ASTHMA AND WEATHER: RELATIONSHIP OF WEATHER TO ASTHMA ATTACKS IN WELLINGTON

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ABSTRACT

A number of well marked seasonal peaks of asthma attacks are found in a one year study of 30 patients (Beasley et al., 1988) in Wellington. The seasonal impact of various meteorological indices and their causal relationships with asthma are investigated.

It is found that damp, light wind conditions in winter are significantly related to the frequency of asthma attacks. This is consistent with such attacks being caused by damp air spora and other allergens present in confined environments such as houses. Overland trajectories are also significantly correlated with asthma attacks. In autumn this may be attributed to damp air spora produced in rural areas to the north and northeast, and in spring to airborne pollens. No clear relationships were found linking cold changes to asthma.

INTRODUCTION

Asthma is a condition which causes considerable concern in New Zealand. For example, an Auckland study (Mitchell, 1984) indicated that hospital admission rates for asthma had increased greatly since the mid 1960's, and a recent national (NZ) asthma mortality study (Sears et al., 1985) showed a mortality rate three times that of the United Kingdom.

In this study, possible relationships are investigated between attacks suffered by asthma patients undergoing treatment at the Wellington Clinical School for the 11 month period 12/1/84 to 17/12/84, and the weather over that period.

The American Thoracic Society has defined asthma as “a ‘disease’ characterised by an increased responsiveness of the trachea and bronchi to various stimuli, and manifested by a widespread narrowing of the airways, that changes in severity either spontaneously or as a result of therapy”. Asthma can also be described as an inflammatory disorder. Narrowing of the airways includes bronchospasm, mucous production and mucosal oedema.

Various theories have been put forward to explain asthma (Tromp, 1980). The allergen theory attributes complaints to allergic reactions; the ‘cold chill’ theory is said to be due to a deficient hypothalamic thermoregulatory mechanism (deficiency in rewarming capability); the infectious theory assumes early bronchial infections of a child; the endocrinological theory attributes the complaints to endocrinological disturbances (partly true in children during puberty and women around the age of 50); and the psycho-somatic theory explains all complaints in terms of psycho-somatic disturbances (once a subject becomes an asthmatic, psychological factors may become important due to continuous respiratory problems). Clearly some of these causes will be related to the weather.

In this paper the weather patterns affecting Wellington are briefly described. Some of the factors likely to cause asthma attacks, and weather conditions under which such factors are likely to occur, are identified. The asthma and weather data are then examined and conclusions drawn about likely relationships in Wellington.
NEW ZEALAND AND WELLINGTON'S WEATHER AND CLIMATE

New Zealand lies in the mid-latitude zone of westerly winds, in the path of an irregular succession of anticyclones which migrate eastwards every week or so (N.Z. Met. Service, 1986). The centres of these anticyclones generally track across the North Island with more northerly paths being followed in spring and summer, and southerly paths in autumn and winter. Anticyclones are areas of descending air and settled weather, with little or no rain, which may bring clear skies, or low cloud and fog.

Between the anticyclones are troughs of low pressure. Within these troughs there are often cold fronts, orientated north-west to south-east, which produce one of the commonest type of weather sequence over the country: as the front approaches from the west, north-westerly winds become stronger and cloud increases, followed by a period of rain for several hours as the front passes over, and then a change to cold showery southerlies.

The frequency of the above systems shows little variation with season except for an increase in anticyclonic activity in autumn, allied to a corresponding decrease in the frequency of troughs. Another feature of autumn is the occasional appearance of decaying tropical cyclones in the area to the north of the North Island, which can cause very moist north or northeast airstreams to flow over the country, followed by a southerly outbreak.

Wellington's proximity to Cook Strait (see Fig. 1) leads to a high frequency of strong winds channelled by the topography to north/south direction. Westerly airstreams are deviated to the northwest, and easterlies are normally deflected to the south. In very unstable situations, these airstreams are less affected by orography.

For the year of the study, 1984, Wellington had a mean temperature of 13.1 °C (0.6 degrees warmer than the average from 1928 to 1980), 1054 mm of rain (20% less than the average) and gales on 19 days (15% fewer days than average).

FACTORS ASSOCIATED WITH ASTHMA ATTACKS

Cold Chill Effect

Tromp (1980) found a highly significant statistical relationship between asthma frequency and atmospheric cooling. Another more recent study in Japan (Suzuki et al., 1988), showed that low temperature and decrease in temperature was significantly related with the asthmatic symptom. However it was noted that further studies were necessary to know whether 'the state of the atmosphere and contents of the air collaborate on the airway to evoke the asthmatic condition'.

This present study investigates asthma data for evidence of this cooling effect. As the exact time of the asthma attack was not available, a relationship between daily asthma frequencies and a change from the warmer northwesterly airstreams to the cold southerly wind was examined.

The data are also examined for seasonal variations, as pollen releases occurring in spring with westerly winds may have a confounding influence.

Allergen theory

The allergic reactions of asthmatics have been related to seasonal pollen peaks (Tonkelaar, 1986), to seasonal pattern of airborne damp air fungal spores (Hasnain et al., 1985; Packe et al., 1985), to the dust-mite, animal proteins and fungal spores that occur in confined environments, in addition to tobacco smoke and other aero-irritants (Mathison et al., 1982).

Damp air fungal spores (open environment)

Studies show that pollens are only weakly
Asthma and Weather

represented in autumn, but other allergy-producing micro-organisms, especially fungal spores from the basidiospore group (damp air spore component), are especially favoured (Hasnain et al., 1985; Pennycook, 1980).

Factors contributing to higher damp air spore concentrations will be: high night-time humidity (more likely in Autumn with lengthening nights and a seasonal lack of wind); rising air motion at ground level; and winds blowing overland towards the observer. Rising air motions occur with day-time convection on sunny days, and are especially strong in airstreams preceding active fronts or during thunderstorms when the atmosphere is 'unstable' (defined in Data and Methods).

According to Hasnain et al., (1985) urban areas with restricted vegetation provide less opportunity for fungal growth than forest or farmlands. Hasnain also documented a close association between the basidiospore and hospital admissions for acute asthma. In the case of Wellington, the north to east sector has the largest overland and rural trajectory and thus airstreams from those directions would be expected to contain higher concentrations of spores.

If allergens are present when the wind is blowing from the north to east sector, and if the asthma is related to the contents of the airstream, then a wind change to a shorter overland trajectory (westerlies or southerlies) should decrease spore concentrations and thus the number of asthma attacks. To avoid the possible confounding influence of the 'cold chill' effect associated with the change to the south, only the change to the westerly flow was investigated.

House mite and damp air spores in confined environments

The Wellington study on aero-allergens in the homes of asthmatics (Sheridan et al., 1985) indicated a range of fungi known to be significant in asthma. These showed seasonal variations, with the number of colonies of two of the most frequent, basidiomycetes and cladosporium, showing a decrease in the months July, August and September.

The mite of the genus ‘dermatophagoides’, one of the most significant causes of asthma, occurs in house dust and is temperature and humidity dependent (Mathison et al., 1982; Korsgarrd, 1982). Optimal growth occurs at 25 degrees C and 80% relative humidity, with live mite populations diminishing rapidly for humidities below 45%.

Fungal spores, the house mite, and other contaminants known to cause asthma, such as formaldehyde in treated plywood or particle board and glues (Matthews, 1985; Yodaiken, 1981; Robertson et al., 1986), have been identified in the indoor environment. Their impact would be exacerbated in badly ventilated, damp buildings, a set of conditions most likely to occur with cold, wet periods or low winds and shorter sunlight hours, in April through to July (late autumn and winter). New Zealand houses may be especially susceptible to the influence of prolonged damp periods, due to the predominance of wood, which will absorb moisture when badly protected.

In addition, there may be a tendency in the early winter period to keep windows shut to conserve heat in inclement weather. A behavioural response to cold changes of restricting air movement and closing windows (following a retreat indoors to a confined environment), will result in a higher humidity air mass and higher concentrations of pollutants and allergens. The relative humidity will be higher in unheated rooms, typically bedrooms, with condensation on cooler surfaces of humid air from warmer parts of the house. Localised warmth in beds (from body heat), in combination with this dampness, may then produce the ideal environment for the house mite.

To ensure that there is no compounding factor of damp air spores originating from the external environment, the contribution of moist long overland trajectory northerly airstreams was also investigated. In spring, high wind levels, increasing insolation and warming temperatures will result in a decrease in dampness in the house, and asthma should then decrease.

Cold changes that arrive after midnight when potential sufferers are probably in bed (and most likely to be subject to allergens such as produced by the house mite), may result in the behavioural response of shutting any windows that remain open. This would lead to higher concentrations of allergenic gases or spores with a corresponding increase in the rate of asthma attacks.

Pollen, dry air spora

Pollen releases occur in spring and continue into summer, when other dry air spora releases become important. The triggering mechanism is some initial dampness, rising
temperatures, and the absence of rain during the critical period of release. Each plant has its own favoured period of release of pollen. Pollen grains on release are entrained by wind gusts and by small turbulent wind eddies. Peaks in concentration may occur during the day or at night when a temperature inversion occurs in the atmosphere trapping spores in a relatively shallow layer of the atmosphere (Tonkelaar, 1986). If spore releases are occurring upstream, large local concentrations may then occur. Rain clears the atmosphere of contaminants and suppresses pollen production, so some allergic symptoms should be alleviated during and immediately after rain. However, note that considerable amounts of damp air spores may then be produced, resulting in problems for a different set of subjects.

Wellington suburban gardens are full of flowering species, and the unoccupied hills to the north, west and east, are covered in gorse, pine trees and native bush. A study in Wellington (Licitis, 1952) indicated that marked pollen peaks occurred in spring, in the period August through to October. If this relationship holds, we would expect significantly higher level of pollen and high asthma levels in spring during fine weather with winds arriving from the west through north to east sector. Southerlies, representing the sector which has the smallest suburban trajectory, should contain the least amount of pollen spores given other ideal conditions. The predominant winds of spring are northwesterlies and these are normally dry (apart from brief periods of showers), and turbulent.

**DATA AND METHODS**

This study uses asthma data on 30 patients collected by the Wellington Clinical School. Patients came from a range of occupations and ages. All resided in the Wellington region, except for one who commuted daily from the Wairarapa. The group were asked to record, on forms, when asthma attacks began and finished in the period from 17th January to the 17th December 1984 (336 days).

The asthma data were categorised in two ways:

a) Asthma Onsets. The numbers of patients suffering an onset of an attack on any day.

b) Asthma Occurrence. The number of patients suffering from asthma on any one day. This includes onsets and characterises the persistence of asthma.

Asthma was defined with reference to a peak flow meter, and confirmed by other measurements when patients reported to the clinic (Beasley et al., 1988).

The daily weather elements used were maximum and mean temperatures, wind run, and significant rain at Kelburn (Wellington). Other indicators such as wind direction, frontal passage, change of airstream, and atmospheric stability indicators were derived from investigation of synoptics charts. Results were found to be best represented for the four seasons, defining autumn as February, March and April; winter as May, June and July; etc.

Airstream winds over Wellington are chosen by sectors to highlight over-land and onshore components:

a) Northerly - the overland sector representing north, northeast, east winds.

b) Northwest - the short overland sector representing northwest and westerly winds.

c) Southerly - the oversea (onshore) sector representing southwest, south, and southeast winds, which are generally associated with lower temperatures.

d) Light and variable - conditions which might indicate a short overland trajectory, local allergen sources, or factors relating to a confined environment.

Unstable conditions in the atmosphere indicate upward, often turbulent motion of air, and also the tendency for airstreams to flow over, rather than around hills. When a trough of low pressure of cyclonically curved isobars on the synoptic map is present, the airmass is taken to be unstable. In cases where there is some uncertainty, the presence of significant quantities of rain (greater than 0.5 mm) is noted as indicating atmospheric dynamic instability.

**RESULTS**

Over the 336 day period of the study, individual attacks persisted for an average of 3.4 days but could extend up to 19 days. The mean daily asthma ‘onset’ rate totalled for the 30 patients is 0.5 attacks per day, with a maximum occurrence of 3 onsets per day. The mean asthma occurrence is 1.6, with a maximum value of 6. Major peaks in asthma occurrence (Fig. 2) were observed in autumn (centred around late March) and in winter (end of July), with smaller ones in spring (late October) and summer (early December).

A three factor analysis of variance was used to show that variations by season, stabil-
ity and wind direction are significant at the 5% level (F-test). The null hypothesis, 'that there is no difference in asthma levels between environmental factors', was tested using a one tailed t-test on paired differences. The analysis was also carried out on the square root of asthma levels to 'normalise' the data.

**Cold chill effect:**

The change from west to southerly sectors occurred on 21 days with a mean decrease in temperature of 2.3 degrees C. The increase in asthma by .04 onsets per day is significant at only the 10% level (p < 0.07). There is a hint of a "U" shape response, of reduced asthma onsets in winter and spring, and increased asthma onsets at other times of the year. Fig. 3 shows that the onset response to southerly change is very scattered, but with a tendency to increased onset. There were ten cases of increase, seven cases of no change, and four cases of decrease.

**Fig. 4: Impact of change from northerly to westerly sector (cut-off of long trajectory spores) on asthma levels.**
Damp air fungal spores (external environment)

The change from northerly to westerly sectors occurred on 20 occasions over the year with a mean decrease of 0.9 asthma onsets (p < 0.005). Fig. 4 shows the influence of this change in sector on asthma levels through the year.

In autumn the most dominant factor associated with asthma levels is the presence of northerlies (mean temperature around 17 deg C). Asthma levels in autumn for the northerly sector airstreams and for light and variable conditions, are found to be significantly higher than that for northwesterlies (p < 0.025). On the 3 autumn days with thunder and lightning events, mean asthma persistence levels were 167% above the seasonal mean, but this was not significant due to the low number of events. No clear correlations were found with airmass instability and the passage of fronts.

House mite and damp air spores in the internal environment

In winter, the most important factors influencing the number of patients suffering asthma attacks are found to be atmospheric instability, rain, southerlies (mean temperature 8 deg C), and light or variable wind conditions. These relationships, shown in Fig. 5, are observed to begin in Autumn. The overall seasonal change in asthma rate from autumn to winter is not significant. However for northerly conditions there is a significant decrease in importance in winter (p < 0.025), clearly indicating the lower importance of the overland sector at this time of the year.

Fig. 5: Asthma onset rate in winter (May to July) corresponding to different airstreams and stability criteria, and the presence of rain (unstable conditions). The overall winter mean and number of events are indicated.

Asthma and Weather

Fig. 6: Impact of arrival time of southerly changes in Wellington (with standard error bars) on daily asthma onset rate.

From winter to spring, the decrease in asthma onsets overall is significant (p < 0.05). However, there is a more highly significant drop for both unstable and wet conditions (p < 0.005), and similarly for southerly sector wind conditions (p < 0.005).

A higher asthma onset rate is observed when southerly wind changes arrive during the night hours (Fig. 6). Individual standard error bars show that changes over four hour adjacent periods are not necessarily significant.

Pollen, dry air spora

In spring, the mean rate of asthma attacks per day is significantly lower than that for the other seasons (Fig. 2). Asthma occurs most readily for northeasterlies, in this period (August, September, October) with levels significantly above those occurring for southerlies (p < 0.025), a reversal of the situation found in winter. The decrease from winter to spring in mean asthma levels occurring with southerly airstreams, is also statistically significant (p < 0.005).

Rain inhibits asthma in spring (p < 0.025) in contrast to winter, where rain is associated with high asthma occurrence. The change in relationship is highly significant (p < 0.001).

The six changes from westerly to southerly airstreams found in spring led to a mean decrease of 0.9 asthma onsets (p < 0.05), which is in contrast to the increases seen at other times of the year (Fig. 3).

The contribution of northwesterlies to higher levels of asthma in August and September, declines significantly into summer (p = 0.05) and no asthma onsets at all were found in the
November/December period with these airstreams.

CONCLUSIONS

A number of different meteorological influences have been found to be associated with asthma attacks through the year. These are highlighted at peak times:
— an autumn peak associated with northerly airstreams;
— the winter peak associated with a wet, low wind period;
— and the spring peak associated with dry weather and winds from the overland sector.

The periods of asthma may be attributed to allergens of distinct varieties:

Autumn — outdoor spores, damp variety predominating and originating from inland sector;
Winter — indoor spores, house mite and other contaminants;
Spring — local pollens;
Summer — airborne spores (mainly dry variety) from inland sector.

The close correspondence of northerlies in autumn with asthma indicates a seasonal relationship with an airstream that has the largest overland bias. Studies such as that done by Hasnain et al., (1985), suggest damp air spores as the allergen responsible for the asthma attacks.

The present study suggests that a major asthma peak also occurs with wet, low-wind or cold conditions in winter, which is likely to be at least partly related to a behavioural response of retreating indoors to closed environment. This is supported by the finding that during winter, the northerly overland winds have the lowest correspondence with asthma. A marked change in environmental conditions associated with asthma attacks then occurs from winter through to spring, with rain and instability losing their importance, and a change to longer and more windy days. This points to allergens occurring in the indoor environment as the major cause of asthma during the winter period. It may indicate that the asthma rate could be diminished if the predominant indoor environments were drier and better ventilated (as in spring when the mean wind is higher). Recent changes towards less draughty homes with the introduction of draught strips, aluminium joinery etc., may have exacerbated internal dampness and pollution, and, as a result, asthma levels (Mathison et al., 1982). A tendency towards higher asthma levels in the early morning hours may also be an indication of a stronger influence of internal environments at that time.

Further research is needed to clarify the importance in New Zealand of these allergens and their relationship to environmental and behavioural factors. The correlations also point to a possible relation between meteorological conditions and asthma which might be found in specific microclimates, such as damp river valleys. The data collected in this study did not include where people actually were, when they experienced their asthma attacks - the importance of micro-climates in asthma incidence in New Zealand deserves further study.

The asthma attack rates found in this analysis indicate the origin of asthma-producing allergens present in spring and summer - northwesterly airstreams and light wind situations representing pollens derived from local vegetation in spring, and northerlies and easterlies representing longer trajectory pollens and spores from rural and forested areas further afield in summer.

The cold chill factor is not clearly shown to be present. This may be due to possible confounding factors resulting from a behavioural response to colder conditions, or to the generally small temperature drops experienced in Wellington's maritime climate.

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REFERENCES


