

Differences in grass pollen allergen exposure across Australia

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Allergic rhinitis is a medically and economically important chronic disease that affects 500 million people worldwide.¹ In a study of the geographical distribution of allergic rhinitis in adults aged 20–44 years living in 35 centres in 15 countries, the prevalence of allergic rhinitis in Australia (Melbourne) was the highest, at 31.8%.² Australia is also prominent with its prevalence of asthma being amongst the highest in the world. For example, Phase Three of the International Study of Asthma and Allergies in Childhood (ISAAC) found the prevalence of current wheeze and severe asthma in children in Australia to be >20% and >7.5% respectively.³ The coexistence of asthma and allergic rhinitis is frequent, and it has been demonstrated that allergic rhinitis usually precedes asthma, and that allergic rhinitis is a risk factor for asthma.⁴

The direct and indirect costs of allergic disease have been estimated at \$7.8 billion annually for Australia alone, with \$1.2 billion (15%) of this being the direct health system expenditure.⁵ The main treatment of seasonal allergic rhinitis is chronic pharmacotherapy including intranasal corticosteroid sprays and non-sedating anti-histamine drugs.

Abstract

Objective: Allergic rhinitis and allergic asthma are important chronic diseases posing serious public health issues in Australia with associated medical, economic, and societal burdens. Pollen are significant sources of clinically relevant outdoor aeroallergens, recognised as both a major trigger for, and cause of, allergic respiratory diseases. This study aimed to provide a national, and indeed international, perspective on the state of Australian pollen data using a large representative sample.

Methods: Atmospheric grass pollen concentration is examined over a number of years within the period 1995 to 2013 for Brisbane, Canberra, Darwin, Hobart, Melbourne, and Sydney, including determination of the 'clinical' grass pollen season and grass pollen peak.

Results: The results of this study describe, for the first time, a striking spatial and temporal variability in grass pollen seasons in Australia, with important implications for clinicians and public health professionals, and the Australian grass pollen-allergic community.

Conclusions: These results demonstrate that static pollen calendars are of limited utility and in some cases misleading. This study also highlights significant deficiencies and limitations in the existing Australian pollen monitoring and data.

Implications: Establishment of an Australian national pollen monitoring network would help facilitate advances in the clinical and public health management of the millions of Australians with asthma and allergic rhinitis.

Key words: pollen, allergen, season, allergic rhinitis, allergic asthma

Unlike medications for asthma management and prevention, most pharmacotherapy for seasonal allergic rhinitis is not subsidised by the Australian Pharmaceutical Benefits Scheme; typically the patient bears the

considerable cost of treatment for this chronic disease over many years. Alarming, pharmacy wholesale purchases for oral anti-histamines and nasal steroids doubled between 2001 and 2010 to \$226.8 million.⁶

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Grass pollen are significant sources of clinically important outdoor aeroallergens and recognised as a major trigger for allergic rhinitis.⁷⁻¹⁰ Allergen challenge studies have demonstrated the causal link between grass pollen allergens and allergic rhinitis in a number of studies.¹¹⁻¹² Environmental exposure to pollen can directly affect patient symptoms of allergic respiratory disease including allergic rhinitis and asthma, and indeed the initial development of these diseases.¹³ For example, increases in the atmospheric concentration of grass pollen have been associated with significant increases in hospital emergency department visits and admissions for asthma.¹⁴⁻¹⁵ Grass pollen and associated cytoplasmic fragments are now widely considered as the major causative allergen in Australian thunderstorm asthma epidemics.¹⁶⁻¹⁹

Establishment of long-term airborne pollen count data across several nations has been an integral aid towards measuring exposure of populations to aeroallergens.²⁰⁻²¹ Improved knowledge of local pollen aerobiology assists people in self-management of both allergic rhinitis and allergic asthma symptoms, thereby reducing the health and financial burden of these diseases. Airborne pollen data has the additional potential to be used in a predictive manner by the generation of short-term pollen forecasting.²²⁻²³

To date, there has been no national compilation of airborne pollen concentration data for Australia. However, regional variability in pollen seasons might be anticipated across the geographically and climatically diverse continent of Australia. Pollen monitoring has been performed in a small number of sites within the coastal state capital cities where most of the Australian population reside. With support from the Australian Government (see Acknowledgements for details), this study sought to integrate all existing available Australian capital city airborne pollen datasets into a national collection and provide, for the first time, a descriptive snapshot of the current status of pollen exposure across Australia, with implications for clinical management of allergic respiratory diseases. The initial report from this study, by Haberle et al.,²⁴ focused on the macroecology and biogeography of diverse pollen types. Here we report an analysis and synthesis of pollen count data from urban centres of Australia for grasses, the major clinically important outdoor aeroallergen source,

with consideration of the public health implications relating to the need to better facilitate management of grass pollen allergen exposure. There are other important aeroallergens (other pollen, mould spores, etc), but our analysis here is just on grass pollen, not these other aeroallergens.

Methods

Daily mean airborne grass (Poaceae) pollen concentration data was analysed for six major urban centres in Australia: Brisbane, Canberra, Darwin, Hobart, Melbourne and Sydney. The other two state capital cities, Adelaide and Perth, were not included because limitations in the available data or documentation prevented determination of grass pollen season using the methods detailed below.

The grass pollen season for each year of every location was determined using the 90% and 98% methods.²⁵⁻²⁷ The 90% method defines the pollen season as the period starting when the sum of daily mean pollen concentrations reaches 5% of the annual total sum and ending when the sum reaches 95% of the annual total sum; i.e. the interval with 90% of the annual pollen amount.

Similarly, the 98% method defines the pollen season as the period starting when the sum of daily mean pollen concentrations reaches 1% of the annual total sum and ending when the sum reaches 99% of the annual total sum; i.e. the interval with 98% of the annual pollen amount.

Pollen season is defined in these ways in order to disregard extremely low, clinically irrelevant, pollen counts leading up to the start and following the end of the clinically important pollen season. The peak grass pollen date for each year and every location was determined as the highest 7-day moving average grass pollen density, similar to that used by Khwarahm et al.²⁸ The peak pollen date is important because it can be clinically significant, as discussed by Ribeiro et al.²⁹ These methods of defining the start and end and peak of the pollen season can only be applied retrospectively, after all the data has been collected for the entire year.

The grass pollen analyses have been expressed across fiscal years, from July to June of the following year, as this illustrates the seasonality patterns more clearly in most cases. The years analysed for each location were: Brisbane (1995-1996 to 1998-1999); Canberra (2007-2008 to 2009-2010); Darwin

(2002-2003 to 2004-2005); Hobart (2007-2008 to 2010-2011); Melbourne (2009-2010 to 2011-2012); and Sydney (2008-2009 to 2012-2013).

Results

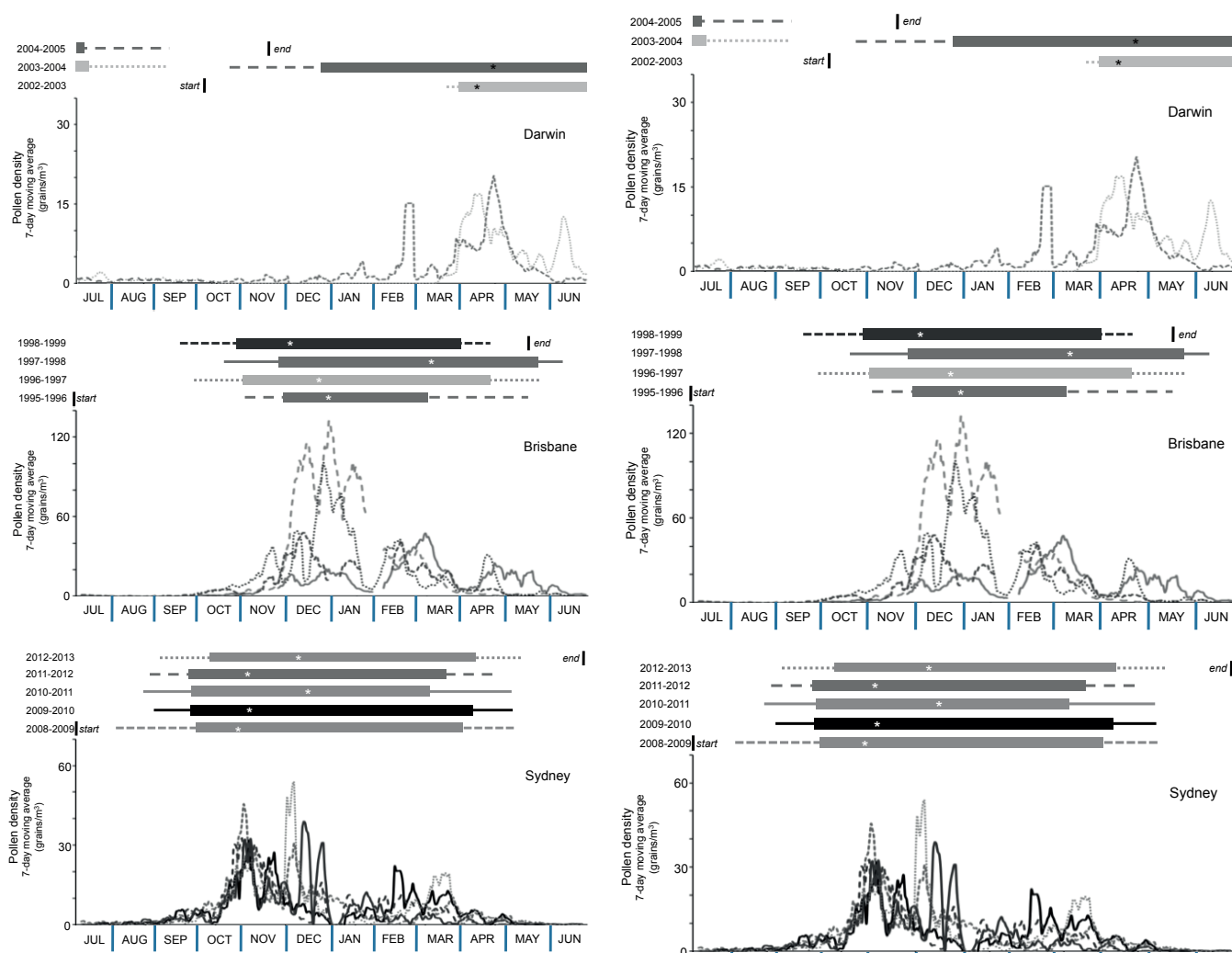
Results for Brisbane, Canberra, Darwin, Hobart, Melbourne, and Sydney are presented in Figure 1. The curves for each year and location show the short-term temporal variation in grass pollen density. There are considerable differences in this variation not only from one location to another but also from year to year at the same location.

Similarly, the peak grass pollen date differs from one location to another but also from year to year at the same location (shown in the curves and indicated by the asterisk in the corresponding grey shade and/or line type box above the curves in Figure 1). For example, three of the five Sydney years have their peak grass pollen date at the end of October/start of November; the other two years have their peak grass pollen date more than a month later in December. For Brisbane, the grass pollen peak date variability is even greater, with three of the four years peaking around December, and the fourth year peaking 2-3 months later in March.

Similar to the short-term temporal variation in grass pollen density and peak grass pollen date, considerable differences in grass pollen season timing and length are observed between locations and from year to year at the same location (Figure 1). For example, over the four years presented, Brisbane's grass pollen season starts anywhere from mid-September to late November (taking both pollen season expression methods into account), whereas Sydney's starts anywhere from the end of July through to early October (taking both pollen season expression methods into account). On the basis of the 90% pollen season definition method, Brisbane's start date varies by more than a month and end date varies by almost three months, for just the four years that are considered here.

The other striking result is the contrasting grass pollen season between Darwin and the other five sites. This suggests latitudinal variation in grass pollen seasons, with Darwin peaking around April based on the data available from two years, and all the other (more southerly) sites preceding this, by several months in most cases.

Figure 1: Atmospheric grass pollen density and seasons for six cities in eastern and northern Australia. The cities are arranged by latitude from north at the top left to south at the bottom right. Grass pollen density is shown as a 7-day moving average across the fiscal year. Grass pollen season is depicted by the combination of thin horizontal line (98% of the annual grass pollen falling in this range) and a thick horizontal box (90% of the grass pollen falling in this time) for each year. Peak grass pollen date each year is indicated by the asterisk in the box, with the corresponding curve in the same shade below. The vertical bars labelled “start” and “end” in the upper part of each panel indicate the start and end of pollen sampling for the corresponding location. Note change in y-axis scale for Darwin and Brisbane.



Conclusions

Examination of the available grass pollen data for Australia presented here highlights the great variability observed in grass pollen seasons across regions and between years. These results demonstrate that static grass pollen calendars, which typically indicate presence or absence of grass pollen on a monthly basis, are of limited utility and in some cases misleading to clinicians, public health professionals and respiratory allergy sufferers in general. Furthermore, static grass pollen calendars are of no value as indicators of peak grass pollen periods. Again, the results of this study clearly demonstrate peaks in airborne grass pollen can occur at almost any stage of the grass pollen season, near

the start, around the middle, or near the end. Notably, although only the highest peak is identified in this study, some locations and/or years will experience multiple peaks, possibly due to variations in flowering intervals of different grass species, as observed elsewhere.³⁰

While detailed analysis of the causes of the temporal and spatial variability in grass pollen season revealed here was not the objective of this study, mention of the likely dominant factors is important. First and foremost, climate and weather will play a dominant role with respect to the spatial distribution of different grass species in Australia as well as the short-term and seasonal temporal variability of grass pollen production. The dominant grasses will vary across the

many climate zones of Australia, with, for example, subtropical Brisbane dominated by subtropical Bahia grass (*Paspalum notatum*) and Bermuda grass (*Cynodon dactylon*), and temperate Sydney, Canberra, Melbourne, and Hobart dominated by the temperate Ryegrass (*Lolium perenne*).⁸ Rainfall, temperature and other meteorological parameters will influence pollen season timing and duration as well as day to day variations in pollen concentration, as will synoptic and larger-scale climate fluctuations such as the El Niño Southern Oscillation. For example, the delayed and diminished 1997–1998 Brisbane grass pollen season corresponded with a 12–14 month El Niño that started early 1997, which was associated with below average rainfall in eastern subtropical Queensland.³¹

This study reports the most comprehensive and systematic analysis and synthesis of Australian grass pollen data conducted, and reveals insights into grass pollen exposure in Australia that were previously unknown. However, they also highlight significant deficiencies in data collection for this continent when compared to the extensive and comprehensive databases available in North America, where there are approximately 87 pollen and mould spore counting stations,³² and Europe, where there are more than 600 pollen counting stations.³³ Furthermore, even for the limited number of Australian sites for which pollen data is available, operation of monitoring in most cases is not continuous. Monitoring in all cases is either unfunded or under-funded by short-term grants. Thus, even with the most recent of Australian pollen data, cities such as Darwin, for example, have just two years of data, ending in November 2004, and Canberra three years, ending in December 2009. Closer inspection of Figure 1 reveals a number of gaps within these limited periods of monitoring, such as for Brisbane (e.g. end January to start February 1995–1996) that experienced several periods of motorised spore trap breakdown.³⁴ These spatially and temporally restricted datasets highlight the poor resourcing of this important enterprise in Australia.

Finally, there are further limitations, and indeed inconsistencies, in the existing Australian pollen data. For example, there is no uniformity in the time that pollen monitors at different locations start and end their 24-hour or 7-day sampling period. Similarly, there is no uniformity in the placement of pollen traps in terms of their height above the ground, clearance from obstacles, etc. And there are no agreed standardised counting methods, despite all collection and count techniques conforming to recommended guidelines.³⁵

Implications

The striking spatial and temporal variability in grass pollen seasons in Australia revealed in this study supports the pressing need for the establishment of a national pollen network. This would result in a systematic and standardised approach to mapping the pattern and nature of the seasons, providing data that is thus far lacking. Such information will lead to an improved understanding of the 'allergy season' for both medical practitioners

and patients. Overseas experience and limited experience in Melbourne strongly suggests that patients with allergic rhinitis and allergic asthma feel a sense of empowerment and control over their symptoms when they have access to actual and forecast pollen levels, which may result in greater compliance with preventative medication use and long-term prevention of pollen allergen-induced emergency department visits and hospital admissions for respiratory disease.³⁶

A further dimension to, and superimposed upon, the striking spatial and temporal variability in grass pollen season revealed herein, is the likely impacts of climate change on grass pollen seasons in Australia. Overwhelming evidence from the Northern Hemisphere now shows that the seasonality of flowering and pollination of many plants is changing.^{37–39} A standardised and long-term national pollen network would enable observation of any long-term trend in atmospheric pollen concentrations, and provide a mechanism to project the impacts of climate change.^{21,40}

For some states and/or territories, and indeed for some cities, there may be a requirement for more than a single pollen sampling site. Katelaris et al.⁴¹ have examined the spatial variability in the total pollen count in Sydney, comparing three sites separated by a maximum of 30 km. Significant differences were found in the total sums of pollen at the three sites, as well as in the temporal variability of pollen from particular species. Similar results over comparable distances have been found in research on the spatial variation of airborne pollen over south-east France, a region that borders the coast, like many Australian cities.⁴²

Other important considerations for an Australian national pollen monitoring network include its sustainability, including secure long-term funding, and its incorporation of new technologies, both now and into the future. One such technology is automated pollen classification and counting, which utilises recent improvements in computing and imaging hardware and software, and which makes this part of the process less labour-intensive.⁴³

A national pollen monitoring network would provide the high-quality pollen data required for trials of new allergy treatments and therapies. Pollen exposure is an independent predictor of hospital admissions for respiratory disease and accurate measurements of ambient levels of pollen

are critical to reduce pollen allergen-induced asthma emergency department visits and subsequent hospital admissions.^{14–15} Another important need for high-quality pollen data is the requirement to include pollen as an important covariate in studies of the relationship between respiratory disease and air pollution (e.g. Jalaludin et al.⁴⁴).

Patients in a small number of Australian cities are currently benefiting from ongoing pollen monitoring, reporting, and indeed forecasting, with Melbourne being perhaps the best served at present (see <http://www.melbournepollen.com.au/>). In conclusion, significant advances in the clinical management and self care of the millions of Australians with asthma and allergic rhinitis could be made through the establishment of an Australian national pollen monitoring network. Knowledge and management of pollen allergen exposure are likely to become increasingly important public health considerations to minimise the impact of these common chronic conditions.

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