

Back Pages

Research model provides unexpected findings on causes of thunderstorm asthma and deadly Australian event

In 2016, the most severe thunderstorm asthma (TA) event reported in the medical literature, to date, caused approximately 14,000 people in the Melbourne, Australia area to seek emergency care for respiratory symptoms and contributed to 10 deaths, according to *9News.com.au* [1]. They also reported the event "prompted an outpouring of government funds to upgrade pollen warning systems and increase surveillance to predict such deadly events." In February 2017, when an interim report about the event was issued, *9News* indicated that $1 million had been pledged by the Victorian state government, led by Premier Daniel Andrews.

Weather and pollen conditions of the event

The TA event occurred on November 21, 2016 at approximately 17:30 local time (6:30 UTC). Prior to the storm, the weather was hot with a maximum temperature of 93°F (34°C) and low humidity (18-19%). More than 133.4 pollen grains per cubic yard (102 grains per cubic meter) indicated the grass pollen season had reached its peak. The storm brought gusty winds but minimal rain of approximately 0.03 to 0.15 inches (1 to 4 millimeters). Limited lightning occurred in Melbourne but more was seen east and south of the city. High humidity and downdrafts followed the storm. Because there was little rain, many people remained outdoors. This increased the number of people exposed to thunderstorm-driven pollen, identified as ryegrass, as it swept in from areas north and west of the city.

14,000 thousand ER presentations; 10 deaths

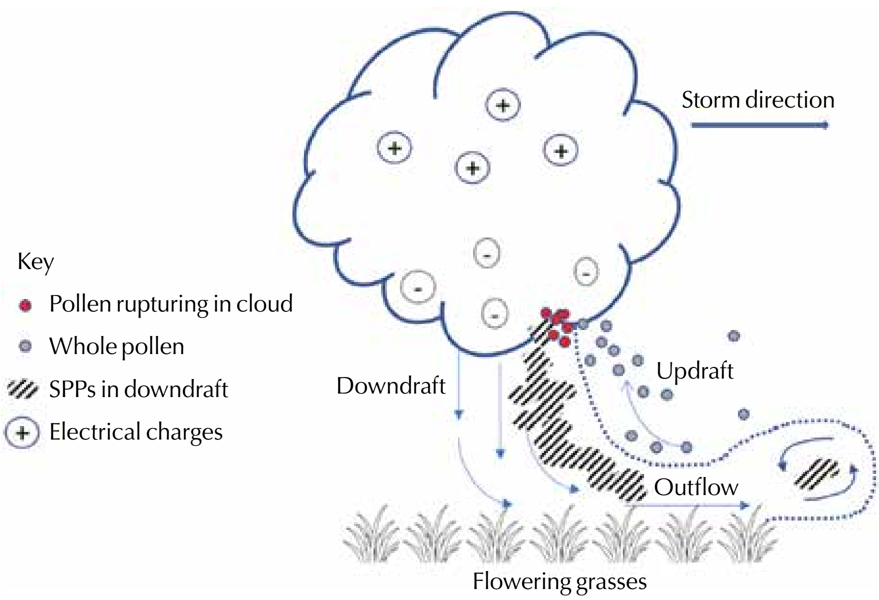
Beginning approximately 30 minutes after the storm front passed, throughout the night and the following day, public hospital emergency departments in Melbourne and nearby Geelong saw 14,000 patients present with respiratory symptoms. In an article published on *Live Science.com* [2], Nicoletta Lanese said this was a 672% increase and 3,365 more cases than anticipated, based on a three-year average. Other healthcare services, including ambulance transports, primary care physicians and pharmacies, also experienced sudden, unforeseen demands, including 2,000 ambulance requests within a 15-minute period, according to *9News*. Ultimately, storm-related asthma symptoms contributed to the deaths of 10 people: 7 men and 3 women, age 18 to 57.

TA occurrences are rare

The first TA event was reported in the medical literature in 1983 and 22 events have been discussed since. Of those, 10 have been in Australia, explained Kathryn Emmerson, a senior research scientist at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). She noted southeastern Australia, and Melbourne in particular, have the highest frequency globally. However, she also referenced data showing

Figure 1

Schematic of hypothesized pollen entrainment into a thunder cloud, rupturing and deposition mechanisms/processes. After Taylor and Jonsson, https://doi.org/10.1371/journal.pone.0249488.



TA events take place approximately once in 5 years in the region and commented that their relative rarity is one reason making preparations can be challenging.

Patients at risk in TA events

Lanese wrote that patients most at risk include those with diagnosed asthma, especially if poorly controlled; people with undiagnosed asthma; and those with seasonal hay fever or a ryegrass allergy, according to a 2017 report from the Victoria State Government's Chief Health Officer.

Potential TA and pollen rupture mechanisms

Mechanisms for thunderstorm asthma are not fully understood. However, it is believed that during TA events, patients can be exposed to airborne allergenic particles, such as fungal spores or pollen grains, which are concentrated in thunderstorm downdrafts. Whole pollen is too large to penetrate deep into lung airways. But some thunderstorms can cause pollen to rupture, releasing large numbers of sub-pollen particles (SPPs) of sub-micron sizes, which can be inhaled deep into the lungs. The SPPs are concentrated at cloud level then transported to ground level by cold downdrafts or thunderstorm outflows, as diagramed in Figure 1 [3]. Suggested causes for pollen rupture include ageing (fragility), mechanical friction and lightning activity within thunderstorm clouds, as well as water-induced swelling or humidity-induced rupture, the potential mechanism cited most frequently.

A new model of pollen behavior

In 2019, a team led by Emmerson, introduced the Victorian Grass Pollen Emission Module (VGPEM1.0) [4], a representation of grass pollen in a three-dimensional dispersion model and the first model of its kind for Australia. The model was designed to be part of the Australian Bureau of Meterology's pilot forecasting system. In addition, Emmerson and colleagues have used the VGPEM to study mechanisms that may be responsible for TA events. An April 2021 paper published in *PLOS ONE* [3] presented their recent findings, which *9News* indicated is the combined work of the CSIRO, the Bureau of Meteorology and researchers from the University of Melbourne, the University of Tasmania and the Environment Protection Authority.

Unexpected findings; Further questions

Notably, the 2021 paper indicated that high humidity was not a useful predictor of TA events. "Conditions of high humidity, a measure of how much water is in the atmosphere, occurred almost every evening—not what you want from a warning system predicting a relatively rare event," Emmerson told *Live Science*.

To study other atmospheric conditions that could cause TA events, the team used the 2016 data and designed models of pollen rupturing. They also conducted lab studies that exposed pollen grains to wind gusts and electrical pulses. Results showed several factors cause pollen rupturing including strong winds, lightning strikes and the build-up and discharge of static electricity brought on by low humidity.

Lightning was the only mechanism to generate a pattern [in sub-pollen particles] that followed the path of the 2016 storm. However, limited lightning struck within Melbourne, where most of the asthma attacks occurred. Therefore, while there appears to be some relationship between the lightning strikes and asthma attacks, the correlation is not ideal.

"None of the tested processes completely satisfied our requirements for a warning system," meaning none stood up as a wholly reliable signal for forecasting thunderstorm asthma events, Emmerson explained to *Live Science*. "We haven't fully cracked the code on the triggers of thunderstorm asthma yet."

Lanese explained that Emmerson and her team "plan to improve upon their current model, in part by better estimating the amount of whole and burst pollen grains higher in the atmosphere, close to the clouds. For now, they believe the best approach for predicting TA events is to monitor for thunderstorms associated with severe wind gusts while also tracking levels of unburst grass pollen in the air."

The *PLOS ONE* article also identified additional areas for study including:

- very high-resolution modeling to simulate the interaction of pollen with the atmospheric boundary layer
- in-cloud processes and potential mechanisms for pollen rupture (shown in Figure 1)
- the number of SPPs required to produce an asthma response
- the lifecycle of an SPP, which increases allergenic properties

Emmerson also mentioned new and promising research that suggests that a thunderstorm itself does not need to be present to cause epidemic asthma, only evidence of strong atmospheric convergence.

References

Content for this article was based on and excerpted from:

1. New Australian study sheds light on cause of Melbourne's deadly 2016 thunderstorm asthma event. Pearce, Lara. 9News. April 16, 2021. www.9news.com.au/national/melbourne-2016-thunderstorm-asthma-deaths-not-caused-by-rain-but-by-lightning-new-csiro-study-suggests/ca60486e-3011-4738-92ec-ea3bcb23af05.

2. Scientists probe mystery of "thunderstorm asthma" event that sent thousands to the ER. Lanese, Nicoletta. Live Science. April 19, 2021. www.livescience.com/thunderstorm-asthma-melbourne-model.html.

3. Emmerson KM, Silver JD, Thatcher M, Wain A, Jones PJ,

Dowdy A, Newbigin EJ, Picking BW, Choi J, Ebert, E, Bannister T. Atmospheric modelling of grass pollen rupturing mechanisms for thunderstorm asthma prediction. PLOS ONE 16(4): e0249488, 2021. https://doi.org/10.1371/journal.pone.0249488.

4. Emmerson KM, Silver JD, Newbigin E, Lampugnani ER, Suphioglu C, Wain A and Ebert, E. Development and evaluation of pollen source methodologies for the Victorian Grass Pollen Emissions Module VGPEM1.0. Geoscientific Model Development 12: 2195-2214, 2019. www.geosci-model-dev.net/12/2195/2019.