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Potential health risk of allergenic pollen with climate change associated spreading capacity: Ragweed and olive sensitization in two German federal states

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ABSTRACT

Background: Global climate changes may influence the geographical spread of allergenic plants thus causing new allergen challenges.
Objective: Allergy patients from two German federal states were compared for their status quo sensitization to ragweed, an establishing allergen, olive, a non-established allergen, and the native allergens birch, mugwort, and ash.
Methods: Between 2011 and 2013, 476 adult allergy patients per region were recruited. Patients completed a questionnaire, participated in a medical interview, and underwent skin prick testing and blood withdrawal for analysis of specific IgE to allergen components (ISAC technology). Data on regional pollen load from 2006 to 2011 were acquired from the German Pollen Information Service Foundation.
Results: Prick test reactivity to ragweed and ash, respectively, was lower in Bavaria than in NRW (ragweed: $p = 0.001$, aOR = 0.54; ash: $p = 0.001$, aOR = 0.59), whereas prick test reactivity to olive was higher ($p = 0.000$, aOR = 3.09). Prick test reactivity to birch and mugwort, respectively, did not significantly differ. 1% (1/127) of patients with prick test reactivity to ragweed showed sIgE to Amb a 1, and 65% (86/132) of olive-but-not-ash reactive patients showed sIgE to Ole e 1 (NRW: 67%, Bavaria: 65%; $p = 0.823$, OR = 0.91). Regional differences in sensitization pattern were neither explainable by cross-reactivity to pollen pan-allergens nor non-exposure variables nor by reported plant population or pollen data.
Conclusions: Spread of ragweed and particularly olive may result in prompt occurrence of allergic symptoms. Early identification of invasive allergens due to climate change does need time and spatial close meshed measurement of respective indicator allergens and sensitization pattern.

Abbreviations: CO_2, carbon dioxide; NRW, North Rhine-Westphalia; IgE, immunoglobulin E; sIgE, specific IgE; DEGS1, first wave of the German Health and Interview Survey for Adults; UBA, German Federal Environment Agency; GA^{2}LEN, Global Allergy and Asthma European Network; SBE, standardized biological units; IR, index of reactivity; G/V, weight/volume; ISAC, Immuno Solid-phase Allergen Chip; ISU, ISAC-standardized units; n.a., not analyzed; n/a, not applicable; PID, German Pollen Information Service Foundation; CASMIN, Comparative Analysis of Social Mobility in Industrial Nations; OR, odd's ratio; CI, confidence interval; min, minimum; max, maximum.

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1. Introduction

Pollen allergens are one of the main triggers of respiratory allergies, the latter being an increasing health problem worldwide (Beasley et al., 1998; Burney, 1996; Eder et al., 2006; Pearce et al., 2000). In Germany, currently 34% of adults are sensitized to inhalant allergens, and 15% and 9% suffer from hay fever and accordingly asthma at least once in their life (Langen et al., 2013). In children, 41% are sensitized to at least one of 20 tested allergens, and 11% and 5% suffer from hay fever and accordingly asthma at least once in their life (Schlaud et al., 2007). Allergic patients may have to face a progressive course of the disease and suffer from high psychological strain. Health care costs of allergic diseases are immense: in Germany, the total health care costs associated with asthma in the year 2008 were as high as 1.8 billion Euro (The Information System of the German Federal Health Monitoring, 2014).

Global climate changes, amongst other factors, have been discussed to play a role especially in the development of pollen-associated respiratory allergies (Beggs and Bambrick, 2005; Behrendt and Ring, 2012). Experimental and association studies have demonstrated a correlation between CO_2 and temperature, respectively, and pollen concentration or biomass production by allergenic plants (Kim et al., 2011; Negrini et al., 2011; Sicard et al., 2012; Song et al., 2012; Ziello et al., 2012; Ziska et al., 2003). An increase in pollen concentration may lead to an increase in allergic sensitization and/or severity of allergic respiratory symptoms (Breton et al., 2006; Innes Asher et al., 2010; Jäger, 2000; Kim et al., 2011). Furthermore, the geographical spread of allergenic plants might change, and this might cause new allergen challenges (Behrendt and Ring, 2012).

This study aimed at analyzing the status quo sensitization to potentially new allergens in two German federal states with different climatic conditions. Concretely, allergy patients from North Rhine-Westphalia (NRW) and Bavaria should be compared for their sensitization to ragweed, an establishing allergen, and olive, a non-established allergen. The native allergens birch, mugwort, and ash should serve as controls.

Ragweed, also referred to as common ragweed and scientifically named *Ambrosia artemisiifolia*, is an invasive plant from North America, which has spread across Europe especially in warmer climates (Starfinger, 2007). The spread of ragweed is caused by anthropogenic activities, but climate change has been discussed to promote this process (Karrer, 2014; Starfinger, 2007). In Germany, ragweed has been found to be growing wild for the last 150 years (Starfinger, 2007). Currently, in both NRW and Bavaria, ragweed is listed as an invasive plant (Botanical State Collection Munich and SNSB IT Center, 2015; North Rhine Westphalia State Environment Agency, 2014a). In 2012, Bavaria documented a higher number of ragweed crops than NRW (Bavarian State Ministry for the Environment and Health, 2013; North Rhine Westphalia State Environment Agency, 2014b). In Germany, currently 8% of adults have IgE to allergen extract from ragweed pollen, and 0.4% are positive for IgE to Amb a 1, the major allergen component of ragweed pollen (Haftenberger et al., 2013). Prick test data on adult allergy patients (study centres: Berlin and Munich) showed sensitization to allergen extract in 14% of patients (Heinzerling et al., 2009). Ragweed pollen is highly allergenic, thus ten pollen grains are efficient to induce nasal symptoms in adult patients with allergic rhinitis (Bergmann et al., 2008).

Olive (*Olea europaea*) is found in all areas around the Mediterranean Sea and partly also around the Black Sea. In Europe, the northernmost tree population with more than 170 trees existed in Cologne, NRW, but due to the cold winters of 2009 and 2010, the plantation had to be given up (Olive E and Più Marzak KG, 2014). At present, field-grown olive is not established in Germany. However, in summer olive can be found as potted plant in cafeterias, restaurants, and balconies. Olive pollen represents a main cause for allergic respiratory problems in Mediterranean countries (Palomares et al., 2006; Villalba et al., 2014). In Germany, population based data on olive sensitization do not exist. Prick test data on adult allergy patients (study centres: Berlin and Munich) showed sensitization to allergen extract from olive pollen in 10% of patients (Heinzerling et al., 2009). These data, however, have been discussed to result from cross sensitization to ash (*Fraxinus excelsior*), a tree established in the temperate zones of Europe (Heinzerling et al., 2009; Palomares et al., 2006), as the major allergen component of olive, Ole e 1, has a homologous counterpart in Fra e 1, the major allergen component of ash (Palomares et al., 2006; Barderas et al., 2005).

NRW, geographically located in the west of Germany and the most populous federal state, is situated in the warm temperate climate zone of Europe with mainly maritime climate composed of relatively cool summers, mild winters and high atmospheric humidity. Bavaria, located in the southeast of Germany and the second most populous federal state, is situated in the transient region between the maritime climate of Western Europe and the continental climate of Eastern Europe. The latter is characterized by hot summers, cold winters and low atmospheric humidity (Bavarian Environment Agency, 2014). Specific data on climate details of both states are provided by the German Weather Service (German Weather Service, 2014).

The study should answer the following questions:

1. Do the two federal states differ with respect to sensitization to the mentioned inhalant allergens? If so, are these differences caused by pollen pan-allergens or non-exposure variables, or can these differences be related to the exposure variables plant population or pollen load?
2. What can be learned from these data with respect to necessary adaption measures to climate change?

2. Methods

2.1. Patients

476 patients from each state were included in the study. In NRW, the study was conducted at the Department of Dermatology and Allergology of the University Hospital of Aachen. In Bavaria, the Department of Otorhinolaryngology, Klinikum rechts der Isar, Technical University Munich, was responsible. The study was approved beforehand by the institutional review boards of both participating centres.

The patient number resulted from expected Amb a 1-sensitization rates of 1% in NRW and 4% in Bavaria which would have been significant with 476 patients in each state (Fisher's exact test, $p < 0.05$, power 0.8). Expected sensitization rates of 1 and 4%, respectively, were deviated from data on sensitization rates in school children from Baden-Württemberg (Baden-Württemberg Health Authority, 2008/9).

Recruitment occurred continually from spring 2011 to summer 2013. To become included, patients had to fulfil the following criteria: (i) age between 20 and 65 years, (ii) principal residence in NRW and accordingly Bavaria for the last 20 years, (iii) at least two of the symptoms of the upper respiratory tract put in parenthesis (sneeze, itchiness, running nose, itching eyes, obstructed nose, retronasal flow of mucus, cough, asthmatic attacks, affinity to infections, seasonal accumulation of symptoms).

Patients filled in a questionnaire, participated in a medical interview, and underwent skin prick testing as well as blood withdrawal for analysis of serum sIgE levels.