

One Health in allergology: A concept that connects humans, animals, plants, and the environment

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One Health is “a collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals, and the environment”, the so-called One Health triad¹ (Figure 1). Historically, aspects of One Health were already discussed in the fourth century by Hippocrates, who realized that a clean environment is very important for human health.¹ More recently, Rudolf Virchow (1821–1902) coined the term “zoonosis” in 1880 and fathered modern One Health in the sense of One Medicine by strongly supporting the view of human and animal health being linked to each other.¹

Amuasi et al² even propose that the One Health policy is vital to ensure health of and on the planet, and avoid future catastrophes: “One Health, which recognizes the fundamental interconnectedness of humans, animals, and their shared environment, is key to ensuring the healthy and sustainable future of the planet.”

Prestigiously, WHO has also taken up the One Health idea, concentrating on food safety, combatting antibiotic resistance, and controlling zoonoses, all for achieving better public health outcomes.³ One Health thus is a timely concept in terms of the current COVID-19 pandemic, considering the interspecies viral transmission (Pali-Schöll et al, EAACI Position Paper in revision).

The importance of the One Health concept has also been acknowledged by the opinion leaders of the European Academy of Allergy and Clinical Immunology (EAACI), who joined into the One Health Summit Strategic Advisory Group of the Global Risk Forum Davos in 2015 to prepare the implementation of this concept into the EAACI profile. With a strong foundation in the Working Group (WG) for Comparative and Veterinary Allergology, this focus led

to the foundation of an independent EAACI WG dedicated to One Health in 2021.⁴

A One Health approach is needed in allergology, as allergic diseases are found in human and non-human mammals alike,^{5–7} the prevalence of some of them still on the rise, and the diagnosis and treatment comparable in many cases.^{8,9} For all mammalian species affected by allergies, a plethora of common factors seems to be responsible for disease development, duration, and severity (Figure 1). Effects of the global warming, climate change, and air pollution have already become clear,¹⁰ among them, we find novel species of plants (eg, ragweed) and animals (eg, insects like *Polistes* spp.) in geographical regions where they have not been resident before. The early and prolonged blooming season due to increased temperature leads to higher and prolonged allergen exposure for patients, and allergenicity of molecules becomes more potent in combination with CO₂,¹¹ ozone,¹² or pollution contributing fine- and ultra-fine particles.¹³

Other factors studied individually, but less investigated in their interconnectedness within the One Health triad, are the environmental hygiene status (ie, meeting microbes, parasites, and dirty soil); body hygiene (shampoos, shaving, deodorants, perfumes, disinfectants, etc.); diet and food composition (dietary fiber, micronutrients); nutritional status (nutrient deficiencies); food processing (cooking, pasteurization, frying, etc.); microbiota (endogenous on skin and in gut; and exogenous on plants and in soil); pollution of water, air, and environment (eg, diesel-exhaust particles); medications like antibiotics or acid-suppressing drugs contributing to increased allergenicity of encountered proteins^{14,15}; and many more.

Abbreviations: BLG, beta-lactoglobulin; COVID, coronavirus disease; EAACI, European Academy of Allergy and Clinical Immunology; ENT, ear-nose-throat; WG, working group; WHO, World Health Organization.

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Factors influencing allergy in people and animals



FIGURE 1 The One Health concept includes all organic life on our planet, humans, animals, and plants, which are all exposed to global threats (bright blue circle). Climate change, pollution, industrial agriculture, and food processing impacts not only quality of life, but also public health. Allergists are aware that these factors also pose an enhanced risk for atopic diseases. Climate change and global warming lead to migration of plants, prolonged flowering seasons, and increased allergenicity, and enhances risk for allergy development and symptoms in animals and people. Welfare and health conditions of animals influence rate and state of their products like proteins in milk or dander, modulating their allergenicity. The living conditions (hygiene, urbanization) and feed of pets and farm animals shape the microbiome of animals and the environment, and subsequently the health of animal and owner. Processing changes allergenicity of food and feed allergens by influencing protein structure and ligand loading, for human and veterinary individuals alike. Pollution of water, soil or air affects allergenicity of proteins from environment, plants, and animals, as does depletion of nutrients/nutrient diversity in soil, which could render proteins in plants devoid of loading molecules, increasing their allergenicity. Many more of these factors may be intertwined. One Health has thus become a strategic program in WHO, and also recently a novel thematic program in EAACI

All of these factors may have a varying influence on development and outcome of allergic diseases. Therefore, to successfully combine them, a well-coordinated approach in humans and in animals is necessary.

How the One Health approach can be applied to allergy, is discussed here by lipocalins in cow's milk as example. Cow's milk can be allergenic, while raw milk protects against allergies.¹⁶ The major whey protein beta-lactoglobulin (BLG), a lipocalin, is a typical milk allergen (Bos d 5), but can also mediate immune resilience. Proteins of the lipocalin family are carrier molecules, for example, for iron-siderophore complexes, vitamins A and D, and zinc. It was shown that the loading of BLG with vitamins and iron complexes is decisive: When BLG shuttles ligands into immune cells, it causes immune-resilience, while uptake without ligands evokes a Th2-response *in vitro*, resulting in allergy in murine models.¹⁷⁻²² Moreover, symptom reduction could be achieved by consumption of loaded BLG in house dust-mite allergic²³ and birch pollen allergic patients.²⁴

Apart from this being an important immunological observation, following the One Health concept, we must scrutinize its systematic impact for humans and animals. The following questions emerge: Which factors during milk processing have an impact on the essential cargo and hence allergenicity? Does the feed of the cow relate to the loading of the protein? Can stress, disease, living/growing conditions, nutritional state of the animals or environmental conditions affect ligand availability and binding efficacy to BLG? How can we strategically communicate important findings to industry, politicians, vets, and breeders to improve husbandry conditions, food production procedures and thereby prevent allergies?

Many more One Health aspects and questions in the context of allergic diseases are still un-addressed:

- The "mini-farm effect" implies that keeping pets, especially dogs, who bring dirt and microbes into the home, can add to preventing

the development of allergy in children. In the One Health context we need to know: Does the hygiene status of the pet dog (de-worming, shampooing and thereby changing the skin microbiome) change the health status of the dog and subsequently also the allergy status of people in the household?

- Allergenic molecules are often carried along with (beneficial or disadvantageous) microbes, ligands, or particles. In the shared environment, does the soil- or the plant microbiome, where the allergens stem from, affect the prevalence of allergies?
- Allergens in pollen and plant food are often pathogenesis-related proteins, getting overexpressed during environmental stress or microbial threats. Does the pollution of air/soil/water or the climate change (temperature, humidity, flowering season) also impair ligand load to carrier molecules in plants?
- Do global warming, climate change, and urbanization affect stress and hormone levels of different species, possibly laying the basis for a decompensated, hyperreactive immune system?

In line with the WHO definition of One Health,³ to address these and upcoming questions in allergology, interdisciplinarity from a broad range of fields of expertise is required, including allergology and immunology, internal medicine, ENT, pediatrics, dermatology, nutrition/dietetics, ecology, biology, agriculture, veterinary medicine, aerobiology, microplastics, water ecology, and many more.

An interdisciplinary and holistic approach is required to prevent diseases like the allergy epidemic, natural catastrophes, and devastation of the planet Earth. This will only be possible by communicating, discussing, and acting according to the One Health concept in an interdisciplinary strategic attempt, including public and lay people, politicians and legislative, practitioners and scientists. One Health has thus not only become a strategic program in the WHO, but also recently a thematic program in EAACI.

CONFLICT OF INTEREST

Dr. Jensen-Jarolim and Dr. Roth-Walter are inventors of EP2894478; "LCN2 as a tool for allergy diagnostic and therapy," EP 14150965.3, Year: 01/2014; US 14/204,570, owned by Biomedical International R + D GmbH, Vienna, Austria. Dr. Jensen-Jarolim is shareholder in this company. Dr. Pali-Schöll has nothing to disclose.

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