One Health Perspectives on Zoonotic Diseases in Aquatic Environments

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Abstract

One Health (OH) approach is a rapidly expanding area of integrative research and action focused on treating zoonotic diseases in the animal, human, and environmental interface. This strategy considers ecological and social dimensions of health issues, encompassing natural and social sciences, and local and conventional perspectives, beyond biomedicine. One Health also offers a transdisciplinary approach to health sciences, bridging disciplinary silos and providing solutions to traditional thinking in public health and biomedicine. This chapter explores the global prioritization of zoonosis surveillance, antimicrobial resistance mitigation, and collaboration among various sectors to address epidemic, and pandemic zoonotic diseases. This chapter starts by distinguishing zoonosis in aquatic environments and their quick propagation due to environmental challenges as well as knowing how and why new zoonosis outbreaks can lead to pandemics and epidemics. Finally, this chapter provides details about how the One Health idea is operationalized as transdisciplinary implementation research, which aims to comprehend and avoid disease onset in the aquatic environmental context and to highlight both new opportunities and problems for global health.

Keywords: One Health (OH); Zoonosis; Biomedicine; Environmental interface; Antimicrobial resistance; Transdisciplinary approach.

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Introduction

Aquatic ecosystems cover over two-thirds of our earth and perform critical roles in maintaining global climatic conditions as well as providing a great range of activities for a rapidly expanding human population including water for irrigation and drinking purposes, recreational prospects, and habitat for economically significant economic aquatic species (Prakash, 2021). The aquatic environment is comprised of freshwater and marine ecosystems. Freshwater ecosystems encompass <1% of our planet's surface and are composed up of lotic, lentic, and wetland ecosystems. In contrast, marine ecosystems cover about 71% of our planet's surface and consists of estuaries, oceans, coastal ecosystems, and coral reefs (Rich & Maier 2015). Together these ecosystems produce 50% of the world's net primary productivity (Hader et al., 2020). But aquatic ecosystems have been threatened rapidly, directly and indirectly, by multiple stressors (Arya, 2021).

Contemporary environmental issues deteriorate aquatic environments, like overuse of aquatic species, the introduction of exotic species, pollution from agricultural areas, industries, cities, and loss of ecological niches, climatic variations, loss of biodiversity, flooding, and acid rain, which are produced by humans in the natural environmental settings (Kumar et al., 2024). Disease-pathogenic microbes, Plastic pollution, overfishing, and climate variations are major emerging threats to aquatic environments for the propagation of waterborne diseases (Conn, 2014). Waterborne diseases are continuously happening, in spite of enhanced water processing and sanitation practices in water bodies (Nwabor et al., 2016). Mostly waterborne diseases are zoonotic and naturally transmittable from vertebrate animals to human beings and vice-versa. These zoonotic diseases are caused by multiple zoonotic pathogenic microbes such as viruses, bacteria, parasitic helminths, and protozoa; through direct contact, with water, food, and vectors in the human and animal ecosystems which comprises a public health risk at greater scale worldwide (Inci et al., 2018).

Zoonotic diseases are contagious and non-contagious infections with evolving characteristics, and their increasing risks affect global health security (Mangili, 2016). Global environmental variations, rising populations, urbanization, migration of animals, and tourism play multiple roles in the emergence of water-borne diseases (Rahman et al., 2020), and many of them are zoonotic. Humans with poor immunity or other chronic conditions are at higher risk and domestic animals particularly those of intensive breeding, are also at high risk. Consequently, zoonotic infections result in great financial losses and could be one of the main reasons for poverty. The population health impacts, and economic consequences of these diseases can devastate the already present overburdened economic circumstances in several areas. In this way, the public health, scientific, and veterinary medical communities are vital in addressing these threats (Ferri et al., 2017).

Waterborne zoonotic pathogenic microbes common between animals and humans indicate the requirement for holistic solutions to

efficiently guard public health as well as food and water security at a worldwide level. One of the most significant aspects associated with mitigating zoonotic pathogenic microbes at the human, animal, and ecological interface is the emergence of a suitable science-based risk management policy that respects transboundary regulations respect (Aguirre et al., 2021). This multifaceted and interrelated health hazard depends on human-animal-environment interactions and significantly needs inter-sectoral cooperation not only to reduce the load but also for efficient control of all zoonosis (Erkyihun & Alemayehu, 2022). This goal can be attained through the One Health concept and its cooperation activities (Lokossou et al., 2021). One health concept serves as a useful platform for bringing together every relevant stakeholder, which also offers substantial advantages to health-based sectors and also to their developmental targets through government-based agencies (Machalaba et al., 2021).

One Health is a multi-sector, interdisciplinary, and collaborative paradigm that can work at regional, local, global, or national levels, along to guarantee optimum health by the identification of relations among humans, environment, animals and plants (Nurunnabi et al., 2022) With the goal of achieving long-lasting health optimization, food safety, healthy environment, and fair trading, this integrative and unitary method can control health-related risks at the junction of humans, natural world, plants, and animals (FAO, 2022). Several disciplines and communities at various levels collaborate to address health issues through one health approach. The main goal is to tackle the mutual requirements for clear water, energy, air, and safe or secure food as well as act on climatic variations to contribute toward sustainable development (WHO, 2020). With regard to regulations and policies, one health concept can be executed to apply programs and policies, by communication across multiple fields to attain better health (Erkyihun & Alemayehu, 2022).

Threats to Aquatic Environment

Aquatic environments are harmed by a diversity of anthropogenic stresses, most of which have been working for decades to centuries. These stressors include water diversions, introduced animal species, heavy metals, organic chemical pollution, overuse of living resources, urbanization, silt, and nutrients. Furthermore, ocean acidification is a main challenge for the health of aquatic bodies, caused by the rise of CO_2 that results in a lower pH as depicted in Figure 1 (Thomas et al., 2022). Additionally, eutrophication as well as climatic variations work in an additive fashion to make an aquatic habitat uninhabitable, whether by producing anoxic zones, rising competition among microbes, or generating lethal phytoplankton (Gangloff et al., 2016). Furthermore, technological advancements and the rising human population have exponentially increased the consequences of many other threats. There is a need of improved management approaches and active involvement which have decreased the scale and degree of many of these harms, like as those posed by overharvesting (Hilborn & Ovando, 2014; Rocha et al., 2014).

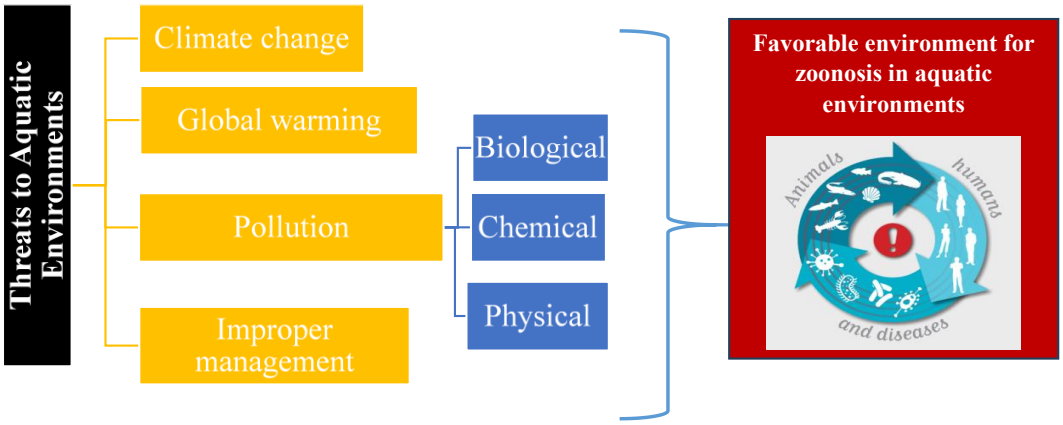

Fig. 1: Emerging Threats to Aquatic Environments.

Control Zoonotic Diseases in Aquatic Environments: Holistic One Health Approach

Aquatic animal species and human populations are infected by many of the common pathogens because they inhabit a common ecosystem. Several pathogenic microbes can be transmitted between humans and animal species. Drug-resistant microbes are capable of transmitting between human beings and animal species through direct contact or consuming contaminated food (Ziarati et al., 2022). Environmental pollution, drug resistance, ecosystem degradation and consumption of polluted food are also among the relevant challenges that cannot be managed through a single sector. Consequently, to address these challenges effectively, a collaborative One health protocol in the human-animal-environmental triangle is required (WHO, 2022). Furthermore, improving the Sustainable Developmental Goals (SDG), mainly SDG 3 ("Guarantee healthy lives and enhance welfare at all stages") as well as SDG 15 ("Protect, restore as well as promote sustainable utilization of terrestrial ecosystems, sustainable management of forests, tackle desertification, halt land degradation & biodiversity loss"); and gives a distinctive chance to related fields for functioning collaboratively (FAO, 2022).

One Health approach is a strong sustainable solution that can enable the achievement of health for the animals-human-environment triad, as well as water and food safety (Selbach et al., 2022). One Health is an appropriate approach, operating in close collaboration with research societies, academic circles, international organizations, the private sector, public societies, and other stakeholders as shown in Figure 2 (Rai et al., 2024). A one health strategy that has been approved by mostly industrialized countries, in which various fields are combined to encourage the preservation and protection of animals, human, and environmental health, is characterized as an ideal model to address aquatic challenges (Behravesh, 2019). It can, therefore, help the means for attaining the SDGs, including those on hunger, clean water and sanitation, poverty, injustice, health, economic growth, sustainable consumption and generation, and partnerships (Sinclair, 2019).

Evolution of One Health Concept

One Health concept originated in the nineteenth century when Rudolf Virchow integrated veterinary medicine with human health. One Health concept expanded globally; however, at the onset of the 21st century, it underwent a paradigm shift, leading to an increase in interdisciplinary collaboration. In order to prevent epidemic diseases and preserve ecosystem integrity, the Wildlife Conservation Society developed the One World-One Health Concept in 2004 by implementing a cross-sectional technique (Evans & Leighton, 2014). In 2008, the United Nations Food and Agriculture Organization (FAO), World Organization of Animal Health (OIE), United Nations Children's Fund, World Bank, and United Nations System Influenza Coordinator published "Contributing to One World, One Health," a strategic framework for reducing infectious disease risks at the animal-human-environment interface (Buttigieg, 2015). An important movement that broadened the concept of One Health by advocating for increased multidisciplinary cooperation among medical and veterinary authorities to improve the health of the human, animal, and environmental triad was the global conference on the One Health approach, which was held in May 2015 by the World Medical Association (WMA) and the World Veterinary Association (WVA). Since then, the one health model has gained widespread acceptance, and its projects have been quickly expanding their reach (Erkyihun & Alemayeh, 2022).

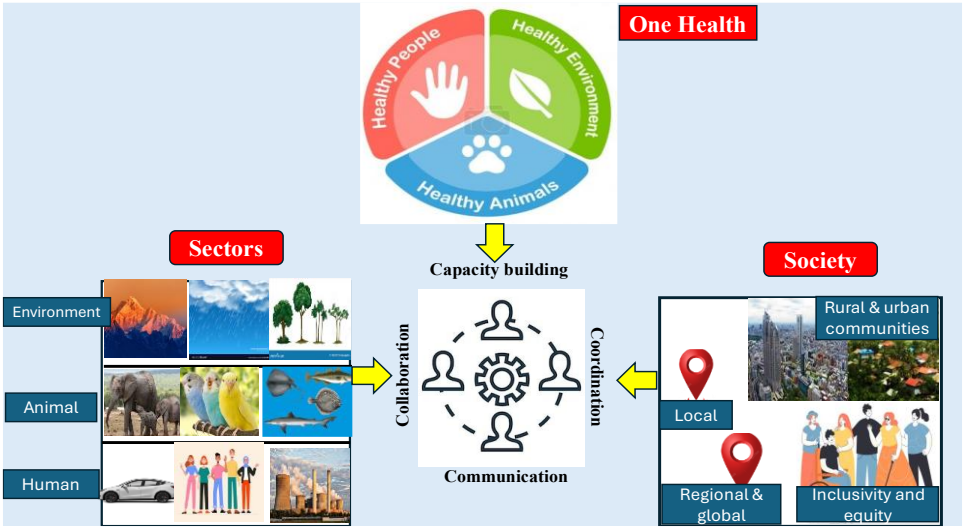

Fig. 2: Concept of One Health Approach.

Different Perspectives of One Health Concept in Aquatic Environments

One health concept is utilized widely for carrying out the surveillance of diseases; prevention of zoonosis; enhancing nutritional security; as well as lowering the drug resistive infections for enhancing the health of human beings and aquatic life as illustrated in Figure 3 (Aggarwal & Ramachandran, 2020). Through encouraging strong cooperation among related fields, the one health strategy supports the surveillance systems of encountering diseases, data distribution mechanism with all participants, and identification of zoonotic diseases (Yasmeen et al., 2022). Commonly, this strategy greatly strengthens global health safety through its efficient multiple-sector cooperation, coordination as well and communication among multiple fields for tackling the health-related threats in aquatic environments, like as zoonotic diseases, drug resistance, and nutritional security (Sinclair, 2019).

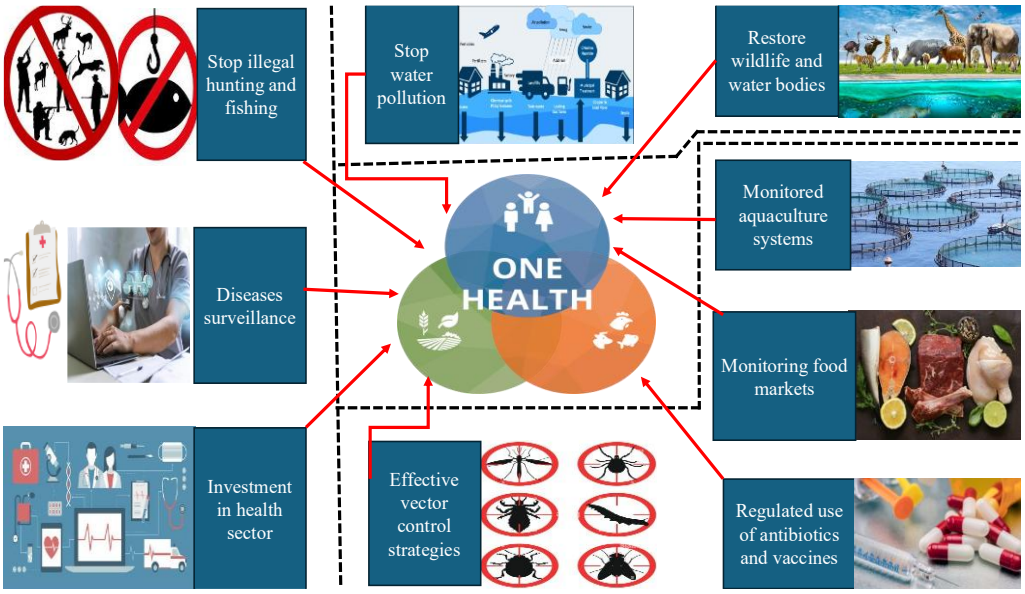

Fig. 3: Control Zoonotic Diseases through One Health Approach.

Joint Disease Surveillance and Management

Joint disease surveillance's main objective is to identify disease-based incidents and improve the application of coordinated response, its functions, and preventative actions. Furthermore, monitoring is supported in order to improve research-based fields along with awareness of the burden of diseases (Hattendorf et al., 2017). Related sectors are included in the zoonotic surveillance system, and common data sources include geospatial data resources, time series data, identification numbers, and locations of shared exposure. The definitions for surveillance cases, recognition procedures, and techniques for case validation, such as laboratory results, are necessary for such endeavors. Along with a strategic plan to prevent the disease, this collaborative system also requires a specific technical grouping that can be involved at all health institutions (Falzon et al., 2019).

The observation and control of illnesses is another crucial element of the one health concept in aquatic environments (Cavalli, 2015). Aquatic habitats make it easier for diseases to spread swiftly among cultured aquatic species. Furthermore, some diseases, referred to as zoonotic diseases, can spread from animals to humans. Regular surveillance and monitoring are essential to identify and manage possible outbreaks of diseases and prevent them from infecting humans or wild aquatic life. We can avoid financial damage, manage the health of ecosystems, and safeguard human well-being by swiftly addressing zoonotic illnesses in aquatic environments (Sleeman et al., 2017).

Antibiotic Application and Resistance

The usage of antibiotics and their resistance are serious problems in aquatic ecosystems. In aquatic farmed animals, bacterial infections are often minimized and treated with antibiotics (Chuah et al., 2016). However, if antibiotics are used carelessly, they may cause bacteria to become resilient, threatening the health of both people and animals. One Health concept encourages ethical antibiotic use in aqua farming to prevent the emergence of antibiotic resistance and protect human health (Velazquez-Meza et al., 2022). By employing good cultural practices, enhancing personal hygiene, and researching non-antibiotic disease management strategies like probiotics and vaccines, the use of antibiotics can be reduced (Kumar et al., 2021).

Environmental Impact

One more domineering constituent of the One Health approach is the impact on the environment. Large-scale activities could contaminate water and destroy habitat, endangering aquatic ecosystems and human populations that rely on healthy water bodies (Bashir et al., 2020). To lessen these consequences, sustainable culture techniques should be promoted, such as integrated multi-trophic aquaculture, which mixes species to create a more balanced and less polluting system (Buck et al., 2018). Long-term sustainability and environmental preservation can also be achieved by implementing appropriate waste management practices and ensuring that aqua farms are located in strategic locations (Ozbay et al., 2014).

Sustainable Nutrition and Feed

Many aquaculture species have substantial financial and environmental challenges due to feed inputs globally, 14.9 million tons of wild fish are harvested for fish meal and fish oils (FMFO). The worth of taking into account the origins of aquafeed for rearing aquatic animals is another point made by One Health (Stentiford et al., 2020). While promising, alternative feeds including plant, insect, or algae proteins have not yet produced trustworthy substitutes. Aquaculture's extractive, non-fed species, such as autotrophic plants, algal grazers, filter-feeding bivalves, and detritivores are believed to have the least negative environmental impact. Compared to open systems, onshore recirculating aquaculture systems may offer better biosecurity, greater environmental control, and a smaller environmental impact, particularly when combined with terrestrial food and energy systems (Hasan et al., 2023).

Collaboration and Communication

To be successful, the One Health approach in the aquatic environment requires a high level of cooperation and communication. Stakeholders from several sectors, including farmers, public health officials, environmentalists, researchers, and policymakers, must work together to develop and implement integrated plans and policies (Hailat et al., 2023). A successful communication plan should cover both government and non-government activities. An internal communication strategy for the government should set up a procedure for information sharing and communication across pertinent sectors and stakeholders. Communication techniques can establish avenues and forms of communication, helping establish consistent expectations, objectives, and messaging while also collaborating within One Health sectors. Regardless of the advantages of collaboration, cross-sector communication can be difficult for a variety of causes, including terminology mismatches. Some tools, such as the One Health European Joint Programme Glossary, can help discover and resolve terminology inconsistencies (Buschhardt et al., 2021).

Additionally, establishing cooperative communication at the commencement of an event can guarantee synchronization from the onset. The main driver of standardized messaging on the zoonotic nature of SARS-CoV-2 within the US government, for instance, is the One Health Federal Interagency COVID-19 Coordination Group, which was created at the start of the COVID-19 pandemic to exchange information among more than 20 government agencies (Albetkova et al., 2017). A communication plan can guarantee that One Health partners and stakeholders receive unified, consistent communications beyond the government that is independent of mandate or agency. Furthermore, a communication plan should drive public awareness campaigns, education on important One Health challenges, and risk communication in order to optimize public support and encourage the adoption and success of any health initiative (Wendt et al., 2015). An efficient response to the multifaceted relationships between animal health, human health, and the environment can be developed through knowledge exchange, the identification of possible dangers, and effective collaboration (Machalaba et al., 2021).

Conclusion

By recognizing the distinctive links between animal, human, and environmental health, the One Health approach offers a comprehensive

structure for addressing the transmission of diseases in aquatic environments. The food production business may prosper while preserving the health of ecosystems, farmed animals, and human consumers by encouraging disease surveillance and administration, fair antibiotic use, sustainable food and dietary intake, and environmental protection. One Health method can be successfully implemented with the help of cooperation, communication, research, and innovation, which will result in a more resilient and sustainable aquatic ecosystem in the future. One Health concept emphasizes the need of global cooperation and innovation in anticipating and combating new zoonotic risks assuring a healthier future for aquatic ecosystems, the animals they sustain, and the human populations who rely on them.

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