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THE NEXUS BETWEEN TOXICOLOGY, ECOSYSTEM HEALTH AND ONE HEALTH

Apollos Ebi-erefa[1], Hyellavala Joseph Fomnya[2*], Kazabu Ahmed Amshi[3], Garleya Bilbonga[4] Inalegwu Adonyikwu[1]

[1]Department of Diagnostic Services, National Veterinary Research Institute, Vom, Nigeria.

[2]Department of Public Health, Faculty of Health Sciences, National Open University of Nigeria.

[3]Departmen of Theriogenology, Faculty of Veterinary Medicine, Ahmadu Bello University Zaria, Nigeria.

[4]Department of Animal Production and Health, Faculty of Agriculture and Life Sciences, Federal University Wukari, Nigeria.

**Corresponding Author: Hyellavala Joseph Fomnya,*

Department of Public Health, Faculty of Health Sciences, National Open University of Nigeria.

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Abstract: **The "One Health" idea comprises a global strategy emphasizing the need for an approach that is whole and transdisciplinary and integrates multisector expertise in dealing with the health of man, animals, and the environment. It stimulates and promotes the interconnectedness, coexistence, and evolution of living things and their environment, which is itself in a state of constant evolution. Industrialization, geopolitical problems, and an increase in human population have led to increasing global changes causing a lot of damage to biodiversity, extensive deterioration of ecosystems, and considerable migratory movement of both mankind and species in general. Over the years, certain zoonoses, such as bird flu or the Ebola and Zika viral epidemics, have illustrated this fact to the entire world demonstrating the interdependence of human health, animal health, and ecosystem health. Many of the same microbes infect animals and humans, as they share the ecosystems, they live in. Efforts by just one sector cannot prevent or eliminate the problem. One toxicology combines wildlife, human, veterinary, and ecological toxicology to support more logical choices as to what chemicals and what concentrations are permitted to come into contact with human beings and their domestic animals. Ecosystems serve as a life support system to mankind. Humans take great advantage of the resources provided by the planet and by doing so the environment is being modified. The shared environment and food sources of animals and humans allow potential exposure to the same toxic and infectious agents. In this review article, we discuss the connection between toxicology, ecosystem health, and one health.**

Keywords: **One health, Ecosystem health, Public health, Zoonotic diseases, Antimicrobial resistance.**

1. INTRODUCTION

The One Health Initiative Task Force (OHITF) defined One Health as the collaborative effort of multiple disciplines-working locally, nationally, and globally – to attain optimal health for people, animals, and our environment. One World - One Health" concept was created in 2004 following the "One Medicine" concept that advocates a combination of human medicine and veterinary medicine in response to zoonoses (Zinsstag et al., 2011). The new thing was the incorporation of ecosystem health, including that of wild fauna.

The "One Health" approach comprises a global strategy emphasizing the need for an approach that is whole and transdisciplinary and integrates multisector expertise in dealing with the health of man, animals, and the environment (AVMA, 2008). It thus stimulates and promotes the interconnectedness, coexistence, and evolution of living things and their environment, which is itself in a state of constant evolution (Lebov et al., 2017).

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Over the years, certain zoonoses, such as bird flu or the Ebola and Zika viral epidemics, have illustrated this fact to the entire world demonstrating the interdependence of human health, animal health, and ecosystem health. Industrialization, geopolitical problems, and an increase in human population have led to increasing global changes causing a lot of damage to biodiversity, extensive deterioration of ecosystems, and considerable migratory movement of both mankind and species in general. These rapid environmental changes are linked to the emergence and re-emergence of infectious and non-infectious diseases (Schwabe, 1984) (Figure 1).

The concept of One Health is founded on the basis that human health, environmental health, and animal health are linked and that the study of any part should be done with an eye toward holistic interdependency. As a combination of ideas from different disciplines, One Health has gained traction due to the encouragement of data sharing, breakthroughs in areas of zoonotic diseases, and the proliferation of holistic environmental views (Buttke, 2011; Kahn, 2017).

It is a collaborative, multidisciplinary, and trans-sectoral idea—working at global, national, regional, and local levels—with the purpose of getting maximum health outcomes by recognizing the interdependencies between plants, animals, humans, and their shared environment (CDC, 2018). The enablers of global environmental changes and their effects are shown in Figure 1 below.

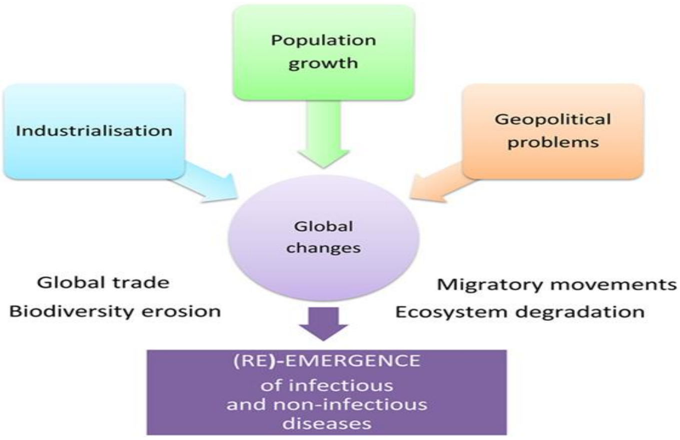

Figure 1: The enablers of global environmental changes and its effects (Destoumieux-Garzón et al., 2018).

2. ONE HEALTH ACCORDING TO WHO

One Health is an approach to designing and implementing programs, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health outcomes.

The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses, and combating antibiotic resistance (WHO, 2017). In today's world, people and animals interact more closely and more often than ever before, sharing environments, diseases, and other health concerns. Every year, millions of people and animals around the world are impacted by zoonotic diseases (diseases that spread between animals and people). Diseases don't recognize borders. Changes in climate and land use affect animal habitat and movement (CDC, 2015).

Many of the same microbes infect animals and humans, as they share the ecosystems they live in. Efforts by just one sector cannot prevent or eliminate the problem. For instance, rabies in humans is effectively prevented only by targeting the animal source of the virus (for example, by vaccinating dogs) (WHO, 2017). Information on influenza viruses circulating in animals is crucial to the selection of viruses for human vaccines for potential influenza pandemics. Drug-resistant microbes can be transmitted between animals and humans through direct contact between animals and humans or through contaminated food, so to effectively contain it, a well-coordinated approach in humans and in animals is required (WHO, 2017).

Over half of the known pathogens infectious to man infect animals as well ("zoonotic" diseases). (Jones et al. (2008) found that most (71.8%) of emerging infectious diseases (EIDs) in man started in wildlife, a proportion that appears to be going up over time. Worldwide, over one billion infections and one million deaths yearly are attributable to zoonoses and vector-borne diseases such as malaria, dengue, and tick-borne infections causing additional health and socioeconomic burdens (Karesh et al., 2012).

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Recognizing these connections means a healthier world for all. The One Health according to the CDC, (2015) approach can:

- Prevent outbreaks of zoonotic disease in animals and people
- Improve food safety and security and economies reliant on livestock production
- Reduce antibiotic-resistant infections and improve human and animal health
- And protect global health security

AVMA (2008) suggest that the strategy to better understanding and addressing the contemporary health issues created by the convergence of human, animal, and environmental domains is the concept of One Health.

A serious movement happened during the 1990-2000s towards improving communication and interaction between health-related disciplines. This was a time when many highly contagious emerging diseases such as avian flu (Ferguson et al., 2004) and severe acute respiratory syndrome (Guan et al., 2003) were causing sickness and death all over the world.

Indeed, many researchers have noted that man's exposure to novel zoonotic agents has resulted in many epidemics of vector-borne diseases as a result of changing climate conditions which change the ranges of normal hosts and reservoirs of these pathogens (Daszak et al., 200; Greer et al., 2008; Lindgren et al., 2012). Research has suggested that many risk factors such as socioeconomic status and land-use practices are connected with “hotspots” of zoonotic disease transmission all over the world (Jones et al., 2008). The concept of one health is presented in Figure 2 below.

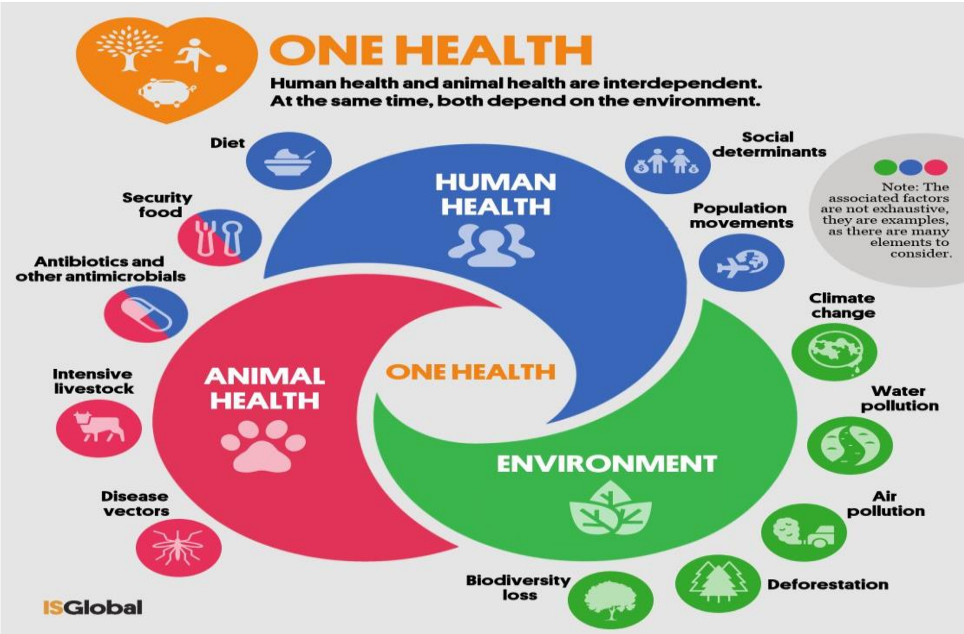

Figure 2: One health concept (Sara soto, 2018).

3. ONE HEALTH AND TOXICOLOGY

Toxicology is the study of the adverse effects of chemical substances on living organisms and the practice of diagnosing and treating exposures to toxins and toxicants. Organisms can be exposed to various kinds of toxicants at any life cycle stage, some of which are more sensitive than others.

Ecotoxicology even goes further to look at the chemically induced disruption of all the interactions among organisms and their interactions with water, soil, minerals, and air of the planet (Beasley, 2009).

Pollutants, insecticides, pesticides, and fertilizers can affect an organism and its community by reducing its species diversity and abundance. Such changes in population dynamics affect the ecosystem by reducing its productivity and stability (Harley, 2017). Climate change is likely to alter human and animal exposure to biotoxins such as those produced by harmful

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algal blooms (HABs). Similarly, increasing human development and expansion will alter production and exposure to heavy metals and organic contaminants. These contaminants affect both animal and human health (Harley, 2017) (Figure 3).

Toxicants increase the dangers of infectious diseases when the immune system is directly or indirectly affected. Immunotoxic effects do not only have a direct impact on human health and the viability of human and animal populations but also affect the broader functioning of ecosystems.

It also supports the passing of zoonotic diseases by promoting the prevalence of pathogens in animal reservoirs or intermediary hosts (Guitart et al., 2010; Marcogliese and Pietrock, 2011; Abi-Khalil et al., 2017).

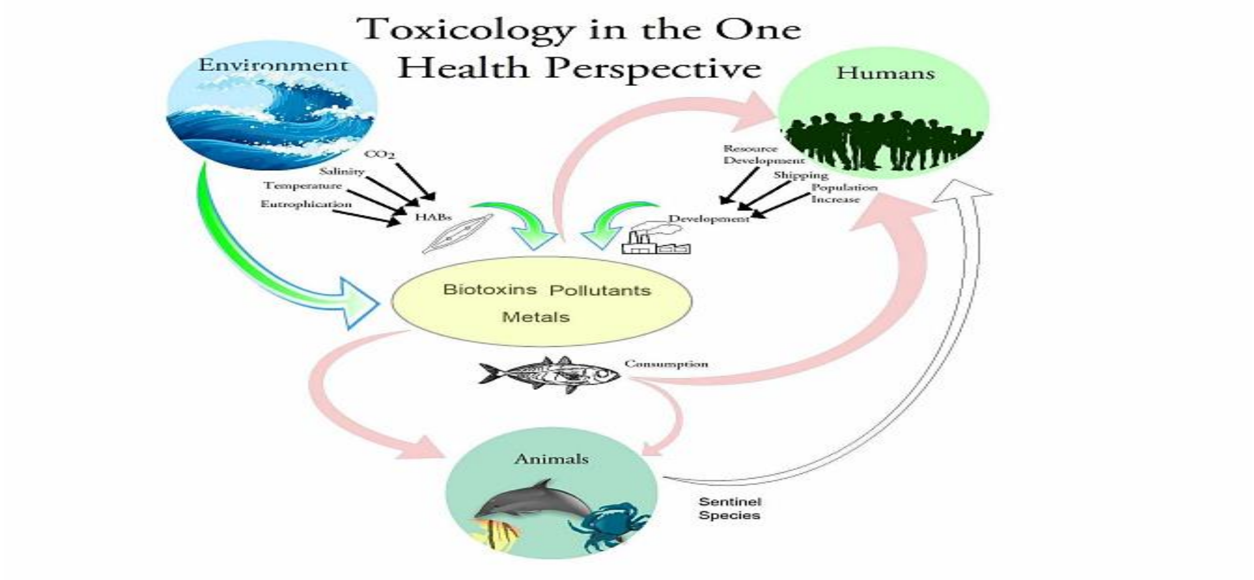

Figure 3: Conceptual model of toxicology from the One Health perspective (Harley, 2017)

4. CONCEPT OF ONE TOXICOLOGY

One toxicology combines wildlife, human, veterinary, and ecological toxicology to support more logical choices as to what chemicals and what concentrations are permitted to encounter human beings and their domestic animals (Beasley, 2009). One toxicology is important to blur the distinctions among humans, veterinary, environmental, and ecological toxicology so that the needs of environmental health and one health are addressed at the same time (Beasley, 2009).

It is emphasized that one-toxicology must go beyond the developed world as a worldwide investigative, clinical, diagnostic, and preventive medicine endeavor that works with public health specialists, wildlife biologists, wildlife managers, physicians, animal scientists, livestock producers, veterinarians, agronomists, large and small-scale farmers, forest managers, aquaculture specialists, other members of the business community, educators, journalists, officials of government and the public to protect the plant, animal, human and microbial biodiversity of the planet (Beasley, 2009).

Producing goods and services for man has often led to industrial and agricultural pollution with untoward consequences on wildlife and the environment. Given the degraded conditions of the ecosystem and the roles of chemical pollutants in the current ongoing sixth extinction (AAAS., 2001; Primm & Brooks., 1997; Raven, 2002), the ethical assignment now must be to manufacture goods and services using chemicals in ways that permit the many beleaguered native species to recover their numbers beyond, around, and even within areas intensively managed to meet man's needs.

Carson's 1962 book, Silent Spring, warned of animal and human effects in the one toxicology domain of emerging manmade chemicals, especially pesticides, such as dichloro-diphenyl-trichloroethane (DDT) and other persistent organochlorines (Carson., 1962).

Considering the fact that many toxic compounds cause harm after a long time of exposure through bioaccumulation (e.g., PCBs) or through recurrent yet subtle incremental 'hit and run' toxicity with delayed results, it is important for the physician, the veterinarian, environmental toxicologist, and the epidemiologist, with other specialists to undertake and promote the role of citizen scientists (Beasley, 2009).

Harmonization of laws and regulations has been making progress, especially in the pharmaceutical and pesticide industries with coordination from the United States, Japan, and the European Union (EU). In recent years, the EU has shown additional leadership, relative to the United States and other parts of the world, in imposing strict laws with regard to regulatory toxicology (Beasley, 2009).

A current challenge will be to make sure that knowledge from government-mandated and other toxicological testing is regularly made available in the public space. Keeping such knowledge under wraps as a part of intellectual property and patent protection deprives physicians, veterinarians, and ecosystem managers of needed diagnostic criteria (Beasley, 2009).

5. ONE HEALTH AND ECOSYSTEM HEALTH

Ecosystem health is generally defined as the absence of signs of ecosystem distress (Rapport et al., 1998). In contrast, ecosystem integrity is defined as an unimpaired condition in which ecosystems show little or no influence from human actions. Ecosystems with a high degree of integrity are natural, pristine, and often labeled as the baseline or benchmark condition. Natural ecosystems, by definition, would continue to function in essentially the same way if humans were removed (Anderson, 1991).

Ecosystems consist of various biotic and abiotic members coexisting in a seemingly balanced environment. The balance in an ecosystem can also be referred to as the health of an ecosystem.

Ecosystem breakdown is often instigated by various non-specific sources of stress.

When the ecosystem is stressed and symptoms are rampant, we begin to see detrimental effects to human (and animal) health as well (Rapport et al., 1998). With the size and spread of the human population, humans have now modified a substantial portion of the planet. These modifications may be beneficial to humans but may not be beneficial to the ecosystems around us.

Human health and Ecosystem health have a complex, dynamic, and political linkage (Dabuko, 2011). The many linkages between human health, ecosystem health, and animal health are important and are becoming more evident (Rabinowitz and Conti, 2013). Ecosystems serve as a life support system to mankind (WHO, 2005). Humans take great advantage of the resources provided by the planet and by doing so the environment is being modified. For instance, intensive farming techniques produce high volumes of food animals in smaller facilities, producing higher volumes of waste and nutrients. This contributes to pollution and eutrophication effects, leading to the loss of biodiversity and environmental health (ecosystem health) and human health at large (Menzi et al., 2010).

Aronson et al. (2016) suggest that global degradation of our ecosystems will likely negatively affect the health and well-being of most if not all humans in some way. It only makes sense to make changes that will benefit ecosystem health and subsequently man’s health. Within the context of the One Health concept, the WHO defines the ‘health’ as a state of complete physical, mental. and social well-being, instead of just the absence of disease or infirmity (Gibbs, 2014).

The expansion of this to ecosystem health seems simple, that ecosystem ‘health’ be defined as a state of complete ecological and environmental health instead of just the absence of signs of ecosystem distress.

Some of the most complex global challenges of the 21st century are presented by global environmental change, global health, emerging disease, and sustainability (Barrett and Osofsky, 2013). One discipline alone cannot address all these issues, there is a need for collaboration and interdisciplinary work. The One Health approach provides an integrated system that acknowledges the connections between ecosystems, humans, and animals. This approach should be used to inform policies, further scientific knowledge, enhance healthcare training and delivery, identify upstream solutions, and address sustainability challenges. and improve conservation outcomes (Barrett and Bouley, 2015)

Humans transform ecosystems for food, fiber, timber, and other ecosystem goods in order to survive; but it has gone beyond survival. More than what is required is being used and a great deal of what is produced is turned into waste and thrown haphazardly back into the environment. By focusing on the overall health of the planet and using the One Health approach, we might be able to bring some balance back. The One Health concept has been used effectively between the human and veterinary disciplines but now needs to be further expanded to incorporate the health of ecosystems and our planet (Barrett and Bouley, 2015). Inter-relationships among professionals working in One Health are presented in Figure 4 below.

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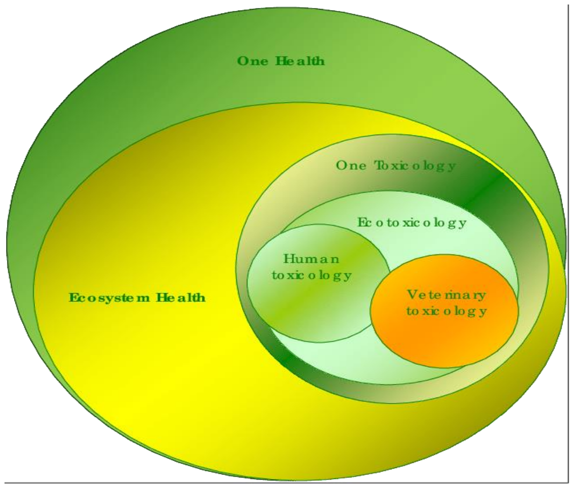

Figure 4: Inter-relationships among professionals working in One Health (Beasley, 2009)

6. THE LINK BETWEEN TOXICOLOGY, ECOSYSTEM HEALTH AND ONE HEALTH

Common Environments

The shared environment of animals and humans allows potential exposure to the same toxic agents. When outbreaks of illness in humans and animals occur concurrently, studying the disease in animals in addition to humans can provide insight into the etiology.

Urgency of diagnosing poisoning in aquatic animals

In 1949, dead fish were observed floating in Minamata Bay in Japan. Catches by fishermen began to decrease (Maruyama, 1996). By 1953, cats ‘danced in circles’ and ‘cat suicides’ were observed when they fell into the bay and died. Seabirds and crows were noted to spiral suddenly into the sea. It was not long after this that the first issues of human illness were observed, but the industry leaders and officials of government at the national level did not directly combat the pollution for many years. Part of the problem was intimidation by industrial polluters and political leaders of the area. The polluting industry was a big employer of labor in the area and concerns of loss of employment hindered public pressure (Maruyama, 1996).

The syndrome in cats was replicated by feeding cats a diet made from fish and shellfish from Minamata Bay. The syndrome in man was specifically noted as methylmercury poisoning in 1959, but the point source of the methylmercury was not identified until 1961 (NIMD, 2008). Waste from a chemical factory that belonged to Chissco Corporation had released methylmercury into the Bay at least as early as 1932 and it was not stopped until 1968. The chemical reaction employed to produce commercially marketed acetaldehyde relied upon a mercury catalyst and produced methylmercury. By March 2001, a total of 2265 human victims were noted (MoE, Tokyo, 2002). Had there been a good system of monitoring the environment, coupled with a fish diagnostic capability and responsive stewardship programmed at the outset, fish, birds, feline and human victims, together with the economic vitality of the region could have been safeguarded. For fish to serve as sentinels of aquatic pollution and toxicity alongside ecotoxic impact, a sustained, active one toxicology approach to monitoring, diagnosis, and research is important.

Concerns for wild animals in one toxicology world

Polyaromatic hydrocarbons (PAHs), like benzo[a]pyrene, are among the most researched carcinogens in man, and the key role of laboratory animal research in deducing mechanisms of carcinogenesis, including through studies of purified PAHs and mixtures of such compounds, is well observed (Poirier, 2004). The scrotal cancer in chimney sweeps, that were explained by the English physician and surgeon Percival Pott in 1775 (and later curtailed by complete washing not in England but in a country like Denmark) were associated with soot and ultimately PAHs. Even today, lessons can still be learned, as exposure to PAHs in cereals, fire-broiled foods, and smoke from tobacco, fossil fuels, and other sources remain ubiquitous causes of cancer in man (Pilot and Dragon, 2001).

Daniel Martineau, a veterinary pathologist at the St Hyacinth veterinary faculty of the University of Montreal led a group that built on an earlier encounter with a stranded beluga whale, which was observed to have cancer, on the shores of the St Lawrence estuary. Ultimately, when Martineau and co-workers kept on monitoring this endangered population of belugas

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for several years later, they discovered a much higher incidence of cancer than would ideally be expected in free-ranging wildlife (De Guise et al., 1994; Martineau et al., 1994, 2002). The belugas, which eat benthic organisms, were being exposed to hydrophobic PAHs that were delivered to the sediment largely from the emissions of hundreds of tons of chemicals from the aluminum company that was nearby. In parallel, cancers were observed at increased rates in the aluminum plant workers and local residents. In both the humans and the belugas, the cancers were in line with what would be expected from exposures to polyaromatic hydrocarbon emissions.

Not thus,long ago, the aluminum manufacturing plant stopped using the most polluting technology and thus decreased regional inputs of PAHs. Media attention concerning the plight of the belugas which are a focus of ecotourism in the region (CBS. 2002; UoM, 2008) may have contributed to the discontinuity of the old technology that released PAHs. That the widespread observation of the mutagenicity and carcinogenicity of PAHs did not profoundly limit the emissions of these pollutants before they harmed the whales and people is a true reflection of some of the recent historical attitudes of some business leaders, not only with regards to wildlife health but also human health at large.

The current issues with PAHs globally today, e.g., fossil fuel burning is not an excuse considering the presently available alternative technologies. Industrial leaders, energy generators, engineers, political leaders, government regulators, health and environmental non-governmental organizations, and consumers can contribute to a large extent to risk reductions in exposures to PAHs. Globally, a decreased dependence on fossil fuel and more widespread and efficient pollution-control technologies give a genuinely important one toxicology/one health opportunity to reduce human and animal discomfort and death.

Free nutrients, climate change, phytotoxins, and one health

Free nutrients in the environment arising from not well-treated animal and human wastes, fertilizers applied for food-producing plants and lawns and air pollution contribute to the rapid growth of phytoplankton that may cause toxic effects, just like the case of cyanobacteria, and to the deaths of algae that constitute dead zones in big lakes and at the mouths of rivers all over the world. Domoic acid originates basically from diatoms of the genus Pseudo-nitzschia (Bates, 2000). As silicon, phosphorus, nitrogen, and iron presence have been linked to the growth of Pseudo-nitzschia and the fact that the subsequent reduction of phosphorus and silicon by these organisms stresses them so that they secrete domoic acid (Wright, 1998), it has been suggested that an increase in the toxic effects of Pseudo-nitzschia might be happening as a result of increased nutrient and desert dust pollution.

In some situations, the planktonic diatoms expand their numbers in the zones of shellfish and fish in relation to upwellings spurred by currents triggered by climate change around the world (Wright, 1998). Moreover, global warming may increase the seasonal growth of Pseudo-nitzschia and expand its global range. Accordingly, pollution from animal agriculture, sewage effluents, crops and lawns, and silica dust from desertification, as well as carbon dioxide and methane that contribute to global warming may all participate (Mos, 2001). The toxins transmitted from the plankton to shellfish and fish are passed across to predators that eat them. The syndrome of domoic acid toxicosis was first observed in relation to what became known as amnesic shellfish poisoning in the area of Prince Edward Island in Canada when 3 elderly persons died and over a hundred individuals developed various poisoning symptoms after eating mussels contaminated by the diatoms (Bates et al., 1998). Only after domoic acid toxicosis was seen in people was the syndrome recognized in marine vertebrates. In recent years, large numbers of multiple species of marine mammals (grey whales, dolphins, sea lions, seals, sea otters) have been noticed to be poisoned off the coasts of California, Oregon, Washington, and Alabama.

In summary, respecting the precautionary principles (Kriebel and Tickner, 2001) and ecosystem services, the control of carbon dioxide and methane emissions, as well as better sewage, agriculture, forest, and lawn management to keep nutrients in higher plants and silicon in soils may lead to a decrease in this syndrome thereby safeguarding humans and wildlife. This is yet another one health and one toxicology concern in which stewardship of ecosystems may have prevented and may yet prevent an emerging toxicological disease.

Infectious diseases (Ecosystem dynamics and imbalances)

In history, the domestication of animals has indirectly enhanced the transmission of infectious agents between humans and wildlife (Day, 2011). Most of the emerging infectious diseases considered to be important in public health have a zoonotic origin (Taylor et al., 2001), and almost three-quarters originate in wild animals (Woolhouse et al., 2005). The study of environmental factors affecting the transfer of infectious agents in wildlife is therefore important in understanding the processes involved in the transgression of species barrier (also referred to as host-switching, host-jumping, or host-shifting) and emergence in the populations of humans. For instance, the density and diversity of hosts, environmental persistence, migration, and interaction within communities of infectious agents have been recognized as determining factors in the emergence of direct and vector-borne transmission agents (Keesing et al., 2010; Telfer et al., 2010). Assessing the danger of the emergence of zoonoses in populations of humans, therefore, needs the analysis of interaction networks among infectious agents, their hosts, and the environment in which they emanate.

Habitat destruction and fragmentation, pollution in the environment, and changes in climate have a confirmed catalyst effect on the occurrence and geographic distribution of infectious agents (Daszak et al., 2001; Patz et al., 2004; Levy, 2015. Recent instances of epizootics, specifically destructive epidemics or zoonoses (bird flu, coronavirus, Ebola, chikungunya, dengue, and Zika) indicate that this spread was on many occasions assisted by global changes. The Ebola epidemic in Western Africa pointed out that epidemics are not only limited to the circulation of viruses or knowing of contamination principles but also deeply influenced by history, political contexts, economic inequalities, and cultural phenomena (Ezenwa et al., 2015; Mwangi et al., 2016).

Globalization of trade and exchange and the industrialization of agriculture, aquaculture, and agribusiness are the cause of the increased migration of humans, animals, and plants with their accompanying infectious agents, who have been able to take over new territories. Industrialization, which has encouraged intensive breeding and farming practices, has also generated stress in organisms, which in turn has created an environment that is comfortable for the spread of infectious agents (Stoate et al., 2001, 2009).

The industrialization of agriculture and farming is also the cause of the widespread and often unnecessary use of pesticides, fertilizers, and antibiotics, which have selected on the one hand resistance to insecticides in mosquitoes that transmit pathogens (etiological agents of malaria, arboviruses, filarioses, etc.) (Tantely et al., 2010) and on the other hand to antibiotics resistance in bacteria (Holmes et al., 2016).

Antimicrobial resistance

Resistance to antimicrobials is a worldwide health challenge with different aspects causing serious threats to health all over the world, food security, and development for the WHO.

Antimicrobials can offer critical benefits for sick people and animals, but their use also can select for and predispose to the spread of antimicrobial resistance. A worldwide epidemic of resistance now poses a big risk to our capacity to treat infections globally. While abusive human clinical use is a notable source of resistance development, use in food production and the food chain can also play a role. Resistance to colistin, a medically important antibiotic was observed in individuals after it was used as a growth promoter in China for pig production (Jim O'Neill, 2016).

Resistance to antimicrobials (as well as other infectious diseases in animals) can also cause high costs and loss of livestock in agricultural production, with potential implications for international trade, and may endanger food security (World Bank 2017).

More than 80% of all antimicrobials used in the United States are used for animal agriculture; up to an estimated 90% are excreted into manure, with the possibility of widespread dispersion into the environment if efficient waste management practices are not followed. Thus, judicious use is needed in human clinical medicine alongside veterinary medicine and agriculture sectors (van Boeckel et al., 2015; Jim O'Neill, 2016.

Using a "One Health" idea linking medicine with some of the well-established fundamental ideas in eco-evolutionary dynamics is urgently required for developing novel approaches to bacterial infection therapy for which resistance is slow to evolve (Read & Woods, 2014).

Urbanization and health

Urbanization, in connection with air and ground pollution, and its role in the change of lifestyle (energy-dense diets with ready-made foods that have high lipid content, less physical activity, more inactive lifestyles, etc.) represents a bulk environmental change for humans. Since 2010, cities and towns have been the living environment of over half of humanity (EU, 2014). Our increasingly urban lifestyle predisposes us to exposure to many stress factors (exposome), the health effects of which we do not yet completely understand, especially among the more delicate members of society. A person's social network will determine his propensity to be infected by directly transmissible pathogens (without an intermediary host) (Finger et al., 2016) and to be affected by non-infectious diseases such as obesity (Christakis & Fowler, 2007) or blood cholesterol.

7. EFFORTS MADE TOWARDS ACHIEVING ONE HEALTH

At a global level, instances consist of the tripartite agreement signed by the World Health Organization (WHO), the Food and Agriculture Organization, and the World Organization for Animal Health to combat threats at the human-animal-ecosystem interface, with a focus on antimicrobial resistance, rabies, and zoonotic influenza. Also, the resolutions of the United Nations Convention on Biological Diversity acknowledged the value of One Health (WHO 2018; CBD 2006). As part of WHO's post-Ebola approaches to strengthen preparedness capacity, a One Health initiative is being sponsored in multisectoral national action planning for health security.

Many professional organizations within the United States have also accepted the One Health concept. The American Veterinary Medical Association (AVMA) has approved position statements directly endorsing One Health in recognition of the role of veterinarians in protecting and advancing human, public, and environmental health, including via disease reporting to local, state, and federal authorities (Wohl and Nusbaum, 2007; AVMA, 2018)

Recent action on antimicrobial use in the United States also recommends the advantages of taking a One Health initiative. In 2015, the White House called for One Health surveillance efforts in its National Action Plan for Combating Antibiotic-Resistant Bacteria, recognizing the possibility of resistance in animals, humans, and the environment. The Council on State and Territorial Epidemiologists (CSTE) in the same year, released a position statement on antimicrobial stewardship that required taking a One Health initiative with improved oversight and judicious use in human and veterinary medicine as well as agriculture (APHA, 2017).

To address different influenzas and other zoonotic disease dangers, the CDC has launched the Public Health Youth Agriculture Education Program jointly with the U.S. Department of Agriculture and CSTE to create awareness among young people specifically, those involved in 4H and Future Farmers of America—about prevention of risk and mitigation. The program works hand in hand with state health departments and local agricultural groups (CDC. 2018)

Sentinel surveillance can suggest an "early warning" benefit to public health. That kind of surveillance has been used to monitor different kinds of public health threats, including West Nile virus in crows (which are highly susceptible to infections), mosquitos, and equids to describe human exposure risks (Hadler et al., 2015); cyanotoxin exposures in animals from harmful algal blooms (Backer et al., 2016); and hunter surveillance for wildlife deaths that may come before human cases of the Ebola virus in Central Africa (WHO, 2015).

8. CHALLENGES AND AMBITIONS OF ONE HEALTH

A big challenge to the development of the "One Health" concept is obviously the lack of communication between veterinary, human medicine, ecological, agronomy, environmental, and evolutionary science. Removing this major drawback implies the integration of a better understanding of other fields, multidisciplinary approaches, and the purpose and conditions of their implementation (Destoumieux-Garzón et al., 2018).

The not-so-sufficient consideration of certain key aspects in the implementation of the "One Health" approach can be described. Specifically, the wildlife aspect and many other related ecological issues (community ecology and evolutionary ecophysiology) are still ignored (Hall, 2015), same as some environmental science components (soil and climate) (Barrett & Bouley, 2015). In addition, social, legal, and economic sciences similarly dealt with some unseriousness (Lapinski et al., 2015). Howbeit, social sciences play a large role in the construction of the challenges facing "One Health" research. The understanding of infectious or toxic risks cannot simply be narrowed down to its chemical and biological components. It is also imperative to take into cognizance the variability, vulnerability, and susceptibility of human societies as well as the different ways they interact with ecosystems and animals. The "One Health" idea, which supports an interdisciplinary and intersectoral movement, must therefore engage at different strata of health governance, from a global level down to a local level, by encouraging participative efforts that connect communities, administrations, scientific researchers, and other key players (NGOs, industry, legal experts, etc.). Infectious and toxic risks must also be addressed through their perceptions and impacts to contribute to the improvement of surveillance and prevention procedures and the resilience of societies in the face of sanitary crises.

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Political willpower and funding for granting it are currently mainly mobilized around disease emergencies. It is even more difficult to build support for the primary prevention of a problem (disease emergence, toxin exposures, foodborne illnesses, etc.) without being able to point to concrete evidence that a future emergency will, in fact, happen. Similarly, even with greater predictive capabilities, it is not likely that One Health initiatives can hinder all public health risks on the horizon; single-sector efforts will still play a significant role in responding to them. Yet, the high costs of health emergencies and the much lower costs of disease prevention suggest the value of risk reduction or at least early warning to avoid or reduce potential public health and economic damage (World Bank, 2012, 2017).

The scope of One Health cases, the different importance of sectors by the situation, and the lack of prescriptive approaches make consistent implementation and evaluation strategies problematic. Additionally, there is not a commonly accepted plan for determining situations in which One Health applications can be value-added; however, they are not likely to be necessary.

Bureaucratic problems present important hurdles to the real and sustained application of One Health. Authority across public agencies is mostly divided, state and federal jurisdictions may not be clear, and leaders of one agency may see collaboration with another public agency to undercut their capacity to “win” more resources in what is seen as a zero-sum struggle for limited public resources. Established structures and systems are not easily overcome; incentives for disciplines to work together remain limited, and there may be a lack of political buy-in without the perceived value of the importance of other disciplines to their work (Brahmbhatt and Jonas, 2015). One Health is intended not to replace or diminish the importance of specific disciplines but, rather, to bring together information from different disciplines to anticipate and address relevant issues more effectively through the inclusion of their input.

9. RECOMMENDATIONS

Public health colleges and programs should make available learning opportunities for interdisciplinary understanding and cooperation on animal health, ecosystem health, and human health by offering projects or courses with faculty or students from other important fields (e.g., veterinary medicine, ecology).

Regulatory agencies may carry out collaborative animal, human, and environmental health impact assessments to explore long and short-term public health effects and externalities in making decisions (e.g., wildlife trade policies, veterinary drug licensing, land planning), combined with economic analyses to inform budgeting procedures. These analyses should include prospective avoided costs to other sectors (e.g., trade, tourism) via preventive or management plans that checkmate or control disease risks (e.g., through vaccination of animals, biosecurity measures, and regulations).

Public health leaders and technical organizations should share discoveries, pay attention to lessons learned, and find ways to operationalize One Health through events and approaches during National Public Health Week, International One Health Day (November 3)**,** the International Day for Disaster Risk Reduction, World Rabies Day, and/or other forums, seeking cooperation with their veterinary and environment counterparts.

Public health leaders should engage appropriate expert bodies (such as the National Association of State Public Health Veterinarians) and arrange with disaster risk reduction managers to jointly sponsor evidence-based disease prevention and containment measures.

Public health officials and technical bodies should circulate information to both public health personnel and the general public concerning human-animal-environment interconnections, including the relationship between ecosystem degradation and public health, such as threats to water and food safety and security, the emergence and transmission of zoonotic and vector-borne diseases, the health implications of biological and natural disasters, ecotoxicology, and other significant and growing threats to health.

10. CONCLUDING REMARKS

The high health, financial, and societal disturbance costs from conventional approaches to public health emergencies can significantly be minimized or thwarted via the One Health perspective that advances prevention and preparedness. An analysis of a One Health technique emphasizing pandemic risk mitigation through the strengthening of human health and veterinary service capacity projected a high return on investment via cost avoidance, with estimates of more than $30 billion gain per year compared to business-as-usual approaches.

One health personnel must identify the need for recovery of lost biodiversity if ecosystems are to provide a better quality of life for man and less suffering for domestic and wild animals in the long term. Controlling and avoiding unwanted contamination of the environment is, therefore, a key component of one health. Interfacing with the public so that they know the complexity of current dangers to health about biodiversity, including how chemicals can cause direct and indirect harm to ecological sustainability is a part of this struggle. If human medical, veterinary medical, wildlife, and ecological professionals understand one another's limitations and skillsets, and if they collaborate to set in motion programs toward the synchronous recovery of human, domestic animal, wildlife, and ecosystem health, they may play a vital role in preserving life on Earth.

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