ORIGINAL RESEARCH

Respiratory storm

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Abstract

Introduction and aim: To examine unusually high numbers of respiratory related presentations over a ten day period during late spring and early summer in 2010, coinciding with local thunderstorm activity. The impact to business continuity in the emergency department, secondary to a related surge in presentations, was also examined. This analysis will build on existing knowledge and literature around thunderstorm asthma.

Design and method: A retrospective cross-sectional descriptive approach was taken to analyse the event. Data was analysed retrospectively covering the period 08-17 November, trending respiratory presentations, with reference to seasonal variations experienced in the Australian Capital Territory (ACT), for the years 2009, 2010 and 2011. The study period was selected in accordance with a peak activity episode noted on the emergency department information system database. Participants were identified as per their presenting complaint and discharge diagnosis. The meteorological seasonal patterns, occurring over the same period, were observed in conjunction with patient presentation patterns.

Result: In 2010 the emergency department experienced an increase in the number of asthma related presentations during early November, coinciding with thunderstorm activity, when compared with the same period in 2009. Thunderstorm activity was identified as a related factor in this surge of presentations. The data showed a fourfold increase in asthma presentations during the observed period in 2010 compared to 2009. In 2011, whilst no thunderstorm activity was recorded, heavy rainfall was recorded, as with a sustained rise in respiratory presentations. During the observed period the number of daily respiratory related presentations increased by 13% (n = 135) during 2011.

Discussion and conclusion: Historically, spring sees a greater number of respiratory related presentations associated with a high pollen count and an increase in general airborne allergens. Despite this regional seasonal variation in respiratory presentations, when combined with meteorological events, especially thunderstorm activity, there is the potential for a significant surge in respiratory presentations to emergency departments, potentially leading to an impact on business continuity. Whilst the link between thunderstorm activity during the period of spring to early summer and asthma has been demonstrated in the literature, the impact of this acute respiratory response, on business continuity in regional, metropolitan and tertiary health care centers is not yet well recognized/understood. Ethics approval: The authors declare that they have no conflict of interest related to the topic of this paper. This study has not been funded nor has it been commissioned. Ethics approval for this paper has been issued through the authors employing organisation (CHCACT HREC ETRN: 1-2014).

Key Words: Thunderstorm, Asthma, Emergency department, Respiratory, Surge, Business continuity, Allergy, Mass presentation, Pollen

1 Introduction

Emergency Departments (EDs) commonly see and treat asthma and respiratory presentations however considerable surges in acute respiratory presentations are not common (in the observed emergency department) and may present a challenge to business continuity. During late spring 2010 there was an unusually high influx of acute respiratory pre-

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sentations seen in a Canberra metropolitan ED, in the Australian Capital Territory (ACT). This surge event found the department ill prepared and poorly resourced to effectively and efficiently manage such a surge in presentations. The department experienced a complete depletion of related consumables and additional staff were required to assist in treating this cohort.

This event left the department questioning what might have caused this unusual phenomena and what could have been done to minimise the impact on departmental business continuity. Post the recognition of the impact associated with thunderstorm activity, the observed emergency department has increased its automated digital capability to identify surges early, through presenting complaint and diagnostic related group pattern recognition, as well as put in place policy and procedures/pathways to support the efficient and consistent management of thunderstorm exacerbated respiratory presentations.

Publication of this event within the literature is hoped to increase awareness of thunderstorm asthma and the subsequent preparedness of emergency departments to deal with the possible surge in related presentations.

Background

Exacerbations of acute respiratory complaints can be linked to a variety of causative factors including; humidity, pollen and other antigen exposure, rainfall, temperature and comorbidities.[1] These variables may be in combination or in isolation.[1] Day-to-day changes generally have a substantial impact on the severity of an individual "asthma attack"[1] or in the case of emergency departments, the numbers of departmental presentations.

The hypothesis that rainfall relieves many respiratory symptoms by "washing" pollen out of the air, has been disproven with instead, a resultant degranulation of pollen and people experiencing a worsening of their symptoms, as reported in respiratory related epidemics experienced both in Australia and internationally.[2–5] When combining weather and seasonal activities (such as pasture and grassland growth) the degree of symptoms an individual may suffer can be increased. For example when combining spring to early summer and thunderstorm activity, the symptomatology a patient may experience is heightened, resulting in a possible acute asthma attack requiring emergency intervention.[6,7]

Grass pastures rely heavily on the wind to distribute pollen, with one hectare of ryegrass releasing hundreds of kilograms of pollen per season.[8] Generally these pollen granules spread along a predictable corridor, according to local prevailing winds, however during the irregular high speed wind patterns associated with thunderstorm activity, the distribution of pollen is more widespread and erratic. Within a thunderstorm, grass pollens and spores are swept up into the atmosphere and rupture (degranulate) following contact with moisture.[9] These respirable aerosolised spore and pollen remnants remain at their highest concentrations nearest their source, however when driven by the thunderstorm winds, these small particles can rise up to levels 50 fold their normal levels along the distribution pathway, over many kilometers.[3,9]

There are normally 1000 pollen starch granules per cubic meter in the air.[10] When combined with rain and humidity, pollen grains absorb the moisture and degranulate, releasing hundreds of finer allergenic protein particles into the air which can then penetrate deeper into the smaller airways, resulting in a global acute respiratory inflammatory response.[11] Pollen degranulation increases the normal atmospheric rates from 1000 granules per cubic meter, to around 54000 granules per cubic meter of air.[10] Storm activity has been shown, during these seasonal pollen periods, to be a key factor in the phenomenon known as "thunderstorm asthma".[2,11] The juxtaposition of clustered thunderstorm activity and a heavy pollen season can cause unusual surges in respiratory presentations in emergency departments along these storm/pollen distribution pathways.

2 Method

Early in November 2010 there was an unexpected surge in respiratory presentations to the observed emergency department coinciding with extreme and unusual meteorological conditions/events. On the 8th of November, a thunderstorm with associated hail and a heavy downpour occurred in the Canberra (Australia) region. The days that followed this thunderstorm, saw a marked increase in acute respiratory presentations to the ED, with the most notable increase in presentations seen between the 11th and the 17th of November 2010.

2.1 Design

A retrospective cross-sectional descriptive approach was taken to analyse the event.

2.2 Setting

Data was analysed retrospectively covering the period 08-17 November across the years 2009 to 2011.

2.3 Population

The residents and persons present in Canberra, within the Australian Capital Territory (ACT), during the period 08-17 November over the years 2009, 2010 and 2011 constituted the studied population.

2.4 Sample

Respiratory presentations with reference to seasonal variations experienced in Canberra were trended for the years 2009, 2010 and 2011. Participants were identified as per

their presenting complaint identified through the Emergency Data Information System (EDIS) triage data section and discharge diagnosis (ICD 9 code from EDIS). The meteorological and seasonal patterns occurring over the same period were observed in conjunction with patient presentation patterns.

2.5 Data collection

An analysis of the retrospective patient data retrieved from the emergency department information database for the period 08-17 November 2010 was undertaken. Patients with a respiratory related presentation complaint or diagnosis were the focus of the study. Comparisons were also made for the corresponding date period pre and post; 2009 and 2011. The factors considered in the data analysis were:

- Presentation numbers per day
- Gender
- Patient triage (Australasian Triage Scale)
- Diagnosis (acute bronchitis, acute bronchiolitis, acute nasopharyngitis, acute/ chronic obstructive airways disease, acute pharyngitis, allergic rhinitis due to pollen, asthma, cough, emphysema, hayfever, shortness of breath and wheezing)
- Disposition
- Home geographical location or address

All data obtained from the emergency department information system database was de-identified by the authors for analysis and maintained on the organisation's computer system, prior to being deleted after publication of this article. The original data remains intact on the emergency department's information system.

2.6 Data analysis

The relationship between emergency department presentations, presenting respiratory complaint and diagnosis, with concurrent weather condition, was considered. Data on pollution levels (pollen inclusive), weather condition and seasonal variations, involving increased pollen count, were collated from the Australian Bureau of Meteorology (BoM) and the Department of Sustainability, Environment, Water, Population and Communities. Due to the established relationship between these environmental factors and respiratory related complaints this air pollution and meteorological information was considered pertinent to the analysis. Patient related data was collected from the hospital's emergency department information system post authority from the Human Research Ethics Committee was sought. The data was then stored on hospital computers and analysed in accordance with the above factors indentified for variables in patient presentation patterns. The period of study was selected in accordance with the initial thunderstorm activity (8th of November 2010) and the period of increased presentations (11-17 November 2010). For comparative purposes, samples were also taken from 2009 and 2011.

2.7 Protection of human rights

Ethics approval was sought and granted from the hospital Human Research Ethics Committee (HREC). There were no conflicts of interest identified within this study. This study has not been funded nor has it been commissioned.

3 Results

Surge related respiratory presentations began four days after the main thunderstorm activity with 1147 patients registering for treatment between the 11th and 17th of November 2010 (1028 patients waited for treatment). On the 14th of November 2010, a particular spike in presentations was noted, with 234 registering for assessment and treatment. Of the 207 individuals that waited to be assessed and treated on the 14th, 23% (n = 48) presented with a respiratory related illness as defined by a diagnosis of: acute bronchitis, acute bronchiolitis, acute nasopharyngitis, acute/ chronic obstructive airways disease, acute pharyngitis, allergic rhinitis due to pollen, asthma, cough, emphysema, hayfever, shortness of breath and wheezing (see Figure 1). Asthma was noted as the predominate diagnosis over the observed period for all three years.

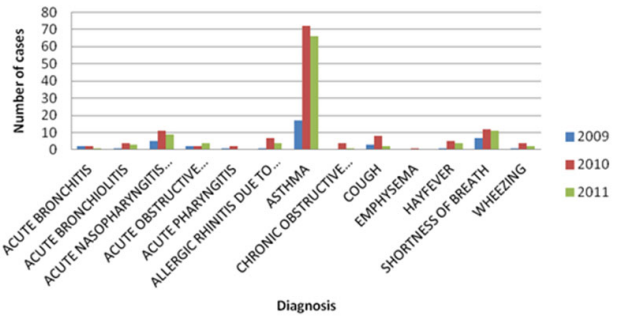

Figure 1: Respiratory presentations per diagnosis, per year, during 11-17NOV

Single years before and after the peak thunderstorm related respiratory presentations of 2010 were also analysed to provide further clarity and conformation of the phenomena experienced. Between the 11th and 17th of November 2009 there were 986 presentations, whilst the same period in 2011 saw 1059 presentations to the emergency department. Both pre and post observed years saw fewer presentations that that noted in the observed period of 2010.

Acuity across the three years observed indicates a parallel rise during 2010. Australian emergency departments utilise the Australasian Triage Scale (a score between 1 and 5, where 1 means that the patient should not wait to be assessed and treated (immediate), whilst a category 5 patient

should be seen within 2 hours) to define urgency secondary to acuity.[12] This scale is applied to the patient on presentation, allowing the allocation of appropriate resources in a timely fashion to minimise deterioration secondary to delays in therapy.[12] During 2009 and 2011 there were no Australasian Triage Scale (ATS) category 1 presentations, with one category 1 patient in 2010. ATS category 2s allocated (2009 n = 3, 2010 n = 9, 2011 n = 9). ATS category 3s allocated (2009 n = 21, 2010 n = 55, 2011 n = 56). ATS category 4s allocated (2009 n = 14, 2010 n = 62, 2011 n = 39). ATS category 5s allocated (2009 n = 3, 2010 n = 7, 2011 n = 3). An increase in the admission disposition of patients from the emergency department, associated with a respiratory presentation, also supported the noted increase in acuity with a doubling of patient's admitted (2009 n = 12, 2010 n = 20, 2011 n = 11) (see Table 1).

Table 1: Respiratory Presentations by Triage Category 2009 - 2011

Year	ATS categories allocated				
	1	**2**	**3**	**4**	**5**
2009	0	3	21	14	3
2010	1	9	55	62	7
2011	0	9	56	39	3

Distribution of the patients, within the respiratory Diagnostic Related Groups (DRGs), failed to identify any specific trend. There was no significant gender variance, with female presentations accounting for 46%, 45% and 45% (2009 n = 19, 2010 n = 60, 2011 n = 48) and male presentations accounting for 54%, 55% and 55% (2009 n = 22, 2010 n = 74, 2011 n = 59).

Across the three years observed (total n = 285) the majority of respiratory presentation patients were aged 40 years or less suggestive of acute presentations rather than exacerbations of chronic disease, though this was not examined in any depth.

Over the 7 days of peak surge activity in 2010, respiratory related presentations accounted for 14% (n = 135) of the total presentations to the emergency department with asthma being the predominant diagnosis at 7% (n = 70). Though asthma is a common presentation in spring, the year 2010 saw a 20% increase over the base asthma presentations noted in 2009. On average, approximately 10 asthma patients were seen per day in 2010, compared to 2 per day in 2009. The figures from 2011 indicated a similar surge in asthma presentations during the same period with 6% (n = 62) of patients treated for asthma.

It is evident from the data presented that respiratory related presentations were markedly elevated in 2010, with some of this heightened activity (to a lesser degree) seen again in 2011 over the same period of seasonal and meteorological activity. The November rainfall in 2010 (48 mm) and 2011 (34 mm) was not evident in 2009 (0 mm), as demonstrated below in the rainfall charts from the Australian Bureau of Meteorology. The data presented supports the established link between increased rain/thunderstorm activity and acute respiratory symptoms when combined with high pollen counts (see Figure 2).

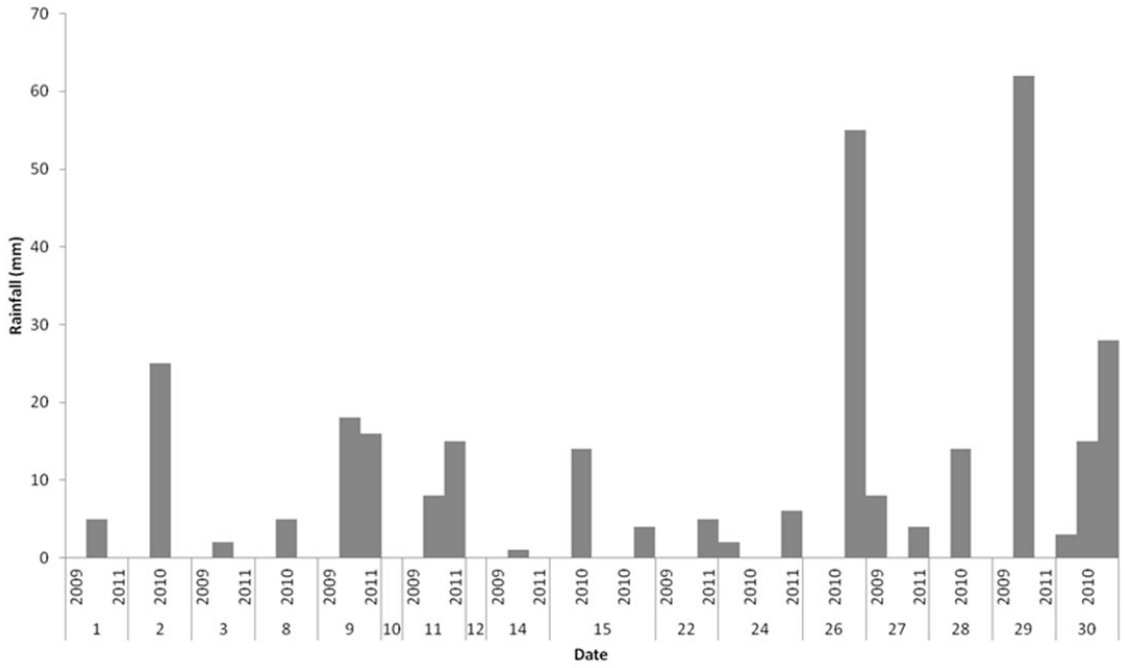

Figure 2: Rainfall per day November 2009-2011 (Bruce, ACT)

Patient presentations related to respiratory illness made up 4% (n=41) in 2009, almost 13% (n=135) in 2010 and 10% (n=121) in 2011 of total emergency departments presentations for the corresponding years (see Figure 3).

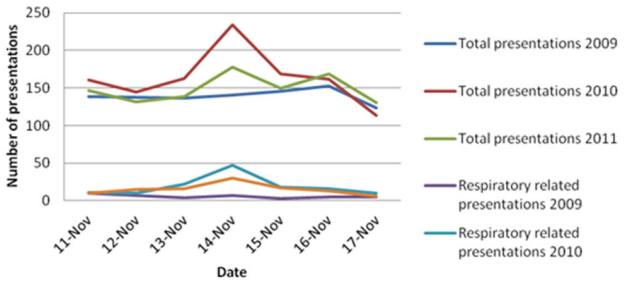

Figure 3: Respiratory related presentations against daily presentations, per year, during 11-17NOV

There was a 12% (n = 29) increase in total period emergency department presentations from 2009 to 2010, with an average of 135 presentations per day in 2009, 164 in 2010 and 149 in 2011. This 2010 peak in average daily presentation rate, during the observed period, again supports the surge experienced at the metropolitan emergency department related to respiratory presentations (predominantly exacerbations of asthma) coinciding with thunderstorm activity.

An analysis of location from which the observed respiratory related patients presented was conducted and included only suburbs with 2 or more patients presenting to the emergency department, in an attempt to reduce distracting data. This analysis indicated that most patients resided in the outer northwestern suburbs of Canberra, including (percentile of related presentations for 2010, n = 134); Dunlop 0.05% (n = 7) and Macgregor 0.05% (n = 7), and the northern suburbs of; Kaleen 0.06% (n = 8) and Palmerston 0.06% (n = 8). These suburbs are all situated near large nature reserves, containing pastures/grasslands. This geographic proximity to the grasslands is consistent with the literature around thunderstorm asthma and is a significant influencing factor on the numbers of patients seen from these locations (see Figure 4).

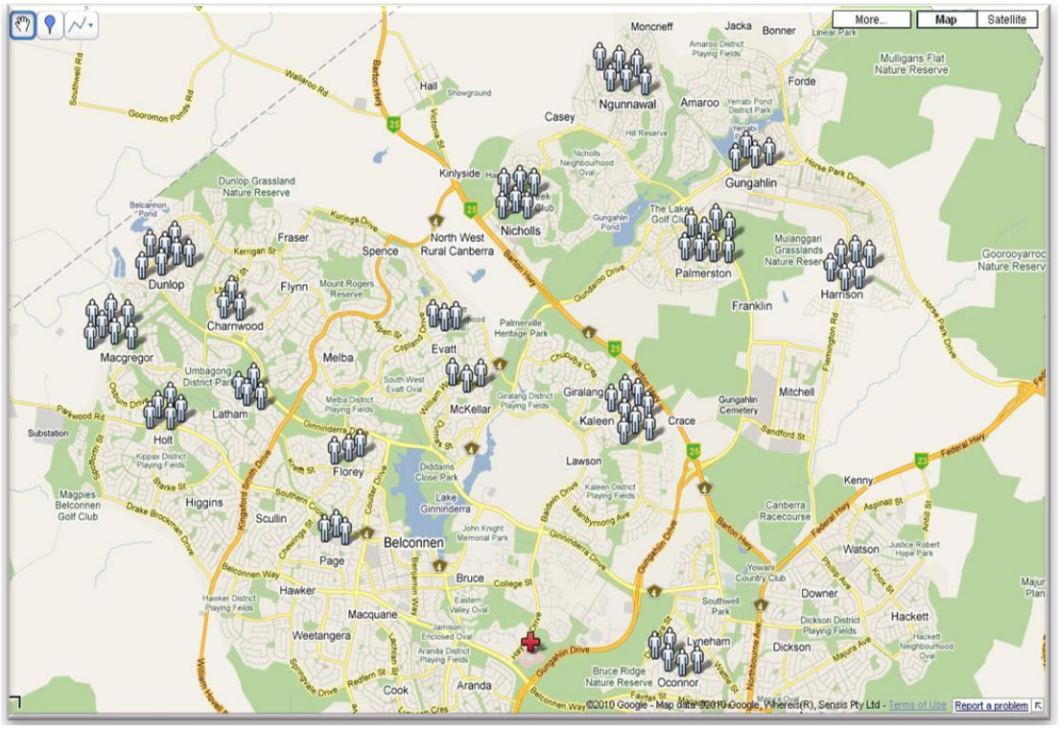

Figure 4: Presentations per northern Canberra suburb (Google Maps, 2010)

4 Discussion

The term thunderstorm asthma has been used and observed throughout Australia for the last 25 years.[13] Emergency departments within the pollen distribution pathways of a thunderstorm need to be on alert for sudden surges in acute respiratory illness, as this may cause increased pressures on health service demand and a depletion of resources, as noted at the observed location.

An overview of the data indicated total presentations to the ED during the period 11th to the 17th of November 2010, showed a notable increase in patient presentations when compared with the year prior. Despite the likelihood of an increase in respiratory complaints during spring and early summer, predicting higher than usual peaks in emergency

presentations based on thunderstorm activity alone is not conclusive. However, based on the focused assessment on this ED's experience, there is an indication that thunderstorm activity during spring and early summer could lead to a surge in acute asthma and respiratory related presentations to primary care centers and emergency departments.

Anecdotal evidence suggested that many of the patients presenting with asthma type symptoms had never been diagnosed with asthma prior to this presentation. This is supported in D'Amato's work on similar respiratory surge situations, where a significant proportion of the presentations were related to a new experience of asthma symptoms.[14] This relationship was not analysed and the noted variance provides the basis for further study.

Another factor identified in the data analysis was the number of respiratory related conditions triaged to a higher Australasian Triage Scale categories, demonstrating a relative/assumed (dependant on inter-rater reliability of the triaging) increase in respiratory illness acuity. In 2010, 10 patients required more urgent care compared to only 3 in 2009. These patients were allocated an Australasian Triage Scale (ATS) category 1 or 2, indicating an increase from 2009. The majority of respiratory presentations in 2009, 2010 and 2011 were later discharged from hospital on the same day, however, in 2010, there were a greater number of patients (2009 n = 12, 2010 n = 20, 2011 n = 11) requiring either overnight or extended admission to the hospital or transfer to other services demonstrating an increase of almost 50% above 2009 and 2011 in acuity, supporting the initial increase in ATS category allocation. Other factors showed that the predominant age group with respiratory related complaints was between 0-40 years, with a greater number of males than females being seen. This demographic phenomenon was consistent between 2009, 2010 and 2011, though not noted a comparatively different.

These surges in presentations may have the potential to impact significantly on human resourcing as well as consumable supplies and subsequently, emergency department business continuity. The Bureau of Meteorology reported that 2010 was the fourth wettest year on record for Canberra, with the highest daily rainfall since 1995, with 2011 seeing similar weather conditions.[15–18] This wet trend combined with increased thunderstorm activity during the late spring and early summer, may also suggest that thunderstorm induced respiratory illnesses will increase during these specific times of the year within the region.

Although it is difficult to predict influxes in respiratory presentations based purely on thunderstorm activity, it is important to consider such occurrences during late spring and early summer when the right variables come into play; thunderstorm activity, rain, a heavy/high pollen count and a susceptible population.[19]

From these findings our experience further builds on the existing knowledge and literature around the thunderstorm asthma phenomena.

Recommendations

As a general rule, emergency departments should have a contingency plan in place to deftly manage mass presentations or surges that may be experienced by the department. The described ED was inadequately prepared for the unpredicted/unsuspected surge of respiratory presentations that was witnessed in November 2010, thus management of the large influx of acute respiratory presentations was difficult. As emergency department overcrowding is a common phenomenon in most countries, any surge on top of this already arduous situation, leads to business continuity impacts.[20]

Consumable resources such as bronchodilator Metered Dose Inhalers (MDIs) and spacers were completely depleted over the first 2 days with additional resources needing to be sourced from other wards, hospitals and suppliers. Nebulised salbutamol was also utilised, though this integrated further issues around available suitable physical space, with access to medical gases, as well as increasing the potential risk of atomising infectious respiratory borne diseases. This made first-line management of the asthma type presentations more difficult to deliver. What occurred in this seasonal thunderstorm related surge episode demonstrated how a lack of preparation can affect an under prepared ED, thus seasonal resource planning should be put in place to accommodate for these potential surges, whilst minimising waste, through stock rotation.

Similar occurrences have been recorded in Birmingham (UK), Europe, Canada and other states of Australia dating back to as early as 1985. Dabrera et al identified spikes in asthma presentations after a thunderstorm struck the Birmingham area, leading to similar impacts in business continuity.[13] More recently in Georgia (US), a study looked at presentations continuing over a nine year period relating to thunderstorm asthma.[11, 13] The studies have all linked these phenomena back to high pollen counts in the troposphere in the presence of thunderstorm activity, linked with respiratory presentations, as also identified in this paper.[21–28]

With its close proximity to large expanses of grassland and a better understanding of the susceptibilities of its population, the studied ED established the necessary plan to manage surges in respiratory presentations during these "perfect" respiratory storm periods. Studies have proven that there is likely to be an increase in the number of respiratory presentations in the hours and days following a thunderstorm, thus it would be prudent to develop plans to minimise the business continuity risk presented by thunderstorm asthma. This knowledge should be used to plan for a staged response in possibly effected EDs and in developing community awareness so that sufferers or potential sufferers can also be prepared.

Hospitals in thunderstorm asthma prone areas should consider the development and application of policy to support the management of respiratory presentations and education around the practise associated with thunderstorm asthma related presentations. These policies would help in the preparation, response and recovery from such surge events, specifically through the standardisation of response.

Public health measures

Whilst an emergency department can risk stratify and establish contingency plans for such surges in respiratory presentations, the general community needs to be empowered toward their own individual care. By being made aware of the potential season ahead (or specific thunderstorm during the higher risk seasons), the public can ensure they have reviewed their asthma management plans[29] with their general practitioners/primary health care providers prior to the event, allowing for prescriptions of preventers and relievers to be updated and filled. This course of action is already supported by national and international asthma organizations.[29]

Dissemination of public health information can be assisted by media agencies, with public health units informing the community of the prevalence of potential storm activity during spring and into late summer and the local pollen count. Educating the public on the contributing factors and signs and symptoms of thunderstorm asthma, as well as the ways in which they can manage deterioration in their health status early, may aid in reducing health care service burden during these periods. Utilising formal media avenues, as well as emerging social media options to disperse information, will reach a wider population and could potentially lead to a decrease in the hospitalisation of effected persons. Utilisation of the media for such public health messages is attended in many settings, though not yet well established nationally and could be used more widely in such situations and for other health conditions.

5 Conclusion

As outlined in this paper, the evidence supporting the presence of "thunderstorm asthma" is noteworthy.

During thunderstorms, in the spring and early summer, there is the potential for a considerable increase in respiratory presentations to proximal emergency departments. Although a combination of a high pollen count and thunderstorm activity may not be easily anticipated, as storm cells can develop rapidly and without warning, preparations to provide the required emergent care to these surge groups of patients should be taken early in the season. Emergency departments should ensure they are prepared by having adequate resources readily available should the need arise.

With cyclic changes in climate in the southeastern parts of Australia and a possible continued relief in drought conditions, this 'thunderstorm asthma' phenomenon may represent a very real concern for local/affected emergency departments.

Whilst the data in this paper is specific to the Canberra region, it provides other health care regions the opportunity to recognise the phenomena and to apply if appropriate, preparing for a potential surge of respiratory presentations that may follow thunderstorm activity during the high pollen count period of spring and into the early summer season.

Conflicts of Interest Disclosure

Ethics approval was sought and granted from the hospital Human Research Ethics Committee (HREC). There was no conflicts of interest identified within this study. This study has not been funded nor has it been commissioned.

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