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Integrated Pest Management (IPM) and One Health — a call for action to integrate

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One Health (OH) has gained considerable prominence since the beginning of the 21st century, among others, driven by the recent epidemics and the increasing importance of zoonotic diseases. Yet, despite the holistic and multidimensional nature of OH, to date, most emphasis has been on the interactions between animal and human health, with considerably less attention to environmental and plant health. However, there is growing evidence that the challenges of climate change, growing food and nutritional insecurity, and biodiversity loss can best be addressed within the context of the OH framework. Conceptionally, Integrated Pest Management (IPM) could perfectly fit into such an approach, but historically, IPM has been practiced very much in a compartmentalized manner. New approaches such as Regenerative Agriculture and Sustainable Intensification offer solutions to how to successfully embed IPM into a OH framework.

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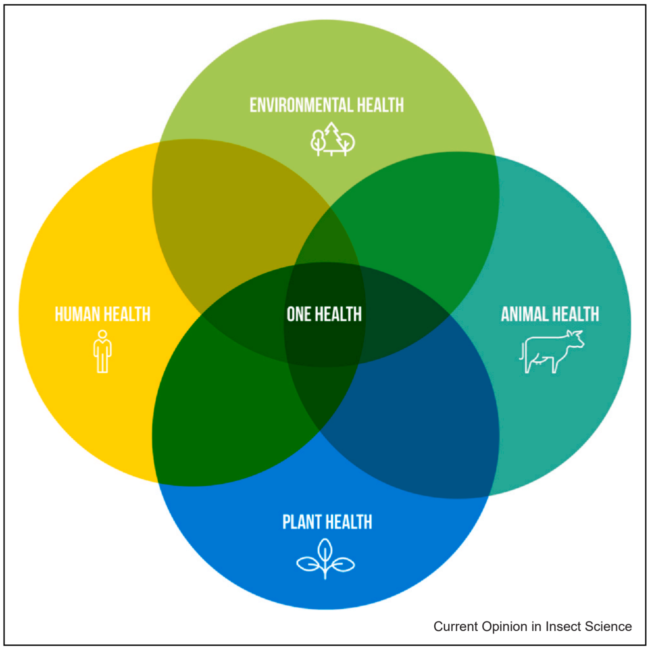
Introduction

One Health (OH) is a concept that has been introduced in the early 2000s and has been gaining popularity ever since. Global disease outbreaks such as severe acute respiratory disease, avian influenza, zika, and most recently COVID-19, have cemented OH in the policy agenda, accelerating various implementation initiatives across the globe. The OH concept is, however, not new but rather a rediscovery of the ancient idea of the interdependencies of human and animal health and their links to the health of ecosystems [1]. The classical depiction of OH consists of a triangle or triad of three interconnected circles, where the three pillars of OH are human, animal, and environmental health. Although plant health is explicitly mentioned in the definition of OH by the One Health Commission [2], it is traditionally not viewed as part of the triad of OH approaches [3••].

Because of its roots in veterinary medicine, the primary focus of the OH concept still lies with zoonotic diseases, seeking collaboration between human and veterinary medicine, along with their allied public health disciplines [4]. The integration of environmental sciences and ecology into OH revolves around the drivers of zoonotic disease spillovers, including land-use changes and biodiversity loss. Another key topic addressed by OH is antimicrobial resistance, where responsible use of therapeutics is required in the human and veterinary health sectors, as well as in agriculture [5]. A perspective on the latter is increasingly integrated into more contemporary OH concepts to strengthen the plant-health component within the traditional triad. This was spearheaded through the ‘Tripartite Agreement’, a collaboration between the World Health Organization, the World Animal Health Organization (WOAH, formerly OIE), and the Food and Agriculture Organization of the United Nations [6]. Finally, the most recent OH definition developed by the One Health High Level Expert Panel explicitly includes plants when laying out the aims of OH [7]. In this regard, the OH principle must recognize a 4 H paradigm by adding plant health to the triad. In fact, the “Berlin Principle of One Health”, adopted in 2019, fully acknowledges the interconnectedness and interdependence of human, animal, plant, and environmental health [8••] (Figure 1).

Indeed, the OH concept has not only gained significant global attention, but has also been expanded thematically. With the increasing number of disciplines and policy dialogs on OH, its focus is rapidly advancing with more emphasis on the role of the environment, ecosystems, and plants for well-being and disease prevention [8••,9••]. Climate-related disasters have major impacts on food and nutritional security and can contribute to biosecurity risks and disease outbreaks [10]. These subsequently jeopardize the stability of animal, plant, human, and environmental health. The accumulation of toxins and chemicals in the environment causes

Figure 1



Expanded One Health conceptualization. Addition of the plant-health sphere to the traditional One Health triad.

significant threats to human and animal populations, while simultaneously endangering the biodiversity and ecosystem integrity. Globally, consumers are encouraged to eat more fruits and vegetables, and consumption patterns are changing. Yet, this is associated with emerging pathogens in such fresh produces, highlighting the need for tackling food-safety issues within the context of OH [11]. For example, one of the top pathogens in leafy greens (cabbage, arugula, and kale) is Norovirus causing serious foodborne illnesses [12]. Hence, OH research into how agricultural practices influence pathogen transmission is urgently needed [11]. Moreover, five billion people in low- and middle-income countries are at risks of exposure to aflatoxins that originate from field- production practices and are exacerbated by insect pests during storage [13]. The inherent health consequences range from acute liver and kidney disease to liver cancer in humans and animals [13]. The concept of Integrated Pest Management (IPM) can tackle these issues and should be a central element in the OH framework. Clearly, IPM can be evaluated from an OH perspective, assessing the direct and indirect effects along the proposed four OH dimensions. However, IPM can also be conceptualized and planned as an OH intervention, where the interactions between different plant species, livestock, arthropods, and humans are optimized to achieve healthy plants, animals, and humans. In fact, food and health systems will be considered resilient within the context of OH if they can withstand shocks from pest and diseases, or rapidly bounce back from epidemics or extreme weather events, and IPM should be central to such dynamics.

A systematic literature review using the terms “One Health and Integrated Pest Management” yielded only six results, none of which explicitly integrate OH and IPM. Owing to the paucity of studies within this domain, it is necessary to illustrate the existing interactions between IPM and the individual OH dimensions and briefly reflect on their possible integration.

The original concept of IPM was very much aligned with a contemporary OH philosophy. In the late 1950s, Stern et al. [14] underlined the “oneness of any environment, natural or man-made” and stressed that any single intervention against one member of such ecosystems needs to consider the ripple effects on others. Building upon this framework, nearly 40 years later, Lewis et al. [15] proposed a ‘total system approach’ that considers all members of a given environment and their complex interactions and which would serve as a functioning alternative to the ‘silver bullet’ solutions in conventional pest control. This would be the only possibility to counteract the escalating environmental and economic consequences of pest control in agriculture. To date, such a holistic concept has not been adopted by mainstream IPM [16]. Rather, a compartmentalized approach is still prevailing, focusing on one or two crucial actors in a given ecosystem and not its entirety. Traditionally, IPM projects have focussed on either substituting pesticides with nonchemical alternatives, or at least promoting a more rational and environmentally more conscious use of them.

In terms of the different dimensions of OH, clearly, the greatest focus of IPM has been on animal and plant health, and in particular on arthropod control. Numerous studies have demonstrated the detrimental effects of conventional, synthetic pesticide-based plant protection against nontarget arthropods, in particular beneficials such as parasitoids [17] and predators [18]. Hence, enhancing biological control through the direct use and/or conservation of beneficials has generally been the mainstake of IPM, and the overall effectiveness of this approach has been widely accepted [19••]. More recently, the negative impact of conventional pest control on important insect pollinators such as bees, especially the widespread use of neonicotinoid insecticides, has gained a lot of attention, both in the scientific and public discourse [20]. Consequently, pollination services have become an additional focus in IPM, leading some practitioners to advocate for the concept of Integrated Pest and Pollinator Management [21]. In a way, this strategy embraces an OH approach that encompasses animal, environment, plant, and human health. Less attention has been paid to the effects on the health of livestock as a consequence of excessive use of pesticides as well as fertilizers. Studies from India suggest that the dairy sector was negatively affected by such management practices, which were greatly promoted during the Green Revolution. This led to a deterioration of the animal health and to high levels of pesticide residues in milk [22]. Another example is the increasing environmental concerns on the widespread use of insecticides against tsetse flies, vectors of trypanosomes, the causal agents of nagana or animal trypanosomiasis, the economically most important disease of livestock in Africa, which has motivated research into environmentally more friendly control strategies [23].

The use of synthetic pesticides can impact human health, both through direct exposure and through consumption of contaminated food, and various negative health effects associated with chemical pesticides include dermatological, gastrointestinal, neurological, carcinogenic, respiratory, reproductive, and endocrine among others [24,25]. The use of pesticides in high-income countries is strictly regulated but considerably less so in low-income countries. Consequently, the 6th World One Health Congress strongly advocated IPM to be part of the OH approach covering the entire value chain — from cultivation, harvest, food processing, and safety, to distribution and access [26]. Recent studies demonstrate that the adoption of a comprehensive IPM program to control fruit fly pests in Kenya can generate considerable health benefits for growers [27]. And a detailed assessment of the impact of > 600 insecticides used for controlling the invasive fall armyworm (FAW) in Africa identified several chemicals that are both effective and pose low risks to human and environmental health and thus could become part of IPM for FAW control [28].

The question is now: how to integrate these various, compartmentalized approaches to IPM into a more holistic OH framework that embraces the different dimensions of the latter concept? As an attempted response to the global challenges, the notion of Regenerative Agriculture (RA) based on Sustainable Intensification (SI) is gaining traction [29••]. A recent large meta-analysis clearly demonstrated that agricultural diversification, a key component of RA and SI, not only promotes multiple ecosystems that are crucial to IPM, but also assures that yields are not compromised [30]. Moreover, nearly 1/3 of farms worldwide already successfully practice some aspects of SI and RA [31]. What is crucially needed at this point are practical agronomic approaches that not only address the increasing need to produce more food for the growing populations in the Global South, but at the same time address the concurrent threats to plant, environmental, human, and animal health in a global environment that is more and more challenged by the effects of climate change. One example that can tick all these boxes is the push–pull system for sustainable cereal production developed in East Africa. It not only significantly increases the yield of maize and other cereal crops, but also generates fodder, leads to improved food and nutritional security, greater availability of dairy and meat, improves soil health, mitigates aflatoxin contamination, and enhances biodiversity through biological pest and weed control [32]. However, scaling up such approaches will necessitate significant investment from various societal actors and most importantly the necessary political will at the national and international level.

Human and environmental crises that are frequently occurring together are creating unimaginable stressors on food systems and threaten the ability to produce sufficient healthy diets that are accessible to all. Mitigating these adversities will require strengthening the resilience of food systems and thinking in more integrated ways within the context of OH. Science and innovations that are central to IPM that embrace RA, SI, and circular economy, and that are fully anchored on the concept of OH, should strengthen plant health, enhance biodiversity, build up equity, and sustain food systems that are resilient to climate change and other shocks while also promoting better health for humans, plants, animals, and the environment. A sustainable and climate-resilient food system anchored in our understanding of OH and IPM will be key for achieving most of the Sustainable Development Goals.

Conflict of interest statement

The authors have no conflict of interest.

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