for asthma in pre-school children.<sup>7</sup> Melia *et al* demonstrated a significant relationship between dampness in the home and respiratory disorders in childhood,<sup>23</sup> and Dales *et al* showed that damp or mould were strongly associated with cough but more weakly with asthma.<sup>24</sup> Apart from the last, we were unable to confirm any of these observations nor could we demonstrate any effect of wall to wall carpeting, insulation, double glazing, or method of cooking on the prevalence of wheeze. However, eczema appears to be associated with more modern houses with double glazing.

Most previous studies of respiratory symptoms and atopy in childhood have concentrated on younger children, and relatively few have focused on the adolescent age group. Our lack of positive findings, and our failure to confirm many previous findings, might be explained by the age group studied; by the age of 12 and 14 years the domestic environment may not reflect accurately the conditions at the time of inception of asthma and atopy which will generally have been some years earlier. However, the population in the Highland Region is relatively stable and we feel it is more likely that the domestic environment does not influence the prevalence of wheeze and atopy in this age group. Our results do, however, support the possibility that exposure to new environmental allergens, or some other factor involved in moving house, might be a risk factor for asthma.

#### Conclusion

The rise in the prevalence of childhood wheeze and asthma throughout the UK has coincided with a trend towards better insulated homes with wall to wall carpeting, central heating, and double glazing, circumstances that are likely to be associated with an increased prevalence of indoor allergens such as the house dust mite. However, in the Scottish Highlands where there is a high proportion of traditionally heated homes, as well as more 'modern' dwellings, although we found some minor associations (and, given the number of associations studied, these may have been chance relationships), we failed to demonstrate any consistent relationship between domestic environment and the prevalence of respiratory symptoms or reported atopy. Our results do, however, suggest that asthma may be more prevalent in children who have lived only a short time in their homes, and we suggest that the increasing mobility of families in the developed world might be one factor underlying the recent increase in the prevalence of childhood asthma. However, we also believe that factors not so far examined, for instance diet,<sup>25</sup> infection,<sup>26</sup> and immunisation practices,<sup>27</sup> are more likely than domestic environmental factors to be responsible for most of the rise in prevalence of asthma over the last three decades.

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