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# Changing trends in asthma in 9–12 year olds between 1964 and 2009

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## ABSTRACT

**Introduction** Childhood asthma is a common condition and the prevalence has increased in many countries during the late 20th century. The Aberdeen schools asthma surveys reported rising lifetime prevalence of asthma between 1964 and 2004 in children aged 9–12 years, but a fall in wheeze in the last 3 years between 1999 and 2004. The present study tested the hypothesis that lifetime childhood asthma prevalence has fallen since 2004.

**Methods** Children aged 9–12 years who attended the same schools surveyed since 1964 were invited to participate. A lifetime history of asthma or eczema and also wheeze in the past 3 years and 12 months was ascertained from a questionnaire. Trends over 1999, 2004 and 2009 were analysed with adjustment for age, gender and an index of deprivation.

**Results** There were 2253 eligible children and 1196 (53%) questionnaires were returned. The lifetime prevalence of asthma rose from 24.3% in 1999 to 28.4% in 2004 but fell to 22.1% in 2009 ( $p<0.001$ ), while wheeze in the last 3 years fell from 27.9% in 1999 to 25.2% in 2004 and fell further to 22.2% in 2009 ( $p<0.001$ ). The lifetime prevalence of eczema among 9–12 year olds was 21.4% in 1999, 34.1% in 2004 and 30.7% in 2009 ( $p<0.001$ ). Reductions in symptom prevalences between 2004 and 2009 were significant for girls but not boys.

**Conclusion** The prevalence of lifetime asthma and wheeze appear to have fallen in school children, especially girls, although the low response rate means some caution is required when interpreting the results. Asthma prevalence remains high and the underlying mechanisms remain incompletely understood.

## INTRODUCTION

Childhood asthma is a very common chronic condition. In the UK, there are approximately one million children with asthma,<sup>1</sup> 5% of children are prescribed inhaled corticosteroids to control persistent asthma symptoms<sup>2</sup> and approximately three children per million die of asthma each year.<sup>3</sup> In many countries, including the UK, the prevalence of childhood asthma rose during the 1980s and 1990s.<sup>4–7</sup> Although globally there was no obvious pattern to changes in childhood asthma prevalence in the early 2000s,<sup>8</sup> recent evidence from some European countries point to a slowing or even a halt in the rise of asthma prevalence among children and adolescents.<sup>9–11</sup>

The first Aberdeen Schools Asthma Survey was completed in 1964<sup>12</sup> and subsequently repeated in 1989<sup>13</sup>, 1994<sup>14</sup>, 1999<sup>15</sup> and 2004.<sup>5</sup> We have recently reported that although the lifetime prevalence of

## What is already known on this topic

- Asthma prevalence has increased in the UK between 1964 and 2004.
- Evidence of a slowing or reversal of rising asthma prevalence has been seen in countries other than the UK.

## What this study adds

- There is evidence that asthma prevalence is now falling in the UK.
- The fall in asthma prevalence seems to be greater in girls.

asthma in 9–12 year old children rose between 1999 and 2004, wheeze in the last 3 years fell in this period.<sup>5</sup> Based on our observations in 1999 and 2004, we speculated that the prevalence of asthma might fall after 2004<sup>5</sup> and in the present report we test this hypothesis using the data from the 2009 survey.

## METHODS

### Study design

Children in primary school aged 5–7 years (approximate ages 9–12 years) were invited to participate. Questionnaires were distributed to children by school staff, completed by parents at home, returned to school and collected by the class teachers prior to collection by the research team. The study was approved by the University of Aberdeen College of Life Sciences and Medicine Ethics Review Board and Aberdeen City Council Education Department. Parental consent was inferred from the return of a completed questionnaire.

### Participants

Children attending the same schools included in all previous surveys were invited to participate. The survey took place during the month of May, as in all previous surveys. The 1964, 1989 and 1994 surveys included only children aged 9–12 years (primary school years 5–7). The 2004 and 2009 surveys also included children aged 7–9 years (primary school years 3–4) and International Study of Allergy and Asthma in Children (ISAAC) respiratory questions<sup>16</sup> were added for all children. The focus of the present report is the results from the 9–12 year olds. Results from 7 to 9 year old

## Original article

participants for the 2009 survey are presented in the online supplement.

### Questionnaire

The same questionnaire used in 2004 was distributed along with a letter explaining the purpose of the survey. The questions included 'Has your child wheezed or had a whistle in the chest in the past three years?', 'Has your child ever had asthma?', 'Has your child ever had eczema?' and 'Has your child ever had hay fever?' Full details of the questionnaire are presented in the online supplement. In addition to questions about asthma and related conditions, a history of smoke exposure and parental asthma were included.<sup>16</sup> Data were entered manually with a small random sample being checked by a second person.

### Data analysis

#### Imputation of missing values

Our previous experience<sup>5</sup> was that approximately 10% of questionnaires would have a response to the wheeze question but not for lifetime experience of asthma, eczema and hay fever questions. For incomplete questionnaires, missing lifetime asthma, eczema and hay fever data were imputed by extrapolating the ratio of wheeze to lifetime asthma, eczema and hay fever from complete questionnaires returned in 2009 while, at the same time, adjusting for school year group and neighbourhood deprivation (using the Scottish Index of Multiple Deprivation, SIMD<sup>17</sup>). For example, the imputed value (probability) of a child having asthma was 0.55 if they had wheeze and were in the 9–12 year age-group and in the most deprived SIMD and 0.46 if they did not have wheeze and were in the younger age group and in the most deprived SIMD. Appropriate standard errors of the proportions were calculated using the actual number of children with valid observations for each question. Only imputed values for asthma, eczema and hay fever are displayed in the tables and figures. Imputation was not possible for questionnaires which were not returned or returned without a response to the wheeze question. Imputation was not undertaken for the ISAAC questions since responses were generally complete (more than 96%<sup>5</sup>).

#### Change in prevalence

Generalised linear model (GLM) was used to analyse changes over the last three surveys adjusting for the effects of sex and deprivation category using imputed values for asthma, eczema and hay fever for years 2004 (imputed from 2004 data) and 2009; imputed values are a continuous variable. The resulting F values were adjusted to reflect the actual numbers observations to minimise the effect of imputation. Logistic regression (for the dichotomous outcome responses, eg, wheeze yes/no) was used to determine the significance of trends over 1999, 2004 and 2009 adjusting for sex, school year group and deprivation category. Standard statistical software was used (SPSS v 17) and significance was assumed at  $p < 0.05$ .

## RESULTS

### Study participants

There were 2253 eligible children aged 9–12 of whom questionnaires were returned in 1196 (53%). Where the wheeze question was answered there were missing responses for questions on lifetime experience of asthma, eczema and hay fever in 8%, 11% and 12% of individuals. The average age (SD) of

children was 10.8 years (0.9) and 588 were male (49%). Twenty six of the 31 eligible schools agreed to participate including four schools, which had not taken part in 2004; five schools which participated in 2004 declined to take part in 2009. There were no differences in SIMD (derived from school postcode) between participating and non-participating schools. In 2004, the prevalence of lifetime asthma for the five schools who did not participate in 2009 was not different to other schools who participated in 2004 and 2009 (online supplement). There were 22 schools (including two schools which had merged between 2004 and 2009) which participated in each of the surveys in 1999, 2004 and 2009. Compared to the whole 2009 study population, the children attending these 22 'common' schools were similar in terms of age, gender, wheeze, lifetime prevalence of asthma, eczema, hay fever and parental asthma but were less likely to be exposed to tobacco smoke at home (32% versus 36%,  $p < 0.001$ ). The symptom outcomes for children attending the 22 'common' schools, and all schools did not differ (table 2 and online supplement).

### Asthma, eczema and hay fever—longitudinal trends

These data are presented in table 1. The lifetime prevalence of asthma rose from 24.3% (95% CI 22.8% to 25.8%) in 1999 to 28.4% (95% CI 26.2% to 30.6%) in 2004 but fell to 22.1% (95% CI 19.6% to 24.6%) in 2009,  $p < 0.001$  (GLM model assessing yearly trends adjusted for sex and SIMD), figure 1. The prevalence of wheeze in the previous 3 years fell from 27.9% (95% CI 26.4% to 29.4%) in 1999 to 25.2% (95% CI 23.2% to 27.2%) in 2004 and fell further to 22.2% (95% CI 19.8% to 24.6%) in 2009 ( $p < 0.001$ , figure 1). Lifetime prevalence of eczema was 21.4% (95% CI 20.0% to 22.8%) in 1999, 34.1% (95% CI 31.7% to 36.5%) in 2004 and 30.7% (95% CI 27.9% to 33.5%) in 2009 ( $p < 0.001$ , figure 1). The lifetime prevalence of hay fever was 15.4% (95% CI 14.1% to 16.6%) in 1999, 26.5% (95% CI 24.2 to 28.8) in 2004 and 25.7% (95% CI 23.1% to 28.4%) in 2009 ( $p < 0.001$ , figure 1). The reduction in wheeze, asthma and eczema between 2004 and 2009 was significant in girls ( $p = 0.021$ ,  $p < 0.001$  and  $p = 0.002$ , respectively), but there was no significant change in prevalence among boys between 2004 and 2009 (table 2). Unadjusted non-imputed results for 9–12 year olds in 2009 were as follows: recent wheeze 22.2% (265/1196), lifetime asthma 22.7% (250/1103), lifetime eczema

**Table 1** Prevalences (%) with 95% CIs for history of wheeze in the past 3 years and lifetime prevalences of asthma, eczema and hay fever and wheeze for children aged 9–12 years attending all schools

|                                   | 1999                             | 2004                             | 2009                             |
|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Wheeze in past 3 years            | 27.9<br>(26.4 to 29.4)<br>n=3540 | 25.2<br>(23.2 to 27.2)<br>n=1915 | 22.2<br>(19.8 to 24.6)<br>n=1196 |
| Lifetime prevalence of asthma*    | 24.3<br>(22.8 to 25.8)<br>n=3540 | 28.4<br>(26.2 to 30.6)<br>n=1684 | 22.1<br>(19.6 to 24.6)<br>n=1103 |
| Life time prevalence of eczema*   | 21.4<br>(20.0 to 22.8)<br>n=3540 | 34.1<br>(31.7 to 36.5)<br>n=1542 | 30.7<br>(27.9 to 33.5)<br>n=1070 |
| Lifetime prevalence of hay fever* | 15.4<br>(14.1 to 16.6)<br>n=3540 | 26.5<br>(24.2 to 28.8)<br>n=1481 | 25.7<br>(23.1 to 28.4)<br>n=1050 |

\*Imputed values are given for asthma, eczema and hay fever 2004 and 2009, sample sizes for these relate to the original from the actual survey. The test for changing prevalence of wheeze in the last 3 years and lifetime prevalences of asthma, eczema and hay fever between 1999 and 2009 was significant ( $p < 0.001$ ) and independent of SIMD and gender.

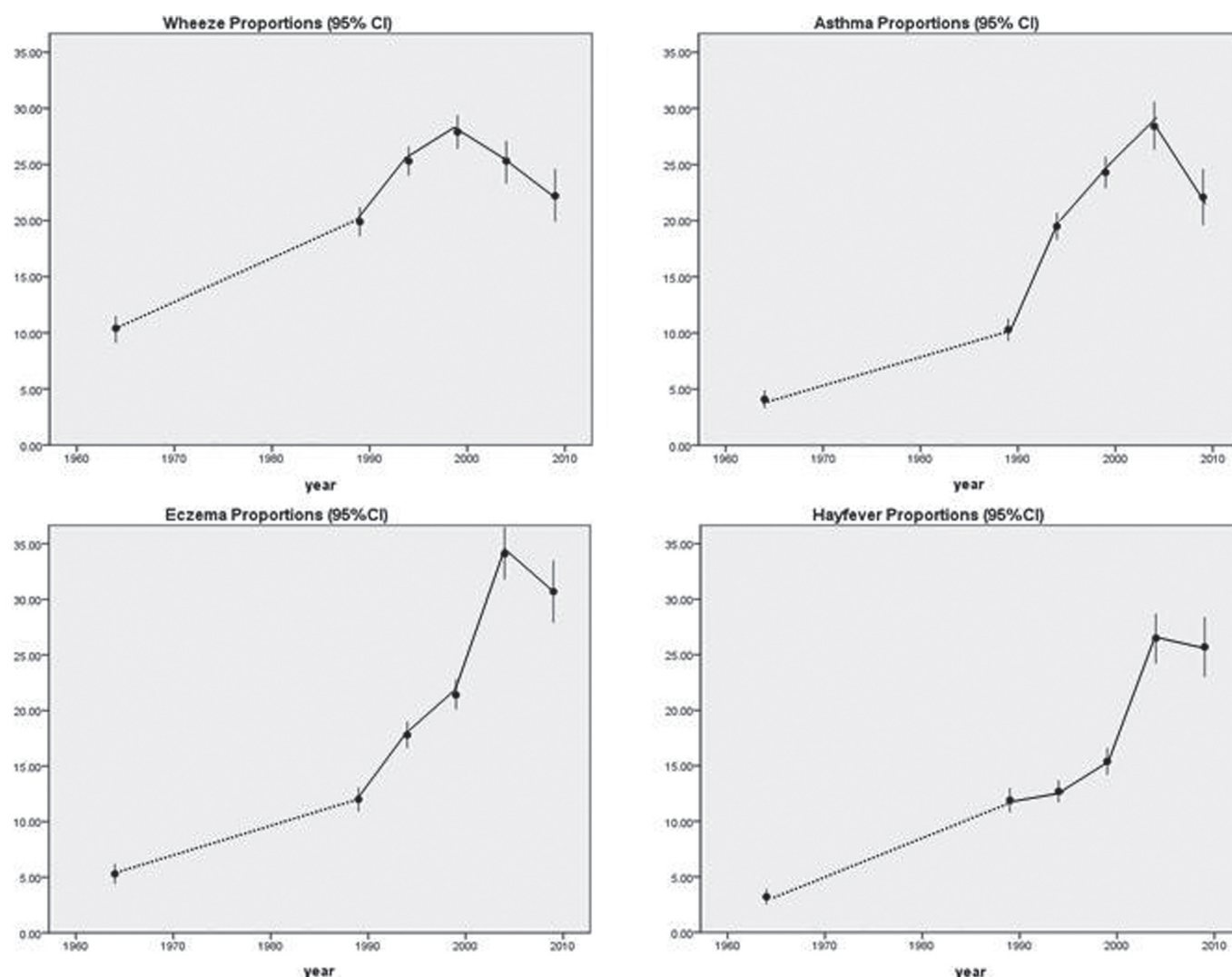


**Figure 1** Trends in wheeze in the last 3 years and lifetime prevalence of asthma, eczema and hay fever in 9–12 year olds between 1964 and 2009. Dots indicate mean prevalence (%) and bars indicate 95% confidence intervals.

30.7% (328/1070) and lifetime hay fever 25.3% (266/1050). The values for wheeze in the past 3 years, lifetime asthma, eczema and hay fever, for 7–9 year olds were similar to the older children (online supplement).

### ISAAC respiratory module questions

The ISAAC questions were completed by 1164 respondents aged 9–12 years in 2009. Wheeze in the previous 12 months was reported to be 18.7% in 2004<sup>5</sup> and 16.2% (189/1164) in 2009,  $p=0.056$ . For girls, wheeze in the previous 12 months was reported to be 20.0% in 2004 and 14.5% in 2009 ( $p=0.014$ ); for boys, the corresponding figures were 19.3% and 18.8% ( $p>0.05$ ). The remaining ISAAC questions showed no significant change over time.

### DISCUSSION

This is the first published survey of asthma prevalence in British children since the mid 2000s, a time when the asthma prevalence was falling in some countries but not in the UK. For the first time in the 45-year history of our survey we report a fall in lifetime asthma prevalence in children aged 9–12 years. There were different trends in boys and girls; the reduction

in asthma prevalence was more obvious in girls compared to boys, and there was evidence of falling wheeze in the past 1 and 3 years and also of reducing eczema prevalence in girls but not boys. Childhood asthma remains a very common condition in the UK, but after many years of increasing prevalence the number of affected children might finally be falling. These results should be interpreted with some caution since the response rate approached 50% and the findings should be confirmed elsewhere.

Comparison of asthma prevalences between populations is complicated by differences in the age groups studied and the questionnaires used. Although a standard methodology for surveys was introduced in 1998,<sup>16</sup> the Aberdeen Schools Asthma Survey began in 1964 and the original methodology has been preserved to allow direct comparison within 9–12 year olds in our population. The falling asthma prevalence reported here supports our hypothesis and is consistent with the fall in prevalence seen in 13–14 year olds in two areas of the UK surveyed in 1994 and 2002.<sup>8</sup> The fall in lifetime asthma prevalence is also consistent with our previous report of falling wheeze in the past 3 years between 1999 and 2004; wheeze in the past 3 years is likely to be a more sensitive index of recent change in asthma compared with lifetime asthma

**Table 2** Separate results for boys and girls for prevalences (%) with 95% CIs for history of wheeze in the past 3 years and lifetime prevalences of asthma, eczema and hay fever and wheeze for children aged 9–12 years attending all schools

|                                  | Boys                             |                                 |                                 | Girls                            |                                 |                                     |
|----------------------------------|----------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|-------------------------------------|
|                                  | 1999                             | 2004                            | 2009                            | 1999                             | 2004                            | 2009                                |
| Wheeze in past 3 years           | 29.5<br>(27.3 to 31.6)<br>n=1752 | 25.0<br>(22.1 to 27.8)<br>n=933 | 25.2<br>(21.7 to 28.8)<br>n=587 | 26.4<br>(24.3 to 28.5)<br>n=1788 | 25.5<br>(22.7 to 28.3)<br>n=977 | 19.4*<br>(16.2 to 22.6)<br>n=608    |
| Lifetime prevalence of asthma    | 26.0<br>(23.9 to 28.1)<br>n=1752 | 28.8<br>(25.7 to 31.9)<br>n=828 | 26.0<br>(22.2 to 29.8)<br>n=535 | 22.6<br>(20.6 to 24.6)<br>n=1788 | 28.1<br>(25.0 to 31.2)<br>n=852 | 18.3**<br>(15.1 to 21.6)<br>n=567   |
| Life time prevalence of eczema   | 21.3<br>(19.3 to 23.3)<br>n=1752 | 32.3<br>(28.9 to 35.8)<br>n=732 | 33.0<br>(28.8 to 37.1)<br>n=507 | 21.5<br>(19.5 to 23.4)<br>n=1788 | 35.8<br>(32.5 to 39.2)<br>n=807 | 28.3***<br>(24.6 to 32.1)<br>n=562  |
| Lifetime prevalence of hay fever | 16.5<br>(14.7 to 18.3)<br>n=1752 | 25.9<br>(22.6 to 29.1)<br>n=722 | 28.3<br>(24.3 to 32.3)<br>n=507 | 14.3<br>(12.6 to 15.9)<br>n=1788 | 26.9<br>(23.6 to 30.1)<br>n=754 | 23.1****<br>(19.5 to 26.7)<br>n=542 |

Imputed values are given for asthma, eczema and hay fever 2004 and 2009, sample sizes for these relate to the original from the actual survey. The test for changing prevalence of wheeze in the last 3 years and lifetime prevalences of asthma and eczema between 2004 and 2009 was significant for girls but not boys, \*p=0.021, \*\*p<0.001, \*\*\*p=0.002 and \*\*\*\*p=0.107.

prevalence. The most recent UK surveys of childhood asthma were completed in 7–12 year olds between 2002 and 2004<sup>5–7</sup> and all reported increasing prevalence; the present study suggests that this trend may be reversing over time. Our results are consistent with studies demonstrating falling asthma prevalence between 1989 and 2001 among 8–9 year olds in the Netherlands<sup>18</sup> and between 2000 and 2005 among Australian 4–6 year olds.<sup>19</sup> Despite differences in study designs, results from across the world indicate that childhood asthma remains a common problem but more evidence is accumulating to suggest that asthma prevalence may be falling in some countries, including the UK.

The reduction in asthma between 2004 and 2009 was greater for girls compared to boys and this might suggest that gender might be relevant to falling symptom prevalence. There was also evidence that lifetime eczema prevalence had fallen between 2004 and 2009 for girls but not for boys (table 2). Although prevalences of asthma and eczema are traditionally understood to differ between sexes with the burden of symptoms being greater for boys,<sup>20</sup> we have previously reported how the prevalence of asthma in boys was greater than for girls in 1989 but the sex difference has narrowed by 2004.<sup>21</sup> The present results suggest that although in the past girls have ‘caught up’ with boys in terms of asthma prevalence, it is predominantly girls who are responsible for the fall in asthma we report here.

This study was not designed to explain why asthma prevalence has decreased. The fall in asthma prevalence is likely in part to reflect a genuine fall in asthma and in part changes in diagnostic practice, for example, the revised 2003 British Thoracic Society/Scottish Intercollegiate Guidelines Network guidelines for asthma.<sup>22</sup> The 1997 BTS/SIGN guideline for managing asthma<sup>23</sup> still advocated the diagnosis of ‘infantile asthma’ and contained a relatively brief section on diagnosis in children. By contrast, the 2003 guideline did not mention ‘infantile asthma’ was much more detailed including a flow chart to guide the decision making process and clues to alternative diagnoses; the 2003 document might have caused clinicians to be more cautious in diagnosing childhood asthma. The pathogenesis for asthma is complex and known to involve factors present in early life. The ban on smoking in public places from 2006 might have contributed to a fall in asthma prevalence between 2004 and 2009 since there is evidence that children’s exposure to second-hand smoke has reduced

in some settings since the smoking ban was introduced in Scotland.<sup>24</sup> The 10% fall in lifetime asthma in girls between 2004 and 2009 was accompanied with a 7% fall in lifetime eczema and thus a fall in atopy may explain part of the reduction in asthma.

There are a number of factors which should be considered when interpreting these data. One strength of our study is the common methodology used over 45 years which provided the opportunity to compare present trends with those from 1964. A second strength is the relatively static population of Aberdeen. A further strength is the use of imputation which allows data to be considered in the 8–12% of individuals where the questionnaire was incomplete. A limitation is that the response rate for the 2009 survey was 53%, in keeping with another community-based study of children in NE Scotland.<sup>25</sup> The response rate in surveys up to 1999 exceeded 80%,<sup>13–15</sup> but with the introduction of Data Protection Act in 2000 we were not able to directly contact parents and this has had implications for recruitment which we are not able to address. Although the participation rate dropped from 84% in 1999 to 57% in 2004, the similar response rate in 2004 and 2009 should permit direct comparison between surveys, although we cannot be certain that reasons for non-participation were constant for both surveys. The 2004 results were comparable with other UK populations in 2002 suggesting that the 2004 results were valid (eg, the proportion with wheeze in the previous 12 months was 17.4% in Aberdeen<sup>5</sup> versus 20.9% elsewhere<sup>8</sup> and a 10% rise in asthma seen in Aberdeen, South Wales and London between 1990s and early 2000s<sup>5–7</sup>). A second limitation is that not all schools participated in each survey; some schools declined to take part whilst several schools had merged or closed and the demographics of the study population might have changed between surveys. To address this potential bias we have demonstrated that children attending the ‘common’ schools were similar to the wider study population with the single exception of a reduced prevalence of exposure to tobacco smoke at home; importantly, there were no differences in the burden of symptoms (online supplement between all children and those attending ‘common schools’).

In summary, we report, for the first time in the UK, a fall in prevalence lifetime asthma in children and we look forward with interest to the results of the 2014 Aberdeen Schools Asthma Survey.

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**Competing interests** ST had support from Allen and Hanbury's and Novartis for the submitted work (payment for printing of questionnaires).

**Ethics approval** This study was conducted with the approval of the University of Aberdeen College Review Board.

**Contributors** The study was designed by the authors, the analysis undertaken by Dr Aucott and data interpreted by all authors. The manuscript was first drafted by Drs Turner and Malik. All authors contributed to revisions of the original draft and have approved the version to be submitted. Dr Turner is the guarantor of this study.

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