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Can we improve pollen season definitions by using the symptom load index in addition to pollen counts?

Katharina Bastl [a,*], Maximilian Kmenta [a,b], Carmi Geller-Bernstein [c], Uwe Berger [a], Siegfried Jäger [a,1]

[a] University Department of Ear, Nose and Throat Diseases, Medizinische Universität Wien, Austria
[b] Department for Paleontology, Universität Wien, Austria
[c] Zabludowicz Center for Autoimmune Diseases, Sheba Medical Center, Tel-Hashomer, Israel

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ABSTRACT

Airborne pollen measurements are the foundation of aerobiological research and provide essential raw data for various disciplines. Pollen itself should be considered a relevant factor in air quality. Symptom data shed light on the relationship of pollen allergy and pollination. The aim of this study is to assess the spatial variation of local, regional and national symptom datasets. Ten pollen season definitions are used to calculate the symptom load index for the birch and grass pollen seasons (2013–2014) in Austria. (1) Local, (2) regional and (3) national symptom datasets are used to examine spatial variations and a consistent pattern was found. In conclusion, national datasets are suitable for first insights where no sufficient local or regional dataset is available and season definitions based on percentages provide a practical solution, as they can be applied in regions with different pollen loads and produce more constant results.

1. Introduction

Allergies occur when the immune system overreacts to a foreign substance such as pollen grains, mould spores, food, house dust, bee venom or pet dander and concern both developed and developing countries. The immune system produces substances known as antibodies. Some of these antibodies protect from unwanted invaders that could cause an infection. In the case of allergies, the immune system produces antibodies that identify a particular allergen as something harmful, even though it is not. When an allergic person comes in contact with the allergen, the immune system's reaction inflames the skin, sinuses, airways or the digestive system (e.g. Rusznak and Davies, 1998). The severity of allergies varies from person to person and can range from minor irritation to anaphylaxis – a potentially life-threatening emergency. While allergies cannot be cured, a number of treatments can relieve allergy symptoms. The most common symptoms of respiratory allergies are allergic rhinitis, asthma, allergic conjunctivitis and also skin eruptions. The antibodies involved in respiratory allergies are induced by environmental airborne particles that contain the respective antigens. These atmospheric particles can be of different origins and prevalence: house dust mites, cockroaches and moulds mainly indoors and pollen and fungal spores outdoors. The Austrian Society of Allergology and Immunology (Pawankar et al., 2011) still reports an increase in allergic rhinitis, asthma and food allergy and the increasing trend is globally not an exception (see also Bergmann, 2014), so allergies are a serious health problem. Information on allergy and the current status as well as recommendations are summarised in Pawankar et al. (2011).

Out of the 250,000 well-described pollen-producing species, less than 100 are significant in terms of pollen allergy (Thommen, 1930, Gregory, 1961; Accorsi et al., 1991; D'Amato et al., 1998). In order to be allergenic, pollen (1) must contain antigens able to elicit a specific IgE-mediated response in allergic subjects, (2) have been produced in high quantities, (3) be buoyant enough to be carried over long distances, and (4) should be produced by plants that grow in abundance in the region of interest. Most allergenic plants are wind pollinated and therefore produce pollen in high quantities (e.g. birch trees and grasses). Furthermore,

Abbreviations: EAN, European Aeroallergen Network; PHD, Patient's Hayfever Diary; SLI, Symptom load index.

* Corresponding author.
E-mail address: katharina.bastl@meduniwien.ac.at (K. Bastl).
[1] Deceased author.

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the allergenicity of pollen is influenced by climate, humidity, temperature and air pollution (e.g. D'Amato et al., 2001; Sofiev and Bergmann, 2013). Indoor and outdoor pollution is associated with the onset of allergy symptoms and allergic diseases as well as an increase in drug use and hospital admissions for respiratory symptoms (Pawankar et al., 2011). The World Allergy Association (Pawankar et al., 2011) recommends abatement of the main risk factors, among which are outdoor air pollution, in order to achieve health benefits globally. Pollen, as “green pollutants”, is an important component in the air and pollen counts above a certain level should be regarded as an assessment for air quality besides carbon dioxide, sulphate, diesel particulate matters, ozone and others. Besides pollen monitoring and pollen counts, data on allergenicity and meteorological data are important for pollen information (e.g. Schäppi et al., 1998; Buters et al., 2010; Pauling et al., 2012; Sofiev and Bergmann, 2013).

Allergies have been referred to as epidemic of the 21st century (e.g. Bergmann, 2014) and have a considerable impact on society and the economy (Bousquet et al., 2011). Allergen avoidance is a crucial factor in allergy management and important pillar in the everyday life of pollen allergy sufferers (Schmid-Grendelmeier, 2012). For the sake of pollen allergy sufferers, the number of interdisciplinary approaches in the field grows and thus there is a trend towards clinical studies including information on the pollen season and aerobiological studies including data on allergy symptoms. Symptom data gathered via crowdsourcing has become important for the latter. These datasets rely on the data entry of users (pollen allergy sufferers) on a voluntary basis. A couple of studies recently processed such symptom datasets to gain insight into the relationship of pollination and allergic symptoms or the structure of the symptom data itself (Voukantsis et al., 2013; Bastl et al., 2014; Karatzas et al., 2014; Kmenta et al., 2014). The source of a large number of available symptom datasets is now most commonly an online tool, like the pollen diary (Patient's Hayfever Diary, PHD; www.pollendiary.com). The symptom load index (SLI) was developed to simplify visualisation of the symptom load in a defined time period for a defined region or population (Bastl et al., 2014). Thus, the SLI can be applied to any pollen season in any place where datasets are available and spatiotemporal definitions are known. Two concerns arise when the symptom load is discussed: 1) is it practical to use national datasets in comparison to regional or even local datasets? How large is the spatial variation of those datasets? 2) How does the definition of the pollen season influence the SLI outcome and can we improve season definitions by such a comparison? Which pollen season definition can be recommended for clinical studies and research focussing on symptom data?

Both questions have not yet been addressed in detail. Besides the pure number of datasets that might plead for the decision of a national rather than a regional dataset, whether differences between those can be detected (e.g. for a region with high user numbers like Austria) was never examined. In addition, we included a local dataset, which has never been done before to seek answers for those crucial questions.

Pollen seasons can be defined in many different ways. Most often, different pollen counts (pollen grains per m^3 air) are chosen to define the start or end of a pollen season. These pollen counts or thresholds are still discussed. However, it is critical to come to an agreement, as the definition of the pollen season is the foundation for clinical trials, allergological research and pollination period descriptions. As a case study, we decided to apply ten pollen season definitions to the birch and the grass pollen seasons, because grass and birch pollen allergy are the most common pollen allergies in Eastern Austria (52.9% grass pollen allergy; 41.7% birch pollen allergy; Hemmer et al., 2010).

2. Material and methods

For the SLI calculations, we requested symptom data from the Patient's Hayfever Diary (PHD). It is an online free web-based tool that is also available as a “pollen” app in Austria (Kmenta et al., 2014). Several studies have already used this database as a source (e.g. Voukantsis et al., 2013; Bastl et al., 2014; Karatzas et al., 2014; Kmenta et al., 2014). The symptom data set is based on crowdsourcing and voluntary participation of persons concerned with allergic problems. In general, crowdsourcing relies on collective intelligence (Lévy, 1997) and was enabled by information and communication technologies. Benefits and limitations of crowdsourcing are reviewed in Aitamurto and Leiponen (2011).

A questionnaire asks for severity and specific symptoms per organ (eyes, nose and lungs). In addition, location and medication use are requested. The high user numbers, especially in Austria, make it the perfect source with which to perform a case study on the dependency of symptom load calculations on pollen season definitions. Datasets requested included a local dataset (users only from Vienna), a regional dataset (users from the region Eastern Austria) and a national dataset (all users from Austria) for the years 2013 and 2014. Those recent years were preferred because they have the highest user numbers. In addition, we wish to compare them to pollen seasons from different years, because the annual variation of impact on pollen allergy sufferers is known (Bastl et al., 2014). SLIs were calculated as described in Bastl et al. (2014). Therefore, the symptom data were normalised to attain numbers between 0 and 10. This index takes into account all available daily symptom data and thus includes symptoms of the organs eyes, nose and lungs as well as medication use. As the SLI is an average of all active PHD users (e.g. of a population in a certain region) extreme values are not realistic. The SLI for a specific season is then calculated as the average for a defined period. The defined periods are described below. We used the most common and widespread pollen season definitions as well as recently discussed definitions.

We tested the definitions of EAN, the AIT trial (TF “Thresholds”, 2014) and additional definitions that are commonly used for Austria based on specific pollen counts. On the whole, we tested ten different pollen season definitions for the birch and grass pollen seasons in 2013 and 2014 in Vienna. The pollen season definitions are listed and explained in detail in the following.

1) Start at the day with 1% of the total annual pollen count and end at the day of 95% of the total pollen annual pollen count. This is the EAN standard season definition.
2) Start at the day with 5% of the total annual pollen count and end at the day of 95% of the total pollen annual pollen count. This definition is readily available in EAN for the principal pollination period.
3) Start at the first day of a sequence of 3 days with at least 5 pollen/m^3 and end at the last day of such a sequences. This definition is discussed by the TF “Thresholds” (TF “Thresholds”, 2014; “option 1”).
4) Start at the first day of a sequence of 3 days with at least 10 pollen/m^3 and end at the last day of such a sequence. This definition is discussed by the TF “Thresholds” (TF “Thresholds”, 2014; “option 2”).
5) Start at the first day of a sequence of 7 days with at least two occurrences of 5 pollen/m^3 or more, end at last day of such a sequence. This definition is discussed by the TF “Thresholds” (TF “Thresholds”, 2014; “option 3”).
6) Start at the first day of a sequence of 7 days with at least two occurrences of 10 pollen/m^3 or more, end at the last day of