Epidemiology of Asthma in Selected Pacific countries

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Abstract

Background

In this thesis, I describe a series of studies of the prevalence, causes, and management of asthma in the Pacific. The core study of the thesis is Phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). The ISAAC study is the largest worldwide epidemiological study on asthma prevalence and was established partly in response to the increases in asthma prevalence in most parts of the world over the last two to three decades. The ISAAC Phase I study found large variations in asthma prevalence globally, but no Pacific countries were involved. Thus, the situation in the Pacific was relatively unknown due to lack of standardised studies on prevalence and time trends. The burden and impact of other non-communicable diseases such as cardiovascular and other metabolic disorder on the other hand have been the target of various studies in the Pacific for the past few decades The ISAAC Phase III study was therefore conducted in eight Pacific countries to address the above issues, as well as to enhance Pacific participation and contribution to international research on the causes and control of asthma. The collaboration also served the purpose of encouraging and strengthening health research capacity in the Pacific. The ISAAC Phase III study was followed by an asthma self-management intervention trial conducted in Tonga by the ISAAC Tonga study team.

Methods

The work presented in this thesis involved: (i) the conduct of the ISAAC Phase III study in the six Pacific islands of Tokelau, Samoa, Fiji Islands, Tonga, Niue and the Cook Islands, as well as the incorporation into the analysis of data that had already

been collected in French Polynesia and New Caledonia; (ii) analysis of the data from an environmental asthma risk factor questionnaire which was included in the ISAAC survey in three countries (Samoa, Fiji and Tokelau); (iii) the conduct of the Tonga Asthma Self-management Study which was intended to assess whether the introduction of asthma education, including asthma self-management plans, would reduce morbidity from asthma.

Results

A total of 20,876 13-14 year olds, in the eight countries involved, participated in the ISAAC Phase III survey, with an overall response rate of 92%. The survey showed that there was considerable variation in the prevalence of asthma symptoms between the eight countries, ranging from 5.8% for current wheeze in Samoa to 16.2% in Tonga. Tokelau reported the highest prevalence (19.7%) for current wheeze, but the number of participants was relatively small. The prevalences of asthma symptoms among Pacific children in the Pacific were lower than those reported for Pacific, Māori and European children living in New Zealand from a previous study (ISAAC Phase I) conducted ten years earlier using the same methodology. The prevalence of 'asthma ever' in Pacific children living in the Pacific was also lower than that found among Pacific, Māori and European children in New Zealand.

The ISAAC Phase III environmental questionnaire data was collected in Samoa, Fiji and Tokelau. The analyses indicated that the major factors associated with current wheeze (across the three countries) were paracetamol use in the previous year (odds ratio (OR) = 1.36, 95% CI 1.15-1.61), the use of open fires for cooking (OR = 1.34, 95% CI 1.13-1.58), lack of physical activity as indicated by television viewing more

than 3 hours per day (OR = 1.24, 95% CI 1.04-1.47), regular meat consumption (OR = 1.30, 95% CI 1.09-1.54) and regular cereal consumption (OR = 1.29, 95% CI 1.07-1.54). However, these risk factors were not particular strong, and did not account for a large proportion of asthma cases (i.e. they had relatively low population attributable risks).

The asthma self-management plan intervention study resulted in significant improvements in asthma morbidity and the management of asthma among individuals and the service provision. The success of the introduction of the self-management plan, in the context of an asthma clinic, was reflected by improvement in measures of asthma morbidity, such as peak expiratory flow rates and nights woken with asthma or coughing. There was also a reduction in the requirement for acute medical treatment, indicated by a decrease in emergency department hospital visits for asthma and hospital admissions. The programme was so successful that the intervention study evolved into a full regular asthma clinic for the main island of Tonga. It is now intended that the asthma self-management programme will be extended throughout the rest of Tonga, through the primary health care system.

Conclusions

The ISAAC Phase IIII survey has shown that, although there is a significant level of morbidity, asthma prevalence in Pacific countries is lower than those among Pacific people in New Zealand. Together with the large variations in prevalence between the six Pacific countries that participated, this further lends support for the role of environmental risk factors in asthma. The availability of data on eight countries using a standardised methodology also provides useful information on the burden of asthma

in the Pacific that is comparable to other countries regionally and internationally as well as forming a basis for ascertaining trends in the future. The crucial role of asthma self-management plans in asthma management is supported by the findings of the Tonga study, and its implementation is essential in the resource-scarce Pacific health setting. The collaborative nature of ISAAC in the Pacific has further raised awareness of the need for capacity building and creating networks and environments that enhance health research in areas other than asthma. The study has also nurtured an environment and network that encourages and strengthens the establishment of health research as one of the vital tools for achieving better health.

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Abbreviations

BHR	Bronchial hyperresponsiveness
BMI	Body Mass Index
CI	Confidence Interval
Can f 1	Dog allergen
Can f 2	Dog allergen
Fel d 1	Cat allergen
Der p 1	Dermatophagoides pteronyssinus allergen
Der f 1	Dermatophagoides farinae allergen
ECRHS	European Community Respiratory Health Survey
EQ	Environmental Questionnaire
FEV_1	Forced Expired Volume in 1 second
FVC	Forced Vital Capacity
GINA	Global Initiative for Asthma
GNP	Gross National Product
HDM	House Dust Mite
IgE	Immunoglobulin-E
ISAAC	International Study of Asthma and Allergies in Childhood
OR	Odds Ratio
PEF	Peak Expiratory Flow
PEFR	Peak Expiratory Flow Rate
POR	Prevalence Odds Ratio

Chapter 1: Introduction

1.1 Health Research in the Pacific

It has been argued that all industrializing societies undergo an "epidemiological transition", including a change from a predominance of infectious disease to "degenerative and lifestyle" non-communicable diseases. Continued globalization will mean that more populations in the Pacific, and throughout the world, will adopt Westernized diets and lifestyles (McCarty and Zimmet 2001). The dynamics of this transition in most Polynesian South Pacific islands has been relatively unprecedented. These countries are geographically scattered, with contrasting environmental, social, and political systems, and in varying stages of economic development, but all have been going through rapid transitions. Processes that took place over thousands of years in Western countries have occurred in a relatively short time in the Pacific.

The island economies in the Pacific reflect small nation states scattered at considerable distances apart as well as far away from the large economies of industrialised countries. Land mass, population and economies vary (Laplagne et al. 2001). For example, there are only a few hundred living in Niue and Tokelau in free association with New Zealand (but subsidized economies); similarly, France subsidizes the economies of the French territories of New Caledonia and French Polynesia. The relatively larger islands of Tonga with a population of just over 100,000 have an economy largely supported by overseas remittances, while the larger islands of Fiji have more industries generating employment. Natural resources are scarce apart from marine resources. Migration to New Zealand, Australia and the

United States has contributed to the dependence of Pacific economies on overseas remittances. The evolvement of social structure also varies with the inevitable integration of cultures, traditional governing systems and Western government structures. These range from a Constitutional Monarchy in Tonga, and a Republic in Fiji, to the self governing islands (in free association with New Zealand) of Tokelau, the Cook Islands and Niue.

The inhabitants of the South Pacific, though small as discrete country populations, together make up a sizable population for health research. The contrasting ethnic groups, a variety of environmental and geographical settings, different stages of socio-economic development, demographic and epidemiological transition stages have provided unique opportunities for "natural experiments" to determine the effects of social and environmental change on population health. This contributed to an influx of health researchers in the early 1960s. Most research projects were initiated and implemented by outside researchers with little emphasis on training of local researchers beyond the minimal *ad hoc* training required to conduct field work for specific projects. Thus, there has been little attempt to sustain and contribute to national capacity training in health research in the Pacific (Foliaki et al. 2004a).

The majority of these research activities focussed initially on communicable diseases such as malaria and filariasis, some of which continue to impact significantly on the region's health burden (Reeder 2003). However, the mid-1960s saw a gradual shift to non-communicable disease research with an emphasis on diabetes, cardiovascular diseases and related metabolic disorders (Foliaki and Pearce 2003a; Foliaki and Pearce 2003b). The global evidence of increasing asthma prevalence indicates that

such increases are also likely to be occurring in the Pacific. It is only recently that the importance of asthma as a major source of morbidity in the Pacific has been recognised. In fact, preliminary studies indicate (Moala and Pearce 2001) indicate that the prevalence of asthma may be higher in Pacific children in New Zealand than in the Pacific (Pattemore et al. 2004). However, little else is known about the prevalence patterns of asthma throughout the Pacific.

1.1.1 History of research in the Pacific

The earliest health research studies of Polynesians include the 1962-1964 studies of Māori and Europeans in New Zealand and Cook Islanders in Avarua and Pukapuka, which were conducted to determine the extent of cardiovascular and related metabolic problems in these populations (Prior and Davidson 1966).

Other early studies included the Tokelau Island Migrant study (Prior et al. 1974; Stanhope and Prior 1976; McKenzie et al. 1978; Stanhope et al. 1981). This was an innovative and unique study which documented the health status of virtually a whole Pacific Island state from blood pressure and fertility patterns to zinc and copper levels from islanders' toenails. The first survey was carried out in Tokelau in 1968. By 1970 a near complete record of all Tokelauans in New Zealand was available and the 1972-1973 survey made detailed examinations, including serum and urinary biochemical analysis, on virtually all Tokelauan adults and children living in New Zealand. In 1976, 2,200 Tokelauan adults and children in New Zealand and 1,580 in Tokelau were included in the next phase of the study. These studies by Prior, and also by other researchers in other Pacific Islands (Coyne 2000), clearly showed that while non-communicable diseases such as diabetes were virtually non-existent in Polynesian

populations maintaining a traditional lifestyle, the reverse was true for the urbanized Polynesian populations (Prior 1973; Zimmet et al. 1981; Zimmet and Whitehouse 1981; Taylor et al. 1985).

A second wave of health research occurred in the Pacific from the 1970s onwards. In many instances this continued to involve individual health workers and social scientists, mostly from Australia, New Zealand and the United States, working directly in the Pacific to conduct research for private or academic reasons. However, this new wave of research also involved international researchers increasingly collaborating with regional health agencies such as the South Pacific Commission and World Health Organisation. Again the emphasis was on non-communicable disease research, particularly for diabetes, cardiovascular diseases and related metabolic disorders. These studies mostly supported or validated earlier findings on the role of social and environmental change in the increase in non-communicable diseases in the region (Foliaki et al. 2004a).

The 1990s also saw Pacific Islanders, and in particular Polynesians, in the metropolitan centres such as Auckland in New Zealand (Scragg et al. 1991; Metcalf et al. 1998) participating in similar surveys on diabetes and cardiovascular diseases.

1.1.2 Non-communicable Diseases in the Pacific

The research that was conducted in the Pacific in the 1960s and 1970s clearly showed the role of increasing "westernization" in the developments of non-communicable disease in the region (Foliaki and Pearce 2003a). Rather than a "transition", we see the rise of "lifestyle" non-communicable diseases at a time when the "receding

pandemics" have not yet receded (Gaylin and Kates 1997). Even in areas where there have been few socio-economic changes to predominantly "westernized" environments, a sizable proportion of the population has migrated internally or regionally to metropolitan areas with a more pronounced westernized lifestyle. As a result, non-communicable diseases, including cancer, have become the major causes of morbidity and mortality, and are currently at epidemic levels among Pacific people both in their traditional homelands as well as in metropolitan centres of their newly adopted Western countries (Foliaki and Pearce 2003a).

Thus, cardiovascular diseases, diabetes and related metabolic disorders have been the focus and emphasis of health research in the South Pacific over the last few decades (Prior and Davidson 1966; Prior and Brauer 1979; Zimmet 1979; King et al. 1984; Zimmet et al. 1990; King and Rewers 1991).

Cardiovascular diseases are one of the leading causes of adult death in 32 of the World Health Organisation's (WHO) Western Pacific Region's 37 countries and territories (http://www.wpro.who.int/sites/ncd/overview.htm). In some Pacific communities they exceed rates in industrialised societies (Foliaki and Pearce 2003a; Foliaki and Pearce 2003b). The prevalence of Type 2 or non-insulin dependent diabetes mellitus (NIDDM) in some of the Pacific Islands (e.g. Nauru) is among the highest in the world, with up to one half of the population in the age group 30-64 years having diabetes (King and Rewers 1991).

However, although there has been a great deal of research into cardiovascular disease and diabetes, there has been relatively little research into asthma in the Pacific (Moala

and Pearce 2001). There is no reason to believe however that the increase in asthma morbidity seen in most parts of the world over the last three decades will not or is already occurring in the Pacific. It is therefore important that research into the causes and control of asthma in the Pacific is conducted. However, it is also important that this research both learns from the successes and avoids the mistakes of the past. In particular, it is crucial that asthma and other public health research in the Pacific is not yet another opportunity for "research colonialism", but instead provides opportunities for Pacific-led research and training of Pacific health researchers (Finau et al. 2000).

1.2 Overview of thesis

In this thesis, I describe a series of studies of the prevalence, causes, and management of asthma in the Pacific. In chapter two I review the clinical diagnosis of asthma and methods for measuring asthma prevalence in epidemiological surveys, including the basic methods of the International Study of Asthma and Allergies in Childhood (ISAAC) (Asher et al. 1995; Ellwood et al. 2005). I then review evidence from population-based surveys that asthma prevalence has been increasing over time in Western countries, and the limited evidence from previous studies in the Pacific. In chapter three I then review current knowledge of asthma risk factors including the "established" risk factors, the "allergen hypothesis" and the "hygiene hypothesis".

In chapters 4-7 I then review the new studies of asthma in the Pacific that were conducted for this thesis. In particular, chapter four presents the basic methodology of the ISAAC Phase III in the Pacific, for which I was the Regional Coordinator. This included new surveys in Tonga, Samoa, Fiji, the Cook Islands, Tokelau, Niue, as well as the incorporation into the analyses of data that had already been collected in French

Polynesia and New Caledonia. This study was the first to determine the prevalence of asthma in a number of Pacific Island countries using standardised methodology and instruments (written and video questionnaires). Of the few studies of asthma prevalence conducted in the Pacific conducted prior to the ISAAC study, none were comparable in either methodology or used similar instruments (see chapter two). In chapter five I present and discuss the findings for asthma prevalence, and in chapter six the findings for asthma risk factors. In chapter seven I then present the methods and findings of the Tonga Asthma Self-management Study. The project was a "follow-up" to the ISAAC study with the intention of returning benefits to the communities that had participated in ISAAC Pacific. It was intended to assess whether the introduction of asthma education, including asthma self-management plans, would reduce morbidity from asthma.

Finally, in chapter eight, I summarize the findings of the new research that was conducted for this thesis, and discuss the public health implications, the policy implications, and the priorities for future research.

Chapter 2: Asthma Prevalence

2.1 Historical

The term asthma is a Greek noun, άσθμα , which derives from the Greek verb *aazein*, *αάζειν* meaning to exhale with open mouth, to pant (Marketos and Ballas 1982). While the term was referenced for the first time in the *Iliad*, its earliest appearance in the medical context was in the *Corpus Hippocraticum.* However, medical historians are undecided on whether the Hippocratic school described asthma as an autonomous clinical entity or simply a symptom; and the leading Greek clinician, Aretaeus of Cappadocia in the 1st century B.C. was among the first to give a clinical description of asthma (Marketos and Ballas 1982). Aretaeus described the prodromal syndromes as:

> "*...heaviness of the chest; sluggishness to one's accustomed work and to every other exertion; difficulty of breathing when running or on a steep road; they [the patients] are hoarse and troubled with cough; flatulence and extraordinary movements in the hypochondrial region; restlessness; heat at night small and imperceptible; nose sharp and ready for respiration.* "

For the actual asthma attack he further gives this vivid illustration.

> "*The cheeks are ruddy, eyes protruberant, as if from strangulation; a rale can be heard during the waking state, but the evil is much worse in sleep; voice is liquid and without resonance; a desire of much and of cold air; they [the patients] eagerly go into the open air, since no house suffices for their*

respiration; they breathe standing, as if desiring to draw in all the air they can possibly inhale; and, in their want of air, they also open the mouth as if best to enjoy the more of it; pale in the countenance, except the cheeks, which are ruddy; sweat about the forehead and clavicles; cough incessant and laborious; expectoration small, thin, cold resembling the efflorescence of foam; neck swells with the inflation of the breath (pneuma); the praecordia retracted, pulse small, dense, compressed, legs slender; and if these symptoms increase, they sometimes produce suffocation after the form of epilepsy. When the crisis turns to an end, the expectoration becomes more copious and richer, the urine increases and the voice becomes louder."

More recently, Beethoven managed to compose unforgettable music while railing against the Vienna physicians who did not fare well in giving him relief from asthma (Cohen 1996), and steroids prescribed for J.F. Kennedy's Addison's disease probably helped control his asthma which plagued his entire adult life (Cohen 1998).

Both ancient Greek and Roman physicians believed that asthma was due to an internal imbalance, which could be restored by diet, plant and herbal remedies, prayers or lifestyle change. Thomas Willis and numerous workers in the nineteenth century contributed to the conclusion that the underlying cause of asthma was a spasm of the bronchial muscles (Becker 1999). Berkert in his 1878 book on asthma described the dominant theory of asthma as being a nervous disorder (Emanuel and Howarth 1995). Later, Melzer in 1910 described asthma as an anaphylactic phenomenon, thereby initiating the hypothesis that asthma was associated with allergic disorders (Becker 1999).

In modern times, two of the most influential definitions of asthma are those from the World Health Organisation (WHO) and the Global Initiative for Asthma (GINA)

The WHO definition (WHO 1975) states that asthma:

> *"is a disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. In an individual, they may occur from hour to hour and day to day and is due to inflammation of the air passages in the lungs and affects the sensitivity of the nerve endings in the airways so they become easily irritated. In an attack, the lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs."*

The GINA definition for asthma (GINA 1995) states that:

> *"Asthma is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role. The chronic inflammation causes an associated increase in airway hyperresponsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment."*

This is a broad definition based on the characteristics of the disease as a consequence of inflammation. Thus, currently there is general consensus that asthma is a

consequence of chronic inflammatory processes and remodelling of the airways (Kariyawasam and Robinson 2005). The cornerstone of asthma management has therefore recently shifted from focussing on relieving bronchial smooth muscle spasm (bronchospasm) to an emphasis on managing the chronic inflammatory processes and mediators now recognised as playing a vital role in asthma.

Despite many advances in our understanding of underlying pathways leading to asthma, morbidity and deaths from asthma have either not declined or in some populations increased during the 1980's. However, recent reports from mostly high income countries indicate that trends in the burden from asthma may have levelled off or even reversed while the rate of reported diagnoses has continued to increase (Weiland and Pearce 2004a; Zollner et al. 2005). The increase in the latter, in the absence of an increased symptom prevalence, may reflect an increased diagnosis of asthma whereas previously many people with asthma symptoms were not diagnosed as asthmatic.

2.2 Clinical Diagnosis of Asthma

2.2.1 Introduction

The above definitions thus emphasise asthma as a chronic inflammatory disorder of the airways and consequently have implications for its diagnosis, prevention and management.

Asthma, as a condition, manifests signs and symptoms that are both intermittent and partially or totally reversible. These manifestations further align themselves according

to phenotypes, specific causative factors and aetiological pathways. It is not surprising, therefore, that there is no agreed definition for asthma. Neither is there a single test that is definitive of asthma (Pearce et al. 1998).

2.2.2 History and Symptoms

Despite the non-specificity nature of the symptoms and physiological signs described above, and the disagreement about the definitions of asthma, the clinical diagnosis of asthma is usually based on a combination of a characteristic history of symptoms of recurrent reversible airway obstruction such as wheezing, chest tightness, cough, dyspnoea; and physical signs (Sistek et al. 2001). A history of spontaneous reversibility of symptoms, or reversibility in response to bronchodilators, and associations of symptoms with exercise, exposure to airborne allergens and pollutants, seasonal variability of symptoms and a family history of asthma and atopic disease are also useful markers. Although the clinical diagnosis of asthma is usually based on the case history and basic clinical signs, other methods that may supplement the case history and physical signs are occasionally used in practice. These are discussed in the remainder of this section.

2.2.3 Physical Examination

The intermittency and variability of the symptoms of asthma can result in the respiratory system appearing normal on physical examination, interval phase, and the common sign of wheezing or decreased air entry being undetected on auscultation. Furthermore, the characteristic symptoms of wheezing may be absent with increasing severity, and progression of the disease usually yields other physical signs such as,

tachycardia, hyperinflated chest, use of accessory muscles, cyanosis, drowsiness, and difficulty speaking (Sistek et al. 2001).

2.2.4 Lung function measurements

While measurement of lung function is an objective method of measuring air flow limitation, in and of itself it does not provide a diagnosis of asthma, without relevant clinical features on history and examination. After lung function measurement became fashionable in the 1990s, current paediatric guidelines have de-emphasised its utility in New Zealand for children between the ages 1-15 years old (Paediatric Society of New Zealand 2005) and Australia (National Asthma Council Australia 2006) for children under 12 years old. The development of the simple spirometer by the British surgeon (John Hutchinson) around 1850 for his research in respiratory physiology has now advanced technologically to an electronically digitalized form for monitoring most aspects of lung dynamics; such as airways resistance, conductance and variability of airways obstruction. Its accessibility from doctor's offices to field surveys has led to the increasing utilisation of physiological measures in individuals. Two of the more widely used methods (in patients over 5 years old) include the measurement of Forced Expired Volume in 1 second (FEV_1) (and the related Forced Vital Capacity (FVC)) measurement by spirometry and the measurement of peak expiratory flow (PEF) using peak flow meters.

Thus, a wide variety of methods exists for assessing pulmonary airflow dynamics in relationship to asthma, and recommendations for the diagnosis of asthma based on spirometry (measuring FEV_1, and FVC) and PEF have been published (GINA 1995). An improvement of at least 12% in FEV_1 either spontaneously, following inhaled

bronchodilator, or in response to a trial of corticosteroids, has been used as an indicator favouring a diagnosis of asthma (Pearce et al. 1998). Various indices of PEF are used as guidelines for a diagnosis of asthma including an improvement of at least 15% after inhalation of a bronchodilator or in response to a trial of corticosteroid therapy, or a diurnal variation in PEF of more than 20% (GINA 2005).

However, the use of pulmonary airflows as a tool for the clinical diagnosis of asthma is not routine. The main reason for this is that asthma involves variable airways obstruction, i.e. a decrease in lung function which "comes and goes". Most asthmatics have normal lung function most of the time, and measurement of lung function on a particular day therefore has very little diagnostic value for asthma. What is required are repeated daily measurements of lung function over a period of several weeks, and this is rarely feasible in clinical practice (or in epidemiological studies).

Nevertheless, measurement of PEF has become a tool that can now be used by patients in their homes for day-to-day objective monitoring and management of asthma. However, the tendency of PEF values to remain relatively unaffected, despite deteriorating lung function, in comparison to spirometry in patients with airflow limitation, makes PEF less sensitive in such situations (GINA 2005).

2.2.5 Airway Responsiveness

Measurements of bronchial hyperresponsiveness (BHR) when challenged with specific stimuli have increasingly been used in population surveys, but these are rarely used in the clinical setting (Pekkanen and Pearce 1999; Pearce et al. 2000a). The measurement by convention is the provoking dose of bronchial challenge of varying stimuli (including inhalation of histamine, methacholine, and cold dry air) that produces a 15-20% fall in FEV_1. A related continuous measure that is equally useful is the dose-response slope..

The sensitivity and specificity of BHR testing varies with the particular test used (Burney et al. 1987). Furthermore, BHR is one physiological marker for one specific aspect of asthma and the degree of hyperresponsiveness does not correlate consistently with disease severity (Josephs et al. 1990; Stein et al. 1997; Pearce et al. 1998), and does not validate well against clinical asthma diagnosis (Pattemore et al. 1990).

2.2.6 Other measures

A further measure, though rarely used clinically, is the evaluation of airway inflammation associated with asthma (GINA 1995), including sputum analysis for eosinophils, metachromic cells as well as other inflammatory markers including nitric oxide (NO) and carbon monoxide (CO). While skin testing or measurement of specific Immunoglobulin-E (IgE) may identify an allergic component it adds little to the diagnosis of asthma in individuals (Pearce et al. 1998).

2.3 Measuring Asthma Prevalence

2.3.1 Introduction

Despite an abundance of studies on the prevalence and burden of asthma in a wide range of populations, different regions and time frames, the lack of precise definitions of asthma and standard instruments and methods for measuring asthma prevalence has made comparisons problematic. Furthermore, as discussed above, there is no agreed clinical definition or single test for asthma. These problems have encouraged further efforts at seeking physiological and pathological markers of asthma. These are often considered to be more "objective", with questionnaires portrayed as being less "objective". However, Jenkins *et al* found a higher Youden's index for self-reported symptoms than BHR in both children and adults (Jenkins et al. 1996), and there is a poor overall correlation of BHR with clinically diagnosed asthma (Pattemore et al. 1990). Moreover, such "objective measures" are often impractical in large epidemiological surveys, as well as having poor validity as measures of asthma (Pearce et al. 2000a).

The continuing debate on the validity of one definition of asthma over another is thus complicated by the absence of a so-called "gold standard" test. Despite this, a physician's clinical diagnosis of asthma is normally straightforward from a combination of a typical history of intermittent and reversible symptoms and signs of airway obstruction. This therefore represents the most appropriate "gold standard" for validating instruments for use in epidemiological surveys of asthma (Pearce et al. 2000a).

2.3.2 Questionnaires

The preferred method for identifying asthma cases in epidemiologic surveys depends on the type of study as well as the aim of such a study (Pearce et al. 2000a). In general, Youden's Index provides the best measure of validity for population prevalence surveys (Pekkanen and Pearce 1999). In this regard, the available evidence indicates that symptom questionnaires have good validity for the measurement of asthma prevalence in population surveys (Pekkanen and Pearce 1999). For example, Jenkins *et al* reported a higher value of Youden's Index for symptom questionnaires (0.76) than for BHR test results with hypertonic saline (0.29) in relation to the "gold standard" of physician diagnosed asthma among 28-44 year old adults (Jenkins et al. 1996).

Thus, symptom questionnaires are regarded as the cornerstone of epidemiological studies of asthma prevalence among and between populations and over time (Pearce 1998). Written questionnaires may not be restricted to symptomatic definitions and may also include diagnosis-based definitions (history of medically certified diagnosis of asthma) and history of use of asthma medication.

The multitude of symptoms associated with, but not specific to, asthma provides the added complication of deciding on which symptoms are to be included in a questionnaire without unduly lengthening the questionnaire and the time and cost of administering it. In practice, most epidemiological studies have found that general questions on wheeze have the best Youden's Index when validated against BHR (Burney et al. 1989; Jenkins et al. 1996; Pekkanen and Pearce 1999), and others find

specifically that "wheezing in the last 12 months" is the most important single question for identifying current asthma symptoms (Pearce 1998).

The ECRHS Questionnaire

The most commonly used asthma symptom questionnaire in adults is that developed for the European Community Respiratory Health Survey (ECRHS) (Burney et al. 1989) (figure 2.1). This is based on the International Union Against Tuberculosis and Lung Disease (IUATLD) bronchial symptoms questionnaires (Burney et al. 1994). It was initially developed in English, and has now been translated into many languages, using translation and back-translation. The questions primarily relate to asthma symptoms and medication use during the previous 12 months (see Figure 2.1).

Figure 2.1: Phase 1 screening questionnaire for the European Community Respiratory Health Survey (ECRHS)

TO ANSWER THE QUESTIONS PLEASE CHOOSE THE APPROPRIATE BOX. IF YOU ARE UNSURE OF THE ANSWER PLEASE CHOOSE 'NO'.

1. Have you had a wheezing or whistling in your chest at any time in the last 12 months? IF 'NO' GO TO QUESTION 2, IF 'YES'

   1.1 Have you been at all breathless when the wheezing noise was present?

   1.2 Have you had this wheezing or whistling when you did not have a cold?

2. Have you woken up with a feeling of tightness in your chest at any time in the last 12 months?

3. Have you been woken by an attack of shortness of breath at any time in the last 12 months?

4. Have you been woken by an attack of coughing at any time in the last 12 months?

5. Have you had an attack of asthma in the last 12 months?

6. Are you currently taking any medicine (including inhalers, aerosols or tablets) for asthma?

7. Do you have any nasal allergies including hay fever?

8. What is your date of birth?

9. What is today's date?

10. Are you male or female?

The ISAAC Questionnaire

A similar questionnaire has been developed for use in children for the International Study of Asthma and Allergies in Childhood (ISAAC) (Asher et al. 1995). Figure 2.2 shows the standard ISAAC questionnaire which is used for self-report by 13-14 year old and parental reporting for 6-7 year old children.

Figure 2.2: ISAAC asthma symptom questionnaire

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1. Have you ever had wheezing or whistling in the chest at any time in the past?
   Yes [ ] No [ ]
   IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

2. Have you had wheezing or whistling in the chest in the past 12 months?
   Yes [ ] No [ ]
   IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

3. How many attacks of wheezing have you had in the past 12 months?
   None [ ] 1 to 3 [ ] 4 to 12 [ ] More than 12 [ ]

4. In the past 12 months, how often, on average, has your sleep been disturbed due to wheezing?
   Never woken with wheezing [ ]
   Less than one night per week [ ]
   One or more nights per week [ ]

5. In the past 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?
   Yes [ ]No [ ]

6. Have you ever had asthma?
   Yes [ ]No [ ]

7. In the past 12 months, has your chest sounded wheezy during or after exercise?
   Yes [ ]No [ ]

8. In the past 12 months, have you had a dry cough at night, apart from a cough associated with a cold or chest infection?
   Yes [ ]No [ ]

Figure 2.3: ISAAC asthma video questionnaire

Scene One:	**The first scene is of a young person at rest**
Question One:	Has your breathing been like this, at any time in your life?
If Yes	Has this happened in the past year?
If Yes	Has this happened one or more times a month?
Scene Two	**The second scene is of two young people exercising. One is in a dark shirt and the other is in a white shirt.**
Question Two:	Has your breathing been like the boy's in the dark shirt During or following exercise at any time in your life?
If Yes	Has this happened in the past year?
If Yes	Has this happened one or more times a month?
Scene Three	**The third scene is of a young person waking at night.**
Question Three:	Have you been woken at night this at any time in your life?
If Yes	Has this happened in the past year?
If Yes	Has this happened one or more times a month?
Scene Four	**The fourth scene is also of a young person waking at night.**
Question Four:	Have you been woken at night this at any time in your life?
If Yes	Has this happened in the past year?
If Yes	Has this happened one or more times a month?
Scene Five	**The final scene is of another person at rest.**
Question Five:	Has your breathing been like this at any time in your life?
If Yes	Has this happened in the past year?
If Yes	Has this happened one or more times a month?

ISAAC Video Questionnaire

The problems of cultural and language differences in interpretation and translation of asthma questionnaires have led to the development of a video questionnaire to supplement the core written questionnaire on asthma symptoms (Shaw et al. 1992). This is essentially a video questionnaire for 13-14 old year children, involving the presentation of audio-visual signs and symptoms of asthma. The questionnaire involves five sequences of clinical asthma symptoms in young persons: wheezing at rest; wheezing after exercise; waking with wheezing; waking with cough; a severe asthma attack. After each sequence, participants are asked whether their breathing had ever been like that of the person in the video; if so they are asked whether this had occurred in the last year, and whether this had occurred one or more times a month. The words "wheeze" and "asthma" are not used in the video. For Phase I of ISAAC, a first version of the video produced in New Zealand involving Caucasian asthmatics was used in 33 centres (Asher et al. 1998). The international version, featuring asthmatics from various ethnic groups, was subsequently developed and used in other centres. For the Pacific region (i.e. the current study) the international version was used. The questions are shown in Figure 2.3.

2.3.3 Other measures used in prevalence surveys

The evaluation of associated aetiological factors in clinical settings, ranging from bronchial responsiveness testing, to skin testing, sputum analysis and serum IgE analysis, add to other measures sometimes advocated for measuring asthma prevalence (Pearce et al. 1998). However, these measures may have poor validity for clinical asthma, and may be more relevant to determining which aetiological

mechanisms are involved (e.g. asthma involving or not involving BHR, atopic or non-atopic asthma) than to determining asthma prevalence itself. Furthermore, they are rarely practicable in large population surveys (Pearce et al. 2000a).

2.3.4 Conclusions

In conclusion, as a condition, asthma has no standard definition, neither is there a single test or pathological feature that is diagnostic for asthma in individuals. While a physician diagnosis of asthma may be seen as the "gold standard" to ascertain asthma prevalence, it also has its limitations in epidemiological surveys, including the need for access to health facilities, the lack of agreed criteria for clinical diagnosis, and the problems of diagnosing a condition with signs and symptoms that are reversible and intermittent.

From an epidemiological perspective, however, the objective is to determine the occurrence of asthma in the population, rather than specifically diagnosing individuals with asthma. This has meant that epidemiological studies of asthma have relied on definitions and methodologies that are simple, logistically sound, feasible and cost effective, yet valid. Hence most large epidemiological studies utilise simple validated symptomatic questionnaires, in some instances supplemented by other measures such as bronchial hyperresponsiveness testing.

The decision as to whether to use questionnaires, other epidemiological instruments, or a combination of two or more instruments, should be dictated by the aims of the epidemiological study. In instances where the epidemiological study aims at determining patterns or time trends of symptoms of asthma, rather than the number of

individuals with a clinical diagnosis of asthma, simple, practical and valid methods such as questionnaires are appropriate (Pekkanen and Pearce 1999). The need for repeated contacts with large numbers of study participants, and the response rates needed for prevalence studies, are further disadvantages in utilising other methods (physiological, aetiological, clinical).

One of the potential drawbacks of questionnaires is the potential for variations in translations. Questionnaires invariably will encounter difficulties in standardization when translations are required for use in different social and ethnically diverse populations. In particular, there may be varying degrees of differing cultural contexts or the absence of specific appropriate terms for some symptoms or conditions. The translation of the standard ISAAC questionnaire from English to other languages follows ISAAC standard guidelines outlined in the ISAAC Phase Three Manual (ISAAC 2000). An archive of translated questionnaires to various languages used in ISAAC Phase One is available, and where no previous translations for other languages are available, translations are done by one or more persons who are bilingual and familiar with the area. Specific translation of health terms and symptoms are to be obtained from local appropriate health personnel, children with asthma and their parents. The appropriate translated questionnaire is to be agreed upon by national experts and back translated to English by an independent translator and pilot tested. The video questionnaire used by ISAAC in combination with the written questionnaire has also helped alleviate translation problems and has been increasingly accepted in assessing asthma burden in population studies (Shaw et al. 1992).

Pearce *et al*, among others (Pearce et al. 1993), therefore advocate that while there may be no 'gold standard' for defining and measuring asthma prevalence, for studies involving large sample sizes with high response rates, it is most appropriate to use simple, inexpensive and practical methods which are as sensitive and as specific for asthma as possible. Such methods include simple asthma symptom questionnaires.

2.4 Studies of Asthma Prevalence

2.4.1 Introduction

Asthma prevalence studies may form the basis for developing hypotheses about the causes of asthma, as well as providing background information for the development of preventive strategies and management guidelines. The lack of standardization, however, in disease definition and study methodologies limits the comparability of prevalence estimates and other results from various studies between populations, time frames and between countries and regions. Despite the lack of a standardized definition for asthma, there is evidence of substantial worldwide increases in asthma prevalence both from descriptive markers of wheeze, airway hyperresponsiveness and doctor diagnosis from epidemiological studies in recent years (Anderson et al. 1994; Pearce et al. 2002).

The European Community Respiratory Health Survey (ECRHS) and the International Study of Asthma and Allergies in Childhood (ISAAC) have played major roles in measuring the prevalence and severity of asthma within and between populations by their use of standardised methodologies for asthma prevalence surveys.

2.4.2 Global Comparisons

The European Community Respiratory Health Survey (ECRHS)

The European Community Respiratory Health Survey (Burney et al. 1994) had as its objectives:

1. To estimate the variation in the prevalence of asthma, asthma-like symptoms and bronchial liability in Europe.
2. To estimate variation in exposure to known or suspected risk factors for asthma; to measure their associations with asthma; and to further assess the extent to which they may explain variations in prevalence across Europe.
3. To estimate the variation in treatment practices for asthma in the European Community.

Existing administrative areas with a population of at least 150,000 were selected, and a postal questionnaire (see Figure 2.1) was sent to at least 3000 participants aged 20 to 44 years, seeking information on asthma symptoms and medication use. Individuals were defined as asthmatic if they answered 'yes' to any one of the following questions relating to the previous 12 months: (i) waking with an attack of shortness of breath (question 3); (ii) an asthma attack (question 5); (iii) or current asthma medications (question 6). The symptoms and medical history questionnaire were taken from the bronchial symptoms questions of the International Union Against Tuberculosis and Lung Diseases (IUATLD) questionnaire (Burney et al. 1994). The questionnaire also sought information on occupation, social factors, smoking, home environment,

medication and health service usage. These questions were based on pre-existing questionnaires previously used in multi-national studies.

A random sub-sample of 600 subjects and an additional sample of up to 150 'asthmatic' individuals were then studied in more detail in Phase II, with measurements of skin prick test to common allergens, serum total and specific IgE, bronchial responsiveness, lung function, and questions on asthma symptoms, medical history, occupation and social status, smoking, the home environment and the use of medications and medical services. Skin-prick testing (SPT) was conducted for selected allergens for all centres, as well as additional locally important allergens where indicated. Lung function testing was based on the Forced Expired Volume in one second (FEV_1) and Forced Vital Capacity (FVC). Immunoglobulin-E (IgE) assays were also determined, and a methacholine challenge was also carried out.

The European Community Respiratory Health Survey (ECRHS) was in the forefront in assessing geographical variation in asthma, allergy, and allergic sensitization in adults using standardized survey methodology. Prior to the ECRHS, a number of studies had identified variations in asthma prevalence, but such findings were limited for comparative purposes due to these studies having used different study designs including a variety of different questionnaires and definitions.

In the ECHRS, standardised nformation was obtained from approximately 140,000 individuals from 22 countries extending from the United Kingdom and Northern Europe to Central and Southern Europe, the Indian continent, the United States, Australia and New Zealand (Janson et al. 2001). The ECRHS found that the

prevalence of asthma varies widely (2.0 - 11.9%) with both strong regional and within country differences in prevalence. The lowest prevalences were seen in the Eastern and Middle European countries followed by the Mediterranean region. The highest prevalences were reported for all English speaking centers. The geographical pattern of asthma symptoms was generally consistent with the distribution of atopy and bronchial responsiveness (Janson et al. 2001).

Environmental exposures, in particular indoor factors and exposures at the workplace, were found to be strongly associated with asthma in adulthood (Janson et al. 2001). The association between sensitization to individual allergens and bronchial responsiveness was strongest for indoor allergens (house dust mite and cat).

International Study of Asthma and Allergies in Childhood (ISAAC)

The International Study of Asthma and Allergies in Childhood (ISAAC) Phase One (Asher et al. 1995) had as its objectives:

1. To describe the prevalence and severity of asthma, rhinitis, and eczema in children living in different centres, and to make comparisons within and between countries.
2. To obtain baseline measures for assessment of future trends in the prevalence and severity of these diseases.
3. To provide a framework for further etiologic research into lifestyle, environmental, genetic and medical care factors affecting these diseases.

Phase I of the study aimed to obtain an overview of the global distribution of the prevalence and severity of asthma, rhinitis and eczema in children and was carried out in schoolchildren of two age groups: 6-7 years and 13-14 years (Asher et al. 1995). It had a simple and inexpensive design so as to encourage maximum participation from as many centres as possible from around the world. At the same time, the quality of the data was ensured by standardisation of the investigative tools used and a uniform approach to sampling of subjects. As noted above, the Phase I tools (see Figure 2.2) comprised a set of standardised written questionnaires relating to asthma, rhinitis and eczema for self-completion by the 13-14 years old schoolchildren, and for completion by parents/carers of the 6-7 years old children. The older age-group was chosen to reflect the period when morbidity from asthma is common and to enable the use of a self-completed questionnaire. The younger age-group was chosen to give a reflection of the early childhood years.

Standardized methods of translation and back-translation were used to attempt to ensure comparability of the findings across different populations and language groups (Weiland 1994). In addition, the video questionnaire (see Figure 2.3) described above was used in the 13-14 year olds in an attempt to overcome the problems associated with translation of the written questionnaire.

For each participating centre the survey was conducted within a specified geographical area (ISAAC Centre), for which a map was provided. Each ISAAC centre was most commonly a city, but occasionally was a region within a country (e.g. in the United Kingdom), or a whole country (e.g. Costa Rica). The school selection

within the sampling frame was either all schools within the age group (33% centres) or a random sample of schools (67% centres) (Beasley et al. 1998).

By the time that the main Phase I study findings were published in 1998 (Beasley et al. 1998), nearly half a million 13-14 year old schoolchildren from 156 centres in 56 countries of diverse ethnic and cultural background had completed Phase I of the study. About one half of the centres also conducted the survey in 6-7 year olds. Striking variations in the prevalence of asthma symptoms were observed between different populations, with up to 15-fold differences seen between countries and smaller differences within individual countries. The prevalence of self-reported wheezing in the previous 12 months (current wheeze) ranged from 2.1% to 32.2% in the older age group and from 4.1% to 32.1% in the younger age group.

The highest prevalences of asthma symptoms were seen in English-speaking countries, i.e. the British Isles, New Zealand, Australia, Canada and USA. While differences in language or labeling of symptoms such as wheeze may contribute partly to the observed international differences, the fact that similar patterns were observed with the video questionnaire suggested that these differences were real (Asher et al. 1998). Furthermore, the European Community Respiratory Health Survey (ECRHS) also reported that asthma symptoms were most prevalent in adults of English-speaking countries (ECRHS. 1996), and the two surveys (ECRHS and ISAAC) generally showed similar prevalence patterns (Pearce et al. 2000c).

High prevalences of asthma symptoms were also found in some non-English speaking countries, with differences between countries sharing the same language; e.g. Peru

and Costa Rica had a higher prevalence than Spain, and Brazil had a higher prevalence than Portugal.

Even populations of similar ethnicity showed differences in asthma symptom prevalence. In particular, schoolchildren in Hong Kong had four times the asthma symptom prevalence of their counterparts in Guangzhou, a city in mainland China just 150 miles north of Hong Kong, using the same language and having similar climate (Asher et al. 1998). These findings strongly support an important role for environmental factors rather than genetic factors in the causation of asthma (Lai and Pearce 2001).

In general, the prevalence of asthma symptoms is higher in the more affluent countries than in developing countries (Pearce and Douwes 2006). In Europe, asthma prevalence in Western Europe was higher than that in the less affluent countries in Eastern and Southern Europe. A similar pattern was seen in Southeast Asia where the most affluent countries (Japan & Hong Kong) had higher prevalence rates of asthma symptoms than the least affluent countries (China & Indonesia).

ISAAC Phase II involved more detailed investigations in 30 study centres in 22 countries (Weiland et al. 2004a), but the results had not been published at the time of preparation of this thesis.

ISAAC Phase III involved a repeat of Phase I to enable the time trends of symptom prevalence to be determined, as well as the incorporation of new centres to enable the development of a more comprehensive "world map" (Ellwood et al. 2005). It involved

approximately 250 centres in 100 countries. To date, only the global ISAAC time trends findings, in the 106 centres that completed both Phase I and Phase III, have been published (Asher et al. 2006; Pearce et al. 2007). These analyses showed that international differences in asthma symptom prevalence have reduced, particularly in 13-14 year olds, with decreases in prevalence in English speaking countries and Western Europe and increases in prevalence in regions where prevalence was previously low (Asher et al. 2006; Pearce et al. 2007). Although there was little change in the overall prevalence of current wheeze, the percentage of children reported to have had asthma increased significantly, possibly reflecting greater awareness of this condition and/or changes in diagnostic practice. The authors concluded that the increases in asthma symptom prevalence in Africa, Latin America and parts of Asia indicated that the global burden of asthma is continuing to rise, but the global prevalence differences are lessening.

A particularly interesting feature of the ISAAC Phase III time trends data is that asthma symptom prevalence has peaked, and may have even begun to decline, in English-speaking countries such as New Zealand, Australia (Robertson et al. 2004), and the United Kingdom (Anderson et al. 2004). Similar patterns have been observed in other recent studies in adults in Europe (Weiland and Pearce 2004b). The reasons for this "levelling off" of the increases in asthma prevalence are unclear, just as the reasons for the increase itself remain unclear (Asher et al. 2006; Pearce et al. 2007).

2.4.3 Other Studies

Prior to ECRHS and ISAAC, very few studies had been conducted to comprehensively compare asthma prevalence between populations within countries,

or globally between countries or regions. Studies from the United States (Grant et al. 1999) showed clear geographic variations in asthma morbidity and mortality, as did studies comparing communities in Australia, New Zealand and the United Kingdom (Asher et al. 1988; Strachan et al. 1990).

More recently, Faniran *et al* found higher prevalence of asthma symptoms among Australian as compared to Nigerian 8-11 year old schoolchildren - essentially a comparison of an affluent and a non-affluent country (Faniran et al. 1999).

Table 2.1: Changes in asthma prevalence in children and young adults

Country	Period	1st study	2nd study	Reference
Australia	1964-1990	19.1%	46.0%	(Robertson et al. 1991)
	1982-1992	12.9%	19.3%	(Peat et al. 1994)
Canada	1980-1983	3.8%	6.5%	(Infante-Rivard et al. 1987)
England	1956-1975	1.8%	6.3%	(Morrison Smith 1976)
	1966-1990	18.3%	21.8%	(Whincup et al. 1993)
	1973-1986	2.4%	3.6%	(Burney et al. 1990)
	1978-1991	11.1%	12.8%	(Anderson et al. 1994)
	1990-1998	11%	19%	(Kuehni et al. 2001)
Finland	1961-1986	0.1%	1.8%	(Haahtela et al. 1990)
France	1968-1982	3.3%	5.4%	(Perdrizet et al. 1987)
India	1979-1999	9%	29.5%	(Paramesh 2002)
Kenya	1995-2000	10.2%	13.8%	(Esamai et al. 2002)
Israel	1986-1990	7.9%	9.6%	(Auerbach et al. 1993)
Japan	1982-1992	3.3%	4.6%	(Nishima 1993)
	1981-1990	3.0%	5.1%	(Senthilselvan et al. 2003)
New Zealand	1969-1982	7.1%	13.5%	(Mitchell 1983)
	1975-1989	26.2%	34.0%	(Shaw et al. 1990)
	1985-1991	7.0%	9.9%	(Mitchell and Asher 1994)
Papua New Guinea	1973-1984	0.0%	0.6%	(Dowse et al. 1985)
Scotland	1964-1989	10.4%	19.8%	(Ninan and Russell 1992b)
	1989-1994	10.2%	19.6%	(Omran and Russell 1996)
Sweden	1971-1981	1.9%	2.8%	(Ahlberg 1989)
Tahiti	1979-1984	11.5%	14.3%	(Liard et al. 1988b)
Taiwan	1974-1985	1.3%	5.1%	(Hsieh and Shen 1988)
USA	1971-1976	4.8%	7.6%	(Gergen et al. 1988)
	1981-1988	3.1%	4.3%	(Weitzman et al. 1992)
Wales	1973-1988	4.0%	9.0%	(Burr et al. 1989)

Source: Adapted from (Pearce et al. 1998)

There are a number of other studies (using various methodologies) in which the same methodology has been used to measure asthma prevalence in the same location at two or more different points in time. These studies are summarized in Table 2.1.

Early reports from the United Kingdom indicated a modest increase from 11.1% to 12.8% in the 12-month prevalence of wheezing among primary school children between 1978 and 1991 (Anderson et al. 1994). Between 1990 and 1998, parent-completed questionnaires in Caucasian children (1-5 years; Leicester County; UK) showed significant increases in the prevalence of reported wheeze ever (16% to 29%), current wheeze (12% to 26%) and diagnosis of asthma (11% to 19%) (Kuehni et al. 2001). This is further supported by other studies from the United Kingdom, which have consistently shown increased prevalence in most measures of wheeze and/or asthma (Ninan and Russell 1992a; Venn et al. 1998a).

Asthma has also been on the rise in the United States since the 1970s. Evans *et al* (Evans et al. 1987) found that hospitalization rates for asthma between 1965 and 1984 had increased by 50 percent in adults and by over 200 percent in children. While there was a smaller increase in overall prevalence of the disease in the United States for the period under study it was shown that this increase was more so in children under the age of 17. The United States Centre for Disease Control (http://www.cdc.gov/mmwr/preview/mmwrhtml/00035450.htm) indicate that from 1982 to 1992, the overall age-adjusted prevalence rate of self-reported asthma in the United States increased by 42%.

Among the initial attempts to systematically determine trends in asthma prevalence in the United States was the Kaiser Permanente, Northwest Division (Portland) report for the period 1967-1987. It showed the treated prevalence of asthma increasing steadily and significantly in both sexes in all age ranges except males over 65 years of age (Grant et al. 1999; Von Ehrenstein et al. 2000).

Direct comparisons of asthma trends between the United States and international findings are limited due to different standards and definitions. The rising asthma figures in the United States since the 1970's however suggest that the US increases in prevalence and mortality rates may reflect worldwide patterns (Sly 1984).

A hospital based study on 20,000 children under 18 years of age throughout the years 1979,1984,1989,1994 and 1999 in the city of Bangalore (India) showed a steady and significant increase in asthma prevalence of 9%, 10.5%, 18.5%, 24.5% and 29.5% respectively (Paramesh 2002).

Studies from New Zealand showed similar increases. In particular, Mitchell and Asher also reported an increase in the prevalence of asthma symptoms between 1985 and 1991 among European school children in New Zealand (Mitchell and Asher 1994).

Studies among 5 to 11 year old Scottish and English school children between 1982 and 1993 reported that the prevalence of asthma and persistent wheeze was increasing (Rona et al. 1995). There have also been reports of significant rises in prevalence of wheeze and diagnosed asthma among Aberdeen school children as well as among Japanese children (Nakagomi et al. 1994; Omran and Russell 1996).

These studies provide clear evidence that the prevalence in asthma worldwide has increased markedly over the last three decades. This trend for increasing asthma prevalence has been replicated in both 'developed' and 'less developed' countries, as well as in populations previously with low asthma prevalence, reflecting a major health, economic and social burden in both young and adult age groups in a wide variety of populations and regions.

2.4.4 Conclusions

In summary, studies that have used standardised methodology at different points in time indicate that asthma prevalence has been increasing in both developed and developing countries in recent decades. This evidence has recently been supported by the much more comprehensive evidence from the ISAAC Phase III study (Asher et al. 2006; Pearce et al. 2007), which has indicated that the prevalence of asthma symptoms in children has continued to increase on a global scale, but that prevalence appears to have levelled off, or even begun to decline, in ISAAC centres in English-speaking countries. As discussed above, the reasons for these patterns and time trends are currently unclear.

2.4.5 Studies in the Pacific

While considerable research has been done on asthma prevalence and access to asthma care among European and Māori, information on the prevalence and severity of asthma in Pacific people in New Zealand is currently sparse (Moala and Pearce 2001). In New Zealand, asthma prevalence in Pacific children is similar to, or lower than, that in non-Polynesian children, whereas in adults the prevalence is higher in

both Pacific and Māori people. Asthma is more severe in Pacific people and Māori, with a higher frequency of hospitalizations. The available evidence also indicates that the greater severity, and the greater adult prevalence, in Pacific people may be partly or wholly due to problems of access to culturally appropriate asthma health care and asthma education (Moala and Pearce 2001).

Previous studies in the Pacific have included those carried out by Liard *et al* among teenagers attending school in Tahiti (Liard et al. 1988a). This study used similar questionnaires for surveys in 1979 and 1984 (see Table 2.1), and found that asthma prevalence had increased in Tahiti with no differences in time trends among the predominant ethnic groups (European, Chinese and Polynesian). A sample of 1,007 nonasthmatics, from the original 6731 pupils who participated in the prevalence study, were further selected for lung function tests. These found that the Polynesian pupils had lower mean ventilatory functions than the non-Polynesians (Neukirch et al. 1988)

Flynn's studies of 5-14 year old children in Fiji (Flynn 1994a), on the other hand, found asthma admission rates (as well other markers of asthma prevalence) to be three times higher in Fiji Indians than in Melanesian Fijians. While the prevalence of wheeze in the previous 12 months among 2,173 Suva City school children was identical in both ethnic groups (20.6%), bronchial hyperresponsiveness was twice as common in Indians as Fijians. The combination of current wheeze and bronchial hyperresponsiveness was also three times higher among Indian children. Flynn suggests that the higher admission rates could be explained by Indians having more severe asthma than Fijians due to genetic or environmental factors acting independently of atopy (Flynn 1994b; Flynn 1994a).

Of 706 children examined in Tokelau (Waite et al. 1980), 11% were classified as asthmatic compared to 25% of 1,160 Tokelauan children living in New Zealand. Of the children examined in New Zealand, there was no significant difference in the prevalence of asthma between those children who were born in New Zealand and those who were born in Tokelau. For Tokelauan boys examined in New Zealand, there were significant differences in 'definite' asthma prevalence with age, decreasing from 58% among the 5-year old group to 28% and 14% for the 5-9 year old and 10-14 year old groups respectively. A similar decrease in prevalence with age was found in girls although this was not statistically significant. The prevalences of a variety of conditions/symptoms such as a positive history of asthma, rhonchi, rhinitis or eczema were also higher among Tokelauan children in New Zealand than in children in Tokelau. Although no specific risk factors were studied, the associations of these conditions with a changing environment were areas identified for further investigation. More recently, Lane *et al* (Lane et al. 2005) reported that Tokelau has a natural low allergen environment due to its well ventilated open-type houses, and small atolls at sea level sustaining little flora and fauna, with no common grasses and no domestic cats or dogs. Dust samples from 76 dwellings and four public buildings showed that mean Der p 1 levels were 1000-fold lower in Tokelau compared to those from 30 Tokelauan households in Wellington, New Zealand. These low allergen levels as well as a significantly higher bed endotoxin levels in Tokelau, were reported as possible explanations for the lower prevalence of asthma and atopy in Tokelau compared to New Zealand.

2.5 Discussion

In summary, the available evidence indicates several key features of asthma in Pacific people (Moala and Pearce 2001). In New Zealand, asthma prevalence in Pacific children is similar to, or lower than, that in non-Polynesian children, whereas in adults the prevalence is higher in both Pacific and Māori people. Asthma is more severe in Pacific people and Māori with a higher frequency of hospitalizations.

There is some evidence that the prevalence of asthma may be higher in Pacific children in New Zealand than in the Pacific (Pattemore et al. 2004), but little else is known about the prevalence patterns of asthma throughout the Pacific. The only Pacific countries that participated in ISAAC Phase I, among the more than 155 centres in 56 countries worldwide, were Australia and New Zealand.

Therefore, systematic standardised prevalence studies, such as ISAAC Phase III studies, would be valuable in assessing the patterns and extent of asthma morbidity throughout the Pacific. Such studies were the subject of this thesis. In particular, the methods and findings of the ISAAC Phase III studies in the Pacific are discussed in chapters 4-6. However, before proceeding to discuss ISAAC Phase III in the Pacific, I first review current knowledge of asthma risk factors in the following chapter.

Chapter 3: Asthma Risk Factors

3.1 Introduction

There has been speculation about the causes of asthma for almost as long as the condition has existed. Ancient Greek and Roman physicians believed that asthma was due to an internal imbalance, which could be restored by diet, plant and herbal remedies, prayers or lifestyle change. Thomas Willis and numerous workers in the nineteenth century reached the conclusion that spasm of the bronchial muscles was the underlying cause of asthma (Major 1910). Berkert in his 1878 book on asthma reported that the dominant theory was that asthma was a nervous disorder (Emanuel and Howarth 1995). Later Melzer suggested in 1910 that asthma was an anaphylactic phenomenon, but asthma was to be later said to be a manifestation of "atopy" rather than anaphylaxis. (Becker 1999).

More recently, as discussed in chapter two, there is general consensus that asthma is a consequence of chronic inflammatory processes and remodelling of the airways (Kariyawasam and Robinson 2005). However, these inflammatory processes may be categorized into two or more phenotypes: eosinophilic (allergic/atopic) asthma, and non-eosinophilic (non-allergic/non-atopic) asthma (Pearce et al. 1999; Douwes et al. 2002a).

In this Chapter I will first review the so-called 'established' risk factors for asthma, before discussing the 'allergen hypothesis' and the more recent 'hygiene hypothesis'.

3.2 'Established' risk factors

For any discussion on risk factors for the development of asthma it is important to recognise and differentiate between risk factors for the development of asthma in individuals (primary causation), and risk factors for the exacerbation of, and persistence of, symptoms of asthma (secondary causation) (Pearce et al. 1998). However, these are not necessarily mutually exclusive. In each instance, I will focus on the evidence for risk factors for primary causation, but I will also consider the evidence for risk factors for secondary causation. Although the review focusses on children, I will also discuss findings from studies among adults where relevant.

In this section I review the so called "established" or "traditional" risk factors that influence or increase the individual's risk of developing asthma. These are grouped broadly into endogenous or host factors, (which include genetic predisposition, atopy, airways hyperresponsiveness, age, gender, and race/ethnicity); and exogenous or environmental factors (which include occupational agents, tobacco smoke, air pollution, respiratory infections and microbial exposures). I will discuss the evidence relating to allergen exposure as a risk factor for asthma separately in the following section.

Until recently, most of the evidence regarding possible asthma risk factors has come from cross-sectional studies in which it is difficult to verify that exposure preceded the development of asthma. However, in recent years, a number of infant cohort studies have begun to produce findings, and these will be referred to in the appropriate sections. The characteristics of these cohort studies are summarized in table 3.1

Table 3.1 Recent infant cohort studies

Reference	Source population for recruitment	No of children/ mothers	Exposures studied	Outcome measures	Follow-up to age
(Cole Johnson et al. 2004)	Newborns from north Detroit,born 1987 - 1989	428	Der f 1; Der p 1	IgE; positive skin test; BHR positive; asthma diagnosis	6-7 year
(Lau et al. 2000b) (Lau et al. 2002)	Newborns in five German cities in 1990	939	Food and inhalant allergens IgE; indoor allergens, HDM, cat allergen, ETS, infections	Asthma; wheeze; BHR	7 year
(Polk et al. 2004)	Newborns in Ashford (England), Barcelona and Menorca (Spain) 1995-1997	1611	Fel d1; Der p1	Number of wheeze each year from birth to 4 years	4 year
(Tepas et al. 2006)	Birth cohort in Boston	131	Cat, cockroach, dust mite and ragweed allergens	BHR	6.5-8.8 year
(Lannero et al. 2006)	Birth cohort of newborns in Stockholm	4089	Maternal smoking	Recurrent wheezing; doctor diagnosed asthma	1-2 year
(Alati et al. 2006)	Birth cohort of Brisbane mothers and children	7223	Maternal smoking	Asthma symptoms	14 year
(Wijga et al. 2006)	Breast feeding mothers from PIAMA Cohort	265	n-3 long chain PUFA in breast milk	Allergic symptoms	4 year
(Brunekreef et al. 2002)	PIAMA Cohort Netherlands	3291	Environmental and dietary risk factors	Allergic manifestations; asthma	7 year
(Illi et al. 2006)	German Mulitcentre Allergy Study cohort (MAS)	1314	HDM, cat, dog allergens;	Wheeze; lung function	13 year
(Hesselmar et al. 1999)	7-9 yr old children from Goteborg, Kiruna (Sweden)	412	Pets exposure, siblings	Allergic rhinitis; asthma	12-13 year
(Remes et al. 2001)	Birth cohort, Tucson, Arizona	1246	Pets in household Viral respiratory tract illnesses Parental smoking	Wheezing; skin test reactivity; IgE	13 year
(Custovic et al. 2001)	Birth cohort: National Asthma Campaign Manchester Asthma and Allergy Study	517	Allergen exposure, pet exposure	Signs and symptoms of atopic disease	1 year
(Sears et al. 2002)	Birth cohort Dunedin children born 1972-1973	1037	Breast feeding	Signs and symptoms of atopy; asthma	26 year
(Le Souef 2002)	Perth infant asthma study	253	Airway responsiveness, IgE	Asthma wheeze	6-12 years

3.2.1 Host factors

Genetics

The lack of a clear definition of asthma phenotypes presents problems when reviewing studies on the genetic basis of asthma. Despite this lack of a clear definition, there is considerable evidence from many studies in many different countries that a family history of asthma is a risk factor for developing asthma, and parental asthma is a stronger predictor of asthma in the offspring than parental atopy (von Mutius and Nicolai 1996). For example, Sibbald *et al* (Sibbald et al. 1980) found a significantly greater percentage of children with at least one asthmatic relative among 1 to 12 year old children who had asthma or wheezy bronchitis compared to controls. Martinez has suggested that maternal asthma is a stronger risk factor than paternal asthma (Martinez 1997b; Martinez 1997a). A number of New Zealand studies have also found family history to be a strong risk factor for asthma (Sears 1998; Wickens et al. 2001; Gillespie et al. 2006; Epton et al. 2007).

However, although a family history of asthma is associated with asthma risk, this is likely to be at least partially due to shared environmental exposures (Sandford et al. 1996). For example Smith and Knowler found that persons whose spouse developed asthma were also more likely to develop asthma (Smith and Knowler 1964). Moreover, the striking increases in asthma prevalence globally cannot be primarily due to genetic factors, since they are occurring too rapidly, and therefore they must be occurring due to changes in environmental exposures (Douwes and Pearce 2002).

Some indication of the possible contribution of genetic factors in asthma is given by studies of twins. For example, Edfors-Lubs (Edfors-Lubs 1971) analysed data on 7000 twin pairs from the Swedish Twin Register and found that concordance of asthma in monozygotic twins was greater than in dizygotic twins. However, the concordance was still only 19%, and even this may in part be due to similar environmental exposures in monozygotic twins, including a common intrauterine environment (Godfrey et al. 1994).

Whole genome screens are beginning to identify gene-rich regions of special relevance to asthma and atopy, although specific 'asthma genes" are yet to be identified. Candidate genes have been identified, but none with any certainty. Attention has particularly focused on chromosomes 5 and 11, both of which may contain genes relevant to asthma and atopy (Doull et al. 1996), including the report of a gene governing airway hyperresponsiveness on chromosome 5q (Postma et al. 1995).

ADAM-33, has been reported as a major susceptibility gene in asthma and has been linked to bronchial hyperresponsiveness (Van Eerdewegh et al. 2002) Van Eerdewegh *et al* in their original description of ADAM-33 reported 14 single nucleotide polymorphisms (SPNs) in the ADAM-33 gene to be strongly associated with asthma, although the study was conducted exclusively in white subjects from the United States and the United Kingdom. Lind *et al* (Lind et al. 2003), on the other hand, reported that ADAM-33 showed no association with asthma among 610 Puerto Rican and Mexican families from San Francisco, New York, Puerto Rico and Mexico City.

However, studies investigating linkage to candidate loci have been affected by bias introduced through the methods of acquiring the probands, the broad and variable definitions of atopy, the assumption of a simple Mendelian pattern of inheritance and the lack of appreciation of antigen-specific factors such as HLA-D encoded immune responses (Morton 1992; van Herwerden et al. 1995). As a result, as with many genetic studies of other major disorders, there have been problems of replicating reported genetic linkages with asthma, atopy and/or BHR.

Demographic factors

Most demographic factors are associated with asthma including age, gender and ethnicity (Pearce 1998). The Melbourne Asthma Study (Phelan et al. 2002) reported that there was a spectrum of asthma in children, from those with a few episodes of wheezing to those who had near-daily symptoms throughout childhood and into early adolescence. Those with infrequent episodes of wheezing had a better prognosis in terms of progression into adulthood. Robertson further reported that among the risk factors for wheeze continuing into adult life were early age of onset, female sex, atopy and eczema (Robertson 2002). The findings of the Melbourne study therefore reinforce the concept that there are distinct phenotypes of asthma in children.

Age is strongly related to asthma symptom prevalence with symptoms usually declining at or before the onset of puberty (Kimbell-Dunn et al. 1999). For example, a follow up study of 38 children (with a mean age of 8.9 years) with clinical asthma found that the rate of improvement was appreciably greater during puberty (Balfour-Lynn 1985; Venn et al. 1998b). This led to speculation that improvement in childhood asthma could be associated with an immunological process from hormones active

during puberty, although it is recognised that asthma in children is a spectrum of many conditions (Silverman 1995). The gender differences in asthma prevalence and severity are not large, but there is consistent evidence that asthma incidence and prevalence is consistently lower in females than in males before age 12 years (Anderson et al. 1987; Morgan and Martinez 1992; Gissler et al. 1999), whereas during adolescence and adulthood there is evidence of higher incidence and prevalence in females (Venn et al. 1998a; Kimbell-Dunn et al. 1999).

Some authors have noted that boys have smaller airways relative to lung size than girls, and that this may explain the greater frequency and severity of lower respiratory tract illness in boys, even though overall infection rates are similar for both sexes (Smith et al. 1971; Martinez et al. 1988). The relatively larger increase in thoracic size among males compared to females in adolescence and adulthood results in a reversal with more females developing asthma (Larsson 1995; de Marco et al. 2000; Nicolai et al. 2003). Alternatively, it is possible that boys have more exposure to factors that increase asthma incidence or duration such as exposure to outdoors and outdoor allergens and exercise (GINA 2005) as well as more health problems in general (Gissler et al. 1999). On the other hand, the relatively higher prevalence (or smaller reduction in prevalence) in females than in males after puberty could be due to hormonal influences on allergic predisposition, airway size, inflammation, and smooth muscle vascular functions (Redline and Gold 1994). Premenstrual asthma may be especially relevant to the hormonal involvement of asthma since it may not only cause asthma exacerbations, but may thereby affect the frequency and duration of asthma symptoms, resulting in an increase in the prevalence of "current asthma".

Many potential risk factors for asthma are related to socioeconomic status. Many reports have shown that higher asthma morbidity and mortality among certain ethnic groups may be associated with the level of education and lower socio-economic status (SES) among these groups rather than ethnicity itself (Litonjua et al. 1999). An analysis of asthma hospitalisations among Māori and non-Māori from 1994-2000 by Ellison-Loschmann *et al* (Ellison-Loschmann et al. 2004), and a further analysis of Māori asthma morbidity in general (Ellison-Loschmann and Pearce 2000), found that asthma hospitalisation rates are higher in Māori than in non-Māori, despite the fact that asthma prevalence was similar in Māori and non-Māori children. A review identified differential management of asthma and inadequate access to appropriate healthcare and asthma education as contributing to the high asthma morbidity rate amongst Māori (Ellison-Loschmann 2004). This supports earlier findings of more severe asthma among children in lower socioeconomic situations, which could be due to inadequate disease management and inadequate access to appropriate health care, or associated environmental factors such as environmental tobacco smoke and nutrition (Pomare et al. 1992a; Pomare et al. 1992b; Littlejohns and Macdonald 1993; Mielck et al. 1996). This means that the social factors influencing asthma prevalence may be different from those influencing asthma incidence and severity. In particular, factors that affect access to health care may be particularly important in terms of asthma severity, and may account for some socioeconomic and ethnic differences in asthma severity. However, access to health care is unlikely to account for differences in asthma incidence, although it may explain differences in the incidence of diagnosed asthma.

In assessing socioeconomic status among young adults from 32 centres in 15 countries (the European Community Respiratory Health Survey), Basagana et al found a higher prevalence of asthma among young adults of lower socioeconomic status (Basagana et al. 2004). In addition, regardless of personal socio economic status, those living in centres with a lower educational level had higher risks of asthma.

The ISAAC Phase I ecological analysis of socioeconomic status and asthma (Stewart et al. 2001) found that, although asthma symptom prevalence was higher in "Western" countries, that the positive association between gross national product (GNP) and asthma symptoms was relatively weak. The authors concluded that patterns of asthma symptom prevalence were related to environmental factors that were "not just related to the wealth of the country".

More recently Sole *et al* (Sole et al. 2007) reported no association between symptoms of asthma and socioeconomic status among Brazilian adolescents. Another recent study found a higher prevalence and incidence of asthma among lower socioeconomic groups (defined by occupational class or education level) in an analysis of data from the European Community Respiratory Health Survey (Ellison-Loschmann et al. 2007). Asthma, rhinitis and sensitization were also reported to be more common in lower than in higher socioeconomic groups in a large cohort of children born between 1994 and 1996 in Stockholm (Almqvist et al. 2005).

Diet

Food production, preferences, processing, supplies and availability are continually changing. Over recent decades "Westernization" has contributed to the above changes, resulting in shifts from a tradition of growing and consuming locally grown food to consuming and practising western diet (Foliaki and Pearce 2003a). In some countries these dietary changes have been linked to increases in non-communicable diseases such as cardiovascular diseases, diabetes and cancer (King and Rewers 1991).

Decreased consumption of fruit and vegetables in the United Kingdom has been postulated to be associated with increased asthma prevalence through the antioxidant properties in fruit and vegetables protecting against inflammation (Seaton et al. 1994). More recent studies support the protective role of fruit and vegetable intake on asthma (Smit 2001; Farchi et al. 2003). As with many other risk factors for asthma, low consumption of fruit and vegetables is associated with lower socioeconomic status.

In a Saudi Arabian study (Hijazi et al. 2000), risk factors for asthma, including diet, were assessed between children with a history of asthma and wheeze in the last 12 months (case) and a control group who had never had asthma or complained of wheeze (114 cases, 202 controls). Eating at fast food outlets and lower intakes of milk, vegetables, fibre, vitamin E, magnesium, calcium, sodium and potassium were significantly related to being an asthma case.

The recent increase in the prevalence of asthma has also been attributed to the parallel increase in the diet of polyunsaturated fat containing polyunsaturated fatty acids such

as linoleic acid (a precursor in the mediation and synthesis of prostaglandin E2 and Immunoglobulin E formation), as well as evidence for a decrease in the consumption of oily fish, rich in omega-3 fatty acids which reduces the synthesis of proinflammatory cytokines (Black and Sharpe 1997). A study from Sydney among zero to three year old children has reported a protective effect against allergic airway inflammation with omega-3 supplementation to the child's diet (Peat et al. 2004). On the other hand, a randomized controlled trial conducted in children with a family history of asthma in whom omega-3 fatty acid supplementation and restriction of dietary omega-6 fatty acids did not prevent asthma, eczema, or atopy at age 5 years (Almqvist et al. 2007).

An ecological analysis of the prevalence rates of symptoms of current and severe wheeze in relationship to diet based on the ISAAC data for 6 to 7 and 13 to 14 year old school children found a consistent inverse relationship between symptoms of wheeze and the intake of starch, cereals and vegetables. A similar inverse relationship was shown between diet and symptoms of allergic rhinoconjunctivitis and atopic eczema (Ellwood et al. 2001). There was a positive association between asthma symptom prevalence and per capita consumption of trans fatty acids (Weiland et al. 1999). As to the exact composition of fatty acid and its associations with asthma, studies have been inconsistent with some reporting no association (Bolte et al. 2006) and others reporting an association (Mickleborough and Rundell 2005).

Breast feeding

Breast feeding is the ideal form of human infant nutrition. However, there has not been a definitive answer as to whether the development of allergic diseases can be

prevented by breast-feeding (Friedman and Zeiger 2005), because of methodological differences among studies, the complex immunological properties and allergens present in breast milk and genetic interactions between mother and infant. Some recent studies have shown breast feeding protects against atopy (Kramer et al. 2001; Oddy et al. 2002; Kull et al. 2004; Laubereau et al. 2004), but other studies have shown that breast feeding induces the development of atopy (Wetzig et al. 2000; Wright et al. 2001; Bergmann et al. 2002; Miyake et al. 2003). Sears *et al*, in a long running cohort of children born in Dunedin, reported that breast feeding did not protect against atopy and asthma and may even increase the risk (Sears et al. 2002). Aberg *et al* found that the delayed onset of allergic disease among breast fed children only occurred in those whose mother and father both had a history of allergy (Aberg et al. 1989), whereas Mandhane *et al* (Mandhane et al. 2007) found that breast feeding increased the risk for atopy in girls with maternal atopy. A maternal diet high in saturated fat during breast-feeding has been reported to be a risk factor underlying the later development of atopic sensitization of the infant regardless of maternal atopic disease (Hoppu et al. 2000). The majority of evidence, however, suggests that exclusive breast feeding for at least four months seems to protect against early childhood wheezing (Friedman and Zeiger 2005). The clinical benefits overall of breast feeding cannot therefore be overlooked, as well as the economic costs of other forms of infant feeding.

Body Mass Index (BMI)

Cross sectional studies have shown associations between increasing body mass index (BMI) and asthma among children (Figueroa-Munoz et al. 2001; von Kries et al. 2001; von Mutius et al. 2001). For example, a case-control study among urban and

rural school children in South Africa reported a positive association between exercise-incuded bronchospasm and increasing BMI (Calvert and Burney 2005). Similar findings have been reported in studies in adults (Schachter et al. 2001; Xu et al. 2002; Luder et al. 2004). Furthermore, weight reduction in obese individuals has been reported to improve lung function and asthma symptoms (Hakala et al. 2000; Stenius-Aarniala et al. 2000; Aaron et al. 2004). Obesity may be closely associated with other asthma risk factors such lack of physical activity and fitness (Rasmussen et al. 2000), although this has not been found in all studies (Kilpelainen et al. 2006). An analysis of BMI measures calculated from the ISAAC data collected in Hawkes Bay (New Zealand) has indicated a rising mean BMI among these children between 1989 and 2000, with the problem being more common in Polynesian than in European children (Turnbull et al. 2004). The causes of obesity among Pacific populations are multifactorial; some factors involved are related to urbanization and migration, but more research is needed (Okihiro and Harrigan 2005). The prevalences of overweight and obesity in Australian children in two national samples between 1985 and 1995 were also high by international standards (Magarey et al. 2001)

Tobacco smoke

The burning of tobacco produces a large variety of gases, vapours and particulate matter; (at least 4,500 compounds have been identified), including hydrocarbons, carbon monoxide, carbon dioxide, nitric oxide and nitrogen oxide. Various studies have described an increased risk of developing asthma in association with tobacco smoking (Larsson 1995; Strachan et al. 1996; Gilliland et al. 2001; Eagan et al. 2002). The evidence on active smoking as a risk factor, however, is conflicting in that some studies report this as exacerbating or triggering wheezing attacks among adults rather

being a primary risk factor for the development of asthma (Siroux et al. 2000), whereas others have documented an associated increased and dose–related risk of developing asthma in adolescents and adults (Eagan et al. 2002). Maternal smoking during pregnancy has been reported to increase the occurrence of physician-diagnosed asthma and wheezing during childhood (Gilliland et al. 2001). In addition to maternal smoking during pregnancy, smoking by household members has also been reported as a risk factor after the child is born (Ehrlich et al. 1996; Strachan et al. 1996; Eagan et al. 2002; Barraza Villarreal et al. 2003). Also, wheezing in the first year of life was significantly more common in children of smoking mothers (Murray et al. 2004).

On the other hand, an analysis at the ecological level of the ISAAC Phase I data found a significant negative correlation between smoking prevalence among men and asthma symptoms in children (Mitchell and Stewart 2001). The analysis did not include information on individual exposures, but these analyses nevertheless indicate that risk factors other than tobacco smoking must account for the observed variations in asthma prevalence at the international level.

More recent large studies have reported positive associations between tobacco smoking and atopy (Feleszko et al. 2006; Gilmour et al. 2006; Gupta et al. 2006). A recent review has demonstrated not only the negative effects of smoking on asthma but it's negative effects on the effectiveness of corticosteroids on asthma management (Livingston, Thomson *et al.* 2005*)*.

Climate

Various studies have reported associations between specific climatic conditions and asthma. An ecological study linking the prevalence of adult asthma symptoms with climate in the 93 New Zealand general electorates found a significant association between asthma prevalence and mean temperature, with the lowest quartile of mean temperature having an approximately 2% lower asthma prevalence (Hales et al. 1998).

More recent results from the Italian Study of Asthma in Young Adults (ISAYA), assessing the role of climate on the geographical variability of the condition, have indicated higher prevalences of asthma symptoms at higher mean annual temperatures as well as the risk of having symptoms increasing with decreasing latitudes (Zanolin et al. 2004).

An ecological analysis of data from ISAAC Phase I found an inverse association between the prevalence of asthma symptoms and the altitude of the study area (Weiland et al. 2004b), a finding which is supported by previous reports (Allegra et al. 1995). However, in contrast to the above New Zealand study there was no association of asthma symptom prevalence with outdoor temperatures and outdoor relative humidity. Among the Western European ISAAC centres there was a positive association between levels of indoor relative humidity and the prevalence of asthma symptoms. Mechanisms suggested to play a role here include the infestation of homes with house dust mites and home dampness and moulds being influenced by levels of relative humidity (Weiland et al. 2004b).

Air pollution

Among the outdoor pollutants normally implicated as causing an increased prevalence of asthma are sulphur dioxide particulate complex (industrial smog), nitrogen oxide and ozone (the major component of photochemical smog) (Koren 1997).
A study of 99,591 adult asthma cases in Taiwan found that high asthma hospitalization rates in spring were significantly positively correlated with levels of particulate matter with aerodynamic diameter $\leq 10\mu m$ (PM10) of SO2, CO, and NO2, and negatively correlated with temperature and hours of sunshine (Chen et al. 2006). Although PM10 and PM2.5 have been reported to have associations with decreased pulmonary functions in a number of studies (Mortimer et al. 2002; Zhang et al. 2002; Barnett et al. 2005) Chimonas *et al* found no association between PM2.5 and asthma outcomes (Chimonas and Gessner 2007).

Shima *et al* (Shima et al. 2002) reported a significant association of asthma with atmospheric concentrations of nitrogen dioxide among Japanese school children, suggesting that air pollution, including nitrogen dioxide, may be an important factor in the development of asthma among children in urban districts in Japan.

Incidence of new diagnoses of asthma has been reported to be associated with heavy exercise in communities with high concentrations of ozone (Wang et al. 1999). Thus, air pollution and outdoor exercise could contribute to the development of asthma in children. Other studies found significant associations of ozone exposure and the development (or diagnosis) of asthma in children (McConnell et al. 2002) as well as in adults experiencing long term exposure to ozone (McDonnell et al. 1999).

In contrast, others have implicated the common air pollutants as aggravating asthma rather than actually causing the development of asthma (Koenig 1999). The global patterns also show regions with high traditionally high levels of air pollution such as some parts of China and Eastern Europe having much lower asthma prevalence than Western Europe, Australia and New Zealand which have lower levels of air pollution. There are also striking differences between neighbouring regions such as Western and Eastern Germany, and between Hong Kong and Guangzhou, with the areas with the highest levels of air pollution showing the lowest asthma prevalence (Pearce and Douwes 2006).

Litte is known about air pollution in the Pacific except for studies conducted in the Pacific rim, although there is evidence of air pollution from larger metropolitan centres travelling across the Pacific Ocean from as far as Siberia to the American West Coast and with increasing long haul air transport and industrialisation it is anticipated that air pollution will be a health issue in the near future. The Pacific islands are scattered over a wide area surrounded by the vast Pacific Ocean with various marine factors that have been documented to adversely affect airways such as the bronchoconstrictions caused by toxins produced by the red tide marine dinoflagellate Karenia brevis (Fleming et al. 2005).

Indoor Pollutants

Modern housing construction and domestic insulation techniques have been suggested to be implicated in the recent increases in asthma prevalence by reducing the circulation of indoor air and thereby increasing indoor air pollution. The range of potential pollutants is large, the determinants of ambient levels involve a complex

interaction of lifestyle and building factors, and precise measurement of airborne or respirable concentrations is difficult. In addition, indoor air pollution may arise from both indoor and outdoor sources.

Domestic burning of fossil fuels, particularly in gas appliances and in poorly ventilated kitchens, produces high concentrations of particulates such as nitrogen dioxide and nitrogen oxide, and these have received by far the most attention in studies of indoor air pollutants. Gas cooking has been positively associated with asthma-like symptoms and reduced lung function (Jarvis et al. 1996; Strand et al. 1996; Sunyer et al. 2002; Sunyer et al. 2004; Wong et al. 2004b; Gauderman et al. 2005). Sulphur dioxide from burning sulphur-containing coal or gas , mosquito coil smoke (Koo and Ho 1994; Walters et al. 1994; Anderson et al. 2004), and formaldehyde (Rumchev et al. 2002) have also been considered as risk factor for asthma. A strong association was reported between sulfate particulates and asthma attacks among West Virginia residents living within half a mile of a high sulphur coal fuel power plant (Cohen et al. 1972). Particulates from wood and coal burning fires have received less attention in developed countries, but have been studied in developing countries where very high indoor levels have been encountered (Anderson 1974; Anderson 1979).

The presence of dampness and mould (Emenius et al. 2003; Wong et al. 2004a) have also been reported to be associated with recurrent wheezing in young children, although the exact aetiological mechanisms remain undetermined with moisture probably being an indicator of other risk exposures in the design of modern buildings (Douwes and Pearce 2003; Emenius et al. 2004).

Indoor exposure to airborne microorganisms and microbial agents is widely recognized as a possible cause of asthma (Douwes et al. 2003). Several population-based studies have suggested that allergic or non-allergic inflammatory reactions to inhaled fungal components, together with reactions to house dust mites, might account for the frequently reported association between living in damp housing conditions and respiratory disorders (Brunekreef et al. 1989; Dales et al. 1991; Jaakkola et al. 1993; Peat et al. 1996).

However, while dampness in general, and non-infectious microbial exposure in particular, have been shown to exacerbate pre-existing respiratory conditions such as asthma, it is in fact not clear whether they cause individuals to develop asthma in the first place (i.e. primary causation) as specific causal mould components have not yet conclusively been identified (Douwes and Pearce 2003).

Several studies have also suggested a role for bacterial exposure and exposure to certain bacterial components such as endotoxins. The studies of Michel *et al* (Michel et al. 1991; Michel et al. 1992; Douwes and Pearce 2003) have suggested that in the home environment, endotoxins in house dust may influence the clinical severity of asthma. A cross-sectional study performed in Belgium by the same authors showed that in 69 adult asthma patients the severity of asthma was related to endotoxin levels, but not with mite allergen concentration, measured in their house dust (Michel et al. 1996). In a Swedish case-control study (Bjornsson et al. 1995), asthma-related symptoms were significantly associated not only with house dust mite exposure but also with levels of airborne

bacteria in homes. Endotoxin has also been implicated in the possible protective effects associated with the hygiene hypothesis (see below).

Finally, it has been suggested that indoor exposure to allergens (Sporik et al. 1990; Sporik and Platts-Mills 1992; Bjornsson et al. 1995; Peat et al. 1996; Custovic et al. 1998; Sporik et al. 1999), including house dust mites, may have increased in recent decades because of changes in housing design, and forms of heating and furnishing, especially the use of carpets. This may have been exacerbated by children spending more time indoors because of television (Platts-Mills et al. 1997). The allergens related to indoor pollutants are discussed in more detail in the following Section on the "allergen hypothesis".

Respiratory Infections

Respiratory infections early in life have been associated with both increased and decreased risks for the development of asthma, as well as causing asthma exacerbations in both children and adults (Gern 2000; Nafstad et al. 2000; Tsitoura et al. 2000). Among the commonest respiratory virus exposures in the first year of life are the respiratory syncytial viruses (RSV), which have been reported to account for 50% of wheezing illness in infancy (Johnston et al. 1995). Sigurs *et al* (Sigurs et al. 2000) reported that, in a cohort study of 47 children hospitalized with a respiratory syncytial virus (RSV) bronchiolitis in infancy compared with 93 matched control subjects recruited during infancy followed up to age of seven years, hospitalization with RSV bronchiolitis was the most important risk factor for the development of asthma and atopic sensitisation. Other important respiratory viruses associated with

wheeze in older children and adults include parainfluenza, rhinovirus and influenza (Gern 2000).

On the other hand other epidemiological studies have shown frequent upper respiratory infections in infancy having a protective effect on the risk of developing asthma later in life (Martinez et al. 1995). Similar findings have been reported from studies in the United States where conditions associated with increased respiratory infections in early life such as attending day care and children with large number of siblings being protective against the development of asthma (Ball et al. 2000). Such findings are in general agreement with the hygiene hypothesis which is discussed separately below.

An ecological analysis was conducted of the relationship between tuberculosis notification rates (confined to those countries in which the tuberculosis notification rates were considered sufficient valid) and the prevalence of symptoms of asthma based on the data for 13-14 year olds from the International Study of Asthma and Allergies in Childhood (ISAAC). Tuberculosis notification rates were significantly inversely associated with the lifetime prevalence of wheeze and asthma and the 12 month period prevalence of wheeze at rest as assessed by the video questionnaire, a finding consistent with recent experimental evidence which suggests that exposure to Mycobacterium tuberculosis may reduce the risk of developing asthma (von Mutius et al. 2000b).

On the other hand, in a study of children who had been notified to the New Zealand Notifiable infectious diseases database (EpiSurv) to have infections in early life (0 – 4

years of age) and a control "general population group" measuring association between infections and the risk of asthma at age 6 – 7 years, there was little difference in the prevalence of current wheeze between the two groups (Cohet et al. 2004).

Other infections reported to be linked with a reduced risk of developing asthma include the report of an inverse relationship between delayed hypersensitivity to tuberculin at the age of 12 years and allergen specific serum IgE levels among 867 Japanese children. Recent studies have shown conflicting results with regards to mycobacteria and BCG. For example it has been pointed out that the results could simply mean that the children's decreased response to tuberculin was a consequence of their being atopic or having had asthma. In addition, Omenaas *et al* found that the prevalence of atopy did not differ between subjects with a positive and those with a negative tuberculin test among 574 young adults who were immunized with BCG at 14 years of age (Omenaas et al. 2000). Furthermore, there is a relatively high prevalence of asthma in United States inner-city communities in New York (Call et al. 1992), where microbial exposures are presumably higher than non-inner-city homes. It has been argued by Warman *et al* (Warman et al. 2006), however, that there is a complex array of interacting risk factors, apart from infections, in inner cities in the United states; these include environmental exposures, medication availability and medication adherence, and smoking exposure as well as aeroallergen exposures.

3.3 The Allergen Hypothesis

3.3.1 "Asthma is an allergic disease"

Until recently, allergens have been considered among the most important risk factors for developing asthma and asthma has frequently been described as "an allergic

disease" (Sporik et al. 1990; Sporik and Platts-Mills 1992; Peat et al. 1996; Platts-Mills et al. 1997; Custovic et al. 1998). The proposed mechanism has involved allergens sensitizing the individual's airways (particularly in infancy) with continuous exposure leading to further development of airways hyperresponsiveness, airways inflammation and reversible airways obstruction (asthma).

Among the allergens identified as of major importance include the house dust mite (HDM) *Dermatophagoides pteronyssinus* allergen (Der p 1), and *Dermatophagoides farinae* allergen (Der f 1), the cat allergens (mostly Fel d 1), dog allergens (Can f 1 and Can f 2), rodents and cockroach allergens (Pearce et al. 2000b). Among the common outdoor allergens cited are fungi and pollen (Zhong 1996).

The term 'atopy', introduced by Coca and Cooke in 1923 to define whealing reactions to common allergens, now generally refers to skin prick test positivity, and the production of abnormal amounts of IgE antibodies, in response to contact with environmental allergens specific to geographic zones (GINA 1995). Skin prick tests for atopy involve a battery of standardised allergens, and people who react to such skin tests for atopy have an increased risk of asthma. For example, Settipane *et al* (Settipane et al. 1994), in a 23 year follow-up study, reported that individuals with either allergic rhinitis or positive allergy skin tests are about three times more likely to develop asthma compared to negative controls. Ulrik *et al* (Ulrik et al. 1996), in a longitudinal study of more than 3,000 Swedish school children with other risk factors including positive skin tests, rhinitis, eczema, a family history of asthma and a smoking mother, also reported that both sensitisation to house dust mite and asymptomatic bronchial hyperresponsiveness are important risk factors for developing

asthma among children and adolescents (7-17 years old), and allergy was found as the most important risk factor for asthma. A temporal association was documented by Martinez of allergic sensitisation and the development of asthma (Martinez 2000); there was a higher risk of children being sensitized to aeroallergens during the first three years of life developing asthma later in life. Children who became sensitised after the age of eight years showed no increased risk compared to children who do not become sensitised. Martinez (Martinez 1997a) therefore suggested that atopy and asthma in childhood are two different syndromes.

3.3.2 Limitations of the allergen hypothesis

In recent years, the dominant role of allergens in the causation of asthma has been called into question in two ways.

Firstly, a systematic review by Pearce *et al* (Pearce et al. 1999) estimated that at most 50% of all asthma is attributable to "allergic" mechanisms as defined by atopy or through "eosinophilic" airway inflammatory processes. Furthermore a further review paper by the authors (Pearce et al. 2000b) reports that most studies and reviews supporting allergens as a major primary cause of asthma were largely based on indirect evidence and have not differentiated between primary and secondary causes of asthma. This further review by Pearce et al (Pearce et al. 2000b) also supports the suggestion by others (Sunyer et al. 2000; Lau et al. 2002) that allergic mechanisms may not be the only, or the major, pathway to asthma.

Secondly, even for allergic asthma, the evidence that allergens play an important primary causal role is relatively weak (Pearce et al. 2000b). Most studies do not show

clear associations between house dust mite exposure and symptoms, even when the analysis is restricted to atopic patients (Kuehr et al. 1995; Platts-Mills et al. 1995; Sporik et al. 1999; Vervloet et al. 1999), and secondary prevention intervention trials have had mixed results (Gotzsche et al. 1998).

Cross-sectional studies of asthma prevalence and current allergen exposure also do not show consistent associations. Furthermore, the problem with the interpretation of such studies is that asthma prevalence in a population reflects both asthma incidence and the average duration of the condition. Thus, a factor that prolongs or exacerbates asthma symptoms may thereby increase asthma prevalence even if it has no effect at all on asthma incidence. In fact, most studies in children show negative associations between allergen exposure and current asthma (Pearce et al. 2000b). However, a major concern in such cross-sectional studies is that allergen avoidance measures may have been adopted as a consequence of developing asthma (Brunekreef et al. 1992). This possibility was examined in only a few studies, and these generally found slightly stronger risks when children whose parents had adopted allergen avoidance measures were excluded from the analysis (e.g. (Verhoeff et al. 1995)). However, in most studies the increase in the odds ratio was very. Thus, even when allergen avoidance is accounted for, these studies do not suggest that allergen exposure is a major risk factor for childhood asthma (Pearce et al. 2000b).

Other major and important potential mechanisms for asthma, other than those involving "allergic" (eosinophilic) asthma, include the neutrophilic mediated asthma such as is commonly seen in some occupations (Douwes et al. 2002b) stemming from

a variety of exposures including organic dust, endotoxin, ozone, particulates and viral infections.

Despite the strong associations between atopy, bronchial hyperresponsiveness and asthma, they are not interchangeable. Even if a significant number of asthmatics are atopic, some atopic subjects may not have bronchial hyperresponsiveness or asthma and subjects with hyperresponsiveness may not be atopic or have asthma.

Sunyer *et al* (Sunyer et al. 2000) in a study of 658 pregnant women in semi rural Tanzania showed that specific IgE levels to HDM (Der p 1) or cockroach were not associated with asthma (3.8% of women with negative specific IgE to either HDM or cockroach had asthma in comparison to 4.0% who had asthma among women with positive specific IgE) and total IgE was not different between the women with and without asthma.

Leung *et al* (Leung and Ho 1994) also reported that while asthma prevalence was low among secondary school students in three South East Asian populations, compared to some English speaking Western countries, there were marked differences in asthma prevalence between these populations (Hong Kong 12%; Malaysia 8%; China 2%).despite similar rates of atopy (58%, 64% and 49% respectively).

A prospective birth cohort study of 939 children by Lau *et al* (Lau et al. 2000a) found no association between cat and house dust mite allergen exposure in the first years of life and the development of childhood asthma, or any consistent dose response relationship between cat mite allergen exposure with asthma. Lau *et al* (Lau et al.

2000a; Lau et al. 2002) further suggest from their findings that the strong relationship found between HDM sensitisation and asthma may reflect the susceptibility of individuals with asthma to become sensitised to the allergens most prevalent in their environment rather than an increased risk of asthma occurring as a consequence of being exposed to these allergens. An equally important issue arising from these considerations is the question as to whether allergy and asthma develop through separate pathways and mechanisms (Sunyer et al. 2000).

There is also little evidence that asthma symptom prevalence patterns correlate with known patterns of HDM exposure levels. The ISAAC study reports uniformly high levels of asthma prevalence in English-speaking countries although HDM levels vary widely across these countries (Martinez 1997a; Pearce et al. 2002; Pearce and Douwes 2006).

There are several other indoor and outdoor allergens that have been suggested to be associated with specific atopic sensitization and the development of asthma including cat, dog, cockroach and *Alternaria* allergens (Platts-Mills et al. 1997). However, the evidence for a causal relationship is even weaker than for house dust mite allergens, and in fact, many of the studies found no associations or even negative associations between allergen exposure and asthma (Pearce et al. 2000b).

Recently, several studies have reported a protective effect of pet ownership early in life with regards to the subsequent development of asthma (Oberle et al. 2003). For example, a recent case control study in Sweden among children aged 12-13 years showed a strong negative association (OR=0.34, 95%CI 0.07-0.77) between pet

ownership during the first year of life and asthma (Hesselmar et al. 1999). This association remained even after excluding children whose parents had decided against pet keeping during early childhood because of allergy in the family. In addition, the authors showed that children exposed to cats during the first year of life were less likely to be skin prick test positive to cat allergen at age 12-13 years.

Similarly, a recent study among 13,932 subjects aged 20-44 years from a large number of countries in Europe showed a protective effect of the presence of a dog in the home in childhood on atopy, even after adjusting for family history of allergies (OR=0.85, 95% CI 0.77-0.94) (Svanes et al. 1999).

Besides other possible reasons such as a potential increased microbial pressure associated with pet ownership that could favour a non-allergic development of the immune system, it could be speculated that pet allergen exposure early in life may induce a specific tolerance which reduces the risk of subsequently becoming allergic or asthmatic (Pearce et al. 2002). Clearly more studies are needed to further elucidate the role of allergen exposure early in life on the later development of allergies and asthma.

3.3.3 Evidence from cohort studies

One limitation of many studies of allergen exposure and asthma is that most studies have been cross-sectional, and it has not been clear that allergen exposure has preceded the development of asthma. In this section, I therefore review evidence from cohort studies in which allergen exposure has been measured prior to the development of asthma.

There are a number of studies which report that exposure to allergens increases the risk of sensitization to these specific allergens. For example, among a cohort of 67 British children (1978 -1989), the 17 children who had active asthma were all sensitized to house dust mite and 16 of these children were atopic (Sporik et al. 1990). A dose and temporal relationship was also documented in this study in which the 16 asthmatic children who had been exposed to more than 10 microgram of Der p 1 showed an association between the level of exposure at the age of one year and the degree of sensitization at age 11 years.

However, the picture is much less clear as to whether allergen exposure increases the risk of asthma itself.

Sporik *et al* (Sporik and Platts-Mills 1992) identified dust mites as not only being associated with the majority of cases of asthma in children and young adults but also as being causally related to the development of asthma. A dose response relationship has also been documented for house dust mite allergen and asthma, specifically that an exposure to greater than 2 micrograms of Der p 1 dust mite allergen or 100 mites per gram of dust increased the risk of children developing sensitization and asthma (Platts-Mills et al. 1991).

Burr *et al* (Burr et al. 1993) conducted a longitudinal study among 453 infants in South Wales with a family history of allergic diseases. Infants were followed up to the age of seven years and house dust mite allergen levels in mattress and carpet dust were determined in the first and seventh year of life. The study involved an

intervention examining the effect of withholding cows milk protein during the first three months of life and replacing cows milk with Soya milk. No other interventions were employed. Doctor-diagnosed asthma and wheezing at age 7 were not associated with mite allergen exposure in the first 12 months of life nor with dust mite levels measured at 7 years of age (odds ratios were not given). Wheezing was also not associated with cat ownership. There were no differences in mite sensitization (determined by skin prick test) at age 7 years between low, moderate and high mite allergen exposed children (20%, 20% and 22%, respectively when initial exposure was compared, and 19%, 19% and 23% when exposure at age 7 years was considered). Withholding cows milk did not affect the incidence of allergy or wheezing. The study also showed that children who had ever been breast fed had a lower incidence of wheeze.

More recently, Lau *et al* (Lau et al. 2000a) conducted a study of 1314 newborns enrolled in five German cities in 1990. At age seven years, sensitization to indoor allergens was associated with asthma and wheeze, but there was no association between early indoor allergen exposure and the prevalence of asthma or wheeze at age seven years.

Most of the longitudinal birth cohort studies (see table 3.1) with data on allergen exposures found no or inconsistent associations between early dust mite allergen exposure and asthma later in childhood. (Cole *et al*., 2004; Polk *et al*., 2004; Tepas *et al*., 2006; Corver *et al*., 2006). In the German Multicentre Allergy Study levels of mite and cat allergens in early life remained strongly related to specific sensitisation at age 3 to 7 years (Lau *et al*., 2000; 2002). However, there was no dose-response

relationship between allergen exposure and any measure of asthma/wheeze at 7 years of age (Lau *et al.*, 2000; 2002). In the Perth infant asthma study a diagnosis of asthma symptoms at the age of 6 years old were strongly associated with the level of airway hyperresponsiveness in infancy at 6 years of age (Le Souef 2002), this increased risk of asthma symptoms with airway hyperresponsiveness was not apparent in the first 2 years of life.

3.3.4 Allergens as a cause of asthma exacerbations

Although there is little evidence that HDM exposure is a primary cause of asthma, there is clear evidence that it is a secondary cause, i.e. that it can cause asthma exacerbations.

Peat *et al* (Peat et al. 1994) reported that sensitisation to house dust mite (HDM) was the most important risk factor for "current asthma" among 1399 school children in Sydney, and the presence of airway hyperresponsiveness was strongly related to the degree of sensitisation to house dust mite allergen. The mean HDM level from 72 homes exceeding 10 times the HDM level per gram of dust was reported as the threshold (Platts-Mills et al. 1991) for sensitisation and asthma in children. Furthermore other studies show improvement of asthma when there is no longer any exposure to specific allergens (Gotzsche et al. 1998).

Peat at al (Peat et al. 1996) also documented a dose relationship between HDM allergen (Der p 1) and asthma severity among a random samples of children from six regions in New South Wales, Australia where the risk of house dust mite sensitized children having current asthma doubled with every doubling of Der p I level.

3.4 The "hygiene" hypothesis

3.4.1 Introduction

The limitations of the 'allergen hypothesis' have in recent decades led to the development of other possible explanations for the global patterns of asthma prevalence. In particular, Strachan (Strachan 1989) in an analysis of a sample of 17,414 British children from the National Child Development Study, found strong and inverse associations between hay fever and family size and position in the household in childhood. Strachan proposed that:

> "*...declining family size, improved household amenities and higher standards of personal cleanliness have reduced the opportunity for cross infection in young families. This may have resulted in more widespread clinical expression of atopic disease...*".

Strachan's proposal suggests that infections in early childhood (and even prenatally) transmitted by "unhygienic" contact with older siblings are protective for "atopic conditions" such as asthma, hay fever and eczema. Thus, the hygiene hypothesis postulates that there is an inverse relationship between exposure to microbial burdens experienced early in one's life and the likelihood of subsequent development of atopic conditions including asthma (Douwes and Pearce 2002). In particular, growing up in a more hygienic environment with less microbial exposure may enhance atopic (TH_2) immune responses, whereas microbial pressure would drive the response of the immune system into a TH_1 direction and away from its tendency to develop atopic immune responses (Holt et al. 1997a; Martinez and Holt 1999; Douwes and Pearce

2002). The focus has been on the early years of life, but more recently attention has shifted towards effects on the immune system throughout life (Kemp and Bjorksten 2003) as well as the studies on infections (Shaheen et al. 1996a; Matricardi et al. 1997; Shirakawa et al. 1997), bacterial endotoxins (Liu and Leung 2000; Tulic et al. 2000; von Mutius et al. 2000a) and lifestyles (Alm et al. 1999).

The microbial exposures now normally considered in the context of the hygiene hypothesis include infections (bacterial, parasitic, viral), microbial components (endotoxins, and micro-organism-associated molecular patterns), gastrointestinal colonisation (lactobacillus, bacteroides, parasites), soil microbiota (mostly gram-positive bacteria), farm environments, and pets. Infections with hepatitis A, *Helicobacter pylori*, toxoplasma and geohelminths have been shown to be associated with reduced risk of atopy by altering T-helper Th1/Th2 regulation (Matricardi et al. 2000). The possible effects of antibiotic therapy and diet acting through the gut flora are also being considered as the hygiene hypothesis continues to evolve (Strachan 2000).

However, there are a number of exceptions and anomalies to the hygiene hypothesis (Sheikh and Strachan 2004). For example, the ISAAC Studies in Latin America, in apparent contradiction with the "hygiene hypothesis", showed high asthma symptom prevalence in a region with a high level of gastrointestinal parasite infestation (Mallol et al. 2000). In fact, there are a number of elements of the "package" of Westernisation, including changes in maternal diet, increased fetal growth, smaller family size, reduced infant infections and increased use of antibiotics and immunization, all of which have been (inconsistently) associated with an increased

risk of childhood asthma, but none of which can alone explain the increases in prevalence (Douwes and Pearce 2002). It is likely that the "package" is more than the sum of its parts, and that these social and environmental changes are all pushing infants' immune systems in the same direction. Thus, the fact that there are inconsistencies and anomalies in the findings for infections and asthma does not necessarily invalidate the hygiene hypothesis, but may indicate that the associations of increased hygiene and westernisation with increases in asthma prevalence are more complex that is assumed under the "standard" version of the hygiene hypothesis (Douwes and Pearce 2002).

3.4.2 Studies of infections and asthma

Among the initial studies that spurred interest in microbial burden as possible protective factors against atopic diseases was the publication of an inverse association between measles infection and atopy in a cohort of young adults in Guinea-Bissau (Shaheen et al. 1996b). Subsequently, Matricardi *et al* (Matricardi et al. 1997) reported an inverse relationship between Hepatitis A infection in childhood and the development of atopy, and Shirakawa *et al* (Shirakawa et al. 1997) published a cross-sectional study that found a lower level of total IgE and Th2 cytokines as well as a lower prevalence of atopy and asthma among Japanese school children who responded positively to tuberculin. In 1999, Martinez *et al* (Martinez and Holt 1999) proposed an important role of microbial burden in protecting against asthma and allergies in childhood.

A cross-sectional study of young adults by Matricardi *et al* (Matricardi et al. 2000) found that respiratory allergy was less frequent among individuals heavily exposed to

orofecal and food borne microbes such as Toxoplasma gondii, H. pylori and Hepatitis A. However, Jarvis *et al* (Jarvis et al. 2004) could not find any evidence that infection with hepatitis A or H. pylori was associated with hay fever among a community-based sample of young British adults.

Several studies have reported a positive association or no association between infections and atopy. These were mostly cross sectional studies, including those on infections due to Hepatitis A, H. pylori, herpes simplex, measles and Mycobacteria (Farooqi and Hopkin 1998; Strannegard et al. 1998; Paunio et al. 2000; Uter et al. 2003). The conflicting evidence with reference to Hepatitis A may be due to a positive serology for Hepatitis A being a marker of other unhygienic environmental exposures, with Hepatitis A itself not being the true cause of any associations; on the other hand the receptor for Hepatitis A is involved in the regulation of CD4 T-cell differentiation, airway inflammation and airway hyperresponsiveness (Schaub et al. 2006).

von Mutius *et al* (von Mutius et al. 2000b), in an ecological analysis of the ISAAC Phase I study data, also reported that national notification rates of tuberculosis were inversely associated with the prevalence of asthma symptoms (lifetime wheeze). However, subsequent work in Western populations, with individual-level exposure data, has contradicted earlier reports of an inverse relationship between BCG vaccination and atopy (Gruber et al. 2002; Annus et al. 2004).

The possible role of *Helicobacter pylori* as being inversely related to the occurrence allergen-specific IgE has also been documented (Kosunen et al. 2002). The varying agents referred to in association with the hygiene hypothesis may in turn indicate a

greater than normal prevalence of microbial infections contributing to the decrease in asthma prevalence, rather than specific individual infective agents having an important effect.

The study by Gerrard *et al* (Gerrard et al. 1976) comparing 819 white Canadians and 275 Metis Indians found a prevalence of asthma and eczema higher among the white Canadians contrasting with a higher prevalence of helminth infestations and other untreated viral and bacterial diseases in the Metis community. The authors postulated that atopic diseases are a consequence of the white Canadians' relative freedom from infectious and parasitic infections.

Children from the Highlands of Papua New Guinea, where asthma prevalence is very low, also have a relatively higher prevalence of respiratory infections compared to children in low lying coastal areas where asthma occurs more frequently (Anderson 1974).

A longitudinal birth cohort of 1314 German children followed for seven years suggested repeated viral infections in early life may reduce the risk of developing asthma up to school age (Illi et al. 2001). For example, those with two or more episodes of runny nose before the age of one year (compared with those with less than two such episodes), were less likely to have a doctor's diagnosis of asthma at seven years old (OR 0.52, 95% CI 0.29-0.92)) or to have wheeze at seven years old (OR 0.60, 95% CI 0.38-0.94)), and were less likely to be atopic before the age of five years.

Commensal bacteria of the gastrointestinal tract may have a role in the development of atopy (Bjorksten et al. 1999; Bjorksten et al. 2001) and specifically quantitative and qualitative differences in intestinal micro flora between children with and without atopy. Recently, interest has been raised on the predominance of Lactobacilli (as immunomodulatory agents) among children without atopy (Holt et al. 1997b; Miettinen et al. 1998). The early use of antibiotics previously shown to affect immune functions has also been reported to have a positive association, when used in the first two years of life, with the subsequent development of "atopic diseases" (Wickens et al. 1999; Droste et al. 2000; McKeever et al. 2002). However, not all studies of antibiotic use in early life have showed positive associations (Celedon et al. 2002), and an ecological analysis of the ISAAC Phase I data (Foliaki et al. 2004b) found little or no association between national per capita antibiotic sales and asthma symptom prevalence.

3.4.3 Studies of farming families

The evidence that growing up on a farm has a protective effect against atopy and atopic asthma has been increasingly supported by studies among Swiss and German children (Braun-Fahrlander et al. 1999; Von Ehrenstein et al. 2000), similar studies from elsewhere in Europe and Canada (Ernst and Cormier 2000; Kilpelainen et al. 2000; Riedler et al. 2000; Riedler et al. 2001; Portengen et al. 2002) and in New Zealand (Wickens et al. 2002; Douwes et al. 2006).

The New Zealand studies by Wickens *et al* (Wickens et al. 2002) and Douwes *et al* (Douwes et al. 2006) found that children living on a farm had less hay fever, allergic rhinitis, eczema and asthma than children not living on a farm (Wickens et al. 2002).

In the context of the hygiene hypothesis, various characteristics attributed to the protective effects of growing up on a farm include larger family size, more pets, less maternal smoking, different dietary habits and more contact with livestock and poultry (Riedler et al. 2000; Von Ehrenstein et al. 2000; Riedler et al. 2001). The findings by Larrick *et al* (Larrick et al. 1983) of high serum IgE in association with low levels of atopy among Latin American Indians (where intestinal parasites were also very common) was among the early studies suggesting such an inverse association. Microbial exposures have been measured showing higher concentrations of bacterial products such as endotoxins, muramic acid in mattresses of farm children compared to those of non-farm children, and similarly higher concentrations of fungal exposures in these environments (van Strien et al. 2004).

3.4.4 Endotoxin and asthma

In addition to actual infections with viable organisms there is accumulating evidence that exposure to nonviable microbial products play a key role in developments pertaining to the hygiene hypothesis and the protective effects of the farming environment (Douwes et al. 2002b). In particular, there is evidence that endotoxin exposure in farming may prevent the induction of new allergic asthma in childhood (Douwes et al. 2002b).

Endotoxins have been identified as protective against atopy by facilitating IL-12 and IFN-γ production by macrophages and T-cells, respectively (Le et al. 1986; D'Andrea et al. 1992). Further studies included those on the relationships between house-dust endotoxin, Type 1 T-cell development and allergen sensitisation in infants at high risk of asthma (wheezing infants). For example, Gereda *et al* (Gereda et al. 2000) reported

that indoor Lipopolysaccharides (endotoxin) may protect against atopy by enhancing Type 1 immunity.

A more recent study by Bolte *et al* (Bolte et al. 2003) could not confirm an inverse association between exposure to endotoxin and the occurrence of atopy. Bolte et al in a prospective longitudinal study of German infants showed no protective effect on atopy development and exposure to Lipopolysaccharides. Rather, any effect from Lipopolysaccharides varies with the type, dose and route of allergen exposure experienced by the child (Liu 2002).

3.4.5 Limitations of the hygiene hypothesis

Thus the current "hygiene hypothesis", may explain an increase in atopy and *atopic* asthma. However, with the large proportion of asthma that is not associated with atopy, it is questionable whether the "hygiene hypothesis" on its own can explain the large increase observed over the last decades (Douwes and Pearce 2002).

Some studies have suggested that only atopic asthma has increased, but in those studies poor markers of atopy were used with unknown validity (Upton et al. 2000). Studies in farmers' children have indicated that protective effects of farming were independent from effects on atopic sensitisation (Riedler et al. 2000; Riedler et al. 2001). Finally, although housing conditions have likely not become more hygienic in US inner city populations, asthma prevalence has increased significantly in those populations, and particularly among African Americans living in poverty (Weiss et al. 1992; Crater et al. 2001), which is in contrast to previous findings showing a positive

association between affluence and asthma prevalence. These studies thus further emphasise the potential limitations of the current hygiene hypothesis.

3.5 Discussion

In summary, a large number of secondary causes of asthma have been identified including tobacco smoke, climatic factors, air pollution, indoor pollutants, respiratory infections, allergen exposure, and occupational exposures. However, in most instances there is relatively little evidence that these factors are primary causes of asthma.

Until recently, the dominant theory of asthma causation was that the condition was caused by allergen exposure early in life. However, in the last decade it has become clear that the allergen hypothesis does not explain the asthma prevalence population patterns and time trends. Furthermore, there is relatively little evidence that allergen exposure is a primary cause of asthma, and at most one-half of asthma cases appear to involve non-allergic mechanisms.

The new dominant theory of asthma causation is the "hygiene hypothesis", which suggests that microbial exposure in early childhood (and even prenatally) may protect against the subsequent development of asthma. However, the evidence for this is inconsistent, and the proposed protective mechanism would only apply to atopic asthma, which only accounts for one-half of the cases. However, whatever mechanism is involved, it is becoming increasingly clear that the "package" of changes associated with Westernization may be contributing to the global increases in asthma prevalence, and that this process involves an increase in asthma susceptibility rather than an

increase in exposure to "established" asthma risk factors (Douwes and Pearce 2002; Pearce et al. 2002).

Chapter 4: ISAAC in the Pacific

The Pacific has not participated actively or adequately in the epidemiological studies on the causes, management and control of asthma in the past (Moala and Pearce 2001). However, findings from the international studies have general implications for public health activities in the Pacific. For instance, there is no concrete reason to believe that the global asthma increase and pattern shown from international studies will not be duplicated, or in fact is not already happening, in the Pacific. There is a public health need to identify risk factors previously 'established' as causing asthma in other environments for further research in the Pacific environment. There is also a need also to 'catch up' with evolving and new research topics and research techniques on asthma.

There is also a need to further investigate asthma risk factors in the Pacific, both in terms of assessing the importance of "established" risk factors from Western countries, and also the potential importance of factors that are relatively unique to the Pacific. Thus, the contrasting socioeconomic and natural environments in the Pacific may provide some answers, as well as additional research questions, on asthma. For example, there have been suggestions that the decline in tuberculosis and typhoid (Jones et al. 2000; Luque et al. 2005); is associated with the recent increase in asthma. The steady decline of tuberculosis and typhoid in Tonga over the last two to three decades makes this an interesting area for research. The pattern of pet ownership and keeping of livestock in Pacific settings and environments are potential areas for collaborative research, particularly regarding endotoxin exposure (Douwes et al. 2002b) which has so far been an unexplored research area in the Pacific. The role of

indoor pollution and burning of wood for cooking (common among Pacific countries) in association with respiratory diseases of children, and inconsistently with asthma, is another area of potential further research. It was therefore considered appropriate to conduct the ISAAC study in the Pacific in order to provide baseline information for the prevention and management of asthma in Pacific countries, and to generate hypotheses for further studies.

4.1. Study Rationale and Aims

As discussed in chapter two, 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, rhinitis and eczema. However, the countries from Oceania that participated in ISAAC Phase One were Australia and New Zealand, and these only included a small number of Pacific children.

Also as discussed in chapter two, a number of other studies have been conducted in the Pacific, including those of Liard *et al* among teenagers attending school in Tahiti (Liard et al. 1988a), Flynn's studies of children in Fiji (Flynn 1994b; Flynn 1994a), and studies of Tokelau children in New Zealand (Waite et al. 1980). However, these studies did not use the same methods and the findings are therefore not comparable across countries.

There is some evidence that asthma may be higher in Pacific children in New Zealand than in the Pacific, but little else is known about the prevalence patterns throughout the Pacific (Moala and Pearce 2001). However, it is plausible that as the Pacific

becomes more "Westernized" that asthma prevalence may increase and eventually reach the same levels throughout the Pacific as are currently seen in New Zealand. The available evidence also indicates that asthma is more severe in Pacific people (than in Europeans/Pakeha) in New Zealand, and that this may be due to problems of access to culturally appropriate asthma health care and asthma education (Moala and Pearce 2001).

A systematic standardised prevalence study, such as Phase III of the ISAAC study, was therefore seen as valuable in assessing, for the first time, the patterns and extent of asthma prevalence and morbidity throughout the Pacific in a standardised manner. This was possible because the ISAAC Phase III study not only involved repeating the survey in centres that had participated in Phase I (Phase IIIA centres), but also included new centres that had not previously participated (Phase IIIB centres).

Participation in Phase III of the ISAAC study was considered to be valuable in assessing the patterns and extent of asthma morbidity throughout the Pacific as well as determining future trends (Moala and Pearce 2001). This 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 (Foliaki et al. 2007).

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. As noted in chapter three, 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 (Douwes and Pearce 2002). The Pacific is of particular interest and importance in that regard since many countries have to some extent retained their traditional diet and lifestyles but are becoming increasingly 'Westernized', particularly in "urban" areas. There are also a variety of exposures to infections and farming environments and 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 islands environments (Foliaki et al. 2007).

In my role as ISAAC Phase III Regional Coordinator for Oceania, I therefore recruited a number of countries from throughout the Pacific. 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 I recruited were Tonga, Fiji Islands, Samoa, Cook Islands, Tokelau Islands, Niue and Nauru. In this chapter I describe the study design and methods used for conducting the ISAAC Phase III survey in these countries. In the following chapters I present the findings and discuss their implications.

As with the ISAAC Phase I surveys in other parts of the world, the purposes of the ISAAC surveys in the Pacific were primarily descriptive, and were intended to be hypothesis-generating rather than hypothesis-testing. The global ISAAC Phase III study aims were (Ellwood et al. 2005):

1. To examine time trends in the prevalence of asthma, allergic rhinoconjunctivitis and atopic eczema in centres and countries which participated in ISAAC Phase One;
2. To describe the prevalence and severity of asthma, allergic rhinoconjunctivitis and atopic eczema in centres and countries which did and did not participate in ISAAC Phase One; and
3. To examine hypotheses at an individual level which have been suggested by the findings of ISAAC Phase One, subsequent ecological analyses and recent advances in knowledge.

Of these aims, the first is not relevant to the ISAAC Phase III studies in the Pacific because no Pacific centres participated in Phase I and it was therefore not possible to examine time trends. However, aims 2 and 3 are clearly relevant. In particular, the ISAAC Pacific Phase III surveys were intended to:

- To describe the prevalence and severity of asthma, allergic rhinoconjunctivitis and atopic eczema in the participating Pacific centres and countries; and
- To examine in the participating Pacific centres and countries hypotheses at an individual level which have been suggested by the findings of ISAAC Phase One, subsequent ecological analyses and recent advances in knowledge.

With regard to the first aim, there were no formal hypotheses, but based on previous work it was expected that the asthma symptom prevalences observed in the Pacific would be lower than those levels previously observed in Pacific children and adolescents in New Zealand (Moala and Pearce, 2001). It could also have been

hypothesized that the level of asthma symptom prevalence in the participating Pacific centres would vary according to the level of "westernisation". However, as discussed further below, there is no simple categorisation of the participating centres as "western" or "non-western", which is another reason why the surveys were regarding as hypothesis-generating rather than hypothesis testing.

With regard to the second aim listed above, the ISAAC Pacific Phase III survey was intended to investigate whether risk factors or protective factors (e.g. infections, family size, passive smoking) that had been found to be associated with asthma risk in studies in other (primarily western) countries were also associated with asthma risk in Pacific countries. The hypotheses involved were therefore delineated by the questions in the ISAAC Phase III Environmental Questionnaire (EQ). A formal listing of the hypotheses was therefore considered unnecessary – it would simply be a list of the EQ questions (see http://isaac.auckland.ac.nz/Phasethr/EnvrQuest/EQFrame.html). None of these risk factors for asthma had been studied previously in the Pacific, and there was no reason to hypothesize that these risk factors would have a different relationship to asthma in the Pacific than in other parts of the world. On the other hand, it could not be assumed that these risk factors would have the same relationship to asthma in the Pacific as in other parts of the world. For example, the ISAAC Phase II survey recently found that atopy was much less strongly associated with asthma symptoms in non-affluent than in affluent countries (Weinmayr et al. 2007), and it was therefore possible that other factors (e.g. family size) might show different associations in the Pacific than, for example, in New Zealand.

4.1.1 Characteristics of participating countries

It should be stressed that the aims of the ISAAC study in the Pacific were primarily descriptive, as was the case for all ISAAC Phase I studies elsewhere in the world (Asher et al. 1995). There were no strong prior hypotheses, although there was some expectation that the more 'westernised' Pacific countries would show higher asthma prevalence, as was shown globally, to some extent, in ISAAC Phase I (Asher and Weiland 1998b). However, it is not simple to characterize the participating countries in terms of their degree of westernization. For example, the Tokelau Islands might be considered the most remote, and the most traditional, of the participating countries, but they also perhaps have the most westernized diet. Fruit and vegetables are scarce, and are only available through boats from Samoa; weather permitting. Tokelau does not have direct access to any other country except by boat through Samoa.

Throughout the thesis the countries are generally referred to as "islands". Being an island though does not necessarily suggest that they are all equally 'small' in terms of size, economy or similar in characteristics. The high migration and isolation of some islands means that some have small populations and are far from major markets. All the countries that participated in the current study had a population of less than one million at the time of the survey, with many being much smaller. The small domestic market does not allow for many options for economic development. There are close trades between sovereign countries and former colonies, with Niue and The Cook Islands trading mostly with New Zealand and French Polynesia and New Caledonia sending most of their exports to France. Samoa and Tonga offset deficits in trade through high remittances from overseas relatives mostly working in New Zealand, Australia and the

United States of America, as well as overseas aid. A vast marine environment and tourism are increasingly being tapped as a major resource.

Many of the small islands have experienced rapid population growth and urbanization aggravating unemployment as well as environmental effects. Many of larger islands with fertile land such as Samoa, Tonga and Fiji have maintained strong subsistence activities, but are increasingly dependent on imported food which affects both trade balance as well as nutritional standards. There is a significant dependence on government activities as a major source of income. There is a complex mix of cultural, social and western legal systems, resulting in legalisation of traditional rights to large amounts of land to a few people in some of the islands, as well as the adoption of a variety of systems of government (kingdoms, republics and self governing island states) as well as the perpetuation of colonies in the cases of French Polynesia and New Caledonia.

Tokelau

Tokelau, the smallest and last of New Zealand's dependent territories, comprises three tiny atolls with a population of 1600 situated about 500 kilometres north of Samoa with a total area of just 12 sq. km. Tokelau has been administered by New Zealand since 1926 but has now evolved into a self-governing territory based on the General Fono in association with New Zealand. All Tokelauans are New Zealand citizens as are Cook Islanders and Niueans (http://www.mfat.govt.nz/Foreign-Relations/Pacific/Tokelau/index.php). Fishery is the only significant revenue earner, and in 2006 80% of its national income was funded by New Zealand Agency for International Development (NZAID). Tokelau's average life expectancy stands at 69 years. The small islets have very little soil and a total land area of 12 square

kilometres, which means that the staple diet is now based on imported flour and rice. Also other food items such as vegetables are only occasionally available depending on any supplies on the weekly or fortnightly ferry from Samoa, weather permitting.

Samoa

The Independent state of Samoa with a land area of 2,934 square lies south of the equator, about halfway between Hawaii and New Zealand with a population of over 176,000. The two main islands are of volcanic origin, and the coasts are surrounded by coral reefs. Rugged mountain ranges form the core of both main islands. The government consists of a Head of State, a Prime Minister and a Cabinet of Ministers who comprise the Executive Council and a Legislative Assembly. The main exports include fresh fish, garments, beer, coconut products and taro. Agriculture remains an important, mainly subsistence, activity in Samoa, particularly in the villages. There are large overseas Samoan communities in New Zealand, Australia and the United States who contribute to the high remittances from overseas and Samoa's largest single source of foreign exchange (http://www.mfat.govt.nz/Countries/Pacific/Samoa.php). The Samoans are Polynesians, as are the rest of the Pacific countries involved in the current study (except parts of Fiji).

Fiji Islands

Situated southwest of Samoa and directly north of New Zealand, Fiji consists of just over 322 islands of which 106 are permanently inhabited by the country's 840,201 inhabitants, with the two main islands of Viti Levu and Vanua Levu sharing 87% of

the population. The British made Fiji a colony in 1874 and also brought Indian labourers for the sugar cane plantations who now account for 43% of the total population with indigenous Fijians (of mixed ethnicity, partly Tongan and Melanesian ancestry) accounting for just over 50%. Life expectancy is similar for both Indian and indigenous Fijians averaging 64 years for males and 68 years for females. The government consists of an elected multi-party parliament headed by a Prime Minister and a President as Head of State with an independent Judiciary (http://www.mfat.govt.nz/Countries/Pacific/Fiji.php). Since independence there have been several military coups with the latest occurring in 2006. Fiji is one of the more developed of the Pacific economies with forestry, mineral, fish resources, garments and the sugar industry. Despite the various coups, the tourism industry appears to have recovered repeatedly.

Tonga

The Kingdom of Tonga consists of four main island groups situated roughly a third of the way between New Zealand and Hawaii, south of Samoa and east of Fiji (on the "wrong" side of the International Dateline). The total land area of 747 square kilometres incorporating 169 islands is spread over 800 miles of ocean. Tonga had a population of 102,300 in 2005.

Tonga's government is based on a hereditary monarchy which has the final power to pass all laws, as well as decisions on dates for commencement and cessation of a Legislative Assembly. This is composed of Cabinet members appointed by the monarch, nine members representing 33 hereditary nobles and nine members representing the rest of the population. In 2004, overseas remittances made up 42.5% of the Gross Domestic Product (GDP). Life expectancy averages 70 years for males

and 72 for females. Similar to the other Pacific islands in the study, except the French territories to some extent, the population pyramid for Tonga has a "developing country" broad base; 35% of the Tongan population are under 14 years old. The keeping of domestic pigs is not an uncommon practice in Tongan homes particularly in villages, which may have implications for endotoxin exposure.

Niue

Niue is located 2,400 kilometres northeast of New Zealand in a triangle between Tonga, Samoa and the Cook Islands. It consists of a single 260 square kilometre raised coral island. Niue's total population, as enumerated in the 2006 Census had decreased to 1,625, down from around 5,000 in the 1960s. At the time of the 2001 New Zealand census, 20,100 Niueans were resident in New Zealand (http://www.mfat.govt.nz/Countries/Pacific/Niue.php). Niue is a self-governing state in free association with New Zealand, sharing the New Zealand currency as well as Niueans being New Zealand citizens. Niue's economy is constrained by limited access to reliable air and sea services, limited land and poor soil quality. The government is the main employer, although recently the government has established joint ventures with Auckland's Reef Group in fish processing and noni (Morinda citrifolia also known as nono or nonu tree with high vitamin and other medicinal nutrients in its juices) farming which have assisted with employment and export earnings.

Cook Islands

The Cook Islands are situated north-east of New Zealand. There are fifteen major islands, which spread over a vast area of the South Pacific Ocean as far north as the

Tokelau group and as far south as the southern latitudes of Tonga. This covers an area of at least two million square kilometres of ocean. The 2006 census estimated a total population of 19,569 with an average life expectancy of 70 and 75 for males and females respectively. The government is made up of an elected parliament, a House of Ariki (Chiefs) which advises the Government on land use and customary issues. The Head of State is the Queen and a separate Head of Government. Like most small Pacific islands, the Cook Islands face development constraints associated with geographical isolation and the dispersion of small population centres amongst 15 islands. The domestic market is small, and the islands are vulnerable to natural disasters such as cyclones. Tourism is estimated to account for around 40% of the gross domestic product in 2004/2005 (http://www.mfat.govt.nz/Countries/Pacific/Cook-Islands.php#facts), which is greater than the earnings from the two largest exports of fishing and pearl farming.

New Caledonia

New Caledonia is located approximately 1,200 kilometres east of Australia and 1,500 kilometres northwest of New Zealand and consists of one main island and several smaller islands. The main island, Grande Terre, has an area of 16,372 square kilometres with a mountain range running the length of the island, with five peaks over 1,500 meters (4,900 ft). New Caledonia is rich in minerals, including about one-quarter of the world's nickel and open-pit mining. This has contributed to severe environmental deterioration. The indigenous Melanesian Kanak community has declined, and now represents 44.6% of the total population, with the rest of the population made up of Europeans (34.5%) (predominantly French), with Polynesians, Asians and Indians making up most of the rest of the population. The average life

expectancy for the total population is 75 years. New Caledonia has a Territorial Congress (http://www.mfat.govt.nz/Countries/Pacific/New-Caledonia.php) and a government with some areas including taxation, health and labour law being administered in New Caledonia. The French Republic remains in charge of other areas, including foreign affairs, justice and treasury. Only a negligible amount of the land is suitable for cultivation, and food accounts for about 20% of imports. In addition to nickel, there is substantial financial support from France as well as income from tourism.

French Polynesia

The eastern-most location among the islands involved in the study was French Polynesia. This is located to the east of the Cook Islands archipelago and consists of over 100 islands and atolls, the largest and most populated being Tahiti. The islands are scattered over 2,500,000 square kilometres of ocean. The indigenous population are Polynesians who now make up 78% of the population, with the rest comprising Chinese (12%), French (locals or from metropolitan France), and others. French Polynesia has been an "Overseas Territory of France" since 1946. Under the March 2004 new autonomy statute, French Polynesia became an "overseas country" of France (http://www.mfat.govt.nz/Countries/Pacific/French-Polynesia.php) with increased domestic and international autonomy and a local government consisting of a Council of Ministers, appointed by the President of the Government, who in turn is elected by a majority vote of all the councillors in the Assembly of French Polynesia. The main imports are pearls and pearl jewellery. French Polynesia's economy is characterised by a narrow export base and a dependency on French financial aid (approximately 35% of GDP). There is a high reliance on France as a critical source

of income, more so during the nuclear testing years. In June 1996, France ended thirty years of nuclear testing in the atolls of Mururoa and Fangataufa. The extent of ecological damage and radiological contamination is reportedly monitored as well as any health effects due to radiological contamination.

4.1.2 Collaborative Aspects

The successful implementation of the ISAAC in the six Pacific Islands for which I coordinated the data collection (in addition to New Caledonia and French Polynesia) demanded a comprehensive process whereby a strong collaboration primarily in health research was established between the respective Ministries of Health and Education, and a world recognised health research institution (Massey University's Centre for Public Health Research), as well as adequate funding. In order for the collaboration to occur, of course, there was the need to convince health officials that quality research would provide strong evidence to base Pacific health development and policies upon. The priorities among the other stakeholders, namely the research institute and funding bodies must also collectively be accommodated.

As such, the health agendas and priorities of individual countries, and the research agendas and areas of expertise of the Centre for Public Health Research assisted in the close collaboration needed for the study. Specifically, the respective Ministries of Health among the six countries participating in ISAAC study in the Pacific have hoped for a real development in training and capacity building in health research for the last few decades, and that health research would address the health priorities for their populations. The proposed ISAAC Phase III study in the Pacific was very relevant to these aims. Furthermore, the public health research on asthma by the

Massey University Centre for Public Health Research (CPHR) is globally recognised and the funding from the Wellcome Trust was specifically targeted to developing health research for nationals of the small developing countries of the Pacific. These interlinked needs and processes provided valid and logical reasons for a collaborative effort to implement the ISAAC Study in the Pacific.

The rationale and specific objectives of the ISAAC Study had been presented at various regional meetings at least 12 months prior to its launch, initially at a Pacific regional health meeting in Nadi (Fiji). This was done by the author, the Director of CPHR, and personnel from the ISAAC International Data Centre. The study was promoted in a similar manner at a Pacific regional health information meeting in Apia (Samoa). Pacific islands health institutions were invited to participate in the ISAAC Study at these meetings as well as through their respective Ministries of Health. The latter was necessary as most representatives at regional health meetings often lack the appropriate authority to decide on research priorities on behalf of their respective Ministries of Health. These presentations at regional meetings were necessary to "capture" as many Pacific health personnel as possible in the discussion of the ISAAC Study and health research in general. These initial contacts were supplemented by personal trips to individual islands among the Pacific to further discuss the study with stakeholders. The author travelled to all of the six Pacific island countries to address the above issues, as well as to assist with the actual field work and data collection. With regards to the latter, I visited all three island atolls of Tokelau in June 2003 and carried out the ISAAC Study in all three schools. I also travelled to Samoa twice for consultation and the commencement of the fieldwork. The data collection was conducted in two of Tonga's three main island groups by the author, as well as the

launching of the study in the main island in Tongatapu. These activities further provided guidance and feedback as to the Pacific island countries that were likely to participate given resource constraints and other commitments. The success of the study was to a large extent due to the close collaboration between the CPHR hosting me as a Wellcome Trust Research Fellow and coordinating the ISAAC Study, the various Ministries of Health in the participating Pacific islands, the ISAAC International Data Centre and the overall coordination or the study by the author.

4.2. Study Design

All the participating centres in the Pacific were Phase IIIB centres since the Pacific countries (apart from Australia and New Zealand) had not participated in Phase I. The ISAAC Phase IIIB centres are the new centres from around the world that did not participate in Phase I but that did participate in Phase III.

The ISAAC Phase III Manual describes in detail all aspects and procedures for implementation of the study by Centres from rationale, planning, implementation to submission of data (ISAAC 2000). The basic study design involved selecting a defined geographical area and taking a random sample of school children 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.

Except for a number of small studies referred to above (Waite et al. 1980; Liard et al. 1988a; Flynn 1994b; Flynn 1994a), all of the centres from the Pacific had not participated in an asthma prevalence survey previously. All participating Pacific Islands had only one collaborating centre for ISAAC, as compared to larger countries such as the United Kingdom and Australia (New Zealand for example had six collaborative centres implementing ISAAC Phase I and five for Phase III).

It was specified that each centre should involve a random sample of at least 3,000 13-14 year old children, with the option of also recruiting 3,000 6-7 year old children. Only one Pacific centre included the younger age group, and the numbers were relatively small, so I will focus here on the survey in 13-14 year olds. The requirement of a sample size of 3,000 was based on the intention to detect differences, if they exist, which are meaningful clinically, epidemiologically, economically and for health service delivery. The sample size required to detect differences in severity of asthma is higher than that required to detect the same magnitude in differences in prevalence of asthma because severe asthma is less common. As the ISAAC Phase I Manual notes (Asher et al. 1995) a sample size of 3000 gives the following power:

1. Prevalence of wheezing: if the true one year prevalence of wheezing is 30% in one centre and 25% in another centre, with a sample size of 3000, the study power to detect this difference will be 99% at the 1% level of significance.
2. Severity of wheezing: if the true one year prevalence of severe asthma is 5% in one centre and 3% in another centre with a sample size of 3000 the study power to detect this difference will be 90% at the 1% level of significance.

The Phase I manual recognised that some centres may have limited resources or populations, but that it was nevertheless desirable for them to be included in the prevalence comparisons. The Manual therefore 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". In terms of the prevalence comparisons, if the true one year prevalence of wheezing is 30% in one centre and 25% in another centre, with a sample size of 1000, the study power to detect this difference will be 81% at the 5% level of significance.

However, the small total population of some Pacific countries meant that even a sample size of 1,000 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 whole population of 13 to 14 year olds in these countries. It was therefore agreed that these countries should be included in the ISAAC Phase III analyses even though they did not meet the sample size requirements.

4.2.1 ISAAC questionnaires

For the 13-14 year old age group, questionnaires were self-completed, usually at school. The ISAAC questionnaires have previously been presented in chapter two, and will only be discussed briefly here.

The key question used for assessing asthma symptom prevalence ('current wheeze') was: "Have you (has your child) had wheezing or whistling in the chest in the last 12

months"? Asthma severity was assessed by three questions relating to symptoms in the last twelve months: the number of attacks of wheezing; sleep disturbed due to wheezing; and wheezing severe enough to limit speech.

The ISAAC rhinitis and eczema questionnaires were also completed and analysed. However the findings from the rhinitis and eczema questionnaires are not the subject of this thesis, and are therefore not discussed here.

The ISAAC Asthma 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 asthma attack. For each of the scenes, students were asked whether their breathing had "ever" been like this. If yes: "in the last year?" If yes: "happened one or more times a month?"

Phase I only involved the basic symptom questionnaires (written questionnaire for asthma, rhinitis, and eczema as well as the asthma video questionnaire). However, Phase III also involved an optional environmental questionnaire asking about potential environmental risk/aggravating factors such as air pollution and diet was also administered to most (but not all) of the Pacific countries.

The three sections (core, environmental and video questionnaire) were all incorporated into one questionnaire. As specified in the ISAAC Phase III manual (ISAAC 2000), the core questionnaire was presented first (asthma-rhinitis-eczema). This was followed by the environmental questionnaire and then by the video questionnaire.

Three of the participating Pacific countries translated the questionnaires into local languages (Tonga, Samoa and 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 four conducted the survey in English (Cook Islands, Niue, Nauru and Fiji) - English is already the dominant/first language in Cook Islands/Niue and Nauru and Fiji, and teachers and health workers in those countries, following their review of the questionnaire, decided that it was most appropriate to conduct the survey in English..

4.2.2 Study population

All Pacific Island centres were registered with the ISAAC International Data Centre (IIDC) through the Regional Coordinator. The Registration Document was completed by each centre's Principal Investigator, declaring their intention to carry out the study according to the ISAAC protocol outlined in the Manual as well as providing contact details. This enabled the IIDC to update its database on collaborators, countries, centres and language codes.

All schools in Tokelau, Niue, the Cook Islands and the Republic of Nauru were selected and participated. In Tonga, all schools in the country were selected and participated 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 and participated. In Fiji all schools in the Suva Subdivision and some schools in the Rewa and Tailevu Subdivisions were selected.

4.2.3 Ethical Issues

Implementation of ISAAC Phase III in the Pacific was preceded by written invitations to Pacific Island countries to participate, along with the wide distribution of the Phase III Manual, announcements and brief presentations in regional scientific meetings and personal one on one consultations between the Regional Coordinator and Heads of Pacific Island countries Ministries of Health and respective National Public Health Departments. Following clearance by respective national Ethics Committees or appropriate national authorities (some countries had no identified "Ethics Committees"), as well as by the Massey University Human Ethics Committee, meetings were arranged and held with both government and non-government education authorities as well as formal submissions of invitation and information about ISAAC. 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 were to be taken as passive consent.

4.2.4 Data Collection

All countries were visited at least once by the regional coordinator, and some countries were visited more than once in preparation for the survey. All countries had a training session for the local health staff who were directly involved with the implementation of the study. The Regional Coordinator launched the data collection in Tokelau, Samoa and Tonga. This included the data collection from all the three schools in all three atolls in Tokelau, the supervision and collection of data from the

first five of the thirty six schools in Samoa and well as supervising and collecting data from two of the three districts in Tonga including one of the schools in the main island. In other countries data collection was done by local investigators under the guidance of the Regional Coordinator. Both government and non-government education authorities in each country were contacted personally as well as receiving written information and an invitation to discuss the ISAAC Study and participate in it. Prior to the actual survey date, further visits to the schools served as final preparations to ascertain a manageable number of students per session as well as ensuring appropriate space and environment for conducting the survey.

All schools in Tokelau, Niue, the Cook Islands, French Polynesia and New Caledonia were selected. In Tonga, all schools in the country 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 firstly 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. All data collection was conducted during school hours.

4.2.5 Data management

Dates of data collection were all documented. 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 to the paper questionnaire. Three countries (Tokelau, Samoa, Cook Islands), due to resource restrictions, were unable to perform their own data entry, and the Regional Coordinator did the data entry for these countries with some part-time assistance from the Massey University Centre for Public Health Research.

Except for Niue, comparisons of first entry and second entry files and its consequent comparisons and final approval were implemented through the Centre for Public Health Research (CPHR) of Massey University. The CPHR coded and transferred the final data set to the ISAAC Phase Three International Data Centre (IIDC) at Auckland via email as described in the ISAAC Coding and Data Transfer Section of the ISAAC Phase Three Manual (ISAAC 2000).

Following completion of data entry, all paper questionnaires will be stored for at least 3 years or of longer duration as per individual country direction.

For each centre, an ISAAC Centre Report was submitted to the IIDC, via the Regional Coordinator, following submission of the final data set. The Centre Report provided details of the local implementation of ISAAC Phase Three addressing key issues including geographical definitions, sampling of schools and children, participation rates, translation of questionnaires, data management including its entry and formats

during submission to the IIDC. The IIDC reviewed individual Centre Reports and contacted centres for further clarifications where appropriate.

4.2.6 Data analysis

For the prevalence analyses the asthma 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. The presented analysis will focus on the six Pacific Island countries that the Regional Coordinator directly coordinated ISAAC in (Tokelau, Samoa, Fiji, Tonga, Niue, Cook Islands), but will also include the previously collected data for the two other ISAAC Phase III Pacific centres of New Caledonia and French Polynesia.

The environmental questionnaire provided an opportunity to estimate the associations of various environmental exposures with symptom prevalence. I examined the association between environmental exposures and current asthma symptom prevalence in both age groups using prevalence odds ratios with adjustment for confounding using logistic regression (Pearce 2004). The data was analysed using both STATA (STATA Statistical Software Release 7.0 2001) and PC SAS.

The findings of the analyses of prevalence, and of risk factors addressed in the environmental questionnaire, are presented in the next two chapters.

4.2.7 Challenges

Finally, I would like to note at this stage some of the challenges involved in undertaking this data collection in the Pacific.

Coordinating health research in some Pacific island countries can be challenging due to either their remote location in relation to other neighbouring countries, or between the islands within a single country. For instance, at the time of the ISAAC study the only means of getting to Tokelau was by way of a weekly or fortnightly (weather permitting) 24 to 30 hour boat trip from Apia, Samoa. Travel between the three Tokelau island atolls is likewise only possible by an average 12 hour trip between each atoll by the same boat which is based in Samoa. Until recently, and at the time of the survey, the only connection between Niue and other countries was through the limited seats available in a once-a-week flight from Tonga in a Twin Otter.

The lack of health research infrastructure can mean delays in implementing approved research due to unavailability of research personnel. The ISAAC study in the Pacific as a result was carried out by the author, health educators and clinical paediatricians and nurses when they had time to spare from their primary responsibilities. The lack of health research structures also meant that there was very little in local support budgets for the individual country ISAAC studies. Three of the Pacific islands that participated had no formal research or ethics committees, with the offices of the Director of Health holding the mandate for research procedures and the equivalent of ethical clearance.

All of these factors meant that there were considerable practical difficulties with the data collection. Despite this, good response rates were obtained, and satisfactory data

collection was completed in all participating countries. The results of this data collection are discussed in the next chapter.

Chapter 5: Findings: asthma prevalence

5.1 Response rates

Table 5.1 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 6-7 and the 13-14 year old children) all the Pacific Island countries surveyed only the 13-14 year olds.

Table 5.1 shows that the response rates among school children were high in Tokelau (100%), French Polynesia (99%), Samoa (96%) as well as for Fiji and Niue (both at 93%), followed by New Caledonia and Tonga (both 87%). The number of participants varied significantly between countries ranging from 66 in Tokelau to 7,247 in New Caledonia. Five of the countries however had more than 2,000 participants with three countries having more than 3,000 participants each.

Table 5.1: Characteristics of participating centres and response rates for 13-14 year olds

Country	Period of data collection	Sampling frame	No. of schools	Selection of children. By grade/level or age	Number 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%)

5.2. Study participants

The characteristics of the participating countries have been described in chapter 4.

Table 5.2 presents the participant characteristics for 13-14 year olds. Of the 20,876 school children that participated 21.9% (4,564) were outside of the 13-14 year old range. For those that were within 1-2 years of the age range, their responses were included in the analysis as is the standard practice for ISAAC (ISAAC 2000); 50 (0.2%) responders did not include information on gender and have been excluded from the analyses presented in Table 5.2, but are included in all other analyses, as were 75 (0.4%) respondents who did not include information on age.

5.3. Prevalence

The prevalence of symptoms of asthma, and specifically those identified by ISAAC as valid markers of asthma burden and asthma at the population, will be the focus of the reported prevalences. I will focus on the findings for the written questionnaire, since this was compulsory and was used by all centres, whereas the video questionnaire was only used in six of the eight centres in 13-14 year olds (and in about two-thirds of the centres worldwide), and was not used in 6-7 year olds. The reader should bear in mind the small numbers encountered in some countries, especially Niue (47 in the 6-7 year old group; 79 in the 13-14 year old group) and Tokelau (66 in the 13-14 year old group).

Table 5.2: Participant characteristics for 13-14 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	16237
>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		20876

5.3.1 Prevalence in 6-7 year olds

Only Niue collected data on 6-7 year olds (Table 5.3). The prevalence of wheeze in the last 12 months ("current wheeze") was 17.0%, which is higher than has been reported in the same age-group in New Zealand (see discussion below).

Table 5.3: Prevalence of asthma symptoms in 6-7 year olds.

	Niue	
	%	n
Asthma symptoms		
Wheezing ever	38.3	18
Wheezing in last 12 months	17.0	8
≥ 1 wheezing attack in last 12 months	17.0	8
Night waking in last 12 months	10.6	5
Severe wheeze in last 12 months	2.1	1
Asthma ever	27.7	13
Exercise wheeze	8.5	4
Night cough in last 12 months	42.6	20

5.3.2 Prevalence in 13-14 year olds

The focus of this chapter will be on asthma symptoms in 13-14 year old children.

Table 5.4 presents the (written questionnaire) prevalence of asthma symptoms among 13-14 year olds for the eight Pacific Islands (Foliaki et al. 2007). Overall, 9.9% of the participants had had wheezing in the last 12 months and 13.8% reported ever having had asthma. The prevalences of asthma severity, as assessed by night waking due to wheeze and wheezing severe enough to limit speech, was 5.5% and 3.2% in the last 12 months respectively. Of the larger centres, Tonga showed the highest prevalence for current wheeze (16.2%) with Samoa showing the lowest (5.8%).

Table 5.4: Prevalence of asthma symptoms in 13-14 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

7Table 5.5: Prevalence of asthma symptoms in 13-14 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

	Tonga		Samoa		Fiji		Niue		Tokelau		New Caledonia		Total	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
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

Table 5.5 presents the responses to the asthma video questionnaire from the same countries (except for the Cook Islands and French Polynesia who did not do the video 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. Thus, Samoa had the lowest prevalence for both the written and video questionnaires. For the video questionnaire, 4.9% of respondents reported waking with wheezing in the last year with little variation among the four Pacific countries that had more than 1,000 respondents; Fiji had the highest reported prevalence (5.7%) and the lowest was in Samoa (3.1%). The overall prevalence rate for children having had a severe attack of wheezing in the last year was 4.5%, ranging from 6.1% (Fiji) to 3.0% (Samoa). The two populations with small study populations (Niue and Tokelau) had prevalences of a severe attack of wheezing in the last year of 2.5% and 6.1% respectively.

5.4. Discussion

This study is the first to determine the prevalence of asthma in nine Pacific Island countries using standardised methodology and instruments (written and video questionnaires). As noted above, of the few studies of asthma prevalence (Waite et al. 1980; Liard et al. 1988a; Flynn 1994b; Flynn 1994a) 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 (Waite et al. 1980) and reported a prevalence of 11.0% among 706 Tokelauan children aged 0--14 years in Tokelau compared to 25.3% of the 1,160 Tokelauan children seen in New Zealand.

Another study, involving a self administered questionnaire completed by 6731 adolescents school children (average age 13.5 years) in Tahiti in French Polynesia, reported 14.3% giving 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. Thus, Liard (Liard et al. 1988a) found no evidence for any differences in asthma prevalence between three main ethnic participants (European, Chinese, Polynesian).

Admissions for asthma however were three times higher in Fijian Indians compared to Fijians (Melanesians) in a study of national hospital admissions among 5-14 year old children in Fiji for the 4 years between 1985 and 1989 (Flynn 1994b; Flynn 1994a).

In contrast with these previous studies, the findings of the current study are comparable across the Pacific countries involved, and with those in Pacific populations in others countries (e.g. New Zealand) that also participated in the ISAAC survey. 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 13-14 year olds) and Niue (79 13-14 year olds and 47 6-7 year olds). These were included since the survey involved the whole population of 13-14 year olds in these countries. However, the prevalence findings for these countries are clearly unstable due to the small numbers involved. Therefore, I will concentrate on the findings for the larger centres in the discussion below.

There are two key findings from the current study. Firstly, there is considerable variation in symptom prevalence through the Pacific. The lowest prevalence for current wheeze (wheezing in the last 12 months) was in Samoa (5.8%) with Tonga reporting the highest prevalence in the larger centres at 16.2%. For 'asthma ever', there was a smaller range of variation, with 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 asthma symptom prevalence on Tokelau (Waite et al. 1980). A recent study attributed these low prevalence levels to the low indoor allergen levels on Tokelau (Lane et al. 2005), but it appears that prevalence has now increased despite these low indoor allergen levels.

Discussion of the differences in prevalence over time for Tokelau should take into account the different methodologies between the Waite study (Waite et al. 1980) (which included physical examinations and lung function tests to define outcomes of asthma interest) and the current study (which was based on questionnaires only). In addition, there are global reports of increasing asthma prevalence implicating environmental factors and the Pacific is very much in midst of these environmental changes. These involve many aspects including social, economic and natural environmental changes. The diverse socioeconomic levels, lifestyle and natural environments characterising Pacific island countries may play a central role in the wide variations in prevalence between Pacific islands countries (Foliaki et al. 2007).

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 (Pattemore et al. 2004). 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 Pacific countries than those reported among Pacific, Māori and European respondents in the ISAAC Phase I survey carried out in 1992-1993 in New Zealand (Asher et al. 2001; Pattemore et al. 2004). In particular, the overall prevalence of current wheeze (9.9%) in the current survey, compared to previous findings for current wheeze among Pacific (21.1%), Māori (30.8%) and European (31.7%) respondents in the New Zealand Phase I ISAAC study. The prevalence of "asthma ever" (13.8%) is also low compared to Pacific Islanders (19.2%), Māori (24.7%) and Europeans (25.2%) in New Zealand (Pattemore et al. 2004). 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 European (8.0%), Māori (8.7%) and Pacific (7.5%) children.

Only Niue collected data on 6-7 year olds (Table 5.3), and there are no readily available data on any previous studies of asthma symptoms among this age group either in Niue or other Pacific Island country. In similar ISAAC studies of the same age group in Wellington that compared Māori and non-Māori in New Zealand all asthma symptoms were higher than those reported here among the Niue group (Ellison-Loschmann 2004). The reported prevalences in Niue for current wheezing (wheezing in the last 12 months), having had more than one attack of wheezing (in the past 12 months) and waking at night due to wheezing for example were 17%, 17% and 10.6% respectively as compared to Māori (31%, 31% and 21%) and non-Māori (23%, 23% and 13%). Similarly, the

prevalences of severe wheeze in the last 12 months (2%), and "ever asthma" (28%) among the Niue population were also lower than those found among Māori (5%, 42%) and non-Māori (4%, 31%) in New Zealand. Pattemore *et al* (Pattemore et al. 2004) compared asthma symptom prevalence among the six New Zealand centres that participated in ISAAC Phase One from 1992-1993. Their comparisons similarly found higher prevalence for wheezing in the last 12 months of 24.2% (Europeans), 27.6% (Māori) and 22.0% for Pacific Island compared to the Niue figure of 17.0%.

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, and that children who migrate can experience an altered risk of asthma as a result of exposure to a new environment during childhood (Pearce et al. 2002). 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 similar prevalence to non-migrant children (Leung 1994; Leung et al. 1994; Leung and Ho 1994; Powell et al. 1999; Gibson et al. 2003; Migliore et al. 2007). This supports the hypothesis that the lower prevalence observed in recent migrants is due to differences in environmental exposures between their countries of origin and their host countries (Foliaki et al. 2007).

In conclusion, this study is the first to determine the prevalence of asthma symptoms, in nine Pacific Island countries using standardised methodology and instruments (written and video questionnaires). It has found that there is considerable variation in

symptom prevalence through the Pacific, but the prevalence levels are generally considerable 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.

As with all other ISAAC prevalence surveys, this study is primarily descriptive and has not been able to, and was not intended to, identify which specific factor or factors may explain the observed prevalence patterns. The descriptive results however can serve to suggest hypotheses and potential areas for future detailed research. Currently it is unclear whether the global asthma prevalence increases that accompany westernisation are due to a single, as yet unidentified, factor, or whether it is a "package" of factors that is responsible (Douwes and Pearce 2002). The degree of westernisation varies across the Pacific countries studied, as indicated by gross national income, lifestyle and exposure to risk factors. For instance, as discussed in chapter 4, the traditional houses in Samoa (which had the lowest asthma symptom prevalence), which are still commonly used, allow for the walls to be rolled up in the daytime, essentially resulting in 'open' and well ventilated houses. This may have implications for reducing indoor allergen exposure as well as exposure to indoor air pollutants such as nitrogen dioxide from gas cooking. The numbers in the Tokelau survey are small, but they are of interest because of contrasting methods of livestock domestication that may contribute to microbial studies in the Pacific. In Tokelau the presence of cats and dogs is illegal. Pigs are encouraged to be killed if found in the village and are kept in a communal pen at the end of the island. These contrasting

Pacific characteristics are therefore areas that merit further research into the potential causes of the observed differences.

The current migration characteristics of the Pacific populations are also an area with great potential for further research. We know from the current study (and previous studies among Tokelau children) that asthma prevalence among Pacific children in the Pacific is consistently lower than among Pacific children in New Zealand. Migration studies would assist in our efforts to ascertain the determinants of the global asthma prevalence patterns and time trends.

Chapter 6: Findings: Asthma Risk Factors

6.1 Prevalence of Environmental Risk Factors

In addition to the ISAAC core symptom questionnaires, the ISAAC Phase III Environmental Questionnaire (EQ) was used in the survey of 13-14 year olds in Fiji (3,093 children), Samoa (2,988 children) and Tokelau (66 children). Clearly, the Tokelau findings are based on small numbers of children, so I will focus on the findings for Fiji and Samoa, and for all countries combined, but will mention the Tokelau findings briefly where they are particularly interesting or relevant. As in the previous chapter, I will focus on the findings for the written questionnaire, since this was compulsory and was used by all centres, whereas the video questionnaire was only used in six of the eight centres in 13-14 year olds (and in about two-thirds of the centres worldwide), and was not used in 6-7 year olds.

6.1.1 Key questions on risk factors

The ISAAC Phase III Environmental Questionnaire (EQ) (see Appendices) and the key variables considered will only be summarised briefly here. The EQ included questions on dietary intakes over the previous 12 months and specifically on the frequency of consuming certain food items such as meat, seafood, fruit, vegetables, pulses, cereal, pasta, rice, dietary products and eggs. The degree of physical activity was also assessed through questions on frequency and level of exercise, and hours watching television. Methods and fuels for cooking (e.g. electricity, gas or open fire) were also assessed, as were methods of household heating (although very few if any households needed heating in these countries).

6.1.2 Prevalence of environmental risk factors

Table 6.1 shows the prevalences of various environmental risk factors by country (Fiji, Samoa, Tokelau), and for all countries combined, for the 13-14 year old study participants. There are striking differences in prevalence for some environmental risk factors between Tokelau and Fiji and Samoa, which are likely to be due to their different geographical circumstances and traditions. For example, there is a marked difference in the prevalence (12.1%) of respondents having vegetables more than three times a week in Tokelau compared to the Samoa and Fijian figures of 62.0% and 84.4% respectively. Similarly, there is a three fold difference in fruit consumption between Tokelau children (21.9%) compared to Fiji (63.8%) and Samoa (62.0%).

Table 6.1 Prevalence of environmental risk factors by country for 13-14 year olds

Variable	Frequency	Fiji % exposed (n)	Samoa % exposed (n)	Tokelau % exposed (n)	Total % exposed (n)
Meat	3 or more times/week	32.8 (1011)	59.2 (1742)	18.2 (12)	45.4 (2765)
Seafood	1 or more times/week	88.6 (2730)	79.5 (2326)	95.4 (62)	84.3 (5118)
Fruit	3 or more times/week	63.8 (1960)	62 (1811)	21.9 (14)	62.5 (3785)
Vegetables	3 or more times/week	84.4 (2611)	62 (1811)	12.1 (8)	72.9 (4418)
Pulses	1 or more times/week	84.5 (2579)	67.1 (1897)	25 (16)	75.5 (4492)
Cereal	3 or more times/week	60.4 (1856)	70.1 (2039)	23.4 (15)	64.7 (3910)
Pasta	3 or more times/week	7.5 (192)	9.5 (131)	83.3 (55)	9.4 (378)
Rice	1 or more times/week	96.9 (2983)	95.2 (2773)	Excludes Tokelau	96.1 (5756)
Butter	1 or more times/week	89.4 (2752)	87.2 (2501)	28.6 (18)	87.7 (5271)
Margarine	1 or more times/week	67.7 (2037)	58.6 (16190	29.2 (19)	62.9 (3679)
Nuts	1 or more times/week	71.8 (2201)	74.3 (2156)	31.8 (21)	72.6 (4378)
Potato	3 or more times/week	41.4 (1273)	37.4 (1094)	Excludes Tokelau	39.5 (2367)
Milk	3 or more times/week	68.5 (2114)	51.2 (1512)	30.3 (20)	59.7 (3646)
Eggs	1 or more times/week	87.6 (2701)	86.1 (2543)	69.7 (46)	86.6 (5282)
Fastfood	1 or more times/week	67 (2041)	83.9 (2468)	56.3 (36)	75.1 (4545)
Exercise	3 or more times/week	25.6 (787)	28.6 (845)	34.8 (23)	27.1 (1655)
Television	3 or more hours/day	67.7 (2091	46.1 (1364)	50 (33)	57 (3488)
Electric cooking	Yes	27.4 (847)	25.2 (752)	7.6 (5)	26.1 (1604)
Gas cooking	Yes	83.1 (2571)	53.2 (1589)	31.8 (21)	68 (4181)
Open Fire cooking	Yes	42.5 (1315)	60.2 (1799)	36.4 (24)	51 (3138)
Other fuel cooking	Yes	0 (0)	23.7 (709)	45.5 (30)	12 (739)
Paracetamol past year	At least once per month	62.5 (1931)	46.1 (1353)	37.5 (24)	54.3 (3308)
Older siblings	0		20 (595)	25.4 (16)	20.1 (611)
	1		18.1 (538)	17.5 (11)	18.1 (549)
	2 +		61.;9 (1837)	57.1 (36)	61.8 (1873)
Younger siblings	0		18.2 (539)	21.3 (13)	18.3 (552)
	1		21.1 (624)	16.4 (10)	21 (634)
	2 +		80.7 (1797)	62..3 (38)	60.7 (1835)
Born in New Zealand	Yes		7.5 (221)	10.8 (7)	7.6 (228)
Years lived in Country of Survey	5 years or less	2.8 (86)	89.5 (590)	79.2 (19)	18.4 (695)
	6 – 10 years	2.5 (76)	7.7 (51)	12.5 (3)	3.4 (130)
	11 – 13 years	58.5 (1809)	2 (13)	8.3 (2)	48.3 (1824)
	14 years or more	36.3 (1122)	0.8 (5)	0 (0)	29.8 (1127)
Trucks pass house	Frequently or almost all day	87 (2690)	45.2 (1315)	40 (26)	66.5 (4031)
Cat now	Yes	37 (1145)	70.6 (2094)	56.1 (37)	53.5 (3276)
Dog now	Yes	64 (1979)	88.5 (2624)	3.1 (2)	75.2 (4605)
Mother smokes	Yes	18.6 (575)	24.4 (720)	83.3 (55)	22.1 (1350
Smokers in house	0	45.7 (1414)	27.4 (810)	12.5 (8)	36.5 (2232)
	1	30.9 (957)	24.3 (717)	28.1 (18)	27.7 (1692)
	2+	23.3 (722)	48.3 (1428)	59.4 (38)	35.8 (2188)

There was also a marked difference in regular meat consumption (three or more times a week) across all three countries with 18.2% prevalence for Tokelau and 32.8% and 59.2% respectively for Fiji and Samoa.

In general, while there are differences in the prevalences of various dietary factors in the three countries, the most striking differences involve imported foods which were less common in the Tokelau Islands. In addition to the above-mentioned dietary factors, other factors with marked differences included butter consumption (28.6% for Tokelau compared to 89.4% and 87.2% respectively for Fiji and Samoa), margarine (29.2% for Tokelau compared to 67.7% and 58.6% respectively for Fiji and Samoa), cereal consumption (23.4% in Tokelau compared to 60.4% in Fiji and 70.1% in Samoa). There were also low prevalences of consumption of nuts (31.8%) and milk (30.3%) in Tokelau compared to Fiji (nuts: 71.8%; milk: 68.5%) and Samoa (nuts: 74.3%; milk: 51.2%). Fiji also processes dairy milk locally.

There was also a much lower prevalence of cooking with electricity in Tokelau (7.6%) in comparison with both Fiji (27.4%) and Samoa (25.2%). Cooking with gas was also very low in Tokelau (31.8%) and higher in Samoa (53.2%) and highest in Fiji (83.1%). Fiji is the major regional distributor of gas (both domestic and industrial) and gas is therefore cheaper there than in the other islands. Open fire cooking on the other hand was highest in Samoa (60.2%) with Fiji (42.5%) next and Tokelau recording the lowest prevalence at 36.4%.

Fiji had the highest prevalence of participants reporting that trucks pass their house frequently or almost all day (87.0%), with Samoa reporting 45.2% and Tokelau

reporting 40%. The small communities in Tokelau generally consist of one road villages where the few vehicles in the islands do pass most houses every time the vehicle travels from one place to another.

Fiji had the lowest prevalence of reported cat ownership (37.0%), with Tokelau being intermediate (56.1%) and Samoa having the highest (70.6%). Tokelau law does not permit dogs in the country, and this is reflected in the estimate of 3.1% having owned a dog in the last 12 months (presumably in another country). However, there is also a sizeable difference in dog ownership between Fiji (64.0%) and Samoa (88.5%).

The majority of mothers of participants in Tokelau (83.3%) smoked tobacco compared to Fijian (18.6%) and Samoan mothers (24.4%) The percentage of participants who reported that there were smokers in the house also varied from 87.5% in Tokelau, to 54.2% in Fiji and 72.6% in Samoa.

6.2. Associations of Environmental Factors with Asthma Prevalence

In this section I will focus on the findings for asthma risk factors, and will only briefly mention, where relevant, the findings for other conditions.

6.2.1 Data analysis

The data analyses involved the key questions on the prevalence of symptoms of asthma, rhinitis and eczema from the ISAAC questionnaire (Asher and Weiland 1998a); (Committee 1998). For the symptom questions, I followed the standard practice for ISAAC questionnaires and coded a missing response as "no symptoms"

(Committee 1998). On the other hand, for the questions on environmental exposures, once again following the standard ISAAC procedures, missing values were treated as "missing" in the analysis. The key asthma questions used were those on "wheeze in the past 12 months" ("current wheeze") and ever had asthma ("asthma ever").

The data was analysed using standard methods for asthma prevalence studies (Pearce 2004). The associations of specific exposures with symptom prevalence were estimated using prevalence odds ratios, with adjustment for confounding using the Mantel-Haenszel method (Mantel and Haenszel 1959) and logistic regression (Breslow and Day 1980). The data was analysed using STATA. After conducting the separate analyses for each of the three participating centres, it was found that the key findings were very similar across the three centres the three data sets were combined in the final analyses, which were adjusted for 'centre'.

6.2.2 Findings for Individual Countries

Tables 6.2-6.4 show the findings for individual countries for the associations of environmental factors with the prevalence of symptoms of asthma. For each symptom, the first column shows the prevalence of the population exposed (among the study participants in that country), followed by the prevalence odds ratio (POR) and 95% confidence interval (95% CI).

Fiji

Table 6.2 summarises the findings in Fiji, adjusted for age and gender. There were strong associations between wheezing in the past 12 months and having margarine once a week or more (POR 1.47; 95% CI 1.13-1.93), vigorous exercise three times a week or more (POR 1.45; 95% CI 1.12-1.87) and taking paracetamol at least once a month (POR 1.42; 95% CI 1.11-1.83).

Among the Fiji participants, the strongest associations with "asthma ever" were with having pasta once a week or more (POR 1.42; 95% CI 1.13-1.78), having meat three times or more a week (POR 1.27; 95% CI 1.02-1.57), having margarine once a week or more (POR 1.32; 95% CI 1.04-1.66), mother smoking (POR 1.38; 95% CI 1.08-1.76), and having two or more smokers in the house (POR 1.33; 95% CI 1.03-1.71).

Table 6.2 Prevalence odds ratios for various environmental risk factors in Fiji, adjusted for age and gender

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95%LCI	95%UCI	% with symptom	POR	95% LCI	95% UCI
Meat	0	Never-once or twice/week	9.9				12.7			
	1	Three or more times/week	11.3	1.14	0.89	1.45	15.5	1.27	1.02	1.57
Seafood	0	Never-occasional	11.4				13.4			
	1	Once a week or more	10.3	0.87	0.61	1.24	13.7	1.02	0.74	1.42
Fruit	0	Never-once or twice/week	9.8				14.4			
	1	Three or more times/week	10.7	1.15	0.90	1.47	13.1	0.91	0.73	1.12
Vegetables	0	Never-once or twice/week	9.1				14.6			
	1	Three or more times/week	10.6	1.20	0.86	1.67	13.4	0.92	0.69	1.21
Pulses	0	Never-occasional	11.8				13.1			
	1	Once a week or more	10.0	0.84	0.62	1.14	13.7	1.06	0.79	1.41
Cereal	0	Never-once or twice/week	11.4				13.2			
	1	Three or more times/week	9.7	0.83	0.65	1.05	13.7	1.05	0.85	1.29
Pasta	0	Never-occasional	10.0				11.9			
	1	Once a week or more	10.8	1.11	0.86	1.43	16.0	1.42	1.13	1.78
Rice	0	Never-occasional	9.6				11.7			
	1	Once a week or more	10.4	1.08	0.54	2.16	13.7	1.19	0.63	2.25
Butter	0	Never-occasional	10.8				13.8			
	1	Once a week or more	10.3	0.94	0.65	1.37	13.6	0.98	0.70	1.36
Margarine	0	Never-occasional	8.0				11.5			
	1	Once a week or more	11.6	1.47	1.13	1.93	14.7	1.32	1.04	1.66
Nuts	0	Never-occasional	12.7				13.3			
	1	Once a week or more	9.5	0.72	0.56	0.92	13.8	1.04	0.83	1.31
Potato	0	Never-once or twice/week	10.5				13.7			
	1	Three or more times/week	10.2	0.97	0.76	1.22	13.7	1.00	0.81	1.23
Milk	0	Never-once or twice/week	10.0				12.2			
	1	Three or more times/week	10.6	1.09	0.85	1.40	14.3	1.21	0.96	1.52

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95%LCI	95%UCI	% with symptom	POR	95% LCI	95% UCI
Eggs	0	Never-occasional	8.6				13.2			
	1	Once a week or more	10.6	1.29	0.88	1.88	13.6	1.03	0.75	1.41
Fastfood	0	Never-occasional	9.8				13.2			
	1	Once a week or more	10.7	1.13	0.88	1.45	13.8	1.06	0.85	1.32
Exercise	0	Never-once or twice/week	9.3				13.3			
	1	Three or more times/week	13.6	1.45	1.12	1.87	14.5	1.08	0.85	1.37
Television	0	Less than 3 hours/day	11.0				12.0			
	1	3 or more hours/day	10.0	0.93	0.73	1.19	14.4	1.24	0.99	1.56
Electric cooking	0	No	10.0				13.0			
	1	Yes	11.5	1.21	0.94	1.56	15.1	1.20	0.96	1.51
Gas cooking	0	No	11.5	0.88	0.65	1.18	14.2			
	1	Yes	10.2				13.5	0.95	0.72	1.24
Open fire cooking	0	No	10.6				13.6			
	1	Yes	10.1	0.95	0.76	1.21	13.6	1.00	0.81	1.23
Paracetamol past year	0	Less than once/month	8.5				12.7			
	1	At lease once/month	11.5	1.42	1.11	1.83	14.2	1.14	0.92	1.41
Years lived in country of survey	0	Less than five	8.6				17.1			
	1	Five to ten	11.3	1.47	0.45	4.87	15.1	0.87	0.33	2.31
	2	Ten or more	10.4	1.32	0.56	3.07	13.5	0.77	0.41	1.44
Trucks pass house	0	Seldom	10.0				14.0			
	1	Most of the day	10.4	1.04	0.74	1.48	13.5	0.96	0.71	1.31
Cat now	0	No	10.0				13.1			
	1	Yes	11.1	1.16	0.92	1.47	14.5	1.14	0.92	1.41
Dog now	0	No	10.4				13.0			
	1	Yes	10.4	0.99	0.78	1.26	13.9	1.08	0.87	1.34
Mother smokes	0	No	9.9				12.9			
	1	Yes	12.3	1.30	0.98	1.72	16.9	1.38	1.08	1.76

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95%LCI	95%UCI	% with symptom	POR	95% LCI	95% UCI
Smokers in house	0	0	9.6				12.9			
	1	1	10.4	1.09	0.83	1.44	12.4	0.95	0.75	1.22
	2	2+	11.8	1.25	0.94	1.67	16.5	1.33	1.03	1.71

Table 6.3 Prevalence odds ratios for various environmental risk factors in Samoa, adjusted for age and gender

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Meat	0	Never-once or twice/week	5.9				12.5			
	1	Three or more times/week	5.7	0.99	0.72	1.36	15.2	1.25	1.01	1.55
Seafood	0	Never-occasional	6.5				12.5			
	1	Once a week or more	5.5	0.86	0.59	1.26	14.4	1.18	0.90	1.55
Fruit	0	Never-once or twice/week	6.3				14.1			
	1	Three or more times/week	5.6	0.91	0.67	1.25	14.1	1.01	0.82	1.26
Vegetables	0	Never-once or twice/week	5.3				13.4			
	1	Three or more times/week	6.0	1.17	0.84	1.63	14.5	1.12	0.90	1.39
Pulses	0	Never-occasional	5.6				14.6			
	1	Once a week or more	5.9	1.05	0.75	1.48	14.3	0.976	0.78	1.22
Cereal	0	Never-once or twice/week	5.5				13.9			
	1	Three or more times/week	6.0	1.12	0.79	1.58	14.3	1.04	0.83	1.31
Pasta	0	Never-occasional	7.4				15.9			
	1	Once a week or more	7.5	1.03	0.67	1.60	16.9	1.07	0.78	1.45
Rice	0	Never-occasional	5.8				6.5			
	1	Once a week or more	5.9	1.17	0.54	2.53	14.5	2.72	1.32	5.59
Butter	0	Never-occasional	6.0				11.2			
	1	Once a week or more	5.8	0.97	0.61	1.54	14.6	1.34	0.95	1.90
Margarine	0	Never-occasional	6.3				12.3			
	1	Once a week or more	5.7	0.90	0.65	1.24	15.6	1.30	1.04	1.63
Nuts	0	Never-occasional	5.8				13.7			
	1	Once a week or more	5.8	1.00	0.70	1.44	14.4	1.04	0.82	1.33
Potato	0	Never-once or twice/week	5.5				13.8			
	1	Three or more times/week	6.5	1.22	0.89	1.67	14.9	1.09	0.88	1.35
Milk	0	Never-once or twice/week	5.8				12.6			
	1	Three or more times/week	5.8	1.01	0.74	1.37	15.5	1.24	1.00	1.53

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Eggs	0	Never-occasional	5.8				13.4			
	1	Once a week or more	5.8	1.06	0.67	1.67	14.2	1.08	0.79	1.46
Fastfood	0	Never-occasional	5.3				13.1			
	1	Once a week or more	5.9	1.14	0.73	1.76	14.3	1.13	0.84	1.52
Exercise	0	Never-once or twice/week	5.3				13.1			
	1	Three or more times/week	7.2	1.32	0.94	1.85	16.6	1.37	1.08	1.73
Television	0	Less than 3 hours/day	5.4				13.3			
	1	3 or more hours/day	6.4	1.18	0.87	1.61	15.0	1.11	0.90	1.37
Electric cooking	0	No	4.7				13.0			
	1	Yes	9.2	2.10	1.53	2.88	17.2	1.38	1.10	1.74
Gas cooking	0	No	5.4				11.9			
	1	Yes	6.2	1.18	0.86	1.61	16.0	1.43	1.15	1.76
Open fire cooking	0	No	6.5				15.0			
	1	Yes	5.3	0.81	0.59	1.11	13.5	0.89	0.72	1.10
Paracetamol past year	0	Less than once/month	5.1				13.3			
	1	At lease once/month	6.7	1.37	1.00	1.87	15.3	1.17	0.95	1.44
Older siblings	0	0	7.9				16.0			
	1	1	5.2	0.63	0.39	1.03	16.4	1.03	0.75	1.42
	2	2 or more	5.3	0.64	0.45	0.92	12.7	0.76	0.59	0.99
Younger siblings	0	0	6.3				12.1			
	1	1	6.7	1.06	0.67	1.70	14.4	1.24	0.88	1.76
	2	2 or more	5.3	0.81	0.54	1.21	14.4	1.26	0.94	1.69
Born in New Zealand	0	No	5.4				13.3			
	1	Yes	10.4	2.01	1.26	3.19	24.0	2.02	1.45	2.81
Years lived in country of survey	0	Less than five	9.5				15.9			
	1	Five to ten	10.9	1.21	0.51	2.84	25.0	1.64	0.86	3.10
	2	Ten or more	13.3	1.51	0.50	4.59	30.0	2.26	0.99	5.17
Trucks pass house	0	Seldom	5.1				12.7			
	1	Most of the day	6.5	1.28	0.94	1.76	15.7	1.26	1.02	1.56

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Cat now	0	No	4.8				10.7			
Cat now	1	Yes	6.3	1.30	0.91	1.86	15.5	1.58	1.23	2.02
Dog now	0	No	4.1				11.4			
	1	Yes	6.1	1.46	0.83	2.55	14.5	1.28	0.90	1.82
Mother smokes	0	No	5.8				13.7			
	1	Yes	5.8	1.01	0.71	1.45	15.6	1.16	0.92	1.47
Smokers in house	0	0	6.3				14.4			
	1	1	5.7	0.91	0.59	1.39	14.1	0.97	0.73	1.29
	2	2+	5.5	0.85	0.59	1.22	14.0	0.95	0.74	1.22

Table 6.4 Prevalence odds ratios for various environmental risk factors in Tokelau, adjusted for age and gender

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Meat	0	Never-once or twice/week	14.8				24.1			
	1	Three or more times/week	41.7	4.55	0.97	21.40	83.3	18.3	3.17	106
Seafood	0	Never-occasional	0.0				0			
	1	Once a week or more	19.4				35.5			
Fruit	0	Never-once or twice/week	18.0				30.0			
	1	Three or more times/week	21.4	1.10	0.23	5.35	50.0	2.14	0.6	7.6
Vegetables	0	Never-once or twice/week	20.7				32.8			
	1	Three or more times/week	12.5	0.45	0.04	4.68	50.0	2.17	0.46	10.3
Pulses	0	Never-occasional	20.8				33.3			
	1	Once a week or more	18.8	0.62	0.13	2.93	43.8	1.34	0.41	4.45
Cereal	0	Never-once or twice/week	20.4				32.7			
	1	Three or more times/week	6.7	0.28	0.03	2.69	33.3	1.18	0.33	4.25
Pasta	0	Never-occasional	0.0				20.0			
	1	Once a week or more	21.3				36.1	2.63	0.24	28.6
Rice	0	Never-occasional								
	1	Once a week or more								
Butter	0	Never-occasional	17.8				42.2			
	1	Once a week or more	22.2	1.71	0.38	7.65	16.7	0.25	0.06	1.06
Margarine	0	Never-occasional	19.6				28.3			
	1	Once a week or more	21.1	1.16	0.27	4.97	52.6	3.36	0.99	11.3
Nuts	0	Never-occasional	20.0				35.6			
	1	Once a week or more	19.0	1.11	0.27	4.61	33.3	1.04	0.33	3.26
Potato	0	Never-once or twice/week								
	1	Three or more times/week								
Milk	0	Never-once or twice/week	15.2				30.4			
	1	Three or more times/week	30.0	2.42	0.62	9.41	45.0	1.77	0.57	5.51

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Eggs	0	Never-occasional	20.0				40.0			
	1	Once a week or more	19.6	0.88	0.21	3.66	32.6	0.6	0.19	1.95
Fastfood	0	Never-occasional	25.0				50.0			
	1	Once a week or more	16.7	0.61	0.16	2.28	25.0	0.33	0.11	1.01
Exercise	0	Never-once or twice/week	18.6				41.9			
	1	Three or more times/week	21.7	1.32	0.34	5.10	21.7	0.37	0.11	1.25
Television	0	Less than 3 hours/day	21.2				33.3			
	1	3 or more hours/day	18.2	0.73	0.19	2.77	36.4	0.99	0.34	2.91
Electric cooking	0	No	19.7				34.4			
	1	Yes	20.0	0.47	0.05	4.81	40.0	0.65	0.09	4.56
Gas cooking	0	No	13.3				26.7			
	1	Yes	33.3	3.57	0.88	14.45	52.4	2.91	0.94	9.04
Open fire cooking	0	No	26.2				47.6			
	1	Yes	8.3	0.18	0.03	0.99	12.5	0.11	0.03	0.49
Paracetamol past year	0	Less than once/month	17.5				30.0			
	1	At lease once/month	25.0	2.40	0.59	9.81	41.7	1.99	0.63	6.27
Older siblings	0	0	6.3				25.0			
	1	1	27.3	4.81	0.39	59.57	45.5	2.39	0.43	13.4
	2	2 or more	25.0	5.97	0.64	56.05	38.9	2.17	0.54	8.67
Younger siblings	0	0	15.4				30.8			
	1	1	20.0	0.42	0.04	4.79	50.0	1.25	0.19	8.12
	2	2 or more	21.1	0.69	0.10	4.84	34.2	0.85	0.2	3.66
Born in New Zealand	0	No	19.0				37.9			
	1	Yes	28.6	1.01	0.15	6.94	14.3	0.19	0.02	1.82
Years lived in country of survey	0	Less than five	16.7				33.3			
	1	Five to ten	0.0				50.0	0.52	0.01	22.5
	2	Ten or more	50.0				0.0			
Trucks pass house	0	Seldom	23.1				46.2			
	1	Most of the day	15.4	0.53	0.13	2.15	19.2	0.24	0.07	0.82

Variable	Level		Wheeze in last 12 months				Asthma ever			
			% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Cat now	0	No	13.8				44.8			
	1	Yes	24.3	2.32	0.58	9.32	27.0	0.45	0.15	1.32
Dog now	0	No	19.0				34.9			
	1	Yes	0.0				0.0			
Mother smokes	0	No	0.0				9.1			
	1	Yes	23.6				40.0	8.56	0.96	76.5
Smokers in house	0	0	0.0				0.0			
	1	1	11.1				38.9			
	2	2+	28.9				39.5			

Samoa

Table 6.3 shows the findings for Samoa, adjusted for age and gender. For wheezing in the past 12 months ("current wheezing") there were significant associations with the use of electricity for cooking (POR 2.10; 95% CI 1.53-2.88), taking paracetamol at least once a month (POR 1.37; 95% CI 1.00-1.87) and having two or more older siblings had a protective effect (POR 0.64; 95% CI 0.45-0.92). Children who were born in New Zealand had an elevated POR for current wheeze of 2.01 (95% CI 1.26-3.19). There was a protective effect of having one (POR 0.63, 95% CI 0.39-1.03) or two or more (POR 0.64, 95% CI 0.45-0.92) older siblings for current wheeze. There was little or no evidence of a protective effect of having younger siblings.

In the Samoan participants, the strongest associations for "asthma ever", were shown with four dietary variables: having meat three times or more a week (POR 1.25; 95% CI 1.01-1.55), having rice once a week or more (POR 2.72; 95% CI 1.32-5.59), having margarine once a week or more (POR 1.30; 95% CI 1.04-1.63), having milk three or more times a week (POR 1.24; 95% CI 1.00-1.53). There were also associations with exercising three or more times a week (POR 1.37; 95% CI 1.08-1.73), electric cooking (POR 1.38; 95% CI 1.10-1.74), gas cooking (POR 1.43; 95% CI 1.15-1.76), trucks passing the house most of the day (POR 1.26; 95% CI 1.02-1.56), currently owning a cat (POR 1.58; 95% CI 1.23-2.02), and having been born in New Zealand (POR 2.02, 95% CI 1.45-2.81).

Tokelau

The marked difference in the prevalence (12.1%) of respondents having vegetables more than three times a week in Tokelau compared to the Samoa and Fijian figures of 62.0% and 84.4% respectively is understandable in that vegetables are scarce in the tiny low lying coral atolls of the Tokelau islands, and vegetables are only available through boats from Samoa; weather permitting. Tokelau does not have direct access to any other country except by boat through Samoa. Similarly, there is a three fold difference in fruit consumption between Tokelau children (21.9%) compared to Fiji (63.8%) and Samoa (62.0%).

Table 6.4 shows the findings for Tokelau, adjusted for age and gender. There were only 13 children in Tokelau who reported wheezing in the previous 12 months and 23 children have ever had a diagnosis of asthma. Because of the small numbers, there were no statistically significant associations between asthma symptoms and the environmental variables and the numbers are far too small.

Table 6.5 Environmental risk factors for all countries, adjusted for age, gender and country

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Meat	0	Never-once or twice/week	8.6				12.8			
	1	Three or more times/week	7.9	1.04	0.86	1.26	15.6	1.23	1.06	1.43
Seafood	0	Never-occasional	8.3				12.8			
	1	Once a week or more	8.2	0.91	0.71	1.18	14.3	1.16	0.94	1.43
Fruit	0	Never-once or twice/week	8.3				14.6			
	1	Three or more times/week	8.3	1.02	0.84	1.24	13.7	0.95	0.82	1.10
Vegetables	0	Never-once or twice/week	7.0				14.5			
	1	Three or more times/week	8.7	1.12	0.89	1.41	13.9	1.02	0.86	1.21
Pulses	0	Never-occasional	8.1				14.7			
	1	Once a week or more	8.3	0.9	0.72	1.12	14.1	0.99	0.83	1.18
Cereal	0	Never-once or twice/week	9.2				14.0			
	1	Three or more times/week	7.7	0.87	0.72	1.05	14.1	1.01	0.86	1.17
Pasta	0	Never-occasional	9.0				13.5			
	1	Once a week or more	10.3	1.18	0.95	1.46	17.0	1.33	1.12	1.59
Rice	0	Never-occasional	7.3				8.6			
	1	Once a week or more	8.2	1.12	0.67	1.88	14.1	1.83	1.14	2.94
Butter	0	Never-occasional	8.8				14.2			
	1	Once a week or more	8.2	0.87	0.66	1.15	14.1	1.00	0.80	1.25
Margarine	0	Never-occasional	7.4				12.3			
	1	Once a week or more	9.0	1.18	0.97	1.44	15.3	1.31	1.12	1.53
Nuts	0	Never-occasional	9.8				14.1			
	1	Once a week or more	7.7	0.77	0.63	0.94	14.2	1.00	0.85	1.18
Potato	0	Never-once or twice/week	8.0				13.8			
	1	Three or more times/week	8.5	1.05	0.87	1.27	14.2	1.04	0.90	1.21
Milk	0	Never-once or twice/week	7.6				12.8			
	1	Three or more times/week	8.7	1.08	0.89	1.3	14.9	1.24	1.06	1.44

			Wheeze in last 12 months				Asthma ever			
Variable	Level		% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Eggs	0	Never-occasional	7.5				14.0			
	1	Once a week or more	8.4	1.15	0.87	1.52	14.1	1.02	0.83	1.27
Fastfood	0	Never-occasional	8.7				13.9			
	1	Once a week or more	8.2	1.05	0.85	1.3	14.2	1.01	0.85	1.20
Exercise	0	Never-once or twice/week	7.5				13.5			
	1	Three or more times/week	10.5	1.37	1.12	1.68	15.6	1.18	1.00	1.39
Television	0	Less than 3 hours/day	7.7				13.1			
	1	3 or more hours/day	8.7	1.04	0.86	1.26	14.8	1.19	1.02	1.38
Electric cooking	0	No	7.5				13.3			
	1	Yes	10.4	1.45	1.19	1.76	16.1	1.27	1.08	1.49
Gas cooking	0	No	7.2				12.8			
	1	Yes	8.8	1.06	0.86	1.32	14.6	1.27	1.07	1.50
Open fire cooking	0	No	9.2				14.6			
	1	Yes	7.4	0.84	0.7	1.01	13.5	0.89	0.77	1.03
Paracetamol past year	0	Less than once/month	6.7				13.3			
	1	At lease once/month	9.6	1.41	1.17	1.71	14.8	1.17	1.01	1.36
Older siblings	0	0	7.9				16.2			
	1	1	5.6	0.70	0.44	1.12	16.9	1.07	0.78	1.46
	2	2 or more	5.7	0.70	0.49	1.00	13.2	0.79	0.61	1.02
Younger siblings	0	0	6.5				12.5			
	1	1	6.9	1.07	0.68	1.69	15.0	1.27	0.90	1.78
	2	2 or more	5.6	0.83	0.56	1.23	14.8	1.25	0.94	1.67
Born in New Zealand	0	No	5.7				13.9			
	1	Yes	11.0	1.96	1.25	3.08	23.7	1.87	1.35	2.60
Years lived in country of survey	0	Less than five	9.4				16.3			
	1	Five to ten	10.7	1.25	0.64	2.43	21.5	1.50	0.90	2.51
	2	Ten or more	10.5	1.37	1.92	2.43	13.7	1.20	0.75	
Trucks pass house	0	Seldom	6.4				13.6			
	1	Most of the day	9.2	1.2	0.95	1.51	14.3	1.15	0.97	1.36

Variable	Level		Wheeze in last 12 months				Asthma ever			
			% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Cat now	0	No	8.4				12.7			
Cat now	1	Yes	8.2	1.16	0.96	1.41	15.3	1.22	1.05	1.43
Dog now	0	No	9.3				13.6			
	1	Yes	7.9	0.93	0.76	1.15	14.3	1.01	0.85	1.20
Mother smokes	0	No	8.0				13.3			
	1	Yes	9.3	1.28	1.03	1.58	17.1	1.33	1.13	1.57
Smokers in house	0	0	8.4				13.4			
	1	1	8.5	1.05	0.83	1.32	13.4	0.99	0.82	1.19
	2	2+	8.0	1.1	0.88	1.38	15.3	1.11	0.93	1.33

Table 6.6 Environmental risk factors for all countries: multivariate analysis.

		Wheeze in last 12 months				Asthma ever			
Variable	Level	% with symptom	POR	95% LCI	95% UCI	% with symptom	POR	95% LCI	95% UCI
Meat	Three or more times/week	7.9	1.04	0.856	1.26	15.6	1.23	1.06	1.43
Pasta	Once a week or more	10.3	1.18	0.95	1.46	17.0	1.33	1.12	1.59
Rice	Once a week or more	8.2	1.12	0.67	1.88	14.1	1.83	1.14	2.94
Margarine	Once a week or more	9.0	1.18	0.97	1.44	15.3	1.31	1.12	1.53
Milk	Three or more times/week	8.7	1.08	0.89	1.30	14.9	1.24	1.06	1.44
Exercise	Three or more times/week	10.5	1.37	1.12	1.68	15.6	1.18	1.00	1.39
Electric cooking	Yes	10.4	1.45	1.19	1.76	16.1	1.27	1.08	1.49
Gas cooking	Yes	8.8	1.06	0.86	1.32	14.6	1.27	1.07	1.50
Paracetamol past year	At lease once/month	9.6	1.41	1.17	1.71	14.8	1.17	1.01	1.36
Older siblings	Two or more	5.7	0.70	0.49	1.00	13.2	0.79	0.61	1.02
Born in country of survey	Yes	11.0	1.96	1.25	3.08	23.7	1.87	1.35	2.60
Trucks pass house	Most of the day	9.2	1.20	0.95	1.51	14.3	1.15	0.97	1.36
Cat now	Yes	8.2	1.16	0.96	1.41	15.3	1.22	1.05	1.43
Mother smokes	Yes	9.3	1.28	1.03	1.58	17.1	1.33	1.13	1.57
Smokers in house	2+	8.0	1.10	0.88	1.38	15.3	1.11	0.93	1.33

All countries

Table 6.5 shows the findings for all countries combined, adjusted for age, gender and country. When the data were pooled across the three countries, adjusting for country as well as age and gender there were statistically significant associations between wheezing in the last 12 months and exercising one or more times a week (POR 1.37, 95% CI 1.12-1.68), electric cooking (POR 1.45, 95% CI 1.19-1.76), using paracetamol at least once a month (POR 1.41, 95% CI 1.17-1.71), maternal smoking (POR 1.28, 95% CI 1.03-1.58), and having been born in New Zealand (POR 1.96, 95% CI 1.25-3.08). There were also marginally significant associations for current wheeze for having one (POR 0.70, 95% CI 0.44-1.12) or two or more (POR 0.70, 95% CI 0.49-1.00) older siblings.

There were strong associations however between having ever had asthma and some environmental variables. Among the dietary variables there were associations with having meat three or more times a week (POR 1.23; 95% CI 1.06-1.43), having pasta once a week or more (POR 1.33; 95% CI 1.12-1.59), having rice once a week or more (POR 1.83; 95% CI 1.14-2.94), having margarine once a week or more (POR 1.31; 95% CI 1.12-1.53), and having milk three or more times a week (POR 1.24; 95% CI 1.06-1.44). Exercise three or more times a week also showed a weak but statistically significant association with "asthma ever" (POR 1.18; 95% CI 1.00-1.39), as did watching television three or more hours a day (POR 1.19; 95% CI 1.02-1.38). Both electric cooking (POR 1.27; 95% CI 1.08-1.49) and gas cooking (POR 1.27; 95% CI 1.07-1.50), showed associations with ever having asthma. Owning a cat was also associated with having ever had asthma (POR 1.22; 95% CI 1.05-1.43), as was

maternal smoking (POR 1.33; 95% CI 1.13-1.57). Having been born in New Zealand was also associated with "asthma ever" (POR 1.87, 95% CI 1.35-2.60).

There were negative associations of asthma symptoms with the numbers of younger and older siblings, but these were generally not statistically significant (with the exception of the association for having one younger sibling (table 6.5)).

Multivariate analysis

Table 6.6 shows the findings of a multiple logistic regression analysis for all countries combined, adjusting for age, gender and country, and all other variables in the model. The analysis included those factors that were of a priori interest (age, gender, older siblings) and/or which showed elevated risks in the univariate analyses (table 6.5). The tables shows the findings both for 'current wheeze" and for "asthma ever".

In the multivariate analysis, the strongest associations with "current wheeze" were for regular exercise (POR 1.37; 95% CI 1.12-1.68), electric cooking (POR 1.45; 95% CI 1.19-1.76), paracetamol use in the previous year (POR 1.41; 95% CI 1.17-1.71), being born in New Zealand (POR 1.96; 95% CI 1.25-3.08) and maternal smoking (POR 1.28; 95% CI 1.03-1.58). Many factors were significantly associated with "asthma ever" including regular consumption of meat (POR 1.23; 95% CI 1.06-1.43), pasta (POR 1.33; 95% CI 1.12-1.59), rice (POR 1.83; 95% CI 1.14-2.94), margarine (POR 1.31; 95% CI 1.12-1.53), and milk (POR 1.24; 95% CI 1.06-1.44), regular exercise (POR 1.18; 95% CI 1.00-1.39), electric (POR 1.27; 95% CI 1.08-1.49) and gas (POR 1.27; 95% CI 1.07-1.50) cooking, paracetamol use in the previous year (POR 1.17; 95% CI 1.01-1.36), being born in New Zealand (POR 1.87; 95% CI 1.35-2.60),

current cat ownership (POR 1.22; 95% CI 1.05-1.43) and maternal smoking (POR 1.33; 95% CI 1.13-1.57)

6.3 Discussion

Several hypotheses related to environmental risk factors have been proposed to explain the increases in asthma in the past two to three decades. These have been discussed in detail in Chapter three. Certain characteristics of the Pacific Islands undertaking the ISAAC study have implications for the above hypotheses and are related to the varying stages of economic development and changing lifestyles, diet, sources of fuel, indoor and outdoor pollutants, tobacco and levels of physical activity. Some of these characteristics are discussed in Chapter four and likely areas for further study are discussed in Chapter five

6.3.1 Limitations of the data

Before discussing the findings of the EQ analyses, their limitations should first be considered.

Firstly, the most obvious limitation of the data is that information on environmental exposures was obtained retrospectively. Thus, some of the findings could be subject to recall bias. However, this would only occur if the recall of particular exposures (e.g. paracetamol use in the previous year) was different in children with asthma symptoms than in children without asthma symptoms.

Secondly, it should be noted that 29 potential risk factors were investigated. Thus, one would expect 1-2 findings to be statistically significant by chance alone, for each outcome measure, and for each country. However, one would expect less than one finding per analysis to be significantly *positive* by chance alone, and all of the analyses had more than one finding that was statistically significant. Thus it is unlikely that all of the findings would be due to chance alone.

A third limitation of the data involves the usual limitations of ascertaining asthma prevalence by symptom questionnaires. However, this is unlikely to be a major concern in the current analyses since the ISAAC questionnaires have generally validated well (Asher et al. 1995; Ellwood et al. 2005), and any misclassification of asthma would only produce bias if the rate of misclassification also differed according to exposure status, e.g. if children of lower socioeconomic status were more likely to erroneously report their asthma symptoms than children of higher socioeconomic status. Of course, such differential misclassification is possible, as with all asthma prevalence surveys of this type, but the likelihood of it occurring will differ for different exposures.

A fourth limitation is that it is possible that response rates may vary according to asthma status, i.e. that children with asthma may be more likely to take part in the study. Conversely, it is possible that children with asthma might have missed the survey through being absent from school. However, this would only create a bias if response rates were also associated with exposure status. In any case, the response rates were relatively high, so response bias is unlikely to be a major concern.

6.3.2 Dietary factors

The most striking finding with regards to dietary factors is that asthma symptom prevalence was relatively high in Tokelau, despite this country having the least "westernized" diet (table 6.1). However, these findings are difficult to interpret because of the small numbers involved, and I will therefore focus on the findings for all three countries combined. Overall, the combined analyses showed no statistically significant associations with current wheeze, but several dietary factors (including meat, pasta, rice, margarine, and milk) were associated with "asthma ever".

The finding for margarine is particularly interesting because this has been observed in several studies in western countries (see chapter three). These include the studies of Weiland *et al* (Weiland et al. 1999), and Bolte *et al* (Bolte et al. 2001), whereas Woods *et al* (Woods et al. 2003) and Ellison-Loschmann (Ellison-Loschmann 2004) found no relationship between the intake of polyunsaturated fatty acid margarine and asthma. Simopoulos (Simopoulos 2002) and Black (Black and Sharpe 1997; Black 1999; Simopoulos 2002) have proposed that increased consumption of polyunsaturated fatty acids (PUFA) may be a factor in the increased prevalence of allergic diseases, particularly an increased consumption of polyunsaturated fats with a high omega 6 to omega 3 ratio. The ISAAC EQ did not differentiate between different types of margarine to identify the ratio of omega 6 to omega 3 PUFA. Omega-6 PUFA, e.g. linoleic acid, is a precursor in the mediation and synthesis of prostaglandin E2 and IgE formation.

The combined analyses showed an association between having meat three times or more per week with ever having had asthma. A similar analysis of environmental

dietary factors among ISAAC Māori and non-Māori participants showed a strong association between "current wheeze" and eating meat three times a week or more (Ellison-Loschmann 2004). The ISAAC Phase II study in Hastings, New Zealand, also showed a dose-dependent association between frequent consumption of hamburgers with asthma symptoms, as well as a similar association between takeaway consumption and BHR (Wickens et al. 2005).

The combined analyses showed an association between asthma ever and having pasta once a week or more. A similar finding was reported among Indian school children (6-7 year olds and 13-14 year olds) where risk factors for current wheeze or asthma included eating pasta or fast-food or meat once or more per week and exercise once or more a week. The same study also identified having vegetables one or more times and fruits three or more times per week as protective (Awasthi et al. 2004). The association between having rice once a week or more and having ever had asthma in the combined analyses is the opposite of what was shown in an ecological study of the ISAAC Phase I data which showed an inverse relationship between prevalence rates of wheeze, allergic rhinoconjunctivitis, atopic eczema with increased per capita intake of calories from rice (Ellwood et al. 2001).

Decreased consumption of fruit and vegetables in the United Kingdom has been postulated to be associated with increased asthma prevalence through the antioxidant properties in fruit and vegetables protecting against inflammation (Seaton et al. 1994). Other dietary studies related to vegetable consumption were those carried out comparing children with a history of asthma and wheeze in the last 12 months with a control group of non-asthmatics (Hijazi et al. 2000). This found that eating at fast

food outlets and lower intakes of milk, vegetables, fibre, vitamin E, magnesium, calcium, sodium and potassium were significantly related to being a case. There were no associations between vegetable intake and asthma symptoms in the current study and the finding of an association between milk intake and ever having had a diagnosis of asthma is inconsistent with the above-mentioned findings.

6.3.3 Exercise

Participating in exercise three or more times a week was associated with an increased risk of "current wheeze" and "asthma ever". The incidence of new diagnoses of asthma has been reported to be associated with heavy exercise in communities with high concentrations of ozone, thus, air pollution and outdoor exercise could contribute to the development of asthma in children. The current study did not specifically collect information on ozone or climate, although other studies have found significant associations of ozone exposure and the development of asthma in children (McConnell et al. 2002) as well as in adults experiencing long term exposure to ozone (McDonnell et al. 1999).

On the other hand, both "current wheeze" and "asthma ever" were associated with exercising three or more times a week. It is important also to note that patients with asthma may have a tendency to gain weight due to limitations in exercise particularly if their asthma is poorly controlled (Glazebrook et al. 2006).

6.3.4 Paracetamol use

There was also an association of using paracetamol at least once a month in the past year with both "current wheeze" and "asthma ever". A recent study in New Zealand has reported a similar association between paracetamol use and an increased risk of asthma (Cohet et al. 2004). Several other studies have also linked frequent paracetamol use and asthma both from the prenatal stage to childhood asthma (Shaheen et al. 2000; Shaheen et al. 2002; Barr et al. 2004), although at this stage it is unclear whether the observed associations are real, or are due to "reverse causation" in that health professionals encourage their asthmatic patients to take paracetamol rather than aspirin because the latter may worsen asthma severity (Cohet, Cheng et al. 2004). Paracetamol is one of the most commonly used drugs in the Pacific, as a safer alternative to aspirin as an antipyretic and analgesic, both for adults and children/infants. Further studies are therefore required of paracetamol as a risk factor for asthma in the Pacific.

6.3.5 Family size

Unfortunately, the questionnaire used in Fiji did not collect information on family size. In Samoa, having older siblings showed a protective effect for "current wheeze" but not for "asthma ever". However, the same associations were not observed in Tokelau, albeit with small numbers, so that overall having older siblings showed a protective effect, but this was only of marginal statistical significance (table 6.6). These findings are nevertheless of interest, since most previous studies of family size and asthma risk have been conducted in western countries where childhood infection rates are relatively low (see chapter three). The findings of the current study indicate

that in Pacific countries, where infections rates are likely to be relatively high, having older siblings has a weak protective effect against current wheeze, and against "asthma ever".

6.3.6 Pet ownership

There was an association between owning a cat and having ever had a diagnosis of asthma (table 6.6). This is in contrast with other studies which have showed that exposure to cat at the age of 2-3 months was associated with a reduced risk of wheezing between the ages of 1 and 5 years (Celedon et al. 2002) and having a cat before the age of 18 protects against adult asthma and atopy, although children who acquired their first cat after 18 years of age showed a higher prevalence rate for asthma symptoms (de Meer et al. 2004) It should also be emphasized that the current study examined asthma prevalence rather than incidence, and it is possible that pet ownership early in life protects against the development of asthma, whereas current pet ownership may increase current symptom prevalence by exacerbating and/or prolonging symptoms of pre-existing asthma. The mechanisms for any protective effect of cat ownership are also not known; although many of the children living with a cat produce serum IgG antibodies to the cat allergen *Fel d* 1 without becoming allergic (Perzanowski et al. 2002).

6.3.7 Passive smoking

The finding of an association between maternal smoking and both current wheeze and having had been diagnosed previously with asthma supports previous studies reporting the link between maternal smoking and asthma (Gilliland et al. 2001) as

well as with tobacco smoking not restricted to those of mothers and includes others such as household members (Strachan et al. 1996; Gilliland et al. 2001; Eagan et al. 2002; Barraza Villarreal et al. 2003). Other studies have reported smoking as a trigger and exacerbates asthma attacks (Siroux et al. 2000) rather than a primary cause.

This provides further evidence of the need for addressing tobacco not only as a risk factor for asthma, but also as a major risk factor for a multitude of important health problems. This is an increasing problem in the Pacific where legislation to control tobacco is either ineffective or not closely monitored and implemented (http://www.wpro.who.int/media_centre/press_releases/pr_20050923_2RCM.htm). Tonga has one of the toughest legislations against tobacco use among minors, yet tobacco sales to minors are still an everyday event, and to date no shopkeeper has been prosecuted and convicted for the sale of tobacco to minors, and no-one has been prosecuted for smoking in restricted public areas and closed quarters.

6.3.8 Cooking and heating

The finding of an association between gas cooking with current wheezing and having previously been diagnosed with asthma supports the findings of some previous studies which found an association with diminished lung functions (Garrett et al. 1998; Wong et al. 2004b), although others showed no association (Moran et al. 1999; Sunyer et al. 2004). The finding of an association with electric cooking may reflect electric cooking as a marker of "affluence" as well as one's degree of "westernization'. Cooking with electricity and avoidance of nitrous oxide fumes on the other hand is not likely to increase significantly due to its higher price than gas. Meanwhile, the use of gas for cooking is expected to increase throughout the Pacific with socioeconomic

development and lifestyle changes including cooking practices. As such, research on indoor pollution in relationship to gas cooking in the Pacific may be of increasing relevance in the future.

6.3.9 Conclusions

In conclusion, this is the first standardised study to examine asthma prevalence in children in a group of Pacific island countries and to identify possible risk factors. There is evidence that some of the risk factors for asthma identified in previous studies from other parts of the world may also play a role in the Pacific. However, most of the relative risks (prevalence odds ratios) were relatively weak, and these risk factors therefore, at least individually, would account for a relatively small proportion of asthma cases. There is however a need for further studies to identify patterns and test environmental risk factors particularly in relationship to changing socioeconomic situations and associated changes in lifestyle in the Pacific as a novel approach to the management, control and prevention of asthma regionally and worldwide.

Chapter 7: The Tonga Asthma Self-management Trial

7.1 Background

Tonga is currently standardizing treatment protocols for asthma, as well as for other common illnesses common. Such standardisation of treatment of illnesses that represent an important health burden is one of the necessary strategies in a country with significant limitations in both specific specialised health care and financial means. The Tonga Asthma Self-management Trial was also an opportunity to return benefits to the communities in Tonga that had participated in ISAAC Pacific, in contrast with common practices in the past of conducting surveys without services (Foliaki et al. 2004a). Although the Tonga Asthma Self-management Trial was only conducted in Tonga, it was intended as a 'demonstration' project that could then also be implemented in other Pacific island countries if they so wished.

7.1.2 Self management plans

Asthma is a common condition. The acute symptoms are reversible with, and occasionally without, medications, and often without any direct medical intervention. These features make asthma a suitable candidate for "primary care" management. Such primary care is usually best delivered at the community level, but often in small countries with limited health manpower and facilities primary care inevitably gets delivered at tertiary and hospital level. The management of asthma in primary care is well understood because of developments in understanding of the mechanisms underlying asthma, i.e. that it is primarily an inflammatory condition of the airways with bronchial smooth muscle spasm as a secondary feature (Tillie-Leblond et al.

2004). It has further been demonstrated that the condition responds well to inhaled corticosteroids (Donahue et al. 1997). When these are used together with beta-2 agonists, both symptoms and exacerbations are often well controlled.

These management procedures are simple and can be easily taught to people suffering from asthma, who are thereby empowered to adequately implement such therapeutic interventions at the individual level, needing little direct medical supervision (Gibson et al. 2000). Alongside these self-management processes, of course, are health experts providing guidance as required. The actual implementation and coordination of most self-management programmes can therefore be implemented by non-medical personnel such as nursing personnel alongside guidance from medical personnel (Page 2000). The use of customised self-management plans for both adult and children with asthma is therefore now routinely recommended, and has been shown to improve morbidity from asthma (Beasley et al. 1989; D'Souza et al. 1994; D'Souza et al. 1996a; D'Souza et al. 1998; D'Souza et al. 2000; Caplin and Creer 2001; Osman et al. 2002). In most instances such self management plans involve the interpretation of monitored symptoms and peak expiratory flow rate (PEFR) diaries.

The first such study on the use of self management plans for chronic asthma, based on routine monitoring of individual peak expiratory flow (PEF) to adjust individual doses of inhaled steroids (belcomethasone dipropionate), was the study of Beasley *et al* (Beasley et al. 1989). This study of 36 consecutive adults with asthma attending an outpatient chest clinic involved an asthma self-management plan based on routine measurement of PEF and adjustment inhaled steroids. It was shown to be effective in reducing asthma symptoms and improving lung function. Subsequent self-

management plan studies further demonstrated the effectiveness of such plans as an essential tool in adult asthma management (Beasley et al. 1989; D'Souza et al. 1994; D'Souza et al. 1996a; D'Souza et al. 1998; D'Souza et al. 2000; Caplin and Creer 2001; Osman et al. 2002).

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Thus, the informed patient, with the ability to objectively assess his/her asthma severity with the support of caregivers and appropriate medications, is the key person to take the helm in caring for asthma (Crane et al. 1991). However, despite the knowledge of what to do, the process of delivering this management process, and knowing how to deliver it, may not be straight forward. For example, a self-management plan may be effective in numerous different communities, but the methods of teaching the use of the plan, and encouraging and supporting asthmatics to use and follow it, may vary widely due to social, economic and cultural factors.

These issues were reviewed in the Māori Asthma Review (Pomare et al. 1992a; Pomare et al. 1992b) which was conducted in New Zealand in 1991-1992 because of concerns about the excessive number of deaths and hospitalisations from asthma among Māori, even though evidence available at the time suggested that asthma was no more common in Māori than non-Māori. There were problems in the management of asthma in Māori, major difficulties in getting expert help when it was required, and a serious lack of readily available, clear information about asthma. The review concluded that asthma prevalence was similar in Māori and non-Māori children, but that asthma severity was greater in Māori children and adults. The most likely explanation for this involved problems of access to asthma health care services. The

review recognised the need for strategies to address both practical asthma management as well as ways to work towards resolving issues concerning access to asthma health services for Māori. At the time of the review, it was becomingly increasingly recognised that the key person in the long term management of asthma is the informed patient, and a stronger emphasis was being placed on self-management of asthma and asthma education involving consumer participation.

One of the responses to the review was the establishment of a partnership between the Wellington Asthma Research Group and the Hauora Runanga in the Wairarapa area to conduct a community-based asthma self-management trial (Beasley et al. 1993; Te Hauora Runanga o Wairarapa et al. 1999). The Wellington Asthma Research Group provided mostly technical assistance and expertise through doctors and researchers, with the Māori community health workers actually coordinating and implementing the asthma self management intervention. Thus, the study had a strong community component in terms of its establishment, implementation and coordination.

The study group comprised 69 asthmatics, and the study involved a "before and after" comparison of their asthma severity in the 12 months before the introduction of the self-management plan, and in the 12 months following the introduction of the plan. In addition, more detailed information was collected on daily symptoms and peak flow measurements for the two months before the introduction of the plan and the four months afterwards.

The findings further supported the effectiveness and acceptability of the self-management plans based on both regular monitoring of PEFR and a symptoms based component. Although the study suggested that the PEFR component of the plan may

be preferred by participants most still indicated that both PEFR and symptoms component were equally useful (D'Souza et al. 1994). Similar findings were reported by Malo *et al* (Malo et al. 2002) who found that simple symptom diaries (such as nocturnal waking) may be as useful as serial PEFR monitoring in documenting asthma exacerbations.

The original study following completion at 6 months (D'Souza et al. 1994) was further followed up 12 month later (18 months) and again another 12 months later (30 months) (D'Souza et al. 1998). At each follow-up period it was concluded that the introduction of the asthma self-management plan had led to a reduction in asthma morbidity. It was observed, however, that the reduced asthma morbidity reported after two years was not entirely maintained at six years although some benefits of participation in the project were still apparent (D'Souza et al. 2000).

In addition to the improvements in asthma morbidity, this partnership between a university-based research group and a traditional Māori community, which emphasised culturally appropriate research processes and implementation at a traditional community centre (marae) with Māori health workers at the 'helm', was also reported to result in other health benefits both to the participants and to their extended families (Ratima et al. 1999; Te Hauora Runanga o Wairarapa et al. 1999).

Other New Zealand studies

There have been two other trials of asthma self-management plans in New Zealand (D'Souza et al. 1996a; Gillies et al. 1996). A trial of a written action plan introduced to 110 asthmatic children between the ages of 3 and 11 years old, recruited through

general practitioners in the Whangarei area, also showed that this was both effective and acceptable with improved overall measures of asthma morbidity. The authors, however, suggested that the observed benefits may in part be because of the possible role of increased awareness among both families and general practitioners due to the conduct of the study resulting in improved communication and understanding of asthma. Other factors raised that may have contributed to improved asthma morbidity outcomes included reviews of, and improved, inhaler techniques (Gillies et al. 1996).

The success and effectiveness of a written self management plan was also reported in a more recent study of 26 adult asthmatic patients discharged from Wellington Hospital's Emergency department following treatment for severe asthma (D'Souza et al. 1996b).

International studies

Turner and colleagues in a prospective trial investigated if there were any differences in standard asthma morbidity outcomes comparing self management plans based on PEF monitoring and plans based on symptoms (Turner et al. 1998) among 92 adult asthma patients. Their findings supported those from studies in New Zealand (D'Souza et al. 1994; D'Souza et al. 1996a; Gillies et al. 1996; D'Souza et al. 1998; D'Souza et al. 2000) and elsewhere (Ignacio-Garcia and Gonzalez-Santos 1995; Lahdensuo et al. 1996; Turner et al. 1998). For example, Lahdensuo also reported no difference in standard measures of asthma morbidity and control between the groups using peak flow compared to those basing action on symptoms (Lahdensuo et al. 1998).

Charlton *et al*, in their randomized controlled trial of 40 children and 69 adults (Charlton et al. 1990), also found that self-management plans were effective in improving asthma morbidity. They also supported Lahdensuo's finding that PEF monitoring was not the key ingredient to improvements in asthma control. The key ingredient was the need for a standardised self-management plan (involving either peak flow measurements or symptom monitoring) with regular review and education. Charlton *et al* did not show any major differences between the two groups (i.e. those using peak flow measurements and those monitoring symptoms) suggesting that standard self-management plans either guided by PEF readings or symptoms are suitable for both adults and children (Charlton et al. 1990).

7.2 The Tonga Asthma Self-management Trial

Despite their success in other countries, asthma self-management plans have not been trialled in Tonga or other Pacific islands. It was considered that the introduction of an asthma self management plan in Tonga would meet a clinical need for individual asthmatics, as well as being a public health priority. With regards to the latter, it would be a vehicle for community health education on the proper management of asthma and a rationale for similar approaches to other disease management protocols, similar to those that have been successful in other developed countries (such as diabetes management) but yet to be practiced in Tonga.

The project was intended to specifically focus on the efficacy of the introduced Asthma Self Management Plan among moderate to severe outpatient asthma clients.

The aims of the project were:

- To assess whether the introduction of asthma education, including asthma self-management plans, would reduce morbidity from asthma
- To assess whether any reduction in morbidity would be sustained beyond the end of the intervention programme

The specific objectives were:

- The education of asthma patients to recognise the early signs of unstable or deteriorating asthma, by monitoring peak expiratory flow rate (PEFR) and/or symptoms.
- To enable individual patients through the use of individualised written guidelines based on PEFR and/or symptoms to determine and/or adjust their medication safely or obtain medical help as well as recognising the required degree of urgency in executing these steps.

The (null) hypotheses to be tested are implicit in the above aim:

- The introduction of asthma education, including asthma self-management plans, will (not) reduce morbidity from asthma
- Any reduction in morbidity will (not) be sustained beyond the end of the intervention programme

The latter hypothesis will be tested in future surveys which are beyond the scope of this PhD. I will therefore focus on describing the study design and findings with regards to the former hypothesis.

7.3 Study Design and Methods

The Tonga Asthma Self-management trial was a "before and after" trial in which each participant served as their own control. It was recognised that this approach was not ideal, and it would have been more appropriate scientifically to have a separate non-intervention control group and to randomise the intervention. However, this was not considered feasible or necessary because: (i) in a small country such as Tonga with strong extended family ties it is not possible to randomize such interventions; (ii) the study obtained greater political and community support because all of the participants were likely to benefit; and (iii) the intervention had been trialled and shown to work in other countries, so the focus was on the practicalities of implementing the intervention in Tonga.

The study was approved by the Tonga National Health Ethics & Research Committee.

The recruitment and registration of patients for the intervention commenced in Tongatapu (the main island of Tonga) in September 2004. All participants who had registered between September 2004 and September 2005 were eligible for inclusion in the current analysis. Recruitment for the programme continued past September 2005, but this reflected the fact that the intervention had become part of "standard treatment", and those recruited at this later stage were not formally included in the study, or in the current analyses.

Prior to its commencement, the trial was discussed with the medical ward personnel who were responsible for conducting the asthma clinic, and who were also part of the team attending the initial clinic. A paediatrician joined the study team at the launch of the project, and conducted a full-time asthma clinic for the paediatric participants. General practitioners and private health clinics in Tongatapu were also informed. The study was announced, and an invitation to asthmatics was by radio and through the primary health care system.

A baseline questionnaire was administered before the intervention to determine asthma morbidity, health service access and asthma medication use. Both the Tongan and English versions are shown in the appendices.

Participants were instructed on how to use a peak flow meter, spacers and how to do a daily recording of the best value from three morning pre-bronchodilator peak flow

recordings. A video on how to use inhalers was also shown to most participants in successive clinics.

7.3.1 The asthma self-management plan

The self-management plan involved two alternative methods of self-assessment of asthma control: "objectively" with peak flow measurements, and "subjectively" using symptoms as instructed during the initial clinic. The method for self-assessment using PEFR was printed in Tongan at the top half of an A4 paper (Figure 7.1), and the symptoms-based approach at the bottom half (Figure 7.2). A copy was given to the patient at the initial clinic.

The asthma self management plan (Figures 7.1 and 7.2) was customized to individuals according to their expected PEFR. Detailed instructions were given and explained to participants on how to manage their asthma in accordance with both PEFR readings and/or symptoms. The patient's individual therapy, inhaled steroid or bronchodilator, and the name and telephone number of emergency help was also written onto the form.

Figure 7.1: The Self Management Plan (PEFR based)

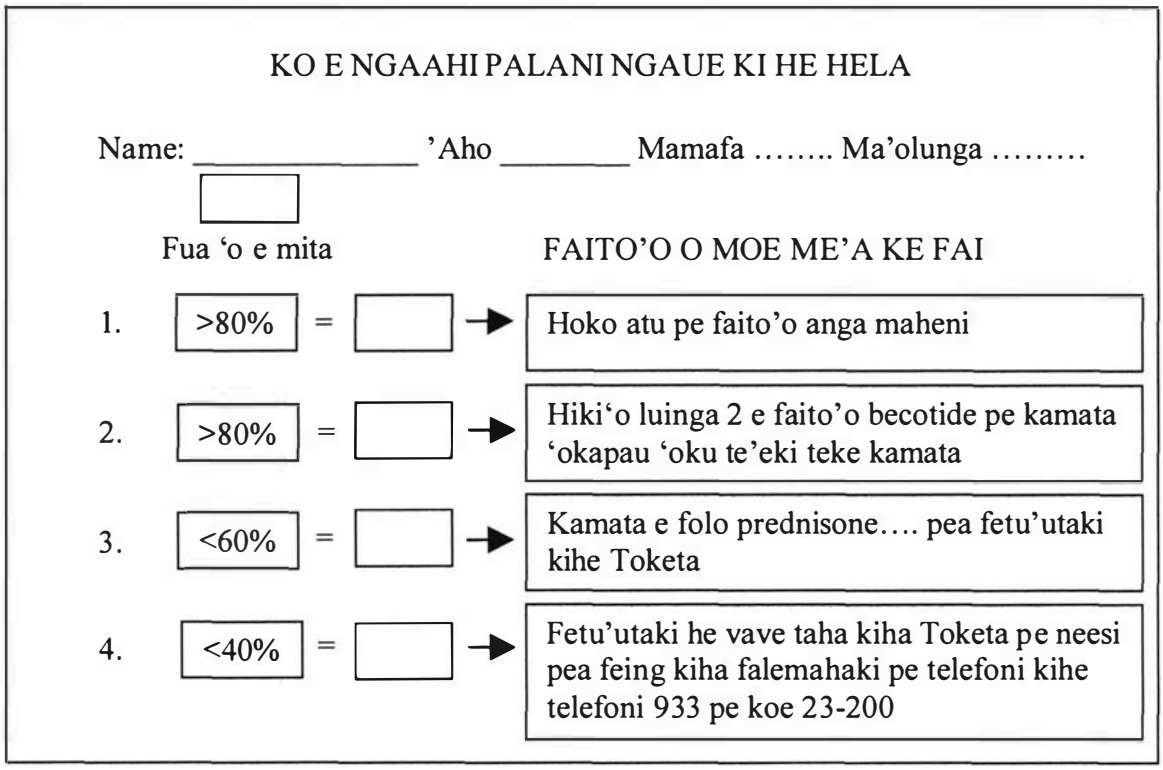
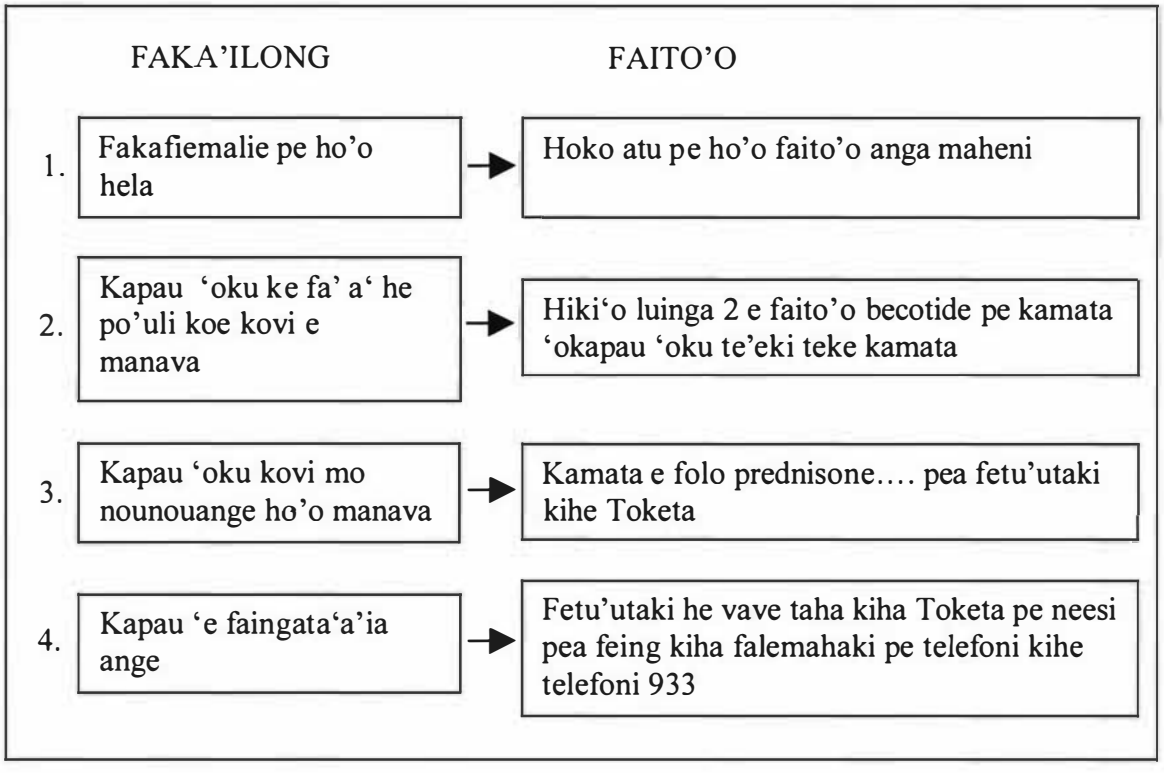


Figure 7.2: The Self Management Plan (symptom based)



The best PEFR was taken as the higher of either the maximum consistent prebronchodilator PEFR recorded in the diaries, or the predicted value taken from standard tables. The "best" PEFR was revised, where appropriate, if increases in PEFR occurred following changes in the patient's treatment.

For both methods of assessment, there are four general stages for which treatment guidelines are recommended (Figures 7.1 and 7.2). At each stage, guidelines are provided as to actions to carry out: (i) continue with regular treatment; (ii) double dose of inhaled corticosteroids; (iii) start prednisone (oral steroids) and call the doctor; (iv) call the ambulance.

A special prescription card for asthmatics was designed with brief instructions on the cover on when and how to use different types of inhalers, the use of spacers, clinic hours and names of the asthma clinic staff and phone numbers.

The initial clinic involved a general talk on asthma, its inflammatory basis, the different actions/mechanisms and use of inhaled steroids in contrast to beta-agonists, adequate drug delivery through appropriate inhaler technique or spacer delivery systems, and the recognition and rationale for the use of an asthma self-management plan.

A monthly diary/questionnaire (figure 7.3) was administered by the clinic staff at the first clinic and during subsequent clinic visits. This asked about ventolin nebuliser use, prednisone use over the previous month, and waking at night due to asthma over

the previous 7 days. For clients not attending a clinic within a month the clinic staff did the interview by telephone.

Figure 7.3: Monthly Diary Questions

Date (/ /)

1.0 Have you had a nebuliser (for your asthma) in the last month?

Yes No

1.1 If yes to 1.0, how many times?_____

1.2 If yes to 1.0, was this given in hospital? YES NO

1.3 If yes to 1.0, was this given at home? YES NO

2.0 Have you had a course of prednisone in the last month?

YES NO

3.0 How many times in the last week did you wake at night because of your asthma?

Answer (1-7)

7.3.2 Participants

The Asthma Self Management Project, while primarily initiated as an intervention study, has evolved into a full time clinic for all asthmatics (pediatric and adult) in the main island of Tongatapu. Because of the need to standardize the outpatient management of asthma as well as to keep track of the dispensing of inhalers all asthmatics and those needing ventolin inhalers regardless of age or medical condition attended the newly formed "asthma" clinic. This inevitably meant that some of the clients attending were not primarily asthmatics but rather chronic obstructive pulmonary diseases (COPD) clients and other medical conditions.

However, the study itself was restricted to participants with moderate to severe asthma, as determined by being registered in the ventolin inhaler dispensing records of those attending the asthma clinic of the Ministry of Health. Patients below 10 years and over 69 years, or who had other uncontrolled medical problems, were excluded from the study.

To date at least 279 clients have been registered at the Asthma Clinic, but the above-mentioned restrictions mean that only 110 were formally enrolled in the study. In addition, the analysis presented here has also been restricted to clients that have completed at least 70% of their daily and monthly diaries and who have also completed the second questionnaire. These tend to be those patients who are regularly attending the clinic.

7.4 Results

7.4.1 Characteristics of study participants

As noted above, 110 patients who met the inclusion criteria were included in the study. Of these, 92 (84%) satisfactorily completed at least 70% of their daily and monthly diaries, as well as the second (follow-up) questionnaire after 12 months.

The 92 participants who qualified for the final analysis had a mean age of 38 years, and comprised (40%) males and 55 (60%) females. The majority (93%) of the 92 participants were Tongans and six were either part-Tongan or non-Polynesian.

Table 7.1 provides a summary of the morbidity measures and medication use of the 110 enrolled participants and the 92 participants who completed the 12-month follow-up, together with the findings at 12 months of follow-up for the latter group.

A relatively high percentage of the enrolled participants (40%) reported waking two or more nights per week with asthma in the previous 12 months. There was also a significant proportion with uncontrolled or unstable asthma as indicated by the high percentage (66%) of participants who had sought emergency medical care for their asthma in the preceding 12 months and the 54% of participants had also had a bad attack of asthma in the previous 12 months. The majority of the participants (82%) had also consulted a doctor about their asthma (in addition to routine clinics and prescription refills of asthma medications) in the previous 12 months. Almost a fifth (19%) of the participants had also been admitted to hospital in the previous 12 months for asthma.

Despite the high morbidity, only 20% of participants had been prescribed or regularly used inhaled steroids. The use/prescription of oral ventolin was relatively high (18%). Not surprisingly, only three participants owned a peak flow meter and none had a written asthma management plan for use as either routine or in emergency situations.

Table 7.1: Morbidity measures and medication use for enrolled participants at baseline and for "completed" participants at baseline and at 12 months of follow-up

	Enrolled participants	"Completed" particpants		
	Baseline (n=110)	Baseline (n=92)	12 months (n=92)	p-value#
Use of Medical Services in previous				
Visit to doctor	85% (93)	83% (76)	22% (21)	<0.001
Emergency visits	68% (75)	66% (61)	18% (17)	<0.001
Hospital admission	19% (21)	19% (18)	3% (3)	0.001
Asthma management in previous 12 months				
Peak flow meter	3% (3)	3% (3)	100% (92)	<0.001
Written management plan	2% (2)	0% (0)	95% (88)	<0.001
Prescribed inhaled steroid	48% (53)	20% (19)	97% (90)	<0.001
Oral Ventolin	21% (23)	18% (17)	10% (9)	p=0.41
Oral Prednisone	10% (11)	10% (9)	16% (15)	p=0.04
Asthma morbidity in previous 12 months				
Days "out of action"				
- None	15% (16)	16% (15)	65% (60)	<0.001
- 6 – 13 days	48% (53)	46% (43)	28% (26)	
- 14 days or more	37% (41)	29% (27)	4% (4)	
Woken two or more nights per week	88% (97)	40% (37)	13% (12)	<0.001
Severe asthma attack	54% (59)	54% (50)	18% (17)	<0.001
PEFR (l/min)	353	341	417	<0.001

comparing 12 month values with baseline values in "complete" participants
*Peak Expiratory Flow Rate

7.4.2 Asthma Morbidity and Management

Measures of asthma morbidity, requirements for emergency services and management practices showed improvements between the period from the commencement to the second review at 12 months (table 7.1). The proportion of study participants with hospital admissions for asthma in the preceding 12 months dropped from 19% to 3%; the number of patients who had visited a doctor for asthma (apart from routine clinics and prescription refills) likewise dropped from 82% to 22% of the participants, and the number of participants who had required medical emergency consultation for asthma also dropped from 66% to 18%. Only three people (3%) had a peak flow meter at baseline whereas 100% were using a peak flow at the time of the second interview at 12 months. All but one of the 92 participants still possessed the self-management plan at the time of the second interview. The number of clients having been prescribed oral beta agonists (ventolin) for asthma management also dropped from 18% to 10% while the number of clients being prescribed inhaled steroids had now increased from 20% to 97%.

The percentage of participants reporting having woken from sleep due to asthma two or more nights over the previous seven days fell from 40% to 13% over the 12 month period. The mean peak flow increased by 22%, from 341 to 417 l-min^{-1} ($p=<0.001$). The term "days out of action" (Table 7.1) in the last 12 months refers to the average number of days a participant did not go to school, work, or carry out routine activities and because of incapacitation due to asthma. There was a marked decrease from 29% to 4% among participants with 14 or more "days out of action". The percentage of participants who had reported a severe attack of asthma in the previous 12 months decreased from 54% at baseline to 16% at 12 months.

Table 7.2: Acceptability of Management Plan at 12 months of follow-up

	% (n)
Instructions on plan difficult to follow?	6% (5)
Plan should be more detailed	13% (11)
Ever used plan to help with asthma in last 12 months?	76% (65)
Did you find the plan useful during a bad attack?	94% (16)

7.4.3 Acceptability and Use of the self-management plan

The majority of the participants (94%) reported that the instructions on the self-management plan were easy to follow with 76% having used the plan to help with their asthma in the previous 12 months (table 7.2). A high percentage (94%) of the participants did not think the instructions on the plan were hard to follow, and most (87%) did not feel the need for more details in the plan. The majority of the participants (71%) kept their plans in a personal handbag or basket as opposed to leaving it in an open space at home. Of the 17 participants who said they had had a bad attack in the previous 12 months 16 found the plan helpful in managing their asthma.

7.5 Discussion

The Tonga Asthma Self-management Intervention Trial was widely discussed among health personnel who were directly involved and responsible for outpatient and inpatient care for asthma patients (physicians, paediatricians, outpatient doctors). The initial feedback was that a self-management plan was not only appropriate, but very much needed, given that there were no standardized management protocols for the outpatient management of asthma and that the Ministry of Health was at the time in

the process of standardising medical therapeutic protocols for common diseases including asthma. Standardising the medical management of common diseases is a special priority in Pacific countries as a result of lack of specialist care and economic realities.

Other accompanying issues highlighted during the carrying out of this study include the limited resources continually faced by small island countries which have implications for supply of peak flow meters, spirometers and adequate drug delivery devices. The limited resources are also reflected in the lack of choice for more potent relievers or preventers, with the pharmacy supplying only one brand each of a reliever and preventer.

7.5.1 Setting for the intervention

The study was conducted at the Tonga Medical Association building which is situated in the main hospital grounds, although not at the usual clinic rooms of the hospital. The setting was in some way different from the usual hospital clinic in that the newly established clinic was specifically for asthmatics, and patients were seen regularly by the same personnel in a relatively comfortable environment away from the usually crowded hospital clinic settings. The study has led to recommendations to the Ministry of Health for further improvements in the clinic setting and the decentralisation of the clinic to primary health care settings and to all islands in Tonga. The reports on the Wairarapa study advocated similar approaches, with an emphasis on community involvement with clinics in the marae as a culturally appropriate and safe environment for health care delivery (Ratima et al. 1999; Te Hauora Runanga o Wairarapa et al. 1999). This approach ensured further compliance

as patients often have difficulties with transport in terms of cost and time travelling to a single central location.

7.5.2 Use of the self-management plan

An issue similarly identified among the New Zealand studies (Ratima et al. 1999) and by Charlton *et al* (Charlton et al. 1990) is that simply prescribing peak flow meters without regular review will be unlikely to improve patient care. The role of asthma education for both the public and health care workers was highlighted by the study participants who, upon achieving better asthma control, voiced their concern as to why inhaled steroids had not been available or prescribed in the past, or why there had been inadequate information given to patients on its use.

The use of the self-management plan was not sustained throughout the entire follow-up period for all of the study participants. Among the factors relating to a subsequent decline in enthusiasm for regular peak flow monitoring were the patient's asthma achieving better control and the subsequent lack of exacerbations which meant that the patient would simply record the same numbers in the peak flow chart for many days in a row. On these occasions the participants were requested to either: (i) continue with the original request for daily recordings; (ii) revert to continuing with the daily PEFR measurements but to actually record in their diaries on alternate days; (iii) do PEFR measurements on alternate days and record these; or (iv) measure their PEFR when their symptoms got worse. A change to daily PEFR measurements and recording was also advised with any signs of deteriorating symptoms. The participants' confidence in his/her ability to now adequately manage his/her

symptoms based on symptoms alone instead of PEFR had also contributed to the progressive lack of monitoring of PEFR in some cases.

The majority of participants kept their plans in a personal hand bag or basket, especially when they had realized the effectiveness of the plan. This can be seen as reflecting not only their appreciation of its usefulness, but also as a reflection of how they see asthma and taking action to deal with this condition as a part of everyday life.

Most participants commented favourably on the usefulness of the plan and did not find it difficult to follow. The majority thought that the plan was sufficiently detailed and that more detail was not required. The plan was printed on an A4 page for reasons of cost and convenience. This approach has been used in a previous study in children, where the participants were advised to store the plan in a prominent place in the home (Gillies et al. 1996). However, this approach may not be suitable for adults, where a credit card sized plan has previously been used (D'Souza et al. 1994), given that 71% of the participants keep their plan in a personal hand bag or basket. Upon full integration of the self-management plan in the management protocol of the Ministry of Health it is recommended that different versions for children and adults be adopted. Prior the self-management plan's integration to the health delivery protocol at the national level, however, there is a need to ensure all service delivery stakeholders are familiar with and agree on the contents and format of both the adult and childhood self-management plans.

Our study used a PEFR level of <80% for doubling the dose of inhaled steroid (or commencing where no inhaled steroid had previously been part of routine

medication), and of and <60% for starting a course of prednisone. These levels were the same as those used in the Wairarapa study (D'Souza et al. 1994). Other studies have used levels of 85% and 70% which were also shown to be effective (D'Souza et al. 1994; Lahdensuo et al. 1996; Lahdensuo et al. 1998).

The New Zealand Athma Guidelines of 2005 (Guidelines 2005) had "de-emphasised" the use of PEFR in asthma management plans for children. The current study however involved both children (10 years and above) and adults, and was based on the self-management plan (involving PEFRs or symptoms) that had previously been successfully trialled in the Wairarapa. Although the PEFR side of the self-management plan was preferred more than the symptom side most participants indicated that they found both sides equally helpful. We did not have enough numbers in the study to compare the relative effectiveness of the PEFR and symptom based plans, but other studies (Charlton et al. 1990) have found them to have similar efficacy. These findings not only reinforce the importance of objective assessment of asthma during acute exacerbations, but also suggest that patients should be offered both PEFR and symptoms-based methods of assessment.

7.5.3 Changes in medication use

One of the interesting findings of the study is that there was a decrease in the number of ventolin inhalers prescribed on Tongatapu in the 12 months following the commencement of the study compared to the previous 12 months according to the Pharmacy Annual Report of 2006 (Anon 2006), even though the percentage of study participants being prescribed ventolin inhalers for the same period had increased from 38% to 95%. This could be explained by a decrease in absolute numbers of ventolin

actually dispensed as participants were better controlled and using less ventolin inhalers. The percentage of participants who were prescribed ventolin tablets regularly dropped from 19% to 2%. Although no ventolin tablets have been prescribed at the asthma clinic its prescription is still common among health personnel in Tonga particularly among primary health care providers even though there are only very limited reports of its role in the management of asthma (Leroux et al. 1991).

The greater use of regular inhaled corticosteroid treatment, in accordance with current recommended and international guidelines (Shigyo et al. 2005), undoubtedly contributed to the observed improvement in asthma morbidity. The increase in the number of participants on inhaled steroids from 52% to 96% had been expected to occur as a result of the intervention, and arrangements were made with the government pharmacy at the beginning of the study to increase purchasing orders for steroid inhalers. However, this increase in inhaled steroids was offset in cost by the relatively greater drop in the prescription of ventolin inhalers for the same period (Anon 2006), not to mention the improved control of asthma among participants.

7.5.4 Changes in asthma morbidity

We found a striking improvement in PEFR (from 346 l/min to 421 l/min, an increase of 22%), similar to that which had previously been observed in adults in the Wairarapa study (Te Hauora Runanga o Wairarapa et al. 1999). The authors of the Whangarei study raised the possibility that increases in PEFR may reflect the growth of the children over the study period as well as better readings due to better understanding of how to use a peak flow (Gillies et al. 1996). Such considerations also apply to the Tonga study where most of the participants (except for three) did not

own or had used a peak flow meter previously as well, and the study participants consisted of both children and adults. However, it is unlikely that the improvements in PEFR were entirely due to such a bias, since we also observed other striking improvements in asthma morbidity.

The marked decrease in emergency visits and hospital admissions for asthma are consistent with findings from New Zealand and other international studies (D'Souza et al. 1994; D'Souza et al. 1996a; Gillies et al. 1996; Lahdensuo et al. 1996; D'Souza et al. 1998; Lahdensuo et al. 1998; D'Souza et al. 2000; Thoonen et al. 2003). For a number of participants, the severity of their asthma had, prior to the commencement of the project, not only limited their daily activities, but also compromised the quality of their lives. It had also meant regular visits to hospitals for nebulisers at unusual hours requiring considerable expense and family commitments. The benefits of a decrease in severity therefore extended beyond the individual to close and extended family members.

As noted above, the greater use of regular inhaled corticosteroid treatment, in accordance with current recommended and international guidelines, undoubtedly contributed to the observed improvement. Other factors include the better understanding of asthma mechanisms and its management, review of asthma control and inhaler technique, encouragement in self-management based on objective assessment of lung function, longer time dedicated to individuals in a client-friendly clinic setting.

All of these factors should be considered as essential elements of any asthma management plan.

7.5.5 Discussion

In summary, this study gives us some understanding of how people with asthma are able to achieve a level of self-care that can extend to the primary health care level and the community. In this prospective study we have found that the asthma self-management plan is both an effective and acceptable system for self-managing asthma, when introduced into a clinic-based programme. The success of the introduction of the self-management plan, in the context of an asthma clinic, was reflected by improvement in measures of asthma morbidity, such as peak expiratory flow rates and nights woken with asthma or coughing. There was also a reduction in the requirement for acute medical treatment, indicated by a decrease in emergency department hospital visits for asthma and hospital admissions. The programme was so successful that the intervention study evolved into a full regular asthma clinic for the main island of Tonga. It is now intended that the asthma self-management programme will be extended throughout the rest of Tonga, through the primary health care system.

Chapter 8: Discussion

This thesis has involved a series of studies of the prevalence, causes, and management of asthma in the Pacific. The core study of the thesis is Phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). The ISAAC study is the largest worldwide epidemiological study and was established partly in response to the increases in asthma prevalence in most parts of the world over the last two to three decades. The ISAAC Phase I study found huge variations in asthma prevalence globally, but no Pacific countries were involved. Thus, the situation in the Pacific was relatively unknown due to lack of standardised studies on prevalence and time trends. The ISAAC Phase III study was therefore conducted in eight Pacific countries to address the above concerns, as well as to enhance Pacific participation and contribution to international research on the causes and control of asthma. The collaboration also served the purpose of encouraging and strengthening health research capacity and environment in the Pacific.

The ISAAC Phase III study was followed by an asthma self-management intervention trial conducted in Tonga by the ISAAC study team.

8.1. Summary of findings

The work presented in this thesis involved: (i) the conduct of the ISAAC Phase III study in the six Pacific islands of Tokelau, Samoa, Fiji Islands, Tonga, Niue and the Cook Islands, as well as the incorporation into the analysis of data that had already been collected in French Polynesia and New Caledonia; (ii) analysis of the findings

from an environmental asthma risk factor questionnaire which was included in the ISAAC survey in three countries (Samoa, Fiji and Tokelau); (iii) the conduct of the Tonga Asthma Self-management Study which was intended to assess whether the introduction of asthma education, including asthma self-management plans, would reduce morbidity from asthma.

The ISAAC Phase III study

A total of 20,876 13-14 year olds, in the eight countries involved, participated in the ISAAC Phase III survey, with an overall response rate of 92%. The survey showed that there was considerable variation in the prevalence of asthma symptoms between the eight countries, ranging from 5.8% (for current wheeze) in Samoa to 16.2% in Tonga. Tokelau reported the highest prevalence (19.7%) for current wheeze, but the number of participants was relatively small. The prevalence of asthma symptoms among Pacific children in the Pacific was lower than those reported for Pacific, Māori and European children living in New Zealand from a previous study (ISAAC Phase I) using the same methodology. The prevalence of Pacific children living in the Pacific having ever been diagnosed with asthma was also lower than that found among Pacific, Māori and European children in New Zealand.

The considerable variation in asthma symptom prevalence throughout the Pacific and the consistently lower levels reported in comparison to Pacific populations in New Zealand further contributes to the evidence of environmental factors playing a key contributing role on asthma prevalence, and that consequent changes in environments can be accompanied by a different risk of asthma.

The ISAAC Phase III Environmental Questionnaire analyses

Only three countries (Tokelau, Samoa, Fiji) implemented the ISAAC Phase III environmental questionnaire. Exposure to environmental asthma risk factors through general lifestyle, smoking, dietary practices, cooking practices, family size, pet ownership and vehicles also differs greatly between countries. These differences are determined to a large extent by socio-economic infrastructure and capacity as well as the location and type of agriculture that can be supported by local soil conditions. The smaller isolated coral atolls of Tokelau being just above sea level with poor soil quality, contributes to the fact that Fiji and Samoa are five to six times higher than Tokelau in the regularity of vegetable intake and the former two having a three fold higher fruit dietary intake than Tokelau. The existence of a nationwide dairy produce processor in Fiji probably plays a role in Fiji having the highest frequency of diary products consumption. Similarly, Fiji is a major regional distributor of cooking and industrial gas and tops the three countries in the use of gas for cooking. Dogs have been outlawed in Tokelau for a few years now and pigs are kept in a communal pen, the legislation of which is very much enforced. The ownership of cats is higher than for Fiji with Samoa having the highest ownership prevalence. There is a marked difference in the prevalence of mothers smoking and very high in some countries as well as a uniformly high level of smokers in households. Although there were significant associations found in individual countries, I will restrict this summary of the risk factor analyses to the findings for all three countries combined, due to the small numbers in many of the single-country analyses.

The ISAAC Phase III environmental questionnaire analyses indicated that the major risk factors for current wheeze (across the three countries) were paracetamol use in

the previous year (odds ratio (OR) = 1.36, 95% CI 1.15-1.61), the use of open fires for cooking (OR = 1.34, 95% CI 1.13-1.58), lack of physical activity as indicated by television viewing more than 3 hours per day (OR = 1.24, 95% CI 1.04-1.47), regular meat consumption (OR = 1.30, 95% CI 1.09-1.54) and regular cereal consumption (OR = 1.29, 95% CI 1.07-1.54). However, these risk factors were not particularly strong, and did not account for a large proportion of asthma cases (i.e. they had relatively low population attributable risks).

The Tonga Asthma Self-management Project

In the asthma self-management plan study there were significant improvements in asthma morbidity and the management of asthma among individuals and the service provision. The success of the introduction of the self-management plan, in the context of an asthma clinic, was reflected by improvement in measures of asthma morbidity, such as peak expiratory flow rates and nights woken with asthma or coughing. There was also a reduction in the requirement for acute medical treatment, indicated by a decrease in emergency department hospital visits for asthma and hospital admissions. The programme was so successful that the intervention study evolved into a full regular asthma clinic for the main island of Tonga. It is now intended that the asthma self-management programme will be extended throughout the rest of Tonga, through the primary health care system. Although this will obviously raise issues of resourcing and sustainability, the strong benefits shown for the intervention indicate that it is likely to be cost-effective. In this respect, it should be emphasized that the resources required for implementing such as intervention as a regular service are much less than when implementing it as part of a research project with regular questionnaires and symptom diaries.

8.2. Public Health Implications

Asthma burden

Asthma has been widely reported to have increased globally over the last few decades (Pearce et al. 2002). Most of these reports have been from studies in developed countries. Studies that have used standardised methodologies across large populations have shown huge variations in prevalence across countries, but with a generally lower prevalence of asthma in developing countries compared to developed countries (Asher et al. 1998; Beasley et al. 1998; Asher et al. 2006; Pearce et al. 2007).

This study has provided, for the first time, standardised information on the burden of asthma in children in eight Pacific countries (Foliaki et al. 2007). However, this study has only addressed the burden of asthma morbidity, and has not considered the socioeconomic or social burden of asthma in the Pacific. Thus, this study should not be seen as an end in itself, but a step in the process whereby relevant information on the burden of asthma in these countries is conveyed in a lay friendly form to the public. Providing relevant information on the burden of asthma in the Pacific is a public health duty in ensuring that health professionals, the public, and asthma patients in particular, recognise the burden of asthma in the community, and that the associated problems of decrease in productivity and morbidity (with compromised education opportunities for young children) are not confined to individuals but extend to families and the community and health costs.

Of particular importance is the need for awareness among health professionals at all levels of the above problems. While the few and isolated internal medicine specialists

and paediatricians in the Pacific are very much aware of the clinical means of asthma management, this does not translate to any in-depth knowledge among these professionals on the public health burden of asthma, nor necessarily the means for asthma control and prevention at the population level. In fact it appears that asthma has had relatively low priority in terms of control and preventive strategies. The primary health care workers on the other hand may have a better grasp of the asthma burden in the community, but at the same time they are often the least equipped in knowledge about the causes and management of asthma. The findings from this study, as well as those from international studies, should also be conveyed to policy makers in health and other sectors as well as to major international public health partners of Pacific countries such as the World Health Organisation to assist with respective collaborative public health programs.

Collaboration

The networks established for the current study will hopefully evolve as a vital component in the surveillance and monitoring of asthma trends in individual Pacific countries. They should also form part of the collaborative global task of surveillance of asthma at the regional and international level. Prior to the current study, at the individual country levels in the Pacific, studies of asthma had been few and in most countries there had been none. Of the few that had been conducted these had used varying methodologies and instruments. The current study achieved a more than satisfactory participation spirit and participation rate. We can now compare between individual Pacific countries as well having available baseline information to realistically start thinking about and planning studies on trends. The collaboration with other asthma surveillance activities at the international level has commenced

with this study through the use of the ISAAC methodology and instruments and participation in the ISAAC programme (Asher et al. 1995; Ellwood et al. 2005). In addition, this has now enabled comparison of local asthma prevalence figures to international rates. It will also be particularly interesting to see if Pacific countries will follow trends reported for asthma prevalence from Western countries with substantial increases following by a more recent "levelling off" in the asthma prevalence epidemic (Asher et al. 2006; Pearce et al. 2007).

However, the surveillance networks established for this study do not have to be restricted to asthma prevalence and trends. The establishment of the 'data' base from the current study is in itself already an opportunity to monitor associated risk factors throughout the Pacific. Such a database would also be beneficial to respective Ministries of Health if it includes vital information such as mortality from asthma, treatment and management practices. Mortality registration is an area particularly identified as lacking in details and completeness in most Pacific countries.

Management and control

The management and control of asthma has not comprehensively been addressed in the Pacific. The approaches for such an attempt are undoubtedly numerous and multi-level. From a public health perspective, however, the westernization 'package' (Douwes and Pearce 2002) means that Pacific countries are likely to experience increases in asthma morbidity in the coming decades. Although the major risk factors for asthma in the Pacific, or in Western countries, are still unclear, most of the risks associated with asthma are common to other priority diseases such as unhealthy diets, smoking, obesity and lifestyle changes in general (Foliaki and Pearce 2003a; Foliaki

and Pearce 2003b). These are areas that currently have established public health programs operating, though at different levels of success (Foliaki and Pearce 2003b). Thus, while research continues into the primary causes of asthma, public health programmes over factors such as smoking and passive smoking, diet and exercise, are worthwhile in themselves, and may also prevent at least some of the population burden of asthma in the Pacific.

The close relationship of asthma and other debilitating airway diseases such as chronic obstructive pulmonary disease in certain areas of management and exacerbating triggers is also a logical area for partnership from a public health perspective. In terms of management, asthma is very much a primary health care condition, and therefore needs management by primary health care personnel and services. Currently, however, the management of asthma, even when carried out in primary health care facilities, does not always involve a primary care approach. The current study has reported the effectiveness of a written self management plan for asthmatics based on simple daily symptom diaries and peak flow readings. It has also reported the acceptance and willingness of a large majority of asthmatics in Tonga to use these simple plans.

Such findings have been reported previously in other countries, and appropriate plans have been in use in mostly developed countries in one form or another (Beasley et al. 1989; Charlton et al. 1990; D'Souza et al. 1994; D'Souza et al. 1996a; Gillies et al. 1996; D'Souza et al. 1998; D'Souza et al. 2000). However, public health clinicians and practitioners in Tonga and the Pacific have not incorporated these approaches to the management of asthma patients at the community level. The incorporation of these

approaches into national health programs for the management and control of asthma would also address the lack of, and sometimes the absence of, guidelines for the community and outpatient management of asthma in most Pacific countries. In addition, the existence and use of asthma management guidelines would strengthen treatment practices and ensure availability of appropriate drugs such as steroid inhalers at the primary health level.

Asthma Research

The Pacific has not participated actively or adequately in the epidemiological studies on the causes, management and control of asthma in the past (Moala and Pearce 2001). However, findings from the international studies have general implications for public health activities in the Pacific. These are the need for Pacific participation in asthma research in areas referred to above such as collaboration in surveillance, prevalence and trends (Foliaki et al. 2004a). There are needs for collaboration in research on asthma treatment and management techniques and on the adoption of proven research results from international research if and when applicable to local and Pacific settings and context.

For instance, there is no concrete reason to believe that the global asthma increase and pattern shown from international studies will not be duplicated, or is not already happening, in the Pacific. There is a public health need to identify risk factors previously 'established' as causing asthma in other environments for further research in the Pacific environment. There is also a need also to 'catch up' with evolving and new research topics and research techniques on asthma. One of the objectives of the ISAAC Pacific study is to address these questions. The prevalence study is but one

component of an overall research need in asthma in the Pacific which should extend to the lack of control, management and treatment needs referred to above.

For example, there are no PEFR 'normal standards' specific for Pacific populations. It is important to determine whether different standards are required, or if standard derived from Western populations are also applicable to the Pacific.

There is also a need to further investigate asthma risk factors in the Pacific, both in terms of assessing the importance of "established" risk factors from Western countries, and also the potential importance of factors that are relatively unique to the Pacific. Thus, the contrasting socioeconomic and natural environments in the Pacific may provide some answers, as well as additional research questions, on asthma. For example, there have been suggestions that the decline in tuberculosis and typhoid (Jones et al. 2000; Luque et al. 2005) is associated with the recent increase in asthma. The steady decline of tuberculosis and typhoid in Tonga over the last two to three decades makes this an interesting area for research. The pattern of pet ownership and keeping of livestock in Pacific settings and environments are potential areas for collaborative research, particularly regarding endotoxin exposure (Douwes et al. 2002b) which has so far been an unexplored research area in the Pacific. The role of indoor pollution and burning of wood for cooking (common among Pacific countries) in association with respiratory diseases of children, and inconsistently with asthma, is another area of potential further research. Finally, migration studies are of major importance for understanding the life-course epidemiology of asthma (Migliore et al. 2007), and there is considerable potential for further such studies in the Pacific. In contrast, the high coverage of vaccination programs and the firm establishment of

immunisation programs in the public health programmes of most Pacific Island countries makes the Pacific a difficult setting for research into vaccines and asthma since there is insufficient population variation.

The continuation of the ISAAC work in the Pacific is strongly recommended to ensure a continuing local commitment to asthma research as well as a direct link to international resources and expertise. Asthma has been identified as a priority disease by the World Health Organisation although their commitment to asthma research or from Pacific islands to asthma research in the Pacific has been minimal.

The current study did not include most of the Melanesian countries (e.g. the Solomons Islands, Vanuatu and Papua New Guinea) as well as the northern Pacific islands; although some had expressed interest in participating. The reasons for the non-participation varied, partly due to unfortunate local situations at the time, but also as a consequence of limited financial backing to meet travel across the vast Pacific region. The wealth of potential information from a study of asthma among these countries is recognised and there would be benefits from conducting asthma research in these countries in future.

The importance of disseminating research results cannot be overemphasised. However, it has not been emphasised in the Pacific, at least with regards to dissemination to appropriate bodies in an appropriate way, and more importantly dissemination in a meaningful manner to the communities researched. This aspect of research needs continuous attention with regards to ethical issues, researcher responsibility and respect for the researched communities, and the appropriate

conduct of future research partnerships. Timely appropriate dissemination of results also provides a service very much needed by health planners and policy makers. The results from ISAAC Pacific have been distributed to all collaborating Pacific countries Ministries of Health and individual countries have distributed the results to schools and encouraged schools to request school presentations by ISAAC Pacific research team members.

8.3. Policy Implications

Asthma prevalence and morbidity have increased worldwide. There is no reason to believe a similar trend will not be replicated or is already occurring in the Pacific. The asthma prevalence among Pacific children is higher in developed countries then among Pacific children in traditional Pacific habitats. There is a lack of a standard guideline for the management, control and preventive strategies for asthma in most Pacific countries.

It is important that policy makers have access to sound information on asthma in terms of the burden to individuals, the community and health costs to individual governments. Likewise clinicians must have access to appropriate information and skills to adequately manage and treat patients. Patients and individuals on the other hand should have access to adequate information to enable them to seek or manage their asthma appropriately in order to maintain an acceptable quality of life.
This could best be achieved with proper policies in place that ensure adequate training of heath care providers, appropriate treatment guidelines and the establishment of adequate health services which are accessible and in turn equipped with adequate and essential remedies for asthma. Treatment guidelines should take into consideration

availability of essential drugs, rather than simply adopting international guidelines that would prove impractical due to lack of expensive drugs.

Among the objectives of the ISAAC Pacific is the use of these basic findings as a framework for further aetiological research into lifestyle, environmental, genetic and medical care factors affecting asthma and other atopic diseases. At the same time, the research agenda in the Pacific is a much debated area in recent years with a general agreement that capacity training of local personnel is a priority (Foliaki et al. 2004a). Policies to strengthen this approach should be firmly in place. At the same time, the role of collaboration with international research centres leading in respective fields must be acknowledged in its own right and also strengthened. The collaboration with ISAAC serves both purposes well.

8.4 Issues for future research

In most Pacific countries, capacity for health research is poor in infrastructure, policy, personnel, information and money. Health policy and decision making are therefore often based on insufficient evidence and imported strategies that may have worked (or even not worked) somewhere else but have not necessarily been proven to work in the local situation. It is reasonable then to start with strengthening the research capacity among Pacific people, and in particular those health workers committed to and based in Pacific countries and institutions, in the future development of health research for the Pacific. This is in contrast to implementing more research in isolation. Such training should go beyond the *ad hoc* training exercises for fieldwork and incorporate formal training both locally and in collaboration with established regional and international research institutions. The Health Research Council of the Pacific

(established in 1998 with an overall aim to assist Pacific people in developing and controlling health research for the Pacific) (Pryor et al. 2000) again needs the support and endorsement of both governments and individual personnel of influence. The continuous striving for "better" quality data must be complemented by building on and recognising existing work by the careful analysis and utilisation of the existing "poor" quality data.

While we live in culturally diverse societies, most health research often fails to accommodate this diversity (Papadopoulos and Lees 2002). We cannot assume that when the researched population is a majority group this will result in a culturally appropriate research paradigm if the researchers are mostly outsiders and outnumber local researchers. At the same time, however, we should not lose sight of the international relevance of research in the Pacific, and the need for maintaining standards of excellence, by burying Pacific research in a "local needs" focus.

The imposition of a unicultural perspective by "outside" researchers often imposing their concepts, beliefs and explanations of relationships, and values on other cultures may lead to invalid research results (Papadopoulos and Lees 2002). Palafox *et al* (Palafox et al. 2002) argue that the large disparity in the health problems of Pacific Islanders in the United States compared to other populations could not be solved by training more Pacific Islanders to do more "western" research. Rather, health researchers should also be culturally competent and understand Pacific perspectives of disease, social connections with disease, health and health care priorities in the context of local, social and economic situations. Most health researchers for example confine their interests to a disease entity or often to a symptom, and lack the broader

perspective needed to understand the local interaction of specific research agendas to local knowledge and priorities. The unravelling of these complex situations requires indigenous models of research and an understanding of indigenous peoples' health beliefs, knowledge, practices and science (Palafox et al. 2002).

Emphasis should be given to research that could realistically have a positive effect, and influence policy and improve health where it matters most. Among the areas that immediately come to mind are social determinants of health and the infrastructures for enabling research in an economically compromised region. This approach is long overdue in populations that have been continuously researched and "described" for the last four decades in research that has had only limited benefits for the populations being studied. It is therefore stating the obvious that a comprehensive and integrated approach to health research is required (Foliaki et al. 2004a).

8.5 Conclusions

In summary, the dynamics of the epidemiological transition in most Polynesian South Pacific islands has been relatively unprecedented. Processes such as advances in public health, health care and technology, social, demographic and economic transitions that took hundreds of years in most (now) developed countries have, as a consequence of rapid globalisation, been compacted in time in the Pacific. These processes have produced major changes in environment and lifestyle, which have produced epidemics of non-communicable disease.

There are considerable advantages in addressing non-communicable diseases as a group, rather than addressing them in a piecemeal fashion. There are common methodologies (particularly epidemiology), and common causes (e.g. socio-economic factors, smoking, diet, occupation) as well as common approaches to their control. However, while it is important to consider non-communicable diseases as a group, it is also important to conduct research into their specific causes. There had been a great deal of research into cardiovascular disease and diabetes in the Pacific, but it is only recently that the importance of cancer as a major source of mortality and morbidity in the Pacific has been recognised, even though it appears to carry a similar burden of morbidity and mortality. Similarly, in terms of policy asthma is categorised as a non-communicable disease, but there has been little work to determine the asthma burden in Pacific populations compared to research on other more "popular" non-communicable diseases such as cardiovascular conditions and metabolic disorders. It is therefore important that research into the causes and control of other disease conditions in the Pacific is conducted. However, it is also crucially important that this research both learns from the successes and avoids the mistakes of the past. In particular, it is crucial that cancer research in the Pacific is not yet another opportunity for "research colonialism", but instead provides opportunities for Pacific-training of Pacific health researchers and the conduct of Pacific-led research.

The ISAAC Phase IIII survey has provided such an opportunity for Pacific-led research. It has shown that asthma prevalence in Pacific countries is lower than those among Pacific people in New Zealand. Together with the large variations in prevalence between the six Pacific countries that participated, this further lends support for the role of environmental risk factors in asthma. The availability of data

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on six countries using a standardised methodology also provides useful information on the burden of asthma in the Pacific that is comparable to other countries regionally and internationally as well as forming a basis for ascertaining trends in the future. The crucial role of asthma self-management plans in asthma care and control is further supported by the findings of the Tonga study; and its implementation is more than essential in the resource-scarce Pacific health setting. The collaborative nature of ISAAC in the Pacific has further raised awareness of the need for capacity building and creating networks and environments that enhance health research in areas other than asthma. The study has also nurtured an environment and network that encourages and strengthens the establishment of health research as one of the vital tools for achieving better health.

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Appendix 1 English ISAAC Phase III Questionnaire

Instructions for completing questionnaire and demographic questions

Examples of instructions for completing questionnaires and demographic questions are given below. **The questionnaire content is fixed.** *(see pages 73-75 for 'office use only' boxes example)*

On this sheet are questions about your name, school, and birth dates. Please write your answers to these questions in the space provided.

All other questions require you to tick your answer in a box. If you make a mistake put a cross in the box and tick the correct answer. Tick only one option unless otherwise instructed.

Examples of how to mark questionnaires: Age [13] years

To answer Yes/No, put a tick in the appropriate box as per example	YES	NO
	[ ]	[√]

SCHOOL: [ ]

TODAY'S DATE: [ ] Day [ ] Month [ ] Year

YOUR NAME: [ ]

YOUR AGE: [ ] years

YOUR DATE OF BIRTH: [ ] Day [ ] Month [ ] Year

(Tick all your answers for the rest of the questionnaire)

Are you: MALE [ ] FEMALE [ ]

Optional questions on ethnicity here

Core questionnaire for asthma

Questionnaire for 13/14 year olds

1 Have you ever had wheezing or whistling in the chest at any time in the past?
- Yes ☐
- No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

2 Have you had wheezing or whistling in the chest in the past 12 months?
- Yes ☐
- No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

3 How many attacks of wheezing have you had in the past 12 months?
- None ☐
- 1 to 3 ☐
- 4 to 12 ☐
- More than 12 ☐

4 In the past 12 months, how often, on average, has your sleep been disturbed due to wheezing?
- Never woken with wheezing ☐
- Less than one night per week ☐
- One or more nights per week ☐

5 In the past 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?
- Yes ☐
- No ☐

---

6 Have you ever had asthma?
- Yes ☐
- No ☐

7 In the past 12 months, has your chest sounded wheezy during or after exercise?
- Yes ☐
- No ☐

8 In the past 12 months, have you had a dry cough at night, apart from a cough associated with a cold or chest infection?
- Yes ☐
- No ☐

Core questionnaire for rhinitis

Questionnaire for 13/14 year olds

All questions are about problems which occur when you DO NOT have a cold or the flu.

1 Have you ever had a problem with sneezing, or a runny, or blocked nose when you DID NOT have a cold or the flu?

Yes ☐
No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

2 In the past 12 months, have you had a problem with sneezing, or a runny, or blocked nose when you DID NOT have a cold or the flu?

Yes ☐
No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

3 In the past 12 months, has this nose problem been accompanied by itchy-watery eyes?

Yes ☐
No ☐

4 In which of the past 12 months did this nose problem occur? (Please tick any which apply)

January	☐	May	☐	September	☐
February	☐	June	☐	October	☐
March	☐	July	☐	November	☐
April	☐	August	☐	December	☐

5 In the past 12 months, how much did this nose problem interfere with your daily activities?:

Not at all ☐
A little ☐
A moderate amount ☐
A lot ☐

---

6 Have you ever had hayfever?

Yes ☐
No ☐

Core questionnaire for eczema

Questionnaire for 13/14 year olds

1 Have you ever had an itchy rash which was coming and going for at least six months?

Yes ☐
No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

2 Have you had this itchy rash at any time in the past 12 months?

Yes ☐
No ☐

IF YOU HAVE ANSWERED "NO" PLEASE SKIP TO QUESTION 6

---

3 Has this itchy rash at any time affected any of the following places:

the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?

Yes ☐
No ☐

4 Has this rash cleared completely at any time during the past 12 months?

Yes ☐
No ☐

5 In the past 12 months, how often, on average, have you been kept awake at night by this itchy rash?

Never in the past 12 months ☐
Less than one night per week ☐
One or more nights per week ☐

---

6 Have you ever had eczema?

Yes ☐
No ☐

ISAAC International Video Questionnaire answer sheet

If the video questionnaire is included with the core questionnaires, the demographic details will have been put onto the front of the questionnaire. If the video questionnaire is administered separately, the demographic questions will need to be added to this section.

SCENE ONE:	The first scene is of a young person at rest.		
QUESTION ONE:	Has your breathing been like this, at any time in your life?	**YES**	**NO**
if **YES:**	has this happened in the past year?	**YES**	**NO**
if **YES:**	has this happened one or more times a month?	**YES**	**NO**
SCENE TWO:	The second scene is of two young people exercising. One is in a dark shirt and the other is in a white shirt.		
QUESTION TWO:	Has your breathing been like the boy's in the dark shirt during or following exercise at any time in your life?	**YES**	**NO**
if **YES:**	has this happened in the past year?	**YES**	**NO**
if **YES:**	has this happened one or more times a month?	**YES**	**NO**
SCENE THREE:	The third scene is of a young person waking at night.		
QUESTION THREE:	Have you been woken at night like this at any time in your life?	**YES**	**NO**
if **YES:**	has this happened in the past year?	**YES**	**NO**
if **YES:**	has this happened one or more times a month?	**YES**	**NO**
SCENE FOUR:	The fourth scene is also of a young person waking at night.		
QUESTION FOUR:	Have you been woken at night like this at any time in your life?	**YES**	**NO**
if **YES:**	has this happened in the past year?	**YES**	**NO**
if **YES:**	has this happened one or more times a month?	**YES**	**NO**
SCENE FIVE:	The final scene is of another person at rest.		
QUESTION FIVE:	Has your breathing been like this at any time in your life?	**YES**	**NO**
if **YES:**	has this happened in the past year?	**YES**	**NO**
if **YES:**	has this happened one or more times a month?	**YES**	**NO**

Appendix 2 Samoan ISAAC Phase III Questionnaire

GOVERNMENT OF SAMOA
DEPARTMENT OF HEALTH

SUESUEGA MO LE MA'I SELA MA ISI AAFIAGA O FAAMA'I PIPISI, I TAMAITI 13/14 TAUSAGA I SAMOA

FAAMATALAGA O LE SUI AUAI

AOGA: ☐

ASO LENEI: ☐ **Aso** ☐ **Masina** ☐ **Tausaga**

SUAFA: ☐

UA FIA OU TAUSAGA: ☐

ASO FANAU: ☐ **Aso** ☐ **Masina** ☐ **Tausaga**

ITUAIGA: ☐ **Alii** ☐ **Tamaitai**

1. Na e aafia muamua i le ii/sela o lau manava? **Ioe** ■ **Leai** ☐

AFAI E "LEAI" FAAAUAU I LE FESILI 6

2. Na e aafia i le ii o le manava i le 12 masina ua tuana'i atu? **Ioe** ☐

Leai ☐

AFAI E "LEAI" FAAAUAU I LE FESILI 6

3. E faafia ona oso lou sela/ii o lau manava i le 12 masina ua tuana'i atu?

0 ☐

1 – 3 ☐

4 – 12 ☐

Sili atu i le 12 ☐

4. I sau faatatau, e faafia ona oso le ii lau manava poo lou sela a'o e moe i le 12 masina ua tuanai atu?

E le oso le sela/ii le manava pe a moe ☐

Lalo ifo o le tasi le po i le vaiaso ☐

Tasi pe sili atu po i le vaiaso ☐

5. E i ai se taimi o le 12 masina ua tuana'i atu sa tau le mafai ai ona e tautala ona o lou sela?

Ioe ☐

Leai ☐

6. Na i ai se taimi o lou soifuaga na e aafia ai i le ma'i sela?

Ioe ☐

Leai ☐

7. I le 12 masina talu ai na e faalogoina le ii o lau manava i taimi e te faamalositino ai pe uma foi ona faamalositino? ☐
Ioe

Leai ☐

8. I le 12 masina talu ai, sa iai se taimi o le po na e tale ai, ae leai se fatutale, e ese mai i le tale o le flu? ☐**Ioe**

Leai ☐

O fesili uma nei e faatatau i auga e aliali mai i se tagata e LE o maua i le flu.

1. E i ai se taimi e te mafatua ai, tafe pe mamafa foi lou isu, ae e te LE o maua i le flu? ☐

Ioe

Leai ☐

AFAI E "LEAI" FAAAUAU I LE FESILI 6

---

2. I le 12 masina ua tuana'i, e i ai se taimi na e mafatua soo ai, tafe pe mamafa foi lou isu ae e te le maua i le flu?

Ioe ☐

Leai ☐

AFAI E "LEAI" FAAAUAU I LE FESILI 6.

---

3. I le 12 masina ua tuana'i, na e faalogoina faatasi ma le mafatua/tafe/mamafa o lou isu, le mageso ma le tagi o mata?

Ioe ☐

Leai ☐

4. O fea o le 12 masina ua tuana'i na aafia ai oe i le mafatua/tafe/mamafa o le isu?

(faamolemole togi mai le masina talafeagai)

Ianuari	☐	**Me**	☐	**Setema**	☐
Fepuari	☐	**Iuni**	☐	**Oketopa**	☐
Mati	☐	**Iulai**	☐	**Novema**	☐
Aperila	☐	**Aokuso**	☐	**Tesema**	☐

5. O le a se tele o le aafiaga o le mafatua/tafe/mamafa o le isu i au galuega o aso uma?

E leai se aafiaga ☐

E lē tele se aafiaga ☐

E feoloolo le aafiaga ☐

E tele le aafiaga ☐

---

6. Na e maua muamua i le hayfever? **Ioe** ☐

Leai ☐

---

1. Na i ai se taimi na e aafia ai i le mageso o le pa'u mo le sili atu i le 6 masina?

Ioe ☐

Leai ☐

AFAI E "LEAI" FAAAUAU I LE FESILI 6.

---

2. Na aafia oe i le ma'i mageso i le 12 masina ua tuana'i atu? **Ioe** ☐

Leai ☐

AFAI E "LEAI FAAAUAU I LE FESILI 6.

---

3. Na aafia vaega nei o lou tino i se taimi i le ma'i mageso? **Ioe** ☐

Leai ☐

Gauga o lima ma gauga o tuli (pito i tua),
luma o le mulivae, ogavae,
vaega o le ua, taliga ma mata?

4. Na i ai se taimi o le 12 masina ua tauna'i atu na te'a atoa ai le mageso i lou tino? ☐

Ioe

Leai ☐

5. I le 12 masina ua tuana'i, e faafia ona e moe alaala i po ona o le mageso?

Sa moe lelei ile 12 masina ua tuanai ☐

Lalo ifo o le 1 le po i le vaiaso ☐

Tasi pe sili atu po i le vaiaso ☐

---

6. Sa e aafia muamua i le ma'i mageso?

Ioe ☐

Leai ☐

FESILI FAATATAU I LE ATA VIDEO

	Ioe	Leai
VAAIGA 1: O le vaaiga i se tagata talavou ao faia sana malologa.		
1. Na i ai se taimi o lou olaga na e manava ai faapea?	☐	☐
Afai e IOE: Na faapea lau manava i le tausaga ua tuanai atu? **Afai e IOE: E faafia ona e manava faapea i se masina?**	☐	☐

VAAIGA 2: O le vaaiga i ni tagata talavou se toalua o lo o faamalositino. O le tasi o loo ofu i se mitiafu uliuli ma le isi i le mitiafu paepae.

	Ioe	Leai
2. Na i ai se taimi o lou olaga na e manava pe sela au e oeu i le alii i le mitiafu uliuli ao faia sau faamalositino pe mae'a foi ona e faamalositino?	☐	☐
Afai e IOE: Na faapea sou sela/manava i le tausaga ua tuanai atu? **Afai e IOE: E faafia ona e sela/manava faapea i se masina?**	☐	☐

	Ioe	Leai
VAAIGA 3: O le vaaiga i se tagata o lo o ala ae i le po		
3. Na i ai se taimi o lou olaga na e ala ai faapea i se po?	☐	☐
Afai e IOE: Na e ala faapea i se taimi o le tausaga ua tuanai atu? **Afai e IOE: E faafia ona e ala faapea i se masina?**	☐	☐

	Ioe	Leai
VAAIGA 4: O le vaaiga i se tagata o lo o ala ae i le po		
4. Na i ai se taimi o lou olaga na e ala ai faapea i se po?	☐	☐
Afai e IOE: Na e ala faapea i se taimi o le tausaga ua tuanai atu? **Afai e IOE: E faafia ona e ala faapea i se masina?**	☐	☐

	Ioe	Leai
VAAIGA 5: O le vaaiga i se tagata foi o loo malolo.		
5. Na i ai se taimi o lou olaga na faapea ai lau manava?	☐	☐
Afai e IOE: Na e manava faapea i se taimi o le tausaga ua tuanai atu?	☐	☐
Afai e IOE: E faafia ona e manava faapea i se masina?	☐	☐

Appendix 3 Tokelauan ISAAC Phase III Questionnaire

HUKEHUKEGA A NIU HILA KITE MANAVA, IHU MA NA FAKAFITAULI OTE PAKU.
FEHILI MO NA TAMAITI AOGA TULAGA LUA

Fakamatalaga mo te fakatumuga ona fehili.

I le laupepa tenei ko ni fehili e fakatatau ki to igoa, aoga mate aho fanau. Fakamolemole fakatumu au tali kina fehili ite avanoa kua haunia. Ko ie tahi fehili e manakomia ke tiki tau tali kina puha. Kafai e hehe oi tuku ki ei te koluhe kae tiki tau tali hako. E fokotahi lava tau tali e tiki vagana ni ie tahi fakamatalaga.

Fakatakitakiga pe vehea ona tali na fehili. Tauhaga ☐

Ke tali "Heai" ☐ Io ☐ Heai ☐

Ke tali "Io" Io ☐ Heai ☐

To Igoa ☐

Aoga ☐

Te aho nei: ☐ Aho ☐ Mahina ☐ Tauhaga

Ko o Tauhaga ☐

To aho fanau ☐ Aho ☐ Mahina ☐ Tauhaga

[Tiki au tali mo na fehili koi totoe]

Ko koe ☐ Taumalo ☐ Tautiti

Te fea te vaega Tagata e hau ai koe ☐ Papalagi ☐ Māori ☐ Tagata Pahefika ☐ Ietahi

Fakapatino ☐

1. Nae gugulu to fatafata pe fakahelahela tau manava? Io ☐ Heai ☐

[Kafai ko koe na tali e **heai** fakamolemole oi fano kite fehili numela 6**]**

2. Nae fakahelahela pe tatagi to fatafata ite 12 mahina kua teka? Io ☐ Heai ☐

[Kafai ko koe na tali e **heai** o fakamolemole oi fano kite fehili 6]

3. E matau e koe na fakafia oi fakahelahela tau manava ite 12 mahina kua teka?

Heai ☐ 1-3 ☐ 4-12 ☐ Ova 12 ☐

4. I te 12 mahina kua teka e fakafia oi oho fakahelahela koe?

e heki ala lele fakahelahela ☐ e fakafoko tahi ite vaiaho ☐ e hili atu ite fakafoko tahi ite vaiaho ☐

5. I te 12 mahina kua teka nae fita koe i tau manava, hae faigata koe ke tautala ite lafoga o he kupu e fokotahi pe lua ite va ona manava?

Io ☐ Heai ☐

6. Na kua hela nei koe?

Io ☐ Heai ☐

7. Na kua faka helahela nei koe i te 12 mahina kua teka i he taimi nae fai ai ni au koleni?

Io ☐ Heai ☐

8. Ite 12 mahina kua teka, na kua tale matuku koe ite po, e kehe mai ai mate tale i he fulu pe ko na famai ote fatafata?

Io ☐ Heai ☐

Ko na fehili ite pahina tenei e uiga kina fakafitauli e pogai mai KAFAI E HEAI he fulu pe he famai tale.

9. Na e i ie he fakafitauli te mafatua, tafe pe poloka na ihu, kae heai ai he fulu pe he famai peehi?

Io ☐ Heai ☐

Kafai ko tau tali e **heai** fakamolemole oi fano kite fehili 14

10. I te 12 mahina kua teka, nae i ei he fakafitauli e mafatua, tafe pe poloka na ihu kae heai ai he fulu pe he famai?

Io ☐ Heai ☐

Kafai ko tau tali e **heai** fakamolemole oi fano kite fehili 14

11. I te 12 mahina kua teka nae tafe he vai ma mageso na mata e hau fakatahi ma na fakafitauli ote ihu?

Io ☐ Heai ☐

12. Ko anafea o te 12 kua teka na tutupu ai na fakafitauli ote ihu?

Ianuali ☐ Fepueli ☐ Mati ☐ Apelila ☐

Me ☐ Iuni ☐ Iulai ☐ Aukuso ☐

Setema ☐ Oketopa ☐ Novema ☐ Tehema ☐

13. I te 12 mahina kua teka nae fakafia i enei fakafitauli o te ihu oi fakalavelave ki na fekau a koe ite aho?

E heai ☐ Taikole ☐ feoloolo ☐ Lahi ☐

14. Na kua faifo koe?

Io ☐ Heai ☐

15. Na kua iei nei ho kili mageho na oho ma galo fuafua ki he ono mahina?

Io ☐ Heai ☐

[Kafai ko tau tali e **heai** fakamolemole oi fano kite fehili 20]

16. Na kua iei nei la he kilimageso mo koe i ho he taimi ite <u>12 mahina kua teka</u>?

Io ☐ Heai ☐

[Kafai ko tau tali e **heai** fakamolemole oi fano kite fehili 20]

17. Te kili mageso tenei i ho he taimi e oho mai ai, na afaina na koga ienei; gauga ote tulilima, tua ona tulivae, mua ona ponapona vae, lalo ona kaulemu, pe faka takamilo i te ua, taliga ma na mata?

Io ☐ Heai ☐

18. Na mate uma la tenei kili mageho i ho he taimi i loto ote 12 mahina?

Io ☐ Heai ☐

19. I te 12 mahina kua teka, nae fakafia, I tau fuafuaga, nae ala ai koe ite po ona ko tenei kili mageho?

E heai ite 12 Mahina kua ☐ E he hili atu fakafoko tahi ite vaiaho ☐ Pe fakafokotahi pe ova atu ite vaiaho ☐

20. Na kua iei nei ho kili Ehema? (eczema)

Io ☐ Heai ☐

FEHILI ATA VITIO

Ata 1: Te ata muamua he talavou e malolo.

1. Na kua venei tau manava, talu to ola mai? Io ☐ Heai ☐

Kafai Io: Na tutupu nei ina tauhaga kua teka? ☐ ☐

Kafai Io: Na tutupu fakafokotahi pe hili atu ite mahina? ☐ ☐

Ata 2: Te ata 2 e toka 2 ia tino talavou e koleni. Tahi tino e kofu tino pauli ma ko te tahi tino e kofutino paepae.

2. Na ve nei tau manava e ve kote tama? e kofu pauli i he taimi pe fakatakitaki e koe te koleni, talu mai to ola? Io ☐ Heai ☐

Kafai Io: Na tutupu nei ina tauhaga kua teka? ☐ ☐

☐ ☐

Kafai Io: Na tutupu fakafokotahi pe hili atu ite mahina?

Ata 3: Te ata 3 he tino talavou ala ite po.

	Io	Heai
3. Na kua ala veia nei koe ihe po, talu mai i to ola?	☐	☐
Kafai Io: Na tutupu nei i na tauhaga kua teka?	☐	☐
Kafai Io: Na tutupu fakafokotahi pe hili atu ite mahina?	☐	☐

Ata 4: Te ata tona 4 ko he tino talavou foki ala ite po.

	Io	Heai
4. Na kua ala veia nei koe i he po talu mai i to olaga?	☐	☐
Kafai Io: Na tutupu nei i na tauhaga kua teka?	☐	☐
Kafai Io: Na tutupu fakafokotahi pe hili atu i te mahina?	☐	☐

Ata 5: Ko te ata mulimuli ko he tino foki e malolo.

	Io	Heai
5. Na kua veia nei tau manava talu mai i to ola?	☐	☐
Kafai Io: Na tutupu nei ina tauhaga kua teka?	☐	☐
Kafai Io: Na tutupu fakafokotahi pe hili atu ite mahina?	☐	☐

Appendix 4 Tongan ISAAC Phase III Questionnaire

SAVEA 'A TONGA KI HE HALANGA MANAVA, PALOPALEMA 'O E IHU PEA MOE NGAAHI PALOPALEMA HE KILI KI HE FANAU AKO TA'U 13 KI HE TA'U 14.

Ki he 'Ofisi pe: | 2 | 0 | 0 | 1 | | | | | | | | | | | | | |

Fakahinohino ki hono fakafonu 'o e fehu'I

Ko e ngaahi fehu'i ni, ki ho Hingoa, 'Apiako mo ho 'Aho Fa'ele'i. Kataki 'o hiki'i pe ho'o tali 'i he feitu'u 'oku faka'ata atu.
'I he ngaahi fehu'i kehe 'oku fiema'u pe ke ke hanga 'o faka'ilonga'i'aki hano fakatonuki 'a e puha tonu. Kapau 'e fehalaaki ho'o 'uluaki fili pea ke kolosi'i pe ka ke faka'ilonga'i 'a e tali tonu.

Fakatata: Ta'u Motu'a [13] Ta'u

Tali "'Ikai"

'Io	'Ikai
	√

Tali "'Io"

'Io	'Ikai
√	

Hingoa :

'Apiako :

'Aho ni : [ ] 'Aho [ ] Mahina [ ] Ta'u

Ta'u Motu'a : [ ] Ta'u

'Aho Fa'ele'i : [ ] 'Aho [ ] Mahina [ ] Ta'u

(Faka'ilonga'i pe 'a e tali tonu ki he toenga 'o e ngaahi fehu'i ko 'eni)

'Oku ke : Tangata [ ] Fefine [ ]

Ko fe 'a e fa'ahinga matakali 'oku ke kau ki ai? Palangi [ ] Tonga [ ] Makehe [ ] ⇩

Fakahaa'I mai 'a e fa'ahinga matakali Ko ia 'oku ke kau ki ai:

1. Na'e ***'i ai nai ha taimi*** he kuohili, ne hangē 'oku hapotupotu mo sisiī pe mapu ai ho'o mānavá?

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA 6

2. Kuó ke 'osi puke nai he hapotupotú pe sisīi pe hangē 'oku mapú ho'o mānaná, ***'i he ngaahi māhina 'e 12 kuo'osi?***

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA 6

3. ***'I he ngaahi māhina 'e 12 kuo'osi***, ko e tu'o fiha nai 'eni ho'o puke he hapotupotú, sisīi pe hangē 'oku mapú ho'o mānavá?

0	1 ki he 3	4 ki he 12	tu'o lahi hake he 12
☐	☐	☐	☐

4. ***'I he ngaahi māhina 'e 12 kuo'osi***, 'okú ke fakafuofua, ne tu'o fiha ha faka'āaki ho'o mohé, tupu mei ha'o puke he hapotupotu pe sisii e mānavá?

te'eki teu 'ā hake ko e hapotupotu	si'i hifo he tu'o taha he uike	laka he tu'o taha he uike
☐	☐	☐

5. ***'I he ngaahi māhina 'e 12 kuo'osi***, kuo 'i ai nai ha taimi kuo fu'u tōtu'a ai e hapotupotu ho'o mānavá pea a'u 'o meimei ke fo'i lea pē 'e taha pe ua 'oku lavá, he taimi 'okú ke talanoa ai?

'Io ☐ 'Ikai ☐

6. Kuó ke 'osi puke tu'o taha he mahaki ko e hela?

'Io ☐ 'Ikai ☐

7. ***'I he ngaahi māhina 'e 12 kuo'osi***, 'oku fa'a hapotupotu pe mapu nai ho'o mānavá 'i ha lolotonga pe hili ha'o fai ha ngāue pe fakamalohisino?

'Io ☐ 'Ikai ☐

8. ***'I he ngaahi māhina 'e 12 kuo'osi***, 'okú ke fa'a tale pakupaku he po'uli, tukukehe 'a e ngaahi tale angamaheni 'i ha'o ki'i fofonu pe ki'i momoko e fatafatá pe niumonia?

'Io ☐ 'Ikai ☐

Ko e ngaahi fehu'i kotoa 'i he peesi ko 'eni 'oku fekau'aki mo e ngaahi palopalema 'oku hoko, 'a ia 'oku hoko ia 'i he taimi 'OKU 'IKAI ke ke lolotonga puke ai ha fofonu pe 'okú ke puke ai he 'flu'.

9. Kuo ***'i ai nai ha taimi tu'o taha*** na'a ke palopalema'ia ai he toutou mafatuá pe lele noa e vai he ihú pe mapuni ho ihu 'o 'ikai ko e tupu mei ha'o puke he fofonu pe ko e 'flu'?

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA

14

10. ***'I he māhina 'e 12 kuo'osi***, kuó ke puke nai 'o lahi pea palopalema kia koe 'a e toutou mafatua pe lele noa e vai he ihú pe mapuni ho ihu 'o 'ikai ko e tupu mei ha'o lolotonga puke he fofonú pe ko e 'flu'?

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA

14

11. ***'I he ngaahi māhina 'e 12 kuo'osi***, 'oku fa'a fekau'aki nai e palopalema ko 'eni ho ihú mo ha veveli mo lelenoa e vai meí ho matá?

'Io ☐ 'Ikai ☐

12. Ko fē nai ha māhina ***'i he ngaahi māhina 'e 12 kuo'osi***, na'e hoko ai 'a e palopalema ko 'eni 'o e ihú?
(kātaki 'o faka'ilonga'i pē ha māhina pe 'ū māhina na'e hoko ai)

Sanuali	☐	Mē	☐	Sepitema	☐
Fepueli	☐	Sune	☐	'Okatopa	☐
Ma'asi	☐	Siulai	☐	Nōvema	☐
'Epeleli	☐	'Aokosi	☐	Tīsema	☐

13. ***'I he ngaahi māhina 'e 12 kuo'osi***, ko e lahi ha e lahi hono uesia 'e he palopalema ko 'eni ho ihú, 'a ho'o ngaahi ngaue faka'ahó?

'ikai ha uesia ☐ uesia si'isi'i pe ☐ ki'i lahilahi pe ☐ uesia 'aupito ☐

14. Kuó ke 'osi puke 'i he kainiloto tu'o taha?

'Io ☐ 'Ikai ☐

15. Kuo ***'i ai nai ha taimi*** kuó ke mo'ua ai 'i ha mahaki kili 'oku veveli mo papata 'oku toutou 'asi mai pē pea toe puli, 'oku ke fe'ao mo ia 'o a'u ki ha māhina nai 'e 6?

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA

20.

16. ***'I he ngaahi māhina 'e 12 kuo'osi***, kuo ke mo'ua nai 'i he fa'ahinga mahaki kili ko 'eni?

'Io ☐ 'Ikai ☐

KAPAU 'OKU KE TALI "'IKAI" KĀTAKI 'O HIKI KI HE FEHU'I FIKA

20.

17. ***Kuo 'i ai nai ha taimi*** na'e uesia ai 'e he fa'ahinga mahaki kili ko 'eni 'a e ngaahi feitu'u ko 'eni 'i ho sino :-

'Io ☐ 'Ikai ☐

tafa'aki ki mu'a 'o e tui'i nima.
'i mui 'i he tui
kia'i va'e
lalo molūu pe tafatafa'aki 'o e kiá,telingá pe ko e matá.

18. ***Lolotonga ko ia 'a e ngaahi māhina 'e 12 kuo'osi***, ne 'i ai ha taimi ne pulia faka'aufuli ai e veli ko 'ení?

'Io ☐ 'Ikai ☐

19. ***'I he ngaahi māhina 'e 12 kuo'osi***, na'e meimei tu'o fiha nai e uesia 'e he lahiange veli ni ho'o mohe he po'uli?

'ikai pe ha uesia he mahina 'e 12 kuo'osi. ☐

si'isi'iange he tu'o taha he uike. ☐

tu'o taha pe he uike. ☐

20. Kuó ke puke tu'o taha nai 'i he mahaki ko e mea?

'Io ☐ 'Ikai ☐

FEHU'I 'O NGAUE'AKI 'A E VITIO.

KONGA 1: KO HA KI'I TALAVOU 'OKU LOLOTONGA MALOLO.

		'Io	'Ikai
	1. Kuo 'osi pehe ni nai ho'o manava 'i ha taimi 'i ho'o mo'ui?	☐	☐
KAPAU 'OKU 'IO:	Na'e hoko nai 'eni 'i he ta'u 'e taha kuo maliu atu?	☐	☐
KAPAU 'OKU 'IO:	Kuo tu'o taha nai pe tu'o lahi hake 'i he mahina 'ene hoko?	☐	☐

KONGA 2: KO HA ONGO TAMAIKI 'OKU NA LOLOTONGA FAKAMALOHISINO. KO E TOKOTAHA 'I HE SOTE FAKAPOPO'ULI PEA TAHA 'I HE SOTE HINEHINA.

		'Io	'Ikai
	2. Kuo 'i ai nai ha taimi 'i ho'o mo'ui ne hange ai ho'o manava ko e tamasi'i 'oku 'i he sote fakapopo'uli 'I he lolotonga pe toki 'osi ha'o fakamalohisino?	☐	☐
KAPAU 'OKU 'IO:	Na'e hoko nai 'eni 'i he ta'u 'e taha kuo maliu atu?	☐	☐
KAPAU 'OKU 'IO:	Kuo tu'o taha nai pe lahi hake ha'ane hoko 'i he mahina 'e taha?	☐	☐

KONGA 3: KO HA TOKOTAKA 'OKU OFO HAKE MEI HE'ENE MOHE HE PO'ULI.

		'Io	'Ikai
	3. Kuo 'i ai nai ha taimi kuo ke ofo hake ai 'i he pouli hange ko 'eni?	☐	☐
KAPAU 'OKU 'IO:	Na'e hoko nai 'eni 'i he ta'u 'e taha kuo maliu atu?	☐	☐
KAPAU 'OKU 'IO:	Kuo tu'o taha nai pe tu'o lahi hake 'i he mahina 'ene hoko?	☐	☐

KONGA 4: KO HA TOKOTAHA PE 'OKU OFO HAKE MEI HE'ENE MOHE HE PO'ULI.

		'Io	'Ikai
	4. Kuo 'i ai nai ha taimi kuo faka'aaki koe mei ho'o mohe hange ko 'eni?	☐	☐
KAPAU 'OKU 'IO:	Na'e hoko nai 'eni 'i he ta'u 'e taha kuo maliu atu?	☐	☐
KAPAU 'OKU 'IO:	Kuo tu'o taha nai pe lahi hake 'i he mahina 'ene hoko?	☐	☐

KONGA 5: KONGA FAKA'OSI KO HA TOKOTAHA 'OKU LOLOTONGA MALOLO.

		'Io	'Ikai
	5. Kuo 'osi pehe ni nai ho'o manava tu'o taha talu ho'o tupu?	☐	☐
KAPAU 'OKU 'IO:	Na'e hoko nai 'eni 'i he ta'u 'e taha kuo maliu atu?	☐	☐
KAPAU 'OKU 'IO:	Kuo tu'o taha nai pe lahi hake 'i he mahina 'ene hoko?	☐	☐

Appendix 5 English Environmental Questionnaire

1. How much do you weigh?: ☐ kg / stone / pounds
(please circle the measurement you used)

2. How tall are you?: ☐ metres / centimetres / feet and inches
(please circle the measurement you used)

3. In the past 12 months, how often, on average, did you eat or drink the following?:
(Please leave blank if you do not know what a food is)

	Never or occasionally	Once or twice per week	Three or more times a week
Meat (e.g. beef, lamb, chicken, pork)	☐	☐	☐
Seafood (including fish)	☐	☐	☐
Fruit	☐	☐	☐
Vegetables (green and root)	☐	☐	☐
Pulses (peas, beans, lentils)	☐	☐	☐
Cereal (including bread)	☐	☐	☐
Pasta	☐	☐	☐
Rice	☐	☐	☐
Butter	☐	☐	☐
Margarine	☐	☐	☐
Nuts	☐	☐	☐
Potatoes	☐	☐	☐
Milk	☐	☐	☐
Eggs	☐	☐	☐
Fast food/burgers	☐	☐	☐

4. How many times a week do you engage in vigorous physical activity long enough to make you breathe hard?:

Never or occasionally	☐
Once or twice per week	☐
Three or more times a week	☐

5. During a normal week, how many hours a **day (24hours)** do you watch television?:

Less than 1 hour	☐
1 hour but less than 3 hours	☐
3 hours but less than 5 hours	☐
5 hours or more	☐

6. In your house, what fuel is usually used for cooking?:

Electricity	☐
Gas	☐
Open fires	☐
Other – Please specify	☐

7. In your house, what fuel is usually used for heating?:

Electricity	☐
Gas, kerosene, paraffin	☐
Wood, coal, oil	☐
Other – Please specify	☐

8. In the past 12 months, how often, on average, have you taken paracetamol (e.g. Panadol, Pamol)?:

Never ☐

At least once a year ☐

At least once per month ☐

9. How many older brothers and sisters do you have?: ☐ brothers and sisters

10. How many younger brothers and sisters do you have?: ☐ brothers and sisters

11. Were you born in (NZ - See instructions)?:

Yes ☐

No ☐

12. How many years have you lived in (NZ - see instructions)?: ☐ years

13. What level of education has your mother received?: (local wording)

Primary school ☐

Secondary school ☐

College, university or other form of tertiary education ☐

14. How often do trucks pass through the street where you live, on weekdays?:

Never ☐

Seldom ☐

Frequently through the day ☐

Almost the whole day ☐

15. In the past 12 months, have you had a cat in your home?:

Yes ☐

No ☐

16. In the past 12 months, have you had a dog in your home?:

Yes ☐

No ☐

17. Does your mother (or female guardian) smoke cigarettes?:

Yes ☐

No ☐

18. Does your father (or male guardian) smoke cigarettes?:

Yes ☐

No ☐

19. How many people living in your house smoke cigarettes?: ☐ people

Thank you very much for your help with this questionnaire. We appreciate your assistance

Appendix 6 Samoan Translated Environmental Questionnaire

ISAAC III FESILI FAATATAU I LE SIOSIOMAGA

1. O le a lou mamafa? _____ **kilokalama / ma'a / pauna**
(faamolemole li'o mai le fua na faaaogaina)

2. O le a lou umi? _____ **mita / senitimita / futu ma inisi**
(faamolemole li'o mai le fua na faaaogaina)

3. I le 12 masina ua tuana'i, e faafia ona e taumafaina meaai nei?
(faamolemole faaavanoa le mea taumafa e te le silafia lea taumafa)

	Ou te le'i ai ai muamua (Seāseā ona 'ai ai)	Faatasi pe faalua i le vaiaso	Faa tolu pe sili atu i le vaiaso
Aano o manu fasi (povi/mamoe /moa/puaa...)	☐	☐	☐
Meaai mai le Sami (i'a....)	☐	☐	☐
Fualaau aina taumafa mata (fruits)	☐	☐	☐
Fualaau aina fai sua (vegetables: greens and root)	☐	☐	☐
Pi fai meaai	☐	☐	☐
Peas/beans/lentils)	☐	☐	☐
Falaoa/Cereals	☐	☐	☐
Pasta	☐	☐	☐
Araisa	☐	☐	☐
Pata (Butter)	☐	☐	☐
Pata (Margarine)	☐	☐	☐
Nuts (pinati/lopa ma isi)	☐	☐	☐
Pateta	☐	☐	☐
Susu (milk)	☐	☐	☐
Fuamoa (eggs)	☐	☐	☐
Fast Food (burgers/chips...)	☐	☐	☐

4. E faafia i le vaiaso ona e faia ni faamalositino malosi ma le umi e te matua sela ai?

E le faamalositino / Seāseā ona faamalositino ☐

Tasi pe lua i le vaiaso ☐

Tolu pe sili atu i le vaiaso ☐

5. I se vaiaso masani, faamata e fia ni itula o le aso (24 itula), e masani ona e matamata ai i le TV?

Lalo ifo i le tasi le itula ☐

Sili atu i le itula ae lalo ifo o le 3 itula ☐

Sili atu i le 3 itula ae lalo ifo o le 5 itula ☐

5 itula pe sili atu foi ☐

6. O fea o ituaiga o afi nei o lo o e faaaogaina i le gaseseina o meaai i le aiga?

Ogaumu e faaaoga ai le Eletise ☐

Ogaumu e faaaoga ai le kesi ☐

ta'inafi ☐

Nisi ituiga ***(faamolemole tusi mai i lalo)*** ☐

7. O fea o ituaiga ua ta'ua i lalo o lo o e faaaogaina e faamafanafana ai lou maota?

Eletise ☐

Kesi/karasini/paraffin ☐

Fafie/coal/suau'u ☐

Nisi ***(faamolemole tusi mai i lalo)*** ☐

8. I le 12 masina ua tuana'i, e faafia ona e inuina le fuala'au o le Paracetamol (Panadol, Pamol)?

E le'i inuina i le 12 masina ua tuana'i ☐

Tasi pe sili atu i le tausaga ona inuina ☐

Tasi pe sili atu i le masina ona inuina ☐

9. E toafia ni ou uso / tuafafine / tuagane matutua? ☐☐

10. E toafia ni ou uso / tuafafine / tuagane laiti? ☐☐

11. Na e fanau i Niu Sila? ● **Ioe** ☐
Leai

12. E fia ni tuasaga na e nofo ai i Niu Sila? ☐

13. E faafia ona pasi ane loli tetele i ou lumafale i aso aunoa (weekdays)?

E leai ni loli tetele e pasi ane i o'u lumafale ☐

E seāseā ona pasi ane i o'u lumafale ☐

E tele loli tetele e pasi ane i o'u lumafale ☐

E pasi ane loli tetele i taimi uma o le aso ☐

14. I le 12 masina ua tuana'i, sa i ai se tou pusi (cat) na tausi i le fale? **Ioe** ☐ ☐
Leai

15. I le 12 masina ua tuana'i atu, sa i ai se tou ta'ifau (maile) i le fale? **Ioe** ☐ ☐
Leai

16. E ulaula lou tina / poo lou tina fai? **Ioe** ☐ ☐
Leai

17. E toa fia tagata ulaula o lo o tou nonofo faatasi i lou fale? ☐☐ **Tagata ulaula.**

Appendix 7 Tokelau Environmental Questionnaire

ISAAC III FEHILI FAKAHIKOHIKOMAGA

1. E fia to mamafa? ☐ Kilo/Hitone/Pauna
(fakamolemole oi hiko fakalapotopoto te fua e ke fakaaoga)

2. E fia to loa? ☐ Mita/Henitemita/futu/inihi

3. I te 12 mahina kua teka, nae fakafia, i tau fuafua, na kai e koe, pe inu na mea ienei?
[fakamolemole nahe talia kafai e he keiloa na meakai]

	Heai pe Heahea	**Fokotahi pe faka2 ite vaiaho**	**Fakatahi pe hili atu ite vaiaho**
Kakano manu [ft. Povi, mamoe, moa, pua]	☐	☐	☐
Meakai ote tai [fakatahi ma te ika]	☐	☐	☐
Fualakau kaina	☐	☐	☐
Fualakau [lanumeamata/fai/aka]	☐	☐	☐
Pase [pi, pi lapotopoto, lenetilo]	☐	☐	☐
Hiliale [fakatahi ain a falaoa]	☐	☐	☐
Alaiha	☐	☐	☐
Pata	☐	☐	☐
Matalini	☐	☐	☐
Tega [Pinati]	☐	☐	☐
Huhu	☐	☐	☐
Fuamoa	☐	☐	☐
	☐	☐	☐

Meakai vave [puta/burgers]

4. E fakafia ite vaiaho e fai ai ni au gaoioiga tau koleni mo he mataloa ke fita ai tau manava?

- E heai ☐
- Fokotahi pe fakalua ite vaiaho ☐
- Fakatolu pe ova atu ite vaiaho ☐

5. E mata fuafua ki he vaiaho, e fia nei ia itula ote aho (24 itula) e matamata ai koe kite TV?

- E he hilia ite itula e fokotahi ☐
- He itula e fokotahi kae he ova atu ite 3 itula ☐
- Tolu itula kae e he ova atu i he 5 itula ☐
- Lima itula pe hili atu ☐

6. He itukaiga malohiaga a e mahani oi fakaaoga ke kukuka ai te koutou kaiga?

- Eletihe ☐
- Kaha ☐
- Afi tafutafu ☐
- Ie tahi-fakamolemole taku mai ☐

7. He malohiaga vehea e fakaaoga [ke fakavevela ai to fale?]

- Eletihe ☐
- Kaha, kalahini, palatine ☐
- Lakau, koale, lolo ☐
- Ie tahi-fakamolemole oi taku mai ☐

8. Ite 12 mahina kua teka, nae fakafia, i tau fuafua, nae inu ai e koe ni vai/fualakau fiva?

- E heai ☐
- Fakatahi ite tauhaga ☐
- Taki tahi ite mahina ☐

9. E fia ni o tuagane ma ni o uho matutua atu ia te koe?

Tuagane ma na uho ☐

10. E fia ni o tuagane ma ni o uho tamaiti ifo ia te koe?

Tuagane ma na uho ☐

11. Na fanau koe i Niu Hila?

Io ☐ Heai ☐

12. E fia te mataloa na nofo ai koe i Niu Hila?

☐ Tauhaga

13. E fakafia oi paahi ni loli ite auala e nofo ai koe ina aho ote vaiaho?

E heai ☐

Heahea ☐

Feoloolo ite aho ☐

Taimi uma ite aho ☐

14. Ite 12 mahina kua teka, nae i ei he puhi i to fale?

Io ☐ Heai ☐

15. Ite 12 mahina kua teka, nae i ei he maile i to fale?

Io ☐ Heai ☐

16. E ulaula to matua pe ko ho he tino i to fale?

Io ☐ Heai ☐

17. E toka fia ia tino i to fale e ulaula?

☐ Tagata

Appendix 8 Tonga Asthma Self-Management PlanStudy - Baseline Questionnaire

We are interested in how your asthma has been in the last year. I am going to ask you the following questions. If you don't understand the questions please ask me. If there are any questions you don't want to answer, please tell me and I will leave them out.

1. In the last 12 months, have you had a bad attack of asthma?

Yes	No	Don't Know
☐	☐	☐

2. What is a 'bad attack for you? **(IN THEIR OWN WORDS, DO NOT PROMPT)**

_____

_____

_____

_____

_____

_____

_____

_____

3. Do you have a peak flow meter?

no	☐	→	**GO TO QUESTION 7**
yes	☐		
not sure	☐	→	**GO TO QUESTION 7**

(PROBE: IF THEY HAVE A PEAK FLOW METER):

4. In the last 12 Months, did you **EVER** use your peak flow meter to help you with your asthma?

no	☐	→	**GO TO QUESTION 7**
yes	☐		
not sure	☐		

5. In the last 12 months, the last time you asthma was **GETTING 'BAD'**, how often did you use you peak flow meter? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐
less than once a week	☐
more than once a week	☐
almost every day	☐
more than once a day	☐
my asthma has never got bad	☐
not sure/can't remember	☐

6. In the last 12 months, when you asthma was **NOT 'BAD'**, how often did you **USUALLY** use your peak flow meter? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐		
less than once a month	☐		
less than once a week	●		
more than once a week	☐		
almost every day	☐		
my asthma is always bad	☐	→	**GO TO QUESTION 6.1**
not sure/can't remember	☐		

(PROBE: "MY ASTHMA IS ALWAYS BAD")

In the last 12 Months, how often did you **USUALLY** use your peak flow meter? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐
less than once a month	☐
less than once a week	☐
more than once a week	☐
almost every day	☐

more than once a day ☐

not sure/can't remember ☐

7.

7. Do you have an asthma action plan? **(SHOW THE PLAN)**

no ☐ → **GO TO QUESTION 15**

yes ☐

not sure ☐ → **GO TO QUESTION 15**

(PROBE:IF THEY HAVE AN ASTHMA ACTION PLAN):

8. Where do you normally keep your Asthma Action Plan?

1. _____

2. _____

3. _____

9. Do you think the instructions on the Plan are difficult to follow?

Yes	No	Don't Know
☐	☐	☐

10. Do you think the Asthma Action Plan should be bigger?

Yes	No	Don't Know
☐	☐	☐

11. Do you think the Asthma Action Plan should present more detail?

Yes	No	Don't Know
☐	☐	☐

12. In the last 12 months, have you ever used your Asthma Action Plan to help you with your asthma?

no ☐ → **GO TO QUESTION15**

yes ☐

not sure ☐

13.

13. In the last 12 months, the last time your asthma was **GETTING 'BAD'**, how often did you use your Asthma Action Plan? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐	→	**GO TO QUESTION 14**
less than once a week	☐		
more than once a week	☐		
almost every day	☐		
more than once a day	☐		
my asthma has never got bad	☐	→	**GO TO QUESTION 14**
not sure/can't remember	☐	→	**GO TO QUESTION 14**

13.1 Did you find the Asthma Action Plan helpful? **(SHOW ASTHMA ACTION PLAN)**

Yes	No	Don't Know
☐	☐	☐

IF YES, 13.1.1 Which side of the Asthma Action Plan did you find **most** helpful?
(SHOW BOTH SIDES OF THE CREDIT CARD)

peak flow side	☐
symptoms side	☐
both sides	☐
don't know/can't remember	☐

14. In the last 12 months, when you asthma was **NOT 'BAD'**, how often did you usually use your action plan? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐	→	**GO TO QUESTION 15**
less than once a month	☐		
less than once a week	☐		
more than once a week	☐		
almost every day	☐		
my asthma is always bad	☐	→	**GO TO QUESTION 14.1**
not sure/can't remember	☐	→	**GO TO QUESTION 15**

(PROBE: "MY ASTHMA IS ALWAYS BAD")

14.1 In the last 12 months, how often did you **USUALLY** use your peak flow meter? **(TICK THE BEST ANSWER THAT APPLIES)**

almost never	☐	→	**GO TO QUESTION 15**
less than once a month	☐		
less than once a week	☐		
more than once a week	☐		
almost every day	☐		
more than once a day	☐		
not sure/can't remember	☐	→	**GO TO QUESTION 15**

14.2 Which side of the Plan did you **USUALLY** use?
SHOW EACH SIDE OF THE ACTION PLAN

neither	☐
peak flow side	☐
symptoms side	☐
both sides	☐
not sure	☐

15. In the last 12 months, how many times have you seen a doctor (GP or specialist) because of your asthma, other than as an emergency visit to a GP, A&E or hospital admission?

never	☐
1-3 times	☐
4-6 times	☐
more than 6 times	☐
don't know	☐

16. In the last 12 months, how many times have you gone to a doctor as an emergency for your asthma?

never	☐	→	**GO TO QUESTION 17**
1-2 times	☐		
3-4 times	☐		
more than 4 times	☐		

(PROBE: IF THEY HAVE SEEN A GP AS AN EMERGENCY)

For the last 12 months, try to remember the last time you saw a doctor as an emergency for your asthma?

16.1 On this occasion, did you use the "action plan" to help you decide to visit a GP? **(SHOW THE ACTION PLAN)**

Yes	No	Don't Know	No Plan
☐	☐	☐	☐

IF YES, 16.1.1 Which side of the plan did you use to help you make this decision? **(SHOW BOTH SIDES OF the ACTION PLAN**

Peak flow side	☐
Symptoms side	☐
Both sides	☐
Don't know/can't remember	☐

17. In the last 12 months, how many times have you gone to the hospital outpatient department (A&E) as an emergency for your asthma?

never	☐	→ **GO TO QUESTION 18**
1-2 times	☐	
3-4 times	☐	
more than 4 times	☐	

(PROBE: IF THEY HAVE BEEN TO OUTPATIENT IN AN EMERGENCY)
For the last 12 months, try to remember the last time you went to the hospital casualty department (A&E) as an emergency for your asthma?

17.1 On this occasion did you consult a doctor before you went to the hospital casualty department?

Yes	No	Don't Know	No Plan
☐	☐	☐	☐

IF NO 17.1.1 Did you use the "action plan" to help you decide to visit the casualty department?

Yes	No	Don't Know	No Plan
☐	☐	☐	☐

IF YES 17.1.2 Which side of the plan did you use to help you make this decision? **(SHOW BOTH SIDES OF ACTION PLAN**

peak flow side	☐
symptoms side	☐
both sides	☐
don't know/cant' remember	☐

18. In the last 12 months, how many times have you been **admitted** to hospital because of your asthma?

never	☐
1-2 times	☐
3-4 times	☐
more than 4 times	☐

19. Please list **ALL** your asthma medications.

A) **Inhalers (pumps, puffers, sprays)**

Name	Usual Number of puffs	Times per day
1.	.....	.....
2.	.....	.....
3.	.....	.....
4.	.....	.....

KEY FOR INHALERS IF DON'T REMEMBER NAME:

1. **RECORD NAME AS STATED**
2. **RECORD COLOUR: (BLUE, LIGHT BROWN, DARK BROWN, OR RED)**

B) **Tablets (pills)**

Name	Dose	Number of Times per day
1.	.....	.....
2.	.....	.....

C) **Other**

Name	Dose	Number of Times per day
1.	.....	.....
2.	.....	.....

20. In the last 12 months, has your asthma woken you?

most nights	☐
some nights	☐
occasionally	☐
never	☐

21. In the last 12 months, have you at any time, used the action plan to help you decide to increase the amount you take of your preventative (BROWN or RED INHALER) inhaler?

No	☐	→	**GO TO QUESTION 23**
yes	☐		
Don't know	☐	→	**GO TO QUESTION 23**
No Plan	☐	→	**GO TO QUESTION 23**

(PROBE:IF THEY HAVE USED THE ACTION PLAN TO HELP THEM DECIDE TO INCREASE THE AMOUNT OF PREVENTATIVE:)

22. Which side of the plan did you use to help you make this decision?
(SHOW BOTH SIDES OF THE ACTION PLAN

peak flow side	☐
symptoms side	☐
both sides	☐
don't know	☐

23. Do you have prednisone tablets (steroids) to use for your asthma in an emergency?

Yes	No	Don't Know
☐	☐	☐

24. In the last 12 months, have you taken a course of prednisone tablets (steroids) for your asthma?

No	☐	→	**GO TO QUESTION 29**
Yes	☐		
not sure	☐	→	**GO TO QUESTION 29**

PROBE: IF THEY HAVE TAKEN A COURSE OF PREDNISONE TABLETS):

25. In the last 12 months, how many courses of prednisone tables have you taken? (Write down **ACTUAL** number as well)

26. Who made the decision to start your last course of prednisone?

You alone	☐	→	**GO TO QUESTION 27**
You and your GP	☐	→	**GO TO QUESTION 28**
Your GP	☐	→	**GO TO QUESTION 28**
Someone else	☐ (specify)		**GO TO QUESTION 29**
	1 ☐		
	2-3 ☐		
	>3 ☐		
	Don't know ☐		
Don't know	☐	→	**GO TO QUESTION 29**

(PROBE: YOU ALONE)

27. Did you use the 'Action Plan' to help you decide to start your last course of prednisone? **(SHOW CREDIT CARD)**

Yes	No	No Plan	Don't Know
☐	☐	☐	☐

→ **GO TO QUESTION 29**

27.1 **IF YES**, Which side of the plan did you use to help you make this decision **(SHOW BOTH SIDES OF CREDIT CARD)**

peak flow side	☐
symptoms side	☐
both sides	☐
don't know	☐

(PROBE: YOU AND YOUR DOCTOR or YOUR DOCTOR TO Question 26

28. Was the decision to start your last course of prednisone made with your GP

By telephone	☐
or	
In Person	☐

29. In the last 12 months, how many days have you been 'out of action' (eg off work or school or stopped you from doing something you otherwise would have done) because of your asthma?

never	☐
1-6 days	☐
1-2 weeks	☐
2-4 weeks	☒
more than 4 weeks	☐
don't know	☐

30. In the last 12 months, have you seen any of the following people about your asthma? **(TICK THE ANSWER(S) THAT APPLY)**

asthma society volunteer	☒
community volunteer	☐
asthma educator	☒
practice nurse	☐
other, please specify	----------

31. Apart from your asthma, would you say the last year was

more stressful than other years	☐
less stressful than other years	☐
same as other years	☐

32. Is there anything else you would like to add?

_____

_____

_____

_____

_____

_____

PERSONAL DETAILS

33. Name: _____

34. Address:
    Street: _____
    Town: _____
    Region: _____

35. Date of Birth

36. Age: _____

37. Sex: _____

38. Telephone: (Day) _____
(Night) _____

39. Usual Doctor's (GP) name _____

40 Usual Specialists Name

YOU MAY CHOOSE NOT TO ANSWER THE FOLLOWING QUESTIONS ABOUT YOUR EMPLOYMENT AND INCOME IF YOU DO NOT WISH TO

41. How have you been spending your time in the last seven days?

☐ Employed
- ☐ Full time (more than 30 hours)
- ☐ Part time (less than 30 hours)

IF YES 41.1 What is your occupation?

_____

☐ Unemployed
- ☐ Available for work (but not actively seeking)
- ☐ Actively seeking work

☐ Not in labour force – *What is your main activity?*

- ☐ Student
- ☐ Home, looking after children
- ☐ Retired
- ☐ Time worker (meat worker, fruit worker)
- ☐ Benefit (Invalid, Disability, etc)

42. Finally, if you take into account yourself, as well as other members of your family who live with you, what has been your household's total income for the last 12 months, before tax and deductions? ***(SHOW SHOWCARD)***

- ☐ Less than $17,500
- ☐ Between $17,500 and $32,500
- ☐ Greater than $32,500
- ☐ decline

Thank you

Appendix 9 Tonga Asthma Self Management Survey Questionnaire

Koe Fokoutua koe Hela
Faka'eke'eke kiho'o Tokangaekina moe Faito'o 'oe Hela

'Oku 'oatu e kole he ngaahi fehu'i ko'eni koe fie'ilo kihe tu'unga ho fokoutua hela he ta'u kuo maliu atu (mahina 'e 12). 'Okapau 'oku 'ikai mahino ha fehu'i pea ke kataki 'o 'eke mai pea kapau 'oku 'i ai ha fehu'i 'oku 'ikai te ke loto ke tali kataki 'o fakaha mai pea he'ikai leva ke fakakau e fehu'i ia koia.

1. 'I he mahina 'e 12 kuo'osi, ne 'iai ha'o puke he hela ne a'u ki ha tu'unga ne **fu'u kovi 'aupito** ?

   'Io ☐
   'Ikai ☐
   'Ikai ke 'ilo ☐

2. Ko e fe taimi ho'o puke he hela'oku ke pehe leva kuo a'u ai kihe tu'unga **fu'u kovi 'aupito**? (TUKU KE NAU FAKAMATALA MAI)

   _____

   _____

   _____

   _____

   _____

   _____

3. 'Oku 'i ai ha'o mita ke fua e tu'unga ho'o hela (peak flow meter)?

   'Ikai ☐ ⟶ hoko ki he fehu'i 7
   'Io ☐
   'Ikai ke fakapapau'i ☐ ⟶ hoko ki he fehu'i 7

   (Fakapapau'i 'okapau 'oku 'i ai ha'ane mita fua hela. (peak flow meter)

4. 'I he mahina 'e 12 kuo'osi, kuo ke ngaue'aki **tu'otaha** ho'o mita fua hela (peak flow meter) ke tokoni kiate koe 'i ho'o hela`?

   ☐

'Io ⟶ hoko ki he fehu'i 7
'Ikai ☐
'ikai ke fakapapau'i ☐

5. 'I he mahina ko'eni 12 kuo maliu, koe taimi koia ne a'u ai ha'o fo'i puke he hela kiha **tu'unga kovi** 'aupito ne tu'o fiha nai ho'o faka'aonga'I ho'o mita fua hela (**tiki 'a e tali tonu taha)**

Fu'u tataaitaha 'aupito ☐
Si'i hifo he tu'o taha he uike ☐
Lahi hake he tu'o 2 he uike ☐
Meimei 'aho kotoa pe ☐
Tu'o 2 pe lahi hake he 'aho ☐
Te'eki a'u ki ha tu'unga kovi 'aupito ☐
'Ikai keu fakapapau'i / ikai manatu'i ☐

6. 'I he mahina 'e 12 kuo'osi, pea 'ihe taimi'oku 'ikai a'u ai ho hela kiha **tu'unga kovi 'aupito** ne meimei tu'o fiha ho'o faka'aonga'i ai ho'o mita fua hela? **(Tiki 'a e tali tonu taha)**

Fu'u tataaitaha 'aupito ☐
Si'i hifo he tu'o taha he mahina ☐
Si'i hifo he tu'o taha he uike ☐
Lahi hake he tu'o taha he uike ☐
Meimei 'aho kotoa pe ☐
'Oku **tu'unga kovi** ma'u pe 'eku hela (Hoko kihe Fehu'i 6.1 ☐
'Ikai ke fakapapau'i / 'ikai manatu'i ☐

(Hoko atu: 'Okapau 'oku tu'unga kovi ma'u pe 'eku hela")

6.1 'I he mahina 'e 12 kuo'osi, na'e meimei tu'o fiha ho'o toutou ngaue'aki 'a ho'o me'afua hela. (peak flow meter)? **(tiki 'a e tali tonu taha)**

Fu'u tataaitaha ☐
Si'i hifo he tu'o taha he mahina ☐
Si'i hifo he tu'o taha he uike ☐
Laka hake he tu'o taha he uike ☐
Meimei 'aho kotoa pe ☐
Laka he tu'o taha he 'aho ☐
'Ikai ke fakapapau'i / 'ikai manatu'i ☐

7. 'Oku 'i ai ha'o palani tohi ki he tokangaeikina moe me'a ke fai kiho fokoutua pe koho puke he hela? (**Fakaha ho'o palani**)

'Ikai ☐ ⟶ hoko ki he fehu'i 15
'Io ☐
'Ikai ke fakapapau'i ☐ ⟶ hoko ki he fehu'i 15

(Hoko atu 'o kapau 'oku 'i ai ha palani ki he tokanga'i e hela)

8. 'Ko fe 'a e feitu'u 'oku ke tauhi ma'u mo lahi tuku ai ho'o **Palani**?
   1. _____
   2. _____
   3. _____

9. 'Oku ke pehe'oku faingata'a ho'o mahino'i pe muimui kihe fakahinohino 'o e palani?

   'Io ☐
   'Ikai ☐
   'Ikai keu 'ilo kihe tali kiai ☐

10. 'Oku ke pehe fu'u 'asi si'isi'i pea 'oku tonu ke toe faka'atalahi ange e palani ?

    'Io ☐
    'Ikai ☐
    'Ikai teu 'ilo ☐

11. 'Oku ke fakakaukau 'oku tonu ke toe fakaikiikiange e ngaahi fakahinohino 'a e palani ki he to'onga ho hela?

    'Io ☐
    'Ikai ☐
    'Ikai te u 'ilo. ☐

12. 'I he mahina 'e 12 kuo'osi, na'a ke 'osi ngaue'aki tu'o taha nai ho palani ke tokoni kiate koe lolotonga ho'o puke ko ia he hela?

    'Ikai ☐ ⟶ hoko ki he fehu'i 15
    'Io ☐
    'Ikai ke fakapapau'i ☐

13.'I he mahina 'e 12 kuo'osi, pea koe taimi koia ne a'u ai ho hela kiha tu'unga **kovi 'aupito** ne tu'o fiha ho'o faka'aonga'i ai ho'o palani?? **(Tiki 'a e tali 'e taha)**

Te'eki ai ☐ → fehu'i 14
Si'i hifo he tu'o taha he uike ☐
Lahi hake he tu'o taha 'i he uike ☐
Meimei 'aho kotoa pe ☐
Lahi hake 'i he 'aho 'e 1 ☐
Ne te'eki ke **kovi 'aupito** hoku hela ☐ → fehu'i 14
'Ikai fakapapau'i / 'ikai manatu'i ☐ → fehu'i 14

13.1 'I ho'o vakai, na'e tokoni mo 'aonga e **Palani**?
(Faka'ali'ali ange 'a e Palani)

'Io ☐
'Ikai ☐
'Ikai ke 'ilo ☐

Kapau Na'e Tali 'IO, 13.1.1 Ko fe konga 'oe palani neke pehe ne fu'u 'aonga ange kiate koe?

Konga Lau Mita ☐
Konga fakamatala kihe manava ☐
Ongo konga loua ☐
'Ikai 'ilo / 'ikai manatu'i ☐

14. 'I he mahina 'e 12 kuo'osi, pea koe ngaahi taimi na'e 'ikai a'u ai ho hela kiha tu'unga kovi 'aupito – Ne meimei tu'o fiha ho'o faka'aonga'i ai ho'o **Palani (Tiki 'a e tali tonu taha)**

Fu'u Tataaitaha ☐
Si'i hifo 'i he tu'o taha he mahina ☐
Si'i hifo he tu'o taha he uike ☐
Laka hake he tu'o taha he uike ☐
Meimei faka'aonga'i he 'aho kotoa ☐
'Oku tu'unga kovi ma'u pe hoku hela 'oku. ☐
'Ikai fakapapau'i / 'ikai manatu'i ☐

(HOKO ATU : Kihe ni'ihi ne nau tali "Oku tu'unga kovi ma'u pe hoku hela 'oku")

14.1 'I he mahina 'e 12 kuo'osi, na'e fakafuofua ne tu'o fiha ho'o ngaue'aki 'a ho'o mita (peak flow meter)? **(Tiki 'a e tali tonu taha)**

Tataaitaha .... ☐ → Hoko kihe Fehu'i 15
Si'i hifo he tu'o taha he mahina ☐

Si'i hifo he tu'o taha he uike ☐
Lahi hake he tu'o taha he uike ☐
Meimei 'aho kotoa pe ☐
Lahi hake 'i he 'aho 'e 1 ☐
'Ikai fakapapau'i / 'ikai manatu'i ☐ → Fehu'i 15

14.2 Ko fe konga 'i he Palani, na'a ke meimei fa'a ngaue'aki? (Fakahinohino ange e ongo konga kehekehe 'e 2)

Lau Mita ☐
Lau Manava ☐
Ongo konga loua ☐
'Ikai ke fakapapau'i ☐

15. 'I he mahina 'e 12 kuo'osi, kuo tu'o fiha nai ho'o sio ki ha toketa koe'uhi ko ho'o puke he hela, tukukehe hono 'omai fakavavevave mai koe ki he Toketa, Fale Talatala pe koe fakatokoto koe 'iha Falemahaki?

Te'eki ai ☐
Tu'o 1 – 3 ☐
Tu'o 4 – 6 ☐
Lahi hake 'i he tu'o 6 ☐
'Ikai keu 'ilo ☐

16. 'I he mahina 'e 12 kuo'osi, na'e tu'o fiha ha'o talatala kiha Toketa koe puke fakatu'upake mo fakavavevave ho'o hela tukukehe 'ae 'alu koe kiliniki hela angamaheni pe koe fakafo'ou ho'o ngaahi faito'o hela?

Te'eki ai ☐ -----→ Fehu'i 17
Tu'o 1 – 2 ☐
Tu'o 3 – 4 ☐
Lahi hake he tu'o 4 ☐

(HOKO ATU: KAPAU NA'E 'OMAI FAKAVAVEVAVE KI HE TOKETA koe'uhi ko'ene hela)

'I he mahina 'e 12 kuo'osi, fakamanatu'iange ange ho'o 'alu ko'eni kihe talatala fakavavevave mo fakatu'upake kihe hela.

16.1 'I he taimi ho'o 'alu koia, na'a ke ngaue'aki ho'o Palani ke iku ai 'oke fakakaukau keke 'alu ai 'o sio kihe Toketa ?(**Fakaha e palani)**

‘Io	☐
‘Ikai	☐
‘Ikai ke ‘ilo	☐
‘Ikai ha palani.	☐

Kapau Na’ake tali “IO: 16.1.1 Ko fe konga ‘i he palani na’e makatu’unga ai ho’o fakakaukau keke ‘alu ‘o sio kihe Toketa?
(Fakahaa’i ‘a e ongo konga ko ‘eni ‘i he palani)

Konga Lau Mita	☐
Konga Fakamatala Manava	☐
Loua e ongo konga	☐
‘ikai ‘ilo / ‘ikai manatu’i	☐

17.‘I he mahina ‘e 12 kuo’osi, na’e tu’o fiha hono fa’a ‘omai fakavavevave koe ki Falemahaki ki he fale talatala ‘i ho’o puke ko ia ‘i he hela?

Te’eki ai	☐
Tu’o 1 – 2	☐
Tu’o 3 – 4	☐
Lahi hake ‘i he tu’o 4	☐

(HOKO ATU KAPAU NA’E ‘OMAI FAKAVAVEVAVE KOE KI HE FALE TALATALA)

‘I he mahina ‘e 12 kuo’osi, fakamanatu’i ange e taimi na’e ‘omai fakamuimui ai koe ki he falemahaki koe’uhi ko ho’o hela?

17.1 ‘I he taimi ko’eni, na’ake talatala ki ha toketa kimu’a pea toki ‘alu ki falemahaki ki he fale talatala?

‘Io	☐
‘Ikai	☐
‘Ikai ke ‘ilo	☐
‘Ikai ha palani	☐

Kapau na’ake tali ‘ikai ‘i ‘olunga 17.1.1 Na’a ke ngaue’aki ho’o **Palani** ke tokoni kiate koe ‘i ho’o fakakaukau koeni keke ‘alu ‘o sio ki he toketa ‘i he fale talatala?

‘Io	☐
‘Ikai	☐

‘Ikai ke ‘ilo ☐
‘Ikai ha palani ☐

Kapau na’ake tali ‘IO 17.1.2 Ko fe konga ‘i he palani na’a ke ngaue’aki ke tokoni kiate koe? **(Fakaha e ongo konga ‘o e palani)**

Konga lau mita ☐
Konga kihe Manava ☐
Ongo konga loua ☐
‘Ikai ‘ilo / ‘ikai manatu’i ☐

18. ‘I he mahina ‘e 12 kuo’osi, na’e tu’o fiha ho’o tokoto‘i falemahaki koe’uhi ko ho’o puke he hela?

Te’eki ai ☐
Tu’o 1 – 2 ☐
Tu’o 3 – 4 ☐
Lahi hake ‘i he tu’o 4 ☐

19. Kataki ‘o hiki mai ‘ae ngaahi faito’o ‘oku ke ngaue’aki ki ho’o hela.

A) PAMU HELA (pumps, puffers, sprays)

Hingoa ‘oe Pamu	**Koe fo’i lomi ‘e fiha**	**Tu’o Fiha‘i he ‘aho**
1.....	.....	.....
2.....	.....	.....
3.....	.....	.....
4.....	.....	.....

FAKAHINOHINO KI HE INHALER ‘O KAPAU ‘OKU ‘IKAI MANATU’I HONO HINGOA:

1. **HIKI ‘AE HINGOA ‘OKU TOHI**
2. **HIKI ‘A HONO LANU: (LANU PULU, KOKO MAAMA, KOKO FAKAPOPO’ULI, PE KULOKULA)**

E) Fo’i ‘akau.

Hingoa	Founga Folo	Tu'o Fiha he 'aho
1.....	.....	.....
2.....	.....	.....

F) Ngaahi Faito'o kehe

Hingoa	Founga Faito'o	Tu'o fiha he 'aho
1.....	.....	.....
2.....	.....	.....

20. 'I he mahina 'e 12 kuo'osi, 'oku ke fa'a ofo pe faka'aaki ho'o mohe he po'uli koe'uhi ko ho'o puke he hela?

Meimei he po kotoa ☐
Ngaahi po pe 'e ni'ihi ☐
Tataitaha ☐
Te'eki ai. ☐

21. 'I he mahina 'e 12 kuo'osi, na'e 'i ai ha taimi kuo ke ngaue'aki ai 'a e Palani ke tokoni kiate ki hono hiki e tousi (dose) ho'o faito'o ta'ofi (preventative)? (pamu lanu koko pe pamu kulokula)

'Ikai ☐ → 'alu ki he fehu'i 23
'Io ☐
'Ikai ke 'ilo ☐ → 'alu ki he fehu'i 23
'Ikai palani ☐ → 'alu ki he fehu'i 23

(HOKO ATU 'O KAPAU NA'E TALI 'IO KI HONO NGAUE'AKI 'A E PALANI KE TOKONI KI HONO HIKI E DOSE 'OE FAITO'O MALU'I (KOKO MO LANU KULOKULA)

22. Ko fe 'a e konga 'i he Palani na'ake faka'aonga'i ke tokonia koe kihono fai e liliu ko'eni?

Konga lau Mita ☐
Konga fakamatala Manava ☐

Fakatou'osi e ongo konga ☐
'Ikai ke 'ilo ☐

23. 'Oku 'i ai ha'o fo'i 'akau predisone (steroids) 'oku ke ngaue'aki ki ho'o hela 'oka ke puke lahi fakafokifa'o ala a'u kiha tu'unga fakatu'utamaki?

'Io ☐
'Ikai ☐
'Ikai ke 'ilo ☐

24. 'I he mahina 'e 12 kuo'osi, kuo ke folo ai (ha course) fo'i'akau predisone (steroids) ke faito'o ho hela?

'Ikai (Alu kihe Fehu'I 29) ☐
'Io ☐
'Ikai ke fakapapau'I ('Alu kihe Fehu'i 29 ☐

(HOKO ATU 'O KAPAU KUO NA'A NAU FOLO PREDNISON)

25. 'I he mahina 'e 12 kuo'osi, na'e tu'o fiha ho'o folo fo'i'akau prednisone. (Tohi mai 'a e fika totonu)

1 ☐
2 – 3 ☐
Lahi hake 'i he tu'o 3 ☐
'Ikai ke 'ilo ☐

26. Ko hai na'a ne fekau'i koe ke kamata ho'o folo e prednisone?

Ko au pe ☐ → hoko atu fehu'i 27
Koau moe Toketa ☐ → hoko atu fehu'i 28
Koe Toketa ☐ → hoko atu fehu'i 28
Ko ha tokotaha kehe ☐ → hoko atu fehu'i 29
'Ikai ke 'ilo ☐ → hoko atu fehu'i 29

(HOKO ATU 'O KAPAU NA'AKE TALI KOAU PE)

27. Na'a ke ngaue'aki 'a ho'o Palani 'i ho'o fakakaukau koia keke folo e prednisone ho'o course fakamuimui taha ?

'Io ☐
'Ikai ☐ ⟶ hoko ki he fehu'i 29
'Ikai ha palani ☐ ⟶ hoko ki he fehu'i 29
'Ikai ke 'ilo ☐

27.1 **Kapau 'oku** tali **'io**, ko fe 'a e konga 'i he palani na'ake ngaue'aki ke makatu'unga ai ho'o folo e prednisone fakamuimui taha ko'eni? (Fakaha e ongo konga e **Palani**)

Konga Lau Mita ☐
Konga Lau Manava ☐
Fakatou'osi pe ☐
'Ikai ke 'ilo ☐

(HOKO ATU 'O KAPAU KO KOE MO HO'O TOKETA PE KO HO'O TOKETA mei he fehu'i 26)

28. Koe fakakaukau ko'eni 'o kau ai 'ae Toketa pea iku 'o kamata ho'o folo fakamuimui taha e predisone na'e fai ia he fetu'utaki:-

'I he telefoni ☐
Femataaki ☐

29. 'I he mahina 'e 12 kuo'osi, ko e 'aho 'e fiha 'oku 'ikai te ke lava ai 'o fai ho fatongia maheni koe'uhi ko ha'o puke 'i he hela? (hange ko e li'aki ngaue pe ako, pe ko ha ngaue pe 'oku ke fa'a fai)

Te'eki ai ☐
'Aho 'e 1 – 6 ☐
Uike 'e 1 – 2 ☐
Uike 'e 2 – 4 ☐
Lahi hake 'i he uike 'e 4 ☐
'Ikai ke 'ilo ☐

30. 'I he mahina 'e 12 kuo'osi, kuo ke sio nai ki ha taha 'i he kakai ko 'eni 'o fekau'aki mo ho'o puke ko ia 'i he hela?

Neesi ☐
Tokotaha fale'i makehe kihe mo'ui ☐
Taha kehe, kataki 'o fakaha 'a e tokotaha ko ia _____

31. Tukukehe e anga ho'o hela 'oku ke pehe koe ta'u 'e taha kuo tau situ'a mei ai na'e:

Fu'u faingata'a ange he ngaahi ta'u kehe ☐
Ikai faingata'a ange he ngaahi ta'u kehe ☐
Tatau pe mo e ngaahi ta'u koe. ☐

32. 'Oku toe 'i ai ha me'a te ke toe fie fakakau mai?

_____

_____

_____

_____

33. Hingoa : _____
Kolo :.....
Vahefonua :.....

34. 'Aho fa'ele'i : .....

35. Ta'u Motu'a :.....

36. Tangata pe fefine :

37. Telefoni : ('Ngaue/Aho) _____
(Po'uli) _____

38. Hingoa e toketa 'oku ke angamaheni hono ngaue'aki

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39. Hingoa e Toketa Mataotao 'oku ke fa'a ngaue 'aki

Fa'iteliha pe teke tali e ngaahi fehu'i ko'eni fekau'aki mo ho'o ngaue moe ma'u'anga mo'ui.

40. Koe ha ha'o tefito'i ngaue na'e fai he 'aho 'e 7 kuo tau situ'a mei ai?

☐ Ma'u ngaue

☐ Taimi kakato(lahi hake he houa 'e 30)
☐ Fakataimi('ikai 'ova he houa 'e 30)
'O kapau 'oku 'io, ko e ha ho'o ngaue?
.....

☐ 'Ikai ke ngaue

☐ Faingamalie pe ke ngaue(ka 'oku 'ikai ke lolotonga kumi ha ngaue)
☐ Mafaifai he kumi ngaue.

☐ 'Ikai keu kau he kau ngaue – ka ko 'eku me'a lahi 'oku fai

☐ Kei ako
☐ Tauhi 'api, tauhi fanau
☐ Malolo mei he ngaue (pension)
☐ Vahe pe mei he pule'anga('ikai ke lava 'o (mahamahaki e sino /fai ha ngaue

Malo 'Aupito