The burden of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in children and adolescents in six New Zealand centres: ISAAC Phase One

MI Asher, *Associate Professor, Division of Paediatrics, University of Auckland;* D Barry, *Paediatrician, Memorial Hospital, Hastings;* T Clayton, *Data Manager, Division of Paediatrics, University of Auckland;* J Crane, *Associate Professor, Department of Medicine, Wellington School of Medicine;* W D'Souza, *Research Fellow, Department of Medicine, Wellington School of Medicine;* P Ellwood, *Research Manager, Division of Paediatrics, University of Auckland;* RPK Ford, *Clinical Associate Professor, Community Paediatrics, Christchurch;* R Mackay, *Paediatrician, Nelson Hospital, Nelson;* EA Mitchell, *Associate Professor, Division of Paediatrics, University of Auckland;* C Moyes, *Paediatrician, Whakatane Hospital, Whakatane;* P Pattemore, *Senior Lecturer, Department of Paediatrics, Christchurch School of Medicine;* N Pearce, *Professor, Centre for Public Health Research, Massey University Wellington Campus, Wellington;* AW Stewart, *Senior Research Fellow, Division of Community Health, University of Auckland.*

Abstract

Aim. To describe the burden of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in children in six New Zealand centres.

Methods. The International Study of Asthma and Allergies in Childhood (ISAAC) Phase One was undertaken in Auckland, Bay of Plenty, Hawke's Bay, Wellington, Nelson and Christchurch during 1992-1993. In each centre, approximately 3000 six to seven year old children and 3000 thirteen to fourteen year old adolescents were studied, a total of 37 592 participants. Both age groups answered written questionnaires and the adolescents a video questionnaire about asthma symptoms.

Results. The prevalences of symptoms were high, for asthma 25% and 30%, allergic rhinoconjunctivitis 10% and 19%, and atopic eczema 15% and 13% in each age group respectively. More than 40% of participants had symptoms in the last year of at least one condition, most commonly asthma. There were no significant differences among regions, except for six to seven year olds in Nelson who had significantly lower prevalences of some symptoms of asthma and allergic rhinoconjunctivitis.

Conclusions. Asthma and allergies are common in New Zealand, with resultant morbidity and cost. However, there is little regional variation with the exception of lower rates in Nelson children. Explanations for these findings will be the subject of further studies.

NZ Med J 2001; 114: 114-20

The International Study of Asthma and Allergies in Childhood (ISAAC) found that the prevalences of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in New Zealand and other English-speaking countries are among the highest in the world.[1-4] The extent of these diseases and regional variations within New Zealand are examined in this paper.

Many New Zealanders believe there are 'good' and 'bad' places for asthma, and during the 1980s regional differences in asthma mortality and hospital admissions were studied. The National Asthma Mortality Study 1981-83, which prospectively examined deaths from asthma, identified regional variations between health districts.[5] Geographic analysis of hospital admissions for asthma 1982-84 found that Nelson had the lowest hospital admission rate and second lowest asthma mortality rate in New Zealand 1982-84.[6] Possible reasons for these variations include asthma prevalence, asthma severity, environmental factors and management practices.

However, the prevalence of asthma symptoms and bronchial hyperresponsiveness in childhood has shown little regional variation in previous studies,[7-11] but it has been difficult to be confident of comparisons among these studies because of differences in methodology. A study among adults in four centres, using identical methodology, found only small regional differences, with Wellington and Christchurch reporting slightly more symptoms and asthma treatment than Auckland and Hawke's Bay.[12] More recently, a similar study of adults in all regions of New Zealand found significant urban/rural differences, as well as marked differences between various rural areas.[13]

ISAAC was developed to measure the prevalence of asthma, allergic rhinoconjunctivitis and atopic eczema symptoms in different populations throughout the world using standardised methodology in two age groups.[14] ISAAC Phase One studied over 700 000 children. The younger age group (N = 257 800) was studied in 91 centres from 38 countries and the older age group (N = 463 801) in 155 centres from 56 countries.[3] In New Zealand, the ISAAC Phase One study was undertaken in six centres among six to seven year old ('children') and thirteen to fourteen year olds ('adolescents') and the results are reported in this paper.

Methods

ISAAC Phase One was undertaken in six centres in New Zealand. Auckland, Wellington and Christchurch were studied from October 1992 to August 1993, and Hawke's Bay, Bay of Plenty, and Nelson were studied from May to August 1993. The Auckland centre is the geographical area known as the Auckland District of the Ministry of Education. The Bay of Plenty centre is made up of the Rotorua, Whakatane, Kawerau and Opotiki territorial local authorities. The Hawke's Bay centre is made up of the Hastings and Napier territorial local authorities. The Wellington Centre comprises Wellington, Lower Hutt and Porirua Cities. The Nelson centre is made up of Nelson City and Tasman territorial local authority. The Christchurch centre is Christchurch City. The study was approved by the relevant Ethics Committee in each centre.

Sample and Subjects. Within the three large cities, schools with pupils in the relevant age groups were randomly sampled to obtain at least 3000 pupils per age group per centre. In Bay of Plenty, Hawke's Bay and Nelson all schools were enrolled. A letter and relevant documentation were sent to the Board of Trustees and school principals requesting permission to conduct the survey. The pupils of the appropriate age group were identified from the school roll and parents sent an information letter about the study. The parents of the adolescents were asked to contact the research team if they did not want their child to participate. If any eligible pupils were absent, the research team returned on another day to include them if possible. For the children, the questionnaire was issued through the class teacher, sent home, and if not returned within one week was sent home again on up to two more

occasions within one month. Some centres issued a stamped self addressed envelope to facilitate return of the questionnaire, and a book sticker was issued to the children to encourage return of the questionnaire. The field research work in schools was done by one trained local person in Auckland, Bay of Plenty and Chirstchurch, two people in Hawke's Bay, four in Wellington and eight in Nelson.

Questionnaire. Three one page core written questionnaires on asthma, rhinitis and eczema symptoms were used for both age groups, and an asthma symptoms video questionnaire was used for the adolescents.[14] The adolescents self completed the written questionnaire and the video questionnaire[15,16] at school. The key question used for assessing asthma symptom prevalence for both age groups ('current wheeze') was: "Have you (has your child) had wheezing or whistling in the chest in the last 12 months?". The severity of asthma symptoms was assessed by three questions that asked about the following symptoms in the last twelve months: number of attacks of wheezing; sleep disturbed due to wheezing; and wheezing severe enough to limit speech to only one or two words at a time between breaths. The video questionnaire showed five scenes of young people with asthma symptoms; wheezing at rest, wheezing with exercise, waking with wheeze, waking with cough, and a severe attack of asthma. The rhinitis questionnaire asked six questions, and 'allergic rhinoconjunctivitis' was defined by positive answers to two questions: "In the past twelve months have you (has your child) had a problem with sneezing or a runny or blocked nose when you (your child) DID NOT have a cold or the flu?". If yes, "In the past twelve months has this nose problem been accompanied by itchy watery eyes?". The six eczema questions included three from which the prevalence of atopic eczema was assessed: "Have you (has your child) ever had an itchy skin rash which was coming and going for at least six months?". If yes: "Have you (has your child) ever had this itchy rash at any time in the last twelve months"?. If yes: "Has this itchy rash at any time affected any of the following places: the folds of the neck, elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?". Additional questions were used to describe the participant's sex and ethnic identity, by self or parental-reporting (European/Pakeha, New Zealand Maori, Pacific Island and Others specified).

Data entry and analysis. Data were entered twice to reduce errors, which were found to be less than 0.1%. Any inconsistencies were checked against the questionnaire. Corrections were not made to the responses to the symptom questionnaires, but obvious inaccuracies in date of completion of the questionnaire were corrected and inconsistencies in dates of birth and age were checked against data from the school and corrections made. A cluster sampling method of analysis was used which randomly sampled schools. The unit of sampling (schools) is therefore not the same as the unit of analysis (pupils). Tests of significance and confidence intervals were calculated with sample sizes appropriately adjusted for cluster sampling, using a correction designed by Rao and Scott,[17] prior to analysis.

For each question, all respondents were separated into those with a positive response and those with either a negative or missing response. The prevalence of symptoms was compared, adjusted for gender, age and ethnicity using logistic regression. As these analyses showed overall significant prevalence differences between centres in children, and because these differences were primarily due to the low prevalences in Nelson, additional analyses were carried out comparing Nelson with the other five centres. Data were analysed using chi squared analysis, to determine whether more regional variation was present than would be expected by chance and confidence intervals were calculated. Due to the multiple analyses undertaken, a stringent significance level of $p = 0.01$ or less was adopted prior to analysis.

There were seasonal differences in responses to questions on rhinitis symptoms in the previous twelve months, suggesting a recall bias relating to recency of symptoms,[18] but this was not found for asthma or atopic eczema. Since all centres collected data between May and August, but only the three urban centres collected data outside that period, the analysis for the allergic rhinits questionnaire comparisons were made only for data collected between May and August. This excludes data from about two-thirds of children and adolescents from Auckland, Wellington and Christchurch, with only 3613 included in the analysis of the allergic rhinitis questionnaire.

Results

The participation rate of schools was high, but varied between centres (children 96-100%, adolescents 73-100%).[1] The sample chosen comprised 40 902 pupils, 20 356 children and 20 546 adolescents. Complete data were available on 18 569 children, a response rate of 91% (49.4% girls) and on 19 023 adolescents (53.3% girls), a response rate of 93%. The participants are described in Table 1.

The results from parents of children who returned the questionnaire at the first issue (94.1%) were compared with those who returned the questionnaire after the second or third issue (5.8%). Using six criteria (current wheeze, asthma ever, current nose symptoms, hay fever ever, current itchy skin rash, and eczema ever), there were no differences in prevalence for those responding on early rather than late returns.

The main reason for schools refusing participation was the pressure of curriculum. Among secondary schools in Auckland, two schools which had already seen the video questionnaire were excluded prior to enrolment. Common reasons for pupil non-participation were absence from school during study period (both age groups) and failure to return the questionnaire (children only). Active refusal in both age groups was rare. In the older age group, a minority cited religious reasons for not participating, and in some of these cases the written questionnaire was completed, but not the video. Information on the ethnicity and sex of non-participant children was obtained from school records. A similar proportion of boys and girls were non-participants. The proportion of non-participants was greater among Maori (18.0%, 11.1%) and Pacific Island (19.2%, 6.0%) than European (6.9%, 6.1%), children and adolescents respectively.

Prevalences for symptoms in all centres were similar, except that Nelson children generally had lower prevalences (Table 2A and Table 2B). The relationship between current wheeze and other symptoms is shown in Table 3.

Asthma symptoms. Children. The prevalence of 'wheeze in the last 12 months' was high, with parents of 24.5% children reporting this symptom (Table 2A). 'Asthma ever' was reported by 26.5% of the total sample. However, only 71.8% of those with current wheeze also reported 'asthma ever' (Table 3). There were significant regional differences seen for responses to most questions. Nelson had a significantly lower prevalence compared to the other five centres combined, at least 20% below the average for all centres for most variables. Among children with current wheeze, 'asthma ever' was reported slightly less often in Nelson than other centres (66 vs. 72.3%). The proportion of children with 'asthma ever' who had other symptoms ranged from 71.8 - 89.0% (Table 4).

For severe wheezing 9% of all parents of children reported, in the last twelve months, four or more attacks of wheezing, 3.5% reported sleep disturbance due to wheezing at least one night per week and 5.1% reported wheeze severe enough to limit speech to only one or two words at a time between breaths. Of children with current wheeze, about one third had >4 attacks in the last twelve months, about one in seven had sleep disturbed one or more times a week, and wheeze limited speech in about one in five (Table 3).

Adolescents. The prevalence of wheeze in the last twelve months was high, with about one in three adolescents (30.2%) reporting this symptom (Table 2B). Asthma ever was reported by 24.4% of the total sample. However, only 54.3% of those with current wheeze also reported 'asthma ever' (Table 3). The only significant regional differences seen for the written questions were responses to questions about dry cough at night, sleep disturbed by wheezing one or more nights a week, and 'asthma ever', with Nelson showing a significantly lower prevalence for 'asthma ever'. Among adolescents with current wheeze, 'asthma ever' was reported slightly less often in Nelson than other centres (46.4 vs. 55.2%). The proportion of adolescents with exercise wheeze who also reported 'asthma ever' was only 44.7%, but the proportion with other symptoms and 'asthma ever' ranged from 54.3 - 75.0% (Table 4).

Table 1. Study sample by region.

Centre	Total Schools	Schools Sampled (%)	6-7 Year Age Group (Children) Children Sampled	Participants (%)	Ethnicity (% of Participants) European*	Maori	Pacific Island
Auckland	369	47 (13)	3908	3526 (90)	63.5	16.7	19.8
Bay of Plenty	45	45 (100)	3090	2681 (87)	52.5	45.7	1.8
Hawke's Bay	75	72 (96)	3612	3338 (92)	71.9	26.3	1.8
Wellington	144	83 (58)	4163	3838 (92)	71.7	16.3	12.0
Nelson	58	58 (100)	1917	1868 (97)	92.6	6.6	0.9
Christchurch	119	62 (52)	3666	3318 (91)	86.9	9.2	3.9
Total	810	367 (45)	20 356	18 569 (91)	72.2	20.2	7.6
Centre	Total Schools	Schools Sampled (%)	13-14 Year Age Group (Adolescents) Children Sampled	Participants (%)	Ethnicity (% of Participants) European*	Maori	Pacific Island
Auckland	75	13 (17)	3388	3206 (95)	65.8	14.7	19.5
Bay of Plenty	12	12 (100)	3178	2813 (89)	50.4	47.7	1.9
Hawke's Bay	49	36 (73)	3672	3550 (97)	69.9	28.0	2.1
Wellington	34	23 (68)	4975	4424 (89)	72.0	15.9	12.1
Nelson	21	21 (100)	1990	1839 (92)	90.5	8.0	1.4
Christchurch	23	14 (61)	3343	3191 (95)	88.4	8.7	2.9
Total	214	119 (56)	20 546	19 023 (93)	71.9	20.7	7.4

*European includes participants identified as 'other' and participants with unknown ethnic origin.

Table 2A. Prevalence (%) of symptoms reported by parents of children.

	Auckland	Bay of Plenty	Hawke's Bay	Wellington	Nelson	Christchurch	Total	P values All centres	P values Nelson vs. other centres
Asthma									
Asthma symptoms in last 12 months									
Wheezing	22.5	24.0	27.0	25.1	18.7	27.2	24.5	<0.001	<0.001
Wheezing with exercise	14.8	15.9	17.7	16.9	13.2	19.2	16.5	<0.001	<0.001
Dry cough at night	27.5	28.9	30.7	31.1	21.1	32.2	29.2	<0.001	<0.001
Wheezing severely in last 12 months									
Four or more attacks of wheeze	7.9	8.2	9.9	9.8	7.1	10.2	9.0	<0.001	0.003
Sleep disturbed by wheeze one or more nights per week	3.7	3.6	3.7	3.3	2.2	3.9	3.5	0.049	0.127
Wheeze limiting speech	5.3	4.8	5.6	4.7	4.6	5.0	5.1	0.278	0.845
Asthma ever	23.8	25.7	28.3	30.8	17.6	28.4	26.5	<0.001	<0.001
Allergic rhinitis									
Allergic rhinoconjunctivitis	9.8	8.7	9.4	10.4	7.5	11.2	9.7	<0.001	0.002
Activities disturbed a lot by nose symptoms in last twelve months	1.8	1.3	0.8	1.2	0.5	0.6	1.1	0.199	0.129
Hay fever ever	12.4	11.6	12.9	12.7	10.2	14.6	12.6	<0.001	<0.001
Atopic eczema									
Atopic eczema	14.4	13.8	14.0	16.6	12.0	15.8	14.7	<0.001	0.171
Sleep disturbed by rash one or more nights per week in last twelve months	3.5	2.6	2.1	2.8	0.9	1.8	2.4	0.154	0.016
Eczema ever	22.3	24.5	27.7	30.6	24.4	28.8	26.7	<0.001	0.003

In the last twelve months, 9.9% of all adolescents reported four or more attacks of wheezing, 3.2% reported sleep disturbance due to wheezing at least one night per week and 8% reported wheeze severe enough to limit speech to only one or two words at a time between breaths. Of adolescents with current wheeze, about one third had >4 attacks in the last twelve months, one in ten had their sleep disturbed one or more times a week, and in one in four wheeze-limited speech (Table 3).

For the video questionnaire (Table 2C), there were no regional differences seen except for responses to one scene showing a severe attack of asthma and asking "Has your breathing ever been like this?" If yes: "in the last year?" Hawke's Bay was lowest and Wellington highest. A small minority of thirteen to fourteen year old children (0.7%, all from Wellington) had seen the video two years before. The proportion of adolescents with 'exercise wheeze' or 'night cough' who also reported 'asthma ever' was 45.5% and 38.3% respectively, but the proportion with other symptoms and 'asthma ever' ranged from 60.0 - 65.7% (Table 4). The video questionnaire showed lower prevalences than the written questionnaire for most comparable questions.

Table 2B. Prevalence (%) of symptoms reported by adolescents.

	Auckland	Bay of Plenty	Hawke's Bay	Wellington	Nelson	Christchurch	Total	P values	
								All centres	Nelson vs. other centres
Asthma									
Asthma symptoms in last 12 months									
Wheezing	26.5	29.5	32.4	31.6	30.9	29.6	30.2	0.054	0.547
Wheezing with exercise	36.1	39.4	42.4	41.1	43.3	40.3	40.3	0.018	0.017
Dry cough at night	29.7	31.3	33.2	30.3	26.3	27.4	30.0	0.003	0.129
Wheezing severely in last 12 months									
Four or more attacks of wheeze	8.0	9.0	11.0	11.1	10.2	9.7	9.9	0.023	0.964
Sleep disturbed by wheeze one or more nights per week	2.7	3.3	4.6	3.0	2.6	2.9	3.2	<0.001	0.651
Wheeze limiting speech	8.1	7.1	8.6	8.3	8.2	7.5	8.0	0.239	0.450
Asthma ever	22.9	22.3	25.7	26.3	20.2	25.9	24.4	<0.001	<0.001
Allergic rhinitis									
Allergic rhinoconjunctivitis	18.9	18.7	18.1	19.8	17.4	19.4	18.9	0.917	0.453
Activities disturbed a lot by nose symptoms in last twelve months	1.3	1.7	1.4	1.6	0.4	1.2	1.3	0.011	<0.001
Hay fever ever	33.7	32.6	38.2	37.3	36.1	40.4	36.6	<0.001	0.261
Atopic eczema									
Atopic eczema	12.4	13.8	12.1	13.2	12.8	12.3	12.7	0.355	0.093
Sleep disturbed by rash one or more nights per week in last twelve months	2.8	3.5	3.0	2.3	2.0	2.3	2.7	0.959	0.958
Eczema ever	23.5	25.3	26.3	27.8	26.2	24.8	25.8	0.380	0.961

Table 2C. Prevalence (%) of positive responses to the video by adolescents.

	Auckland	Bay of Plenty	Hawke's Bay	Wellington	Nelson	Christchurch	Total	P values	
								All centres	Nelson vs. other centres
Prevalence in last year									
Wheeze	16.3	18.6	19.5	19.5	19.0	17.4	18.4	0.032	0.110
Exercise wheeze	28.4	28.4	29.9	31.0	32.3	32.2	30.3	0.221	0.045
Night wheeze	11.3	11.4	12.7	12.2	10.5	11.3	11.7	0.235	0.381
Night cough	20.7	25.2	22.5	23.1	23.3	22.4	22.8	0.177	0.038
Severe wheeze	11.4	12.8	9.8	14.9	11.7	13.2	12.4	<0.001	0.643

Allergic rhinoconjunctivitis. Children. Symptoms of allergic rhinoconjunctivitis in the last twelve months were common with parents of 9.7% of children reporting this symptom. There were significant regional differences seen for 'allergic rhinoconjunctivitis' and 'hay fever ever', which were lowest in Nelson. Nelson was also lowest for disturbance of activities, but this was not statistically significant. 6% of all children with allergic rhinoconjunctivitis had their activities in the past twelve months disturbed 'a lot' by their nasal symptoms.

Table 4. The proportion of pupils with symptoms who reported 'asthma ever' (%).

Written Questionnaire	Children	Adolescents
Current wheeze	71.8	54.3
Exercise wheeze	80.8	44.7
Four or more attacks	89.1	72.9
Sleep disturbed ≥1 night/week	80.4	75.0
Speech limited by wheeze	84.5	65.4
Video Questionnaire		
Wheeze		60.0
Exercise wheeze		45.5
Night wheeze		65.7
Night cough		38.3
Severe wheeze		63.4

Adolescents. The prevalence of allergic rhinoconjunctivitis in the last twelve months was high, with about one in five adolescents (18.9%) reporting this symptom (Table 2B), double the younger age group. There were no regional differences seen except for 'hay fever ever', where Bay of Plenty was lowest and Christchurch the highest. 5% of all adolescents with allergic rhinoconjunctivitis had their activities in the past twelve months disturbed 'a lot' by their nasal symptoms.

Atopic eczema. Children. The prevalence of atopic eczema in the last twelve months was high, with parents of about one in seven children (14.7%) reporting this symptom. There were significant regional differences seen for 'atopic eczema' and 'eczema ever'. Nelson was the lowest, 18% and 9% respectively below the average of all centres. Symptoms of eczema which disturbed sleep at least one night a week occurred in 14% of those with atopic eczema.

Adolescents. The prevalence of atopic eczema in the last twelve months was high, with about one in eight (12.7%) adolescents reporting this symptom. There were no significant regional differences seen for any responses. Symptoms of eczema which disturbed sleep at least one night a week averaged 16% of those with atopic eczema.

Table 3. Proportion of children with current wheeze who have selected other symptoms (%) – winter only results for allergic rhinoconjunctivitis.

	Auckland	Bay of Plenty	Hawke's Bay	Wellington	Nelson	Christchurch	Total	P values	
								All centres	Nelson vs. other centres
6-7 Year Age Group (n=4557)									
Four or more attacks of wheeze	32.7	33.2	36.2	38.7	37.7	36.8	35.9	0.153	0.598
Sleep disturbed one or more times a week	14.5	14.4	13.1	13.1	12.0	13.7	13.6	0.670	0.815
Speech limited	21.8	19.3	20.2	18.7	22.9	18.2	19.8	0.241	0.027
Asthma ever	68.6	69.1	70.0	77.5	66.0	74.5	71.8	<0.001	0.011
Allergic rhinoconjunctivitis symptoms	23.7	21.4	20.7	16.9	26.0	22.5	21.5	0.082	0.035
Hayfever ever	27.3	21.3	22.6	18.6	29.7	25.0	23.3	0.039	0.040
Atopic eczema symptoms	26.9	22.5	23.9	26.6	24.6	24.4	25.0	0.377	0.363
Eczema ever	35.8	34.9	40.4	43.5	41.4	40.0	39.5	<0.001	0.490
13-14 Year Age Group (n=5742)									
Four or more attacks of wheeze	29.5	30.3	33.3	35.0	32.0	33.0	32.5	0.486	0.607
Sleep disturbed one or more times a week	9.6	11.0	13.6	9.6	7.4	9.8	10.4	0.012	0.169
Speech limited	28.9	22.1	25.3	26.1	25.8	24.8	25.5	0.277	0.508
Asthma ever	55.1	50.5	54.0	57.5	46.4	57.4	54.3	<0.001	<0.001
Allergic rhinoconjunctivitis symptoms	27.5	30.9	31.1	31.8	30.6	28.3	30.6	0.890	0.453
Hayfever ever	48.2	47.0	57.8	53.9	49.4	56.6	52.7	<0.001	0.101
Atopic eczema symptoms	20.7	20.7	18.8	19.8	21.3	19.8	20.0	0.274	0.081
Eczema ever	33.1	33.8	34.8	39.5	35.1	35.6	35.7	0.410	0.846

All three conditions. The population relationship between symptoms in the last twelve months of asthma, allergic rhinoconjunctivitis and atopic eczema shows that 36.1% of children and 44.1% of adolescents had symptoms of at least one condition, 10.5% of children and 14.7% of adolescents had symptoms of at least two conditions, and only 2.3% of children and 2.9% of adolescents had current symptoms of all three conditions (Figure 1). Of all those with current symptoms, two-thirds had symptoms of only one condition, most commonly asthma. Among children with current wheeze, 'hayfever ever' was reported in only 23.3% and 'eczema ever' in only 39.5% (Table 3), and for adolescents the rates were 52.7% and 35.7% respectively. Among children with current wheeze, atopic eczema was more common than allergic rhinoconjunctivitis, but among adolescents this relationship was reversed.

Discussion

This study has demonstrated that children and adolescents in New Zealand have a high prevalence of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema, and that there are a large number who have severe symptoms. Compared with the 55 other countries that undertook ISAAC Phase One, New Zealand ranked among the top twelve for all parameters,[1-4] and the prevalence for each condition was generally similar to other English speaking countries. The prevalence and severity of these conditions is remarkably similar among children and adolescents throughout New Zealand, with the exception of the younger (but not the older) age group of Nelson children who had rates about 20% lower than in the other centres. ISAAC used a standardised approach which ensured that the same methodology was used in each participating New Zealand centre, so results are comparable to the 56 countries that participated in ISAAC Phase One. The questionnaires used have incorporated questions taken from pre-existing questionnaires with a level of sensitivity and specificity which is acceptable for the purposes of multicentre comparisons.[1-4, 14] The consistency of the ISAAC findings within New Zealand, and with previous New Zealand studies[7-11] gives further confidence in the results.

The worldwide variation demonstrated by ISAAC Phase One, other studies showing increasing prevalence of symptoms with time, and migration studies all suggest that environmental factors are important. The uniformity of the findings in New Zealand children and adolescents also suggests that the high rates in New Zealand could be due to exposure of the whole population to environmental factors which can induce and perpetuate asthma and allergic diseases in genetically susceptible individuals. The explanation for the worldwide variations in prevalence, including high rates in New Zealand, have been explored with ecological analyses using the ISAAC Phase One data. These studies have found a weak protective effect from vegetables in the diet,[19] immunisations,[20] tuberculosis,[21] and a positive association with economic development,[22] but no association with climate.[23] Further in-depth studies are being done in ISAAC Phase Two which is being conducted in over 25 international centres, including Hawkes Bay, New Zealand. This is assessing the relationship between 'objective' markers of asthma and allergies (lung function testing, bronchial hyperresponsiveness, skin prick testing), symptom prevalence, and genetic and environmental factors.

The proportion of children who had wheezing in the last twelve months and also had 'asthma ever' was 72%, and in adolescents the corresponding proportion was only 54%, and Nelson had slightly lower rates in both age groups. There may be several explanations for this apparent under-diagnosis of asthma. Firstly, there may be genuine under-diagnosis of asthma in both age groups, more marked in adolescents, who may not see a doctor for their symptoms. Secondly, parents, and especially adolescents may have forgotten or even deny a previous label of asthma. Thirdly, wheezing may reflect another diagnosis other than asthma, such as bronchiectasis. Fourthly, in adolescents in particular, normal breathlessness after exercise may be erroneously reported as wheeze, supported by our finding of a particularly low rate of 'asthma ever' reported in those with exercise wheeze, on both the written and video questionnaires. These observations warrant further exploration.

Asthma, allergic rhinoconjunctivitis and atopic eczema are generally regarded as atopic diseases with the underlying assumption that the inflammatory response is similar among the three conditions. However, this study demonstrated that most children and adolescents with asthma do not have symptoms or past history of allergic rhinoconjunctivitis or atopic eczema, although there is some interrelationship

between these conditions. The separateness of asthma and eczema in New Zealand children has been previously noted in Christchurch.[24] The three conditions behave differently, with the prevalence of asthma and allergic rhinoconjunctivitis increasing with age, while the prevalence of atopic eczema shows a small decline. These observations suggest that the factors inducing and perpetuating the inflammatory responses of asthma, allergic rhinoconjunctivitis and atopic eczema, and even the nature of the inflammatory response may be different between the three conditions. There is evidence that asthma is increasing in New Zealand,[25-27] but we do not know if it is atopic or non-atopic disease which is increasing, or both.

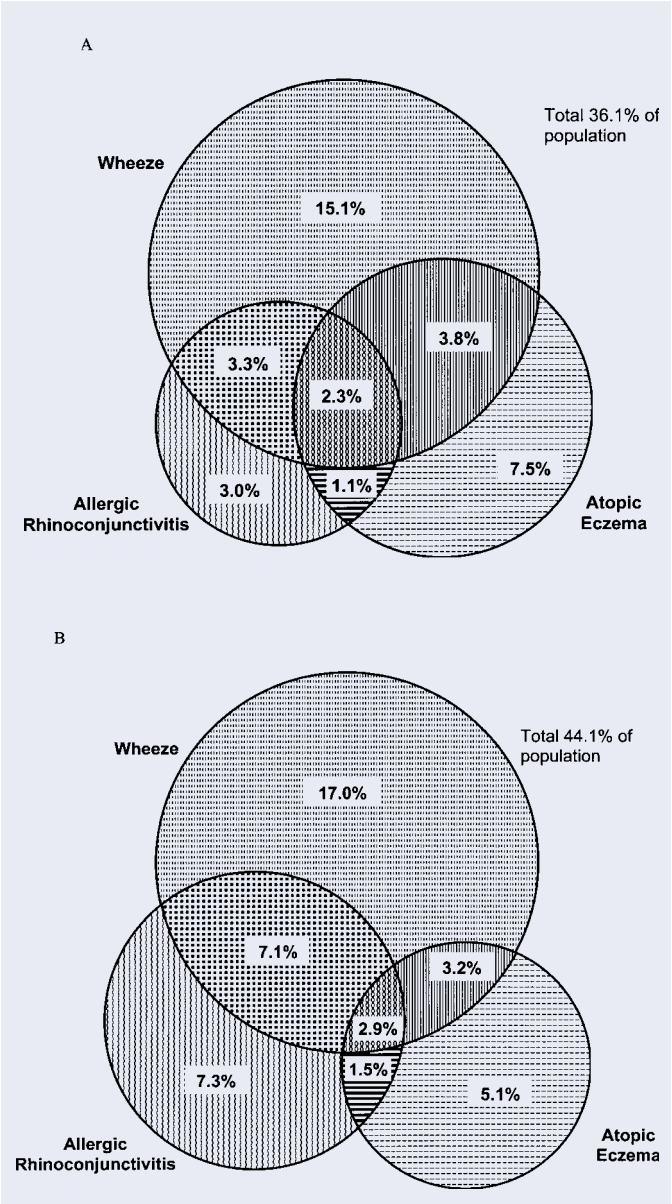

Figure 1. Venn diagrams of prevalence (% of study population) of current symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in 6-7 year olds (A), and 13-14 year olds (B).

The younger age groups in Nelson showed lower symptom prevalences of asthma, allergic rhinoconjunctivitis and atopic eczema than the other centres. This finding is of interest because of observations in 1982-84 that Nelson had the lowest hospital admission rate in New Zealand[6] (confirmed in 1993 [NZ Health Information Service]) and second lowest asthma mortality rate.[5] There may be less diagnostic labelling of disease in Nelson, although there is no direct evidence that this has occurred. Other potential explanations include different genetic influences or environmental exposures. However, in contrast to the younger age group, no significant differences were found between Nelson and the other centres for adolescents. Furthermore, the national survey of asthma symptom prevalence in adults[13] found only slightly lower prevalence of 'current asthma' in Nelson (12%) compared with other electorates (15%). These observations suggest the possibility that the findings reported here for six to seven year olds may be due to chance.

Our study has estimated that 25-30% of New Zealand children and adolescents have symptoms of asthma, of whom 10-14% had 'severe' symptoms defined as sleep disturbed due to wheezing one or more times a week. Other 'severe' symptoms were more common; 10-19% of children and adolescents had allergic rhinoconjunctivitis of whom 5-6% had severe symptoms; and 13-15% of children and adolescents had eczema of whom 14-16% had severe eczema. We did not collect data on the cost of treatments for participants in this study. However, the total cost (direct and indirect) of these conditions is high. The Asthma & Respiratory Foundation of New Zealand in 1998 conservatively estimated that the direct and indirect costs of asthma for the whole New Zealand population is $376 million or $835 per person with asthma. For allergic rhinitis, the costs in New Zealand are not known, although costs have been estimated in adults in the USA.[28] The costs of atopic eczema have recently been estimated in Australia, from A$1142 per child with mild eczema to A$6099 per child for a child with severe atopic eczema.[29]

In conclusion, ISAAC Phase One has demonstrated that New Zealand children and adolescents have prevalences of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema among the highest in the world. However, in the six centres studied within New Zealand, there were no regional differences, except for lower rates in the younger age group of Nelson children (but not adolescents). There were large numbers of children and adolescents affected by each of the three conditions. Symptoms of asthma were twice as common as symptoms of allergic rhinoconjunctivitis and eczema, and symptoms of asthma occurred most commonly without reported symptoms of either of the other two conditions. Further research is needed to explain the high rates of these three conditions in New Zealand and other English-speaking countries. Any strategies to reduce the prevalence or severity of these conditions will have a large economic benefit to the sufferers, their families and New Zealand.

Acknowledgements. We acknowledge the cooperation of the participating schools, children, parents, teachers, principals and Boards of Trustees. The field work in Christchurch was carried out by Beryl Slade, in Hawke's Bay by Susan Cook and Lesley Price, in Bay of Plenty by John Waldon, in Nelson by the Public Health Nurses, and in Wellington by Tania Slater and Amy Crothall. Secretarial assistance was provided by Christine Thomas. Drs Crane and Pearce were funded by Professorial Research Fellowships and the Wellington Asthma Research Group was funded by a Programme Grant from the Health Research Council of New Zealand. Financial support was received from the Health Research Council of New Zealand, Hawke's Bay Medical Research Foundation, Nelson Marlborough Health Services Ltd and Glaxo Pharmaceuticals New Zealand Ltd.

Correspondence. Associate Professor MI Asher, Division of Paediatrics, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92019, Auckland 1001. Fax: (09) 373 7602.

1. Strachan D, Sibbald B, Weiland S et al. Worldwide variations in prevalence of symptoms of allergic rhinoconjunctivitis in children: The International Study of Asthma and Allergies in Childhood (ISAAC). Pediatr Allergy Immunol 1997; 8: 161-76.
2. The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema: ISAAC. Lancet 1998; 351: 1225-32.

3. The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variations in the prevalence of asthma symptoms: The International Study of Asthma and Allergies in Childhood (ISAAC). Eur Respir J 1998; 12: 315-35.
4. Williams H, Robertson C, Stewart A et al. Worldwide variations in the prevalence of symptoms of atopic eczema in the International Study of Asthma and Allergies in Childhood. J Allergy Clin Immunol 1999; 103: 125-38.
5. Sears MR, Rea HH, Beaglehole R et al. Asthma mortality in New Zealand: a two year national study. NZ Med J 1985; 98: 271-5.
6. Mitchell EA, Borman B. Regional variations in mortality and hospital admissions for asthma. NZ Fam Phys 1987; 14: 14-6.
7. Jones DT, Sears MR, Holdaway MD et al. Childhood asthma in New Zealand. Br J Dis Chest 1987; 81: 332-40.
8. Asher MI, Pattemore PK, Harrison AC et al. International comparison of the prevalence of asthma symptoms and bronchial hyperresponsiveness. Am Rev Respir Dis 1988; 138: 524-9.
9. Barry DMJ, Burr ML, Limb ES. Prevalence of asthma among 12 year old children in New Zealand and South Wales: A comparative survey. Thorax 1991; 46: 405-9.
10. Shaw R, Crane J, O'Donnell TV. Asthma symptoms, bronchial hyperresponsiveness and atopy in a Maori and European adolescent population. NZ Med J 1991; 104: 175-9.
11. Shaw R, Woodman K, Crane J et al. Risk factors for asthma symptoms in Kawerau children. NZ Med J 1994; 107: 387-91.
12. Crane J, Lewis S, Crossland L et al. The self reported prevalence of asthma symptoms amongst adult New Zealanders. NZ Med J 1994; 107: 417-21.
13. Lewis S, Hales S, Slater T et al. Geographical variation in the prevalence of asthma symptoms in New Zealand. NZ Med J 1997; 110: 286-9.
14. Asher MI, Keil U, Anderson HR et al. International study of asthma and allergies in childhood (ISAAC): rationale and methods. Eur Respir J 1995; 8: 483-91.
15. Shaw RA, Crane J, Pearce N et al. Comparison of a video questionnaire with the IUATLD written questionnaire for measuring asthma prevalence. Clin Exp Allergy 1992; 22: 561-8.
16. Shaw R, Woodman K, Ayson M et al. Measuring the prevalence of bronchial hyperresponsiveness in children. Int J Epidemiol 1995; 24: 597-602.
17. Rao JNK, Scott AJ. A simple method for the analysis of clustered binary data. Biometrics 1992; 48: 577-85.
18. Stewart AW, Asher MI, Clayton T et al. The effect of season-of-response to ISAAC questions about asthma, rhinitis and eczema in children. Int J Epidemiol 1997; 26: 126-36.
19. Asher MI, on behalf of the ISAAC Steering Committee. Diet, asthma and allergies: A further ecological study with ISAAC (International Study of Asthma and Allergies in Childhood) Phase One worldwide data. Eur Resp J 1999; 14 (Supp 30): 151s.
20. Anderson HR, Poloniecki JD, Strachan DP et al on behalf of the ISAAC Phase 1 Study Group. Immunization and child atopy. Am J Public Health, in press.
21. von Mutius E, Pearce N, Beasley R et al. International patterns of tuberculosis and the prevalence of symptoms of asthma, rhinitis and eczema. Thorax 2000; 55: 449-53.
22. Stewart AW, Mitchell EA, Pearce N et al. The relationship of per capita gross national product to the prevalence of symptoms of asthma and other atopic diseases in children. Int J Epidemiol, in press.
23. Weiland SK. Climatic conditions and the prevalence of wheeze in children: ecological analysis of data from the International Study of Asthma and Allergies in Children (ISAAC). Eur Respir J 1998; 12 (Supp 28): 13s.
24. Fergusson DM, Horwood LJ, Shannon FT. Parental asthma, parental eczema and asthma and eczema in early childhood. J Chronic Dis 1983; 36: 517-24.
25. Mitchell EA. Increasing prevalence of asthma in children. NZ Med J 1983; 96: 463-4.
26. Shaw RA, Crane J, O'Donnell TV et al. Increasing asthma prevalence in a rural New Zealand adolescent population: 1975-89. Arch Dis Child 1990; 65: 1319-23.
27. Mitchell EA, Asher MI. Prevalence, severity and medical management of asthma in European school children in 1985 and 1991 (published erratum appears in J Paediatr Child Health 1997; 33(2): 177). J Paediatr Child Health 1994; 30: 398-402.
28. Ray NF, Baranuik JN, Thamer M et al. Direct expenditures for the treatment of allergic rhinoconjunctivitis in 1996, including the contributions of related airway illnesses. J Allergy Clin Immunol 1999; 103: 401-7.
29. Kemp AS. Atopic exzema: its social and financial costs. J Paediatr Child Health 1999; 35: 229-31.