

Original Article

Nasal allergies and hayfever among young adults in Melbourne, Australia

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ABSTRACT

Although there is wide variation in the prevalence of nasal allergies internationally, the extent to which this is due to variation in etiological factors is not known. The purpose of the present study was to define the relative importance of atopy and other risk factors for nasal allergies, including hayfever, among young adults in Melbourne. The subjects were participants in the second phase of the European Community Respiratory Health Survey; 876 adults between 20 and 45 years of age completed a detailed respiratory questionnaire, 745 had skin prick testing with common aeroallergens and 675 underwent methacholine challenge. Total and allergen-specific IgE levels were measured in 701 and 693 subjects by radioimmunoassay and RAST, respectively. Nasal allergies, including hayfever, were reported by 47.5% of randomly selected participants. Females, non-smokers, subjects with a family history of allergies, those with current asthma, a history of eczema and nasal symptoms induced by dust, pollen or food were significantly more likely to have nasal allergies. Oral antihistamines had been used by 45.7% of those reporting nasal allergies and 12.4% had received allergen immunotherapy. The risk of nasal allergies, including hayfever, was increased 6.1-fold by atopy, particularly by positive skin tests to outdoor allergens

such as Birch, Timothy grass, plantain, olive, *Cladosporium* and Rye grass pollen. Total serum IgE was significantly higher in subjects reporting nasal allergies than in those who did not report such allergies. There were significant trends in the prevalence of nasal allergies with increasing titers of specific IgE directed against all allergens tested. In conclusion, the significant independent risk factors for nasal allergies, including hayfever, in young adults were atopy, particularly sensitization to Timothy grass, house dust mites and plantain, current asthma, not smoking, a history of eczema and female gender. Future research needs to distinguish between hayfever and perennial allergic rhinitis, which was not possible in the present study.

Key words: atopy, bronchial hyperreactivity, hayfever, immunoglobulin E, nasal allergies, questionnaires, skin prick tests.

INTRODUCTION

Allergic rhinitis and hayfever are common and distressing disorders in many Western societies. Hayfever was reported by 10.3% of respondents in the Australian 1989–90 National Health Survey,¹ the second most common chronic condition after visual disorders. Furthermore, the prevalence of hayfever is increasing in Australia. In 1991–93, 41.3% of a cohort of Tasmanian adults reported hayfever, compared with 19.2% of their parents in 1968.² Although allergic rhinitis is not by itself life-threatening, the symptoms can have profound effects upon the quality of life³ and result in substantial loss of productivity and absenteeism from school and from work.

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The prevalence of allergic rhinitis is also high in the United Kingdom, where distinct patterns have been described in the population. A survey of adults registered with a London general practice found that the prevalence of rhinitis was at least 24%.⁴ Seasonal symptoms were reported by 3% of respondents, perennial symptoms were reported by 13% and 8% had perennial symptoms with seasonal exacerbations. Another survey of a Nottingham general practice found that 29% of adults claimed to have had hayfever within the preceding 2 years.⁵

Until now there has been little published information comparing the prevalence of allergic rhinitis or hayfever in adults between countries utilizing standardized epidemiological methods. This gap in our knowledge is being addressed by the European Community Respiratory Health Survey (ECRHS) in over 50 centers around the world.⁶ The first phase of the ECRHS⁷ has now confirmed that nasal allergies are more common in Australia (40.9%), New Zealand (35.1–37.8%), US (39.4%), France (28.1–30.3%), Britain (23.6–28.3%) and Scandinavia (19.5–22.3%) than in East Germany (13.4%) or Spain (12.1–17.6%). The ECRHS is also investigating risk factors that may explain the international variation in the prevalence of rhinitis or hayfever.

Previously reported risk factors for allergic rhinitis and hayfever include Asian ethnicity,⁸ family history of allergies,^{9,10} season of birth, pollen exposure¹¹ and atopy to aeroallergens. Recognized trigger factors include dust, pollen, animals, food, viral infections, odors and emotional stress. There are also associations between rhinitis and eczema, asthma⁴ or bronchial hyperreactivity (BHR) to methacholine.¹² The aim of the present study was to define the most important risk factors for nasal allergies and hayfever among young adults in Melbourne, Australia. This study was conducted as part of the ECRHS and used objective measurements of atopy and BHR.

METHODS

Subjects

The subjects were participants in the second phase of the ECRHS in Melbourne. The full details of the sampling protocol have been described elsewhere;^{6,13} briefly, 4500 adults between 20 and 44 years of age were randomly selected from the electoral roll. Postal questionnaires were returned by 3200 (72%) subjects in the first phase of the ECRHS. A random sample of 553 young adults and a sample of 204 with symptoms of asthma attended the laboratory for testing. The study was approved by the Ethics Review Committee of the Alfred Hospital.

Questionnaire

Participants completed the detailed second phase ECRHS questionnaire administered by one of three trained interviewers. The background and validity of this questionnaire have been described elsewhere.⁶ Briefly, the questionnaire covered history of allergies, family history, home environment, pets, nasal symptoms, trigger factors, smoking, demographic information, medications and management. The questionnaire was completed by 757 participants in the laboratory and a further 119 participants by telephone interview.

Lung function testing

Lung function was measured with a computerized Fleisch number 3 pneumotach connected to a Hewlett Packard (Waltham, MA, USA) lung function analyzer. Initial FEV₁ was recorded as the best of five blows that met American Thoracic Society criteria. Methacholine (Provocholine™; Hoffman La Roche, Basel, Switzerland) was delivered by a Mefar 3B dosimeter (Mefar srl, Bovezzi, Italy) until FEV₁ fell by 20% from the initial value or up to a cumulative dose of 2 mg (10 µmol). The challenge protocol has been described in detail elsewhere.^{6,14} Methacholine challenge tests were completed by 675 subjects (89% of those who attended the laboratory).

Skin prick testing

Skin prick testing for allergies was performed on the volar surface of the forearm, using Phazets™ (Kabi-Pharmacia, Uppsala, Sweden), which are lancets precoated with a standard amount of allergen. The ECRHS allergen panel of *Dermatophagoides pteronyssinus*, cat, Timothy grass, birch, olive, *Parietaria*, ragweed, *Cladosporium* and *Alternaria* was used, together with positive (histamine) and negative (uncoated lancet) controls. In addition, standard extracts of the local allergens rye grass pollen and plantain (Hollister-Stier, Spokane, WA, USA) were used with conventional lancets. Wheals were measured after 15 min. A maximum diameter of 3 mm or greater was considered positive. Valid skin prick tests were performed on 745 subjects (98% of those who attended the laboratory).

In vitro allergy tests

Serum was obtained from 701 subjects (93% of those who attended the laboratory). Total serum IgE was measured by radioimmunoassay using the standard CAP

system (Kabi-Pharmacia). Allergen-specific IgE was measured in 693 specimens by radioallergosorbent tests (RAST). The immunoCAP used were Timothy grass, rye grass, *D. pteronyssinus*, ragweed, plantain, *Cladosporium*, *Alternaria* and cat. Results are expressed as RAST classes 0–6, with cutpoints of 0.35, 0.7, 3.5, 17.5, 50 and 100 kU_A/L.

Definitions

The principal outcome of interest was a positive response to the question 'do you have any nasal allergies including "hayfever"'. Bronchial hyperreactivity was defined as a provocative dose causing a 20% reduction (PD₂₀) in the forced expiratory volume in one second (FEV₁) < 2 mg methacholine. Atopy was defined as a positive reaction to any allergen, in the context of a positive histamine control and a negative reaction to the uncoated lancet. Current asthma was defined as the combination of wheezing in the past 12 months and BHR.¹⁵

Statistical analysis

Data from the questionnaires, lung function tests and skin prick tests were professionally entered and verified. Range and logic checks were performed to confirm the validity of the data. All analyses were conducted using the SAS computing package.¹⁶ Because total serum IgE levels followed a skewed distribution, the data were log transformed prior to further analysis. Association between categorical variables was assessed by the χ^2 test or Fisher's exact test and comparisons of continuous variables were made by the Student's *t*-test. Confidence intervals (CI) for proportions were estimated by the normal approximation to the binomial distribution. Cohen's κ was used to assess agreement beyond that expected by chance and McNemar's χ^2 was used to assess differences in the prevalence of positive results from paired tests. Odds ratios and 95% CI were calculated by the Mantel-Haenszel method.¹⁷ A multivariate model of nasal allergies was fitted with stepwise multiple logistic regression. A *P* value < 0.05 was considered statistically significant.

RESULTS

Description of subjects

The 876 subjects who completed the questionnaire in the second phase of the ECRHS had a mean age of 34.2

years. There was a slight female preponderance (52.9% female, 47.1% male). Nasal allergies, including hayfever, were reported by 467 (53.3%) of all respondents and 317 (47.5%) of the random sample. Most of those reporting nasal allergies probably did have hayfever; 376 (42.9%) reported pollen-induced symptoms (i.e. a runny or stuffy nose or sneezing when near trees, grass, flowers or pollen, especially in the spring). Bronchial hyperreactivity was demonstrated by 240 (35.6%) of the 675 subjects who completed the methacholine challenge test. The definition of current asthma was satisfied by 172 subjects, 25.5% of those who were challenged.

Atopy

Atopy was present in 420 (56.4%) of the 745 subjects who underwent skin prick testing. The proportions (and 95% CI) who reacted to specific allergens on skin test are summarized in Table 1. Geometric mean ($\pm$ geometric SD) total IgE was 48.9 $\pm$ 7.5 kU/L and 80% of non-atopic subjects had levels below 142 kU/L. The proportion of subjects with detectable allergen specific IgE by RAST is also summarized in Table 1. There were significant (*P* < 0.0001) relationships between total IgE levels and RAST class for all allergens tested. Agreement between the results of skin prick tests to most allergens and each corresponding RAST was generally good (Table 1), although skin prick tests were significantly more sensitive. For ragweed, there was no agreement beyond chance and, surprisingly, RAST was more sensitive than the skin prick test (McNemar χ^2 = 52.3; *P* < 0.0001).

Table 1. Evidence of allergen-specific IgE on skin tests (*n* = 745) and RAST (*n* = 693) and agreement between the two methods

Allergen	% Skin test positive (95% CI)	% RAST positive (95% CI)	κ
<i>D. pteronyssinus</i>	41.2 (37.7–44.7)	39.4 (35.8–43.0)	0.83
Rye grass	40.8 (37.2–44.3)	35.8 (32.2–39.4)	0.78
Timothy grass	30.5 (27.2–33.8)	33.3 (29.8–36.8)	0.78
Plantain	24.2 (21.1–27.3)	14.7 (12.1–17.4)	0.50
Cat	14.6 (12.1–17.2)	12.0 (9.6–14.4)	0.63
<i>Alternaria</i>	10.6 (8.4–12.8)	10.3 (8.0–12.5)	0.76
Birch	6.2 (4.5–7.9)	NT	
Olive	3.2 (2.0–4.5)	NT	
<i>Cladosporium</i>	2.1 (1.1–3.2)	3.3 (2.0–4.7)	0.45
<i>Parietaria</i>	0.7 (0.1–1.3)	NT	
Ragweed	0.3 (0–0.6)	8.5 (6.4–10.6)	0.0

NT, not tested; CI, confidence interval.

Medications and management

Oral antihistamines had been used in the preceding 12 months by 45.7% of subjects reporting nasal allergies, including hayfever. This was significantly more than the 14.6% use among subjects not reporting such allergies ($\chi^2 = 41.2$; $P < 0.0005$). Allergen immunotherapy ('vaccination for allergy') had been attempted at some time by 12.4% of subjects reporting nasal allergies compared with 1.5% of those not reporting such allergies ($\chi^2 = 38.6$; $P < 0.0005$).

Risk factors for nasal allergies, including hayfever

Subjects who reported nasal allergies, including hayfever, are compared with those who did not report such allergies in Table 2. Females, non-smokers and those with a family history of allergies, current asthma (see earlier), a history of eczema and nasal symptoms induced by dust, pollen or food were significantly more likely to have nasal allergies. Age, country of birth, parental smoking during childhood, keeping cats, dogs or birds, household mold, fuels used for heating, hot water and cooking were not related to nasal allergies. Although pets kept during childhood were generally unrelated, hamsters had been kept by 0.6% of those who reported nasal allergies, compared with 2.4% of those who did not report nasal allergies (Fisher's exact test $P = 0.046$).

Not surprisingly, atopy was a strong risk factor for nasal allergies, including hayfever. Subjects with any positive skin test were 6.1-fold (95% CI 4.5–8.3) more likely to report nasal allergies. The greatest risks were associated with skin reactivity to birch, Timothy grass, plantain, olive, *Cladosporium* or rye grass pollen in that order. The risks associated with skin reactivity to indoor allergens, such as cat, *D. pteronyssinus* and *Alternaria*, were less, but were still significantly elevated (Fig. 1). Although subjects with

Table 2. Comparison of demographic characteristics, smoking, family history, asthma, eczema and nasal symptoms between young adults reporting and those not reporting nasal allergies, including hayfever ($n=876$)

	Nasal allergies	No nasal allergies	<i>P</i>
Female	56.1%	49.1%	0.04
Current smoker	21.4%	29.3%	0.007
Paternal allergy	33.4%	19.6%	<0.0005
Maternal allergy	44.2%	28.7%	<0.0005
Sibling allergy	46.3%	34.7%	0.001
Current asthma	38.5%	11.2%	<0.0005
BHR ($n=675$)	49.3%	20.5%	<0.0005
Eczema	52.7%	39.1%	<0.0005
Dust symptoms	73.2%	30.3%	<0.0005
Pollen symptoms	80.5%	19.1%	<0.0005
Food symptoms	18.9%	2.1%	<0.0005

BHR, bronchial hyperreactivity.

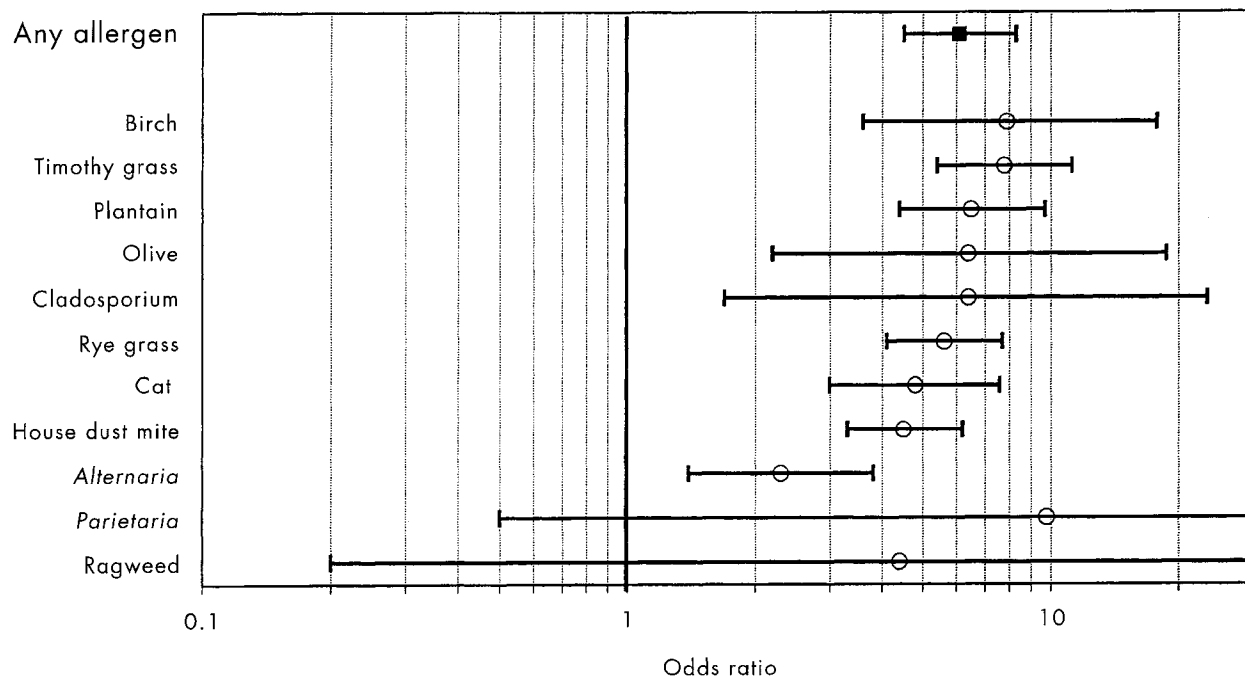


Fig. 1 Risk (bivariate odds ratios and 95% confidence intervals) of nasal allergies, including hayfever, in relation to positive skin prick tests to specific allergens ($n=745$).

Table 3 Significant independent predictors of nasal allergies, including hayfever, in young adults by multiple logistic regression ($n=707$)

Predictor	OR	95% CI	P
Timothy grass skin test-positive	3.4	2.1–5.7	<0.0001
Current asthma	3.1	2.0–5.0	<0.0001
House dust mite skin test-positive	2.1	1.4–3.1	0.0001
Plantain skin test-positive	2.1	1.2–3.7	0.0001
Current smoking	0.53	0.36–0.80	0.002
Eczema or skin allergies	1.5	1.1–2.1	0.023
Female gender	1.5	1.04–2.1	0.03

OR, odds ratio; CI, confidence interval.

positive skin tests to *Parietaria* or ragweed were more likely to report nasal allergies, their numbers were small and the risks did not reach statistical significance.

Total serum IgE was significantly higher among subjects reporting nasal allergies, including hayfever, than among those who did not report such allergies (geometric mean 86.7 vs 25.3 kU/L; $P < 0.0001$). There were similar findings for allergen-specific IgE, although there were a few qualitative differences between RAST and skin tests. There were significant monotonic relationships between the prevalence of nasal allergies and the level of allergen-specific IgE as reflected by RAST class for all allergens tested (data not shown). This was true even for ragweed and *Cladosporium*. However, there was a decline in nasal allergy prevalence among subjects with a moderately positive *Cladosporium* RAST, probably an artefact of small numbers.

A multivariate model of nasal allergies including hayfever is summarized in Table 3. The sample size for the multiple logistic regression was reduced because of missing data, particularly for current asthma. The results of skin tests were used to indicate allergen-specific IgE rather than RAST, because of their greater sensitivity. The significant independent predictors were positive skin tests to Timothy grass pollen, house dust mite and plantain, current asthma, a history of eczema or skin allergies and female gender. Current smoking was associated with a lower risk of nasal allergies. Age, family history, early respiratory infection, the results of skin tests with other aeroallergen extracts and total serum IgE did not enter the model.

DISCUSSION

This study has confirmed the extremely high prevalence of nasal allergies among young adults in Melbourne. Indeed, the proportion of all subjects who reported symptoms consistent with hayfever (40.4%) is very close

to that previously found in the Tasmanian cohort study.² In contrast, hayfever was less commonly reported by respondents in the Australian National Health Survey,¹ which used a more representative sampling strategy, including older subjects and those resident outside capital cities.

The addition to our sample of subjects with symptoms of asthma inflated the estimated prevalence of nasal allergies from 47.5 to 53.3%. We have previously found some evidence of non-response bias in that randomly selected subjects who returned the postal survey promptly were more likely to report wheeze, asthma or nasal allergies than those who only responded after repeat mailings or telephone follow-up.¹⁸ The overall prevalence of nasal allergies, including hayfever, among all 3200 respondents to the postal survey was 41.0%,¹³ suggesting that those with nasal allergies were over-represented to some extent in the present study.

Notwithstanding these biases, the prevalence of allergic rhinitis still appears to be higher in Australia than in many other countries. Allergic rhinitis was reported by only 4.5% of adults in Singapore,¹⁹ 2.1% of secondary students in China, 11.2% of secondary students in Malaysia and 15.7% of secondary students in Hong Kong,²⁰ 14.2% of adults in Switzerland²¹ and 16.4% of adults in Colombia.²² The Dutch component of the ECRHS found that 29.5% of adults between 20 and 70 years of age reported nasal symptoms.²³ While it is tempting to speculate that these differences are related to climate, local pollens, indoor allergens, lifestyle or economic development, the findings could be seriously confounded by different definitions and methodology. A more complete explanation awaits the final international analysis of the full ECRHS data set.

The greater sensitivity of skin tests compared with RAST (even using the Pharmacia CAP system) to detect low titers of allergen-specific IgE has been previously observed.²⁴ However, we found the opposite in relation to ragweed-specific IgE, which was much more readily detected *in vitro* than by skin test. Unlike North America, ragweed is not a major allergen in Melbourne. The ragweed Phazets™ had to be specifically imported for this study, but it is unlikely that they had lost biological potency by the time of testing. The most likely explanation for this discrepancy lies in some antigenic difference between the batch of ragweed allergen in the immunoCAP and that used to coat the ragweed Phazet™. The Dutch ECRHS group have recently suggested that skin tests and RAST may provide complementary information in diagnosing allergic rhinitis.²³

Our study confirms that oral antihistamines are widely used in Australia for the control of nasal symptoms. In the National Health Survey, 83.3% of persons who reported hayfever took medication for allergy, 65% of which was fully prescribed.¹ In contrast, 54% of hayfever sufferers in Nottingham, UK, used over-the-counter treatments and one-third said that they felt drowsy after using them.⁵ The newer non-sedating antihistamines, such as terfenadine, astemizole and loratidine, are now available over the counter without prescription in Australia. It is interesting that 14.6% of our subjects without nasal allergies reported using antihistamines, presumably for other conditions, such as eczema, insect allergy, motion sickness and urticaria.

Allergen immunotherapy is used for the prophylaxis of seasonal allergic rhinitis. The benefit of controlling nasal symptoms and reducing medication must be weighed against the small risk of life-threatening anaphylactic reactions to aqueous allergen extracts. The depot allergen preparations generally used in Australia have not been associated with anaphylaxis. The retrospective nature of our data does not really permit any valid assessment of the efficacy or safety of immunotherapy for allergic rhinitis. Immunotherapy was also reported by a few subjects without allergic rhinitis who had been treated for other conditions, such as asthma or eczema.

Some of the risk factors for allergic rhinitis identified in this analysis were already recognized. Although some previous studies have not found any difference in hayfever prevalence between males and females,^{21,25} the Dutch ECRHS group has also found that nasal symptoms are more common in women.²³ The familial nature of the condition and the strong associations with other allergic disorders, such as eczema and asthma, are well known.^{4,9,10} Exposure to allergens from animals, feathers or dust, trees, grass, plants, flowers or pollen and eating particular foods were confirmed as common trigger factors for nasal symptoms in Australia. The relationship between these environmental triggers and nasal symptoms persisted after controlling for asthma. In fact, nasal symptoms related to food were largely confined to those subjects without asthma.

There were a couple of surprising findings in the present study. Although also found by the Dutch investigators,²³ it is unlikely that smoking actually reduces the risk of nasal allergies. It is more probable that subjects with nasal allergies are unable to tolerate the odor of tobacco smoke. Indeed, Sibbald and Rink⁴ found that subjects with seasonal rhinitis were less likely to have

a smoker in the household. While people who keep hamsters are unlikely to be significantly protected from the development of nasal allergies, it is possible that families with allergic children may be less likely to have furry pets. However, other studies have not found any consistent relationship between keeping pets and allergic rhinitis.¹⁹

Atopy is clearly an important factor in the development of nasal allergies, including hayfever, in young adults. As previously found,^{4,11,25} the association is strongest with sensitization to outdoor allergens, such as pollens, and less, although still significant for indoor allergens. We found dose-response relationships between the titers of allergen-specific IgE and the prevalence of nasal allergies, which is some evidence of causality. However, the postulated temporal sequence of allergen exposure, atopic sensitization and clinical disease cannot really be established by a single cross-sectional study.

One potential weakness of the present study was the wording of the key question, which made it very difficult to distinguish between seasonal and perennial allergic rhinitis. This is reflected in the final multivariate model, where sensitization to Timothy grass, plantain and house dust mites were all significant independent predictors. The failure of sensitization to other allergens to enter the model presumably represents allergenic cross-reactivity, as the risk estimates for positive skin tests to birch, olive, *Cladosporium* and rye grass were of similar magnitude. Although strongly associated with nasal allergies, including hayfever, in bivariate analyses, a family history of allergies was no longer a significant predictor after allowing for the effects of atopy, asthma and eczema.

Further research into the environmental causes of allergic rhinitis will require cohort studies with prospective measurement of allergen exposure. There is a pressing need for generally accepted epidemiological definitions of hayfever and perennial allergic rhinitis. Future self-report symptom questionnaires should be validated against objective markers of nasal inflammation. Unfortunately, the sensitivity and specificity of the available markers, such as non-specific nasal challenge and nasal lavage, remain to be established in the general population. In addition, the key outcome of quality of life should be assessed with validated disease-specific questionnaires.³ Only then will it be possible to develop and evaluate effective public health strategies to reverse the rising prevalence and morbidity of allergic rhinitis in Australia and in many other Western societies.

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