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Original article

Prevalence of symptoms of childhood asthma, allergic rhinoconjunctivitis and eczema in the Pacific: The International Study of Asthma and Allergies in Childhood (ISAAC)

The International Study of Asthma and Allergies in Childhood (ISAAC) has provided valuable information regarding international prevalence patterns and potential risk factors for asthma, allergic rhinoconjunctivitis and eczema. However, the only Pacific countries that participated in ISAAC Phase I were Australia and New Zealand, and these included only a small number of Pacific children. Phase III has involved not only repeating the Phase I survey to examine time trends, but also to include centres and countries which are of interest but did not participate in Phase I. The ISAAC Phase III study was therefore conducted in the Pacific (in French Polynesia, New Caledonia, Tonga, Fiji Islands, Samoa, Cook Islands, Tokelau Islands and Niue). The overall prevalence rates of current symptoms (in the last 12 months) were 9.9% for asthma, 16.4% for allergic rhinoconjunctivitis and 10.7% for atopic eczema. The prevalence of current wheezing (9.9%) was generally much lower than that has been observed in Pacific children in New Zealand (31%), but there was considerable variation between the various Pacific centres: Tokelau Islands (19.7%), Tonga (16.2%), Niue (12.7%), French Polynesia (11.3%), Cook Islands (10.6%), Fiji Islands (10.4%), New Caledonia (8.2%) and Samoa (5.8%). The reasons for these differences in prevalence across the Pacific are unclear and require further research. The finding that prevalence levels are generally considerably lower than those in Pacific children in New Zealand adds to previous evidence that children who migrate experience an altered risk of asthma as a result of exposure to a new environment during childhood.

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The International Study of Asthma and Allergies in Childhood (ISAAC) has provided valuable information regarding international prevalence patterns and potential risk factors in the development of asthma, allergic rhinoconjunctivitis and eczema (1, 2). However, the only Pacific countries that participated in ISAAC Phase I were Australia and New Zealand, and these included only a small number of Pacific children (3). A number of other studies have been conducted in the Pacific, including those of Liard et al. among teenagers attending school in Tahiti (4), Flynn's studies of children in Fiji (5) and Tokelau children in New Zealand (6). However, these have used a variety of methods and the findings are therefore not comparable. There is some evidence that asthma levels may be higher in Pacific children in New Zealand than in the Pacific (7) and it is therefore plausible that, as the Pacific becomes more 'westernized', asthma prevalence may increase and eventually reach the same levels throughout the Pacific as are currently seen in New Zealand (8).

The ISAAC Phase III study not only involved repeating the survey in centres that had participated in phase I (Phase 3A centres), but also included new centres that had not previously participated (Phase 3B centres) (9). Participation in Phase III of the ISAAC study was regarded as an important first step in the prevention and management of asthma throughout the Pacific, as well as having the potential for encouraging the development of other health research projects throughout the region. It was also considered that the information gained from the Pacific would also be of value for assessing the causes of the increases in asthma prevalence worldwide. The 'hygiene hypothesis' is generally consistent with the epidemiologic evidence, but it remains unclear as to whether any single factor can explain the global trends (8). The Pacific is of particular interest and importance in that regard because many countries have to some extent retained their traditional diet and lifestyles but are becoming increasingly 'westernized', particularly in 'urban' areas. There are also exposure to infections,

farming environments, a range of other domesticated animals such as pigs (as sources of endotoxins for example) and other risk factors that may be 'specific' to Pacific island environments.

The ISAAC Phase III study was therefore conducted in the Pacific with Dr Sunia Foliaki as Regional Coordinator for Oceania. In this paper, we report the findings on the prevalence of symptoms of asthma, allergic rhinoconjunctivitis and eczema.

Methods

All the participating centres in the Pacific were Phase 3B centres, because the Pacific countries had not participated in Phase I. Two Pacific centres, French Polynesia and New Caledonia, had already conducted Phase III surveys (these were 'late Phase I' surveys that had been conducted too late to be included in the Phase I analyses and therefore were 'held over' for Phase III). The new countries that were specifically recruited for ISAAC Phase III included Tonga, Fiji Islands, Samoa, Cook Islands, Tokelau Islands and Niue.

The ISAAC Phase III Manual describes in detail all aspects and procedures for implementation of the study by centres from rationale, planning and implementation to submission of data (9). The basic study design involved selecting a defined geographical area and taking a random sample of schoolchildren from that area (the details are described below). The study is therefore based on centres that are selected by the investigators. These centres are often selected for reasons of convenience, and are not required to be 'typical' of the countries in which they are based. In many parts of the world, the geographical area was based on a city (usually the city in which the researchers were based), and the ISAAC study therefore predominantly involved urban centres. However, in the Pacific each 'centre' usually involved an entire island, or an entire country.

It was specified that each centre should involve a random sample of at least 3000 13- to 14-year-old children, with the option of also recruiting 3000 6- to 7-year-old children. Only one Pacific centre included the younger age group, and the numbers were relatively small, so we will focus on the findings in 13- to 14-year olds.

The Phase I manual stated that 'centres with sample sizes in the range of 1000–2999 will only be included in the prevalence comparisons but not the severity comparisons'. However, the small total population of some Pacific countries meant that even a sample size of 1000 could not be obtained in some countries. These included Tokelau, Niue and the Cook Islands. Nevertheless, the small sample sizes obtained from these islands represented the entire population of 13- to 14-year olds in these countries. It was therefore agreed that these countries should be included in the ISAAC analyses even though they did not meet the sample size requirements.

For the 13- to 14-year-old age group, questionnaires were self-completed, usually at school. The same key questions for asthma, allergic rhinoconjunctivitis and eczema symptoms were used as have been used in previous ISAAC publications (10). Three of the participating Pacific countries translated the questionnaires into local languages (Tonga, Samoa, Tokelau), In each case, the translation was done by bilingual local health workers and back-translated into English independently. Two countries (French Polynesia and New Caledonia) conducted the survey in French based on the same questionnaire that was used in France, and three conducted the survey in English (Cook Islands, Niue and Fiji).

Implementation of ISAAC Phase III in the Pacific was preceded by written invitations to Pacific Island countries to participate. Following clearance by the relevant national Ethics Committees or appropriate national authorities (some countries had no identified 'Ethics Committees'), meetings were arranged and held with both government and non-government education authorities as well as formal submissions of invitation and information about ISAAC. All schools in Tokelau, Niue, the Cook Islands, French Polynesia and New Caledonia were selected. All schools in Tonga were selected except for two schools in the isolated northern islands of Niuatoputabu and Niuafo'ou. In Samoa all schools from the Apia urban area were selected. In Fiji all schools in the Suva Subdivision that had students between 13 and 14 years old (37 primary, one intermediate and three secondary schools) were selected, as different schools had different policies for admission in terms of age groups. Those that had different age categories for admissions were not included. There were three primary schools and one secondary school from the Rewa Subdivision. These schools were chosen first as they had the appropriate age groups and the closest to the Suva Subdivision. There was also one secondary school from the Tailevu Subdivision which was chosen based on proximity to the Suva Subdivision. Letters to parents were distributed via schools where appropriate and parents requested to contact the school only if they did not wish their children to participate and no contact or action from the parents was to be taken as consent. All data collection was conducted during school hours. Dates of data collection were documented, and all data were double-entered and the two files compared using SAS. Any discrepancies between the first and second entry files were then resolved by referring them to the questionnaire.

For the prevalence analyses, the asthma, rhinoconjunctivitis and eczema symptom prevalences for each centre were calculated by dividing the number of positive responses to each question by the number of completed questionnaires for the written and video questionnaires separately (10).

Results

Table 1 shows the characteristics of participating centres including sampling frames, number of schools, selection criteria for children, age groups, levels or years selected for children's participation and response rates. Except for Niue (which surveyed both the 6- to 7- and the 13- to 14-year-old children), all the Pacific Island countries surveyed only the 13- to 14-year olds.

Table 2 presents the participants' characteristics for 13- to 14-year olds. Of the 20 876 schoolchildren who participated, 21.9% (4564) were outside the 13- to 14-year range. For those who were within 1–2 years of the age range, their responses were included in the analysis as is the standard practice for ISAAC (10); 50 (0.2%) respondents did not include information on age and have been excluded from the analyses presented in Table 2 but are included in all other analyses, as were 75 (0.4%) respondents who did not include information on age.

Only Niue collected data on 6- to 7-year olds. Using the standard ISAAC definitions (10), the prevalences of self-reported symptoms were 17.0% ($n = 8$) for current wheeze, 8.5% ($n = 4$) for allergic rhinoconjunctivitis, and 23.4% ($n = 11$) for eczema symptoms.

The focus of this paper is on the findings among 13- to 14-year-old schoolchildren. Table 3 presents the (written

Table 1. Characteristics of participating centres and response rates for 13- to 14-year olds

Country	Period of data collection	Sampling frame	No. of schools	Selection of children – by grade/level or age	No. of grades/levels or years of age selected	No. of participants (response rate)
Tonga	April–October 2002	All schools in Tonga except for two schools in two remote islands	3	Age	2	2671/3082 (87%)
Samoa	October 2003	All schools in Urban Apia	41	Age	2	2986/3110 (96%)
Fiji	November 2002	All schools in Suva Subdivision and some schools from Rewa and Tailevu Subdivision	69	Age	2	3093/3317 (93%)
Cook Islands	February 2003	All schools in Cook Islands	8	Age	2	445/472 (94%)
Niue	October 2002	All schools in Niue	3	Age	2	79/85 (93%)
Tokelau	June 2003	All schools in Tokelau	3	Age	2	66/66 (100%)
New Caledonia	May–June 1998	All schools	47	Age	2	7247/8312 (87%)
French Polynesia	February–March 2000	All schools	28	Age	2	4289/4339 (99%)

Table 2. Participant characteristics for 13- to 14-year olds

	Tonga		Samoa		Fiji		Cook Islands		Niue		Tokelau		New Caledonia		French Polynesia		Total	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Gender																		
Male	50.6	1352	44.2	1320	46.8	1447	51.9	231	45.6	36	50.0	33	48.0	3481	46.9	2012	47.5	9912
Age (years)																		
<13	4.3	114	2.9	88	0.0	0	16.4	73	6.3	5	18.2	12	24.5	1774	1.5	63	10.2	2129
13–14	92.9	2482	96.2	2874	99.9	3090	80.7	359	93.7	74	78.8	52	58.9	4271	70.8	3035	77.8	16 237
>14	2.8	75	0.6	17	0.1	3	2.5	11	0.0	0	3.0	2	16.4	1185	26.6	1142	11.7	2435
Total	2671		2986		3093		445		79		66		7247		4289		20 876	

questionnaire) prevalence of asthma, allergic rhinoconjunctivitis and eczema symptoms by ethnicity among 13- to 14-year olds for the eight Pacific Islands. Overall, 9.9% of the participants had had wheezing in the last 12 months (current wheeze) and 13.8% reported ever having had asthma. Asthma severity as assessed by night waking because of wheeze and wheezing severe enough to limit speech were 5.5% and 3.2% in the last 12 months respectively. There was considerable variation in the prevalence of current wheeze across the participating centres ($P < 0.001$). Of the larger centres, Tonga showed the highest prevalence for current wheeze (16.2%) with Samoa showing the lowest (5.8%). Overall, about one-third (3.2% of 9.9%) of those with current wheeze also reported current symptoms of allergic rhinoconjunctivitis, but in the larger centres this proportion varied from 23% in Tonga to 50% in Samoa (not shown in table). In the small Tokelau survey, none of those with current wheeze also reported having current allergic rhinoconjunctivitis symptoms.

Table 4 presents the responses to the video asthma symptom questionnaire. Overall, 9.0% of participants reported wheezing at rest in the previous 12 months, with Fiji reporting the highest prevalence (16.3%), and Samoa the lowest (5.1%) of the larger centres (the prevalence was lower in Niue but the numbers were very small). Thus, Samoa had the lowest prevalence for both the written and video questionnaires.

Discussion

This study is the first to determine the prevalence of asthma, allergic rhinoconjunctivitis and eczema in eight Pacific Island countries using standardized methodology and instruments (written and video questionnaires). To our knowledge, there have been no previous surveys of allergic rhinoconjunctivitis or eczema in the Pacific. As noted above, of the few studies of asthma prevalence (4–6) conducted in the Pacific prior to the ISAAC study, none were comparable in either methodology or used similar instruments. Waite et al. used a self-completed questionnaire (6) and reported a prevalence of 11.0% among 706 Tokelauan children aged 0–14 years in Tokelau compared with 25.3% of the 1160 Tokelauan children seen in New Zealand. Another self-administered questionnaire study of 6731 adolescent schoolchildren (average age 13.5 years) in Tahiti in French Polynesia reported that 14.3% gave an affirmative answer to the question 'Have you ever had attacks of asthma?'; the prevalence was 11.4% among Europeans, 13.7% among Chinese, 13.8% among Polynesians, and 15.3% among children of mixed Polynesia–European ancestry (4). Thus, Liard et al. (4) found no evidence for any differences in asthma prevalence between the three main ethnic groups participating (European, Chinese, Polynesian). Admissions for asthma however were three times higher in Fijian Indians compared to Fijians (Melanesians) in a study of national

Table 3. Prevalence of asthma, allergic rhinoconjunctivitis and eczema symptoms for 13- to 14-year olds (written questionnaire)

	Tonga		Samoa		Fiji		Cook Islands		Niue		Tokelau		New Caledonia		French Polynesia		Total	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Asthma symptoms																		
Wheezing ever	26.6	710	11.2	333	20.4	630	19.6	87	36.7	29	43.9	29	15.7	1141	12.2	522	16.7	3481
Symptoms in last 12 months																		
Wheezing	16.2	432	5.8	173	10.4	321	10.6	47	12.7	10	19.7	13	8.2	594	11.3	486	9.9	2076
≥1 wheezing attack	15.4	412	5.8	173	9.8	304	10.8	48	12.7	10	12.1	8	7.3	537	9.5	411	9.1	1903
Sleep disturbed by wheeze one or more nights per week	11.1	297	3.6	109	7.1	221	6.5	29	6.3	5	10.6	7	3.4	248	5.2	223	5.5	1139
Severe wheeze	5.3	142	3.8	113	4.8	149	3.8	17	1.3	1	7.6	5	1.8	127	2.7	109	3.2	674
Wheezing with exercise	26.2	701	28.0	838	24.2	747	20.4	91	7.6	6	59.1	39	13.1	949	11.7	466	18.6	3878
Night cough	30.3	808	49.7	1486	42.0	1300	14.8	66	38.0	30	48.5	32	23.8	1723	23.8	934	31.0	6464
Asthma ever	12.5	335	14.1	420	13.6	421	14.8	66	30.4	24	34.8	23	12.5	909	16.0	638	13.8	2880
Allergic rhinoconjunctivitis symptoms																		
Nose symptoms ever	28.8	769	55.1	1646	56.0	1733	40.9	182	64.6	51	57.6	38	55.5	4021	52.3	2083	51.2	10 698
Symptoms in last 12 months																		
Nose symptoms	18.1	484	43.8	1310	43.8	1354	28.5	127	40.5	32	56.1	37	46.1	3340	43.0	1714	40.9	8548
Eyes affected (allergic rhinoconjunctivitis)	9.8	262	22.4	670	23.5	727	12.4	55	17.7	14	21.2	14	13.8	999	15.7	624	16.4	3425
Activities disturbed by nose symptoms	15.0	400	29.1	871	37.4	1157	23.1	103	26.6	21	40.9	27	25.2	1828	29.1	1160	27.2	5684
Hayfever ever	16.1	430	9.7	289	10.3	320	12.8	57	25.3	20	31.8	21	9.9	719	10.6	424	11.1	2324
Eczema symptoms																		
Rash ever	22.9	611	20.8	622	18.1	561	14.4	64	25.3	20	22.7	15	21.3	1543	25.9	1030	22.0	4583
Symptoms in last 12 months																		
Rash	17.9	479	15.2	454	14.9	462	7.6	34	16.5	13	16.7	11	12.9	933	13.6	543	14.3	2979
Flexural areas (atopic eczema)	15.1	404	15.6	466	13.0	402	7.0	31	15.2	12	13.6	9	7.2	524	8.9	355	10.7	2239
Sleep disturbed by rash one or more nights a week	13.5	360	11.0	329	11.0	340	7.2	32	8.9	7	7.6	5	4.9	359	7.3	291	8.4	1758
Eczema ever	16.1	429	41.1	1229	7.2	222	14.2	63	16.5	13	10.6	7	12.5	904	12.3	490	16.3	3411

Table 4. Prevalence of asthma symptoms for 13- to 14-year olds (video questionnaire)

	Tonga		Samoa		Fiji		Niue		Tokelau		New Caledonia		Total	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Wheezing (while at rest)														
Ever	15.1	404	8.8	262	22.0	679	8.9	7	15.2	10	10.9	768	13.4	2123
In the last year	10.7	285	5.1	151	16.3	504	3.8	3	7.6	5	6.9	487	9.0	1432
In the last month (one or more times)	6.1	164	3.1	92	8.7	269	2.5	2	3.0	2	2.3	164	4.4	691
Wheezing after exercise														
Ever	21.3	568	13.6	407	25.5	790	3.8	3	10.6	7	17.4	1229	18.9	3001
In the last year	15.1	403	8.3	249	19.8	613	3.8	3	6.1	4	12.3	869	13.5	2138
In the last month (one or more times)	8.3	223	5.6	167	10.7	331	1.3	1	3.0	2	5.0	353	6.8	1076
Waking with wheezing														
Ever	8.0	214	5.1	151	7.7	238	3.8	3	1.5	1	8.9	625	7.7	1229
In the last year	4.8	129	3.1	92	5.7	175	2.5	2	1.5	1	5.5	389	5.0	786
In the last month (one or more times)	2.7	73	2.1	63	2.4	74	1.3	1	1.5	1	1.9	135	2.1	346
Waking with cough														
Ever	23.0	614	24.1	720	27.4	847	20.3	16	24.2	16	16.9	1192	21.4	3389
In the last year	15.9	424	15.8	473	18.8	582	15.2	12	10.6	7	11.1	782	14.3	2268
In the last month (one or more times)	8.9	237	10.6	317	11.4	352	3.8	3	4.5	3	3.3	236	7.2	1145
Severe attack														
Ever	9.4	250	5.4	160	9.2	285	5.1	4	6.1	4	6.5	457	7.3	1156
In the last year	5.6	150	3.0	91	6.1	190	2.5	2	6.1	4	3.9	277	4.5	712
In the last month (one or more times)	3.2	86	2.0	60	3.3	102	1.3	1	1.5	1	1.3	90	2.1	339

hospital admissions among 5- to 14-year-old children in Fiji for the 4 years between 1985 and 1989 (5).

In contrast with these previous studies, the findings are comparable across the Pacific countries involved in the study, and with those in Pacific populations in others countries (e.g. New Zealand) that also participated in the ISAAC survey. Furthermore, although the ISAAC Phase III study is based on questionnaires rather than more

'objective' measures, the ISAAC asthma symptom questionnaire has been found to validate well against physician-diagnosed asthma (11). The ISAAC study in the Pacific has also provided an opportunity to establish and sustain an environment for health research in the participating countries. Two of the participating countries had small populations, i.e. Tokelau Islands (66 13- to 14-year olds) and Niue (79 13- to 14-year olds and 47 6- to 7-year olds). These were included as the survey involved the whole population of 13- to 14-year olds in these countries. However, the prevalence findings for these countries are clearly unstable because of the small numbers involved. Therefore, we will concentrate on the findings for the larger centres in the discussion below.

There are two key findings from the current study. First, there is considerable variation in symptom prevalence through the Pacific ($P < 0.001$ for current wheeze). The lowest prevalence for current wheeze (wheezing over the last 12 months) was in Samoa (5.8%), with Tonga (16.2%) reporting the highest prevalence in the larger centres. This large variation in symptom prevalence within the Pacific warrants further investigation as to which risk factors may be responsible. The countries concerned not only involve an increasingly 'Western lifestyle', but also relatively high rates of infection and exposure to other risk factors of particular interest (e.g. endotoxin exposure from pigs). For 'asthma ever', there was a smaller range of variation, with the French Polynesia (16.0%) showing the highest prevalence, and Tonga and New Caledonia (12.5%) the lowest prevalences, of the larger centres.

Of the smaller centres, Tokelau had a very high prevalence of wheezing in the last 12 months (19.7%, 95% CI 11.9–30.8%) and 'asthma ever' (34.8%, 95% CI 24.5–46.9%). This is in contrast to studies from the 1970s which reported very low prevalence in Tokelau (6). A recent study attributed these low prevalence levels to the low indoor allergen levels in Tokelau (12). However, the evidence that allergen exposure is a primary cause of asthma is relatively weak (13) and it appears that prevalence has now increased despite these low indoor allergen levels.

The second feature of the findings reported here is that most countries show lower prevalences than have previously been reported for Pacific children in New Zealand (3). None of the eight Pacific Island countries and territories in the current survey participated in ISAAC Phase I. However, the prevalence of asthma symptoms is lower in these Pacific countries than those reported among Pacific, Maori and European respondents in the ISAAC Phase I survey in New Zealand (3, 14). In particular, the overall prevalence of current wheeze (9.9%) was lower in the current survey than in Pacific (21.1%), Maori (30.8%) and European (31.7%) respondents in the New Zealand Phase I ISAAC study (3). The prevalence of 'asthma ever' (13.8%) is also low compared with Pacific Islanders (19.2%), Maori (24.7%) and Europeans (25.2%) in New Zealand (3).

Similarly, the prevalence of wheezing severe enough to limit speech in the last 12 months was 3.2% overall, an estimate which is lower than those previously reported in New Zealand for Europeans (8.0%), Maori (8.7%) and Pacific (7.5%) children (3). Thus, there are considerable differences in asthma prevalence and severity between Pacific children living in the Pacific, and children from the same ethnic groups living in New Zealand. This adds to previous evidence both on the importance of environmental factors on asthma prevalence (15), and that children who migrate can experience an altered risk of asthma as a result of exposure to a new environment during childhood (16). In particular, a number of studies show that the prevalence of asthma and wheeze is lower in migrant children who have arrived recently, but migrant children who have been in their host country for some years generally have a prevalence similar to non-migrant children (16–19). This supports the hypothesis that, despite the importance of exposures during pregnancy and early in life (20, 21), the lower prevalence observed in recent migrants is due to more recent differences in environmental exposures between their countries of origin and their host countries (16).

In conclusion, this study is the first to determine the prevalence of asthma, rhinoconjunctivitis and eczema in eight Pacific Island countries using standardized methodology and instruments (written and video questionnaires). It has shown that there is considerable variation in symptom prevalence through the Pacific, but the prevalence levels are generally considerably lower than have been observed in Pacific children in New Zealand. This adds to previous evidence both on the importance of environmental factors on asthma prevalence, and that children who migrate can experience an altered risk of asthma as a result of exposure to a new environment during childhood.

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