



The medical and scientific responsibility of pollen information services

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Received: 29 June 2016 / Accepted: 14 September 2016 / Published online: 19 October 2016
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Summary Pollen information as such is highly valuable and was considered so far as a self-evident good free for the public. The foundation for reliable and serious pollen information is the careful, scientific evaluation of pollen content in the air. However, it is essential to state and define now the requirements for pollen data and qualifications needed for institutions working with pollen data in the light of technical developments such as automated pollen counting and various political interests in aerobiology including attempts to finally acknowledge pollen and spores as relevant biological particles in the air worth being considered for pollution and health directives. It has to be emphasized that inadequate pollen forecasts are a considerable health risk for pollen allergy sufferers. Therefore, the responsibility of institutions involved in pollen monitoring and forecasting is high and should be substantiated with respective qualifications and know-how. We suggest here for the first time a portfolio of quality criteria and demand rigorous scientific monitoring and certification of such institutions in the interest and for the protection of persons affected by a pollen allergy.

Keywords Pollen measurements · Pollen data · Pollen information services · Patient's hayfever diary · Pollen allergy

Introduction

Pollen allergies are a global health concern [28] and a widely acknowledged disease affecting a considerable fraction of the population in various countries [1, 7, 10], including Austria [15] and Germany [6]. Pollen information/forecasts have been proven to be a highly valuable tool for allergen avoidance as well as for handling and treating pollen allergies [21, 33].

Various communication media should disseminate pollen forecasts as a source of information in order to reach a large audience. Mobile Health (mHealth) using mobile technology (smart phones, tablets, any wireless devices) has become increasingly important in recent years to accomplish this task. Meanwhile, the range of mobile applications is complex and users of pollen information applications might not be capable to discern between useful apps containing pollen forecasts based on scientific data and applications disseminating completely wrong pollen information with obviously hardly any source of botanical/aerobiological information. Considering the importance of reliable pollen forecasting, it is necessary to define parameters of good scientific practice for ascertained pollen data and pollen forecasting, which we hereby propose.

Pollen information is consumed more often during the pollen season [22], which underlines its importance to the public. Pollen forecasts can not be compared with weather forecasts because the forecasting activities are more complex and require more sources of information than weather parameters alone. Inadequate pollen information can severely harm those affected with pollen allergies. Special attention should be paid here to the intake of medication that is not indicated medically and related side effects that could occur or medically recommended medication is not taken in a timely manner, which would augment the

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level of suffering. Insufficient dosing or overdosing can be a consequence of inadequate pollen forecasts. Therefore, it is important to recognize institutions that are capable of disseminating reliable pollen information and also independent in terms of conflicts of interest. A company earning money from, for example, selling medication is not in an objective position to distribute pollen information. A controlling institution would be desirable to change the situation in order not to mislead pollen allergy sufferers.

Pitfalls for pollen information by means of automated pollen counting

It is not acceptable to use misinterpreted data for pollen information or to disseminate pollen information without relevant data sources. Pitfalls comprise—besides missing or wrong data—(1) lack of experience in pollen forecasting, (2) minor botanical knowledge including the lack of phenological routines, and (3) no contact with pollen allergic patients. As an example of these pitfalls we elucidate problems with automated pollen counting developed so far.

Pollen data are a fundamental dataset for reliable pollen forecasts. There are new approaches for pollen counting, which are not suitable for pollen forecasting so far since these systems can not be compared to established methods and have to be validated in the long term. However, those ongoing developments in the field make it necessary to discuss recent technological developments here. There are a fair number of studies about the detection of pollen grains via imaging using an automated pollen counting system [17, 18, 24, 25, 27]. Pollen detection systems can be based on models [29], color and shape information [24] or pollen spectra by Fourier transform infrared spectroscopy [17], time-resolved scattering and fluorescence [8] and many more (like fluorescence microscopy, flow cytometry, photoacoustic microscopy, fluorescence spectroscopy, laser ablation mass spectrometry or Raman microscopy; see [18]). So far, precision rates of automated pollen counting systems range from 61 % (with 86 % detection [24]), 83 % [29], 83 % (grass pollen [8]), 84 % [32] to more than 90 % [19] such as 93.3 % of known pollen (only 72.2 % of the total amount with an increasing rate by only 7 % in three years [27]), but do not reach the postulated minimum precision rate of 95 % [18]. A precision rate of 95 % is so far reached only by the Plair PA-300, but only for the total pollen amount, not for separate pollen types such as grass pollen [8]. Human pollen counters in Austria count on average 65 pollen types and at least 40 pollen types are required for a broad application [36], whereas automated pollen counts comprise only one [25, 32], a couple [17, 19, 29] to a maximum of 26 taxa [31].

The dependence of the software is critical for these approaches and changes will lead to incomparable results and thus incomparable pollen data. The same

applies to the “hardware” that will have to be exchanged after several years and may show a different performance than the previous “hardware” settings. Furthermore, the learning process of some machines is again dependent on humans and/or validated with a Hirst-type trap nearby and thus not more “objective” than human pollen counters. The same reference images and reference library is a prerequisite for the comparability of pollen counts that are performed by machines [18], which do not take into account that pollen from different regions may have a different appearance [9, 11]. Up to now, unidentified pollen grains have to be identified and counted by human pollen counters in addition for most automated techniques. It is worth mentioning that the same discussion takes place in different scientific fields, e. g., stereoscope microscopy performed by a human counter assessing the 3D shape of features vs. microwave texture analysis with automatic analysis of features based on 2D imaging with comparable problems [34]: results of the automated method do only persist as long as the same surface/spot is scanned.

Summarizing, the major pitfalls of automated pollen counting consist of (1) still too low precision rates in the identification of specific pollen types not reaching even the minimum of 95 % [18], (2) the very limited pollen type range assessed, (3) incomparability of datasets due to updates of the software/exchange of hardware, (4) efforts to build comparison databases that are dependent on humans again, and (5) inflexibility to react to ongoing changes in the pollen spectrum or special conditions (clumped or fragmented pollen grains). Those problems should not be underestimated and show that pollen data generated by automated pollen counting samplers so far are not suitable for output that addresses pollen allergic patients. The reliability of any method—automated or not—has to be proven and validated before it is used for any purposes affecting pollen allergy sufferers and their state of health.

Requirements for pollen information services

The state-of-the-art monitoring uses Hirst-type pollen traps [16] that are the most commonly used pollen samplers in Europe and evaluated by human pollen counters. This type of trap sucks in 10 l/min continuously which corresponds to the average human lung flow and therefore directly refers to the amount breathed in by humans. The trap has to be located on a flat roof in 10–20 meters height to cover a region and not the local pollen loads only. It is still examined if and how pollen concentrations differ between ground level and rooftop level (very different: [30]; not much different: [13]). Pollen information networks use this data as the basis for pollen forecasts in Europe. Minimum requirements and recommendations have been published [14] including a documentation of inter- and intra-observer error for human pollen

counters. Recently, evidence was found for a deviation functioning in those traps due to airflow errors produced by flowmeters [26]. Those issues have to be solved by the manufacturers of these pollen samplers in the future. Nonetheless, the advantages of Hirst-type pollen traps are up to now unsurpassed: (1) long-term experience and standard operating device in aerobiology in Europe, (2) continuous volumetric functioning with by-hourly resolution in contrast to, for example, other long known traps such as Rotorod, (3) robust technology in contrast to new systems in development which are critically dependent on software, (4) archiving of sample slides (possible only for some of the automated methods), (5) availability of long-term datasets, (6) financing (monitoring by Hirst-type trap is unequally cheaper), (7) awareness of changes in the pollen spectrum (new pollen types, unusual morphology of pollen, etc.), and (8) large numbers of pollen types assessed. As pollen data are one of the prerequisites, we want to specify here the requirements for such datasets. Those comprise (1) continuous monitoring, (2) evaluation/supervision by trained personnel, (3) repeatability, and (4) reproducibility. For the state-of-the-art pollen monitoring criteria and limits of these monitoring procedures are well defined and based on minimum requirements to ensure quality of pollen data and comparability between sites and countries [14, 20].

However, pollen data alone do not guarantee or enable the capability to reliably forecast pollen. It is necessary to possess a number of knowledge sources for this purpose. Biogeography of the region/country of interest must be well known. Geography, climate, and other factors play an important role in determining distribution of a species. The region of interest for pollen information must be divided in its biogeographical regions that differ from each other concerning the distribution of the vegetation. The different vegetation patterns will also be reflected in the pollen loads. More than one trap is required for each such region to guarantee continuous monitoring. As plants do not mind political borders, it is also necessary to seek co-operations with neighboring countries or on a broader scale. Most pollen monitoring stations in Europe take part in the European Aeroallergen Network (EAN; www.ean-net.org), which pools pollen data from Hirst-type pollen traps adhering to the minimum requirements. Phenology documents the life history events of a plant [12]. In addition to pollen monitoring, phenological routines focus on the flowering of allergenic plants. Those observations are important as they give clues on the season progress (start, peak, and end) before it is recorded by pollen measurements and indicate events such as intensive flowering. Long-term series [12] and reference plants are of special interest for pollen forecasting. Forecast and pollen dispersal models are tools comparable to weather forecasting models in meteorology. The aim of pollen forecast models is to support the forecaster

in providing a reliable forecast. Start, peak, and end of the season as well as pollen concentration level are modeled. A number of such models exist and a complete list is not intended here. However, it should be noted that models such as SILAM and COSMO-ART are numerical simulations. SILAM is a numerical simulation of a large-scale atmospheric transport of allergenic pollen [35], at the moment available for the pollen types alder, birch, grasses, olive, mugwort, and ragweed. COSMO-ART is a numerical simulation of the dispersion of pollen grains [37] available for alder, birch, grasses, and ragweed. Models usually include information on forest inventories, a flowering model, climatological dataset, and reliable pollen data. The pollen forecast is improved with the aid of different flowering start/pollen dispersal models because they provide additional information, e. g., large-scale trends, air streams, and possible long-distant transport.

The quality of pollen forecasts is an important parameter for allergologists taking care of hay-fever and pollen asthmatic patients. A premature forecast announcing huge quantities of allergenic pollen can mislead the public and cause an unnecessary or overdosed medication intake. The use of anti-allergic tablets is entirely and frequently related to a risk of side effects especially concerning those relevant in traffic. Otherwise, wrong indications of a low pollination trigger symptoms that could have been avoided and a progress of the disease during the season like the transition from hay-fever to allergic asthma. Dissemination of pollen forecasts without medical-allergological expertise can thus not be accepted.

The importance of symptom data for the field of aerobiology and pollen forecasts is growing, as those datasets give a different view besides pollen data [4, 23]. Pollen allergy sufferers immediately react to their allergen and may experience a burden before first relevant pollen loads can be traced in the air. This may be related to the divergence in allergen release and pollen loads [2], a local phenomenon [3], psychological reasons due to the announcement of the pollen season, or other reasons. Symptom data are of high value for pollen forecasters as it shows the onset, progress, and end of allergic events that can be connected to the season progress, not to mention that those data are available in real-time. Weather services provide another source of necessary data, meteorological data. A trustworthy, independent meteorological institution is a precondition for a fruitful co-operation in order to come to reliable pollen forecasts. The meteorological forecast itself has to be as accurate as possible to allow an accurate pollen forecast. However, weather data alone can never lead to a pollen forecast or be the major source for a pollen forecast.

The last ingredient for reliable pollen information is the forecast expertise. Up to now, there is no training for pollen forecasting and persons responsible have

different backgrounds throughout Europe including biology, botany, pharmacy, medicine, ecology, meteorology, or others. This diversity is welcome in the first place as it shows and promotes the interdisciplinary nature of this field. The lack of standards for pollen forecasting should not be neglected because it makes it difficult to compare forecasts between countries. However, different “thresholds” or levels for pollen concentrations make sense for different regions. Therefore, we conclude here that forecast expertise has to be proven in the light of a common agreement and the crucial importance of the forecast expertise. Such proof could be an evaluation of the accuracy of forecasts, evaluation of symptom, pollen and model data, a training over years by supervision of an expert forecaster and botanical knowledge of the concerned region.

A reliable, scientific-based pollen forecast must be based on (1) scientific, high quality pollen data as defined above on local, regional, and national scale with at least two pollen traps per biogeographical region, (2) phenology (regular phenological monitoring of the local and regional vegetation), (3) a number of forecast models with national and international scope to assess long range transport, (4) medical-allergological expertise including contact with pollen allergic patients to perceive the symptom burden and medication influence, (5) access to symptom data (via a symptom diary like the PHD or the “Pollen” app [4, 5, 23]), (6) co-operations with acknowledged meteorological institutions for high-quality weather data, and (7) expertise to forecast pollen loads. Only independent, nonprofit institutions with medical, aerobiological, and botanical competence collecting the required data and performing routine work in pollen monitoring are capable to disseminate scientific pollen information. It is within the medical and scientific responsibility of institutions to be sensible of this responsibility and not to risk the well-being of pollen allergy sufferers. Thus, we demand the continued use of traditional, state-of-the-art pollen monitoring with Hirst-type pollen traps and recommend institutions, e.g., entrusted with pollen forecasting, to fulfill the requirements set up here to receive permission to work in this field. Pollen forecasts and related services should never be a business, but a mission.

Conclusion

Scientific and medical responsibility requires strict compliance to proven procedures including the completeness and reliability of all necessary data sources (e.g., pollen and meteorological data), the high quality of these data, the careful handling of results of forecast models, the know-how for routine work like phenological monitoring, the contact to pollen allergic patients and the expertise for pollen forecasts. Pollen information has to be based on long-term series, scientific data, pollen calendars, and has to be

disseminated only by institutions that have no conflicts of interest. Financial interests or inadequate pollen forecasts must never risk the health state of pollen allergy sufferers. Pollen information based on unreliable datasets can be considered as physical injury and must be avoided by all means possible.

Acknowledgements We thank an anonymous reviewer for his/her careful review.

Conflict of interest K. Bastl, K.-C. Bergmann, M. Kmenta and U. Berger report to have taken part in the development of the app “Pollen” that is freely available and without advertisement and thus of no financial interest. M. Berger declares that he has no competing interests.

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