# Role of Aquatic Parasites in Emerging Zoonotic Diseases

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## Abstract

Aquatic parasites are the major contributors for the emergence and transmission of zoonotic diseases. These parasites can cause a number of diseases that spread between animals and humans. These are found in both fresh and marine ecosystems where they can infect through contaminated water, food or direct contact with infected ones. Zoonotic aquatic parasites that belongs to the groups of Nematodes, Cestodes and Trematodes have complex life cycles involving an intermediate hosts including fish or snails that facilitates the transmission of infection to the final host's humans of animals. The impact of climate change, habitat alteration and increases human-wildlife interaction are altering the distribution of these parasites, expanding their range and creating new health risks. Additionally, the global level trade of aquaculture practices introduced new threats through host-parasites interactions. Control measures and effective monitoring are the solutions to control these risks posed by new emerging aquatic zoonotic diseases and it is crucial also to pinpoint the specific causes that give rise to these zoonotic infections.

**Keywords:** Aquatic parasites, Zoonosis, Zoonotic parasites, Zoonotic diseases, Emerging infections, Water borne parasites

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## Introduction

The term zoonosis describes a transmissible infection that spreads from one animal species to humans (Han et al., 2016). Numerous infectious disease-causing agents, such as parasites, viruses, bacteria, and fungi can spread from animals to humans through a variety of pathways, such as ingestion, animal bites, penetration through damaged or abrasive skin, vectors and direct contact such as inhaling respiratory particles or coming into contact with the skin or mucous membranes (Rahman et al., 2020). Humans can be directly infected by viruses that typically affect animals or it can be done through a vector (Wolfe et al., 2007). Many infectious diseases are considered to be important to aquatics, according to the widespread consensus (Shamsi, 2019). It is underestimated because of a lack of monitoring and surveillance as well as lack of awareness. However, there may be serious repercussions, including death (Zorriehzahra & Talebi, 2021).

In an estimation, 260,000 Americans were infected from contamination of seafood each year. Additionally, around 857 outbreaks linked to fish, produced 4815 diseases and 359 fatalities (Barrett et al., 2017). There are many diseases that are prevalent in aquatic animals. The World Health Organization (WHO, 2021) defines an emerging disease as one that "has occurred in individuals for first time, or that may have occurred previously but is now growing rapidly in prevalence or geographical range." One characteristic of newly discovered diseases is the shortage of data regarding their zoonotic potential (Zorriehzahra et al., 2014).

Consumption for seafood has surged in recent years due to the world's population growth and rising seafood consumption. Although the fisheries and aquaculture sectors have demonstrated sustainable expansion globally, they are not risk-free because seafood is one of the human body's protein sources (Shamsi, 2019; Tran et al., 2019). Including seafood-related food sickness, humans can contract aquatic diseases. Preventing the aquatic zoonotic infections is a critical function of the immune system. However, there are two primary causes of human diseases. Consuming fish that has been undercooked or raw and ingesting water or other materials tainted with infected fish mucus or feces. The second way is to come into contact with the disease-causing agent via wounds that are open or skin abrasions or scratches. As reported by Raissy(2017) 15% of zoonotic infections originated from fish have multiple routes of transmission, while 46% are spread orally. The rates of transmission through skin contact while handling fish and ingestion of water contaminated with pathogens are 19% and 24%, respectively.

Despite being rare, human contamination by fish diseases poses a significant risk to the welfare of humans (Aggarwal and Ramachandran, 2020). Meanwhile, human developing infectious diseases have been linked to zoonotic infections (Jones et al., 2008). According to the WHO 2021, the spread of zoonotic agents poses a major danger to global healthcare and causes serious damage everywhere. The importance of human-animal contact in the transmission of zoonotic diseases has been underlined once more by the COVID-19 pandemic, especially for livestock and wildlife species that may act as hosts and virus reservoirs (Meurens et al., 2021).

The spread of fish pathogens to humans depends on a number of variables, including microorganism, host status (wounds on the body, spine penetration), and surroundings (contaminated water) (Haenen et al., 2013). Bacteria, viruses and parasitic organisms are the most significant infectious agents among fish-associated pathogens (Shamsi, 2019; Meurens et al., 2021). The current chapter focusses on parasitic infections as zoonotic diseases and its risk to humans and ultimately, their prevention and management due to the world's rapidly expanding fisheries and aquaculture industry.

## 1. Fish-derived Parasites

Consuming raw or poorly prepared fish or fish products is the primary way that humans contract parasitic tapeworms, roundworms and flukes derived from fish, which cause morbidity (Cong & Elsheikha, 2021). The importance of seafood in the worldwide diet and the growing health risks of parasite diseases and illnesses originating from seafood are well covered in the previous literature and many parasites have been shown to reside in a variety of edible fish (Shamsi, 2019). Humans can contact many of these parasites, and some, such gnathostomiasis and anisakidosis, can pose a major threat to the health of humans (Audicana et al., 2002).

According to reports, seafood especially fish products ranks highly among food-derived disorders (Huss et al., 2000). Parasites are frequently disregarded in talks on seafood safety, despite their prevalence (Shamsi, 2020). Because of this, parasites originating from fish are frequently overlooked and are the cause of a number of newly discovered zoonosis (Shamsi, 2019). According to Williams et al. (2020), food inspection standards and procedures for identifying disease pathogens differ greatly between nations.

The rising incidence and prevalence of zoonotic infection issues have been attributed to climate change and growing consumer demand for raw foods (Shamsi & Sheorey, 2018). From an estimation, 680 million persons are at risk of contracting aquatic liver flukes, and approximately 45 million individuals are currently infected (Saijuntha et al., 2021).

Helminthic parasites are particularly concerning among seafood parasites and they frequently infect fish (Ogbeibu et al., 2014). For instance, 213 species of fish in Vietnam have been found to harbour 268 helminthes species (Nguyen et al., 2021). The trophic orientation of the parasite lifecycle, which depends on the food chain for host transmission, is one explanation (Polley & Thompson, 2009).

More than 40 fish parasite taxa have the potential to infect humans, according to Shamsi (2019). Some can be extremely pathogenic and represent a major public health danger while others are uncommon. Over half a billion people's health may be at danger due to helminthic parasites (dos Santos & Howgate, 2011). Fish-derived helminthic diseases can cause severe symptoms like hemiparesis and cancer, or mild to severe allergic or digestive conditions like diarrhea, indigestion, and abdominal pain as exemplified in Figure 1, (Cong & Elsheikha, 2021). Routine observation is necessary to avoid the transmission of these infections, even if freezing imported edible fish renders the parasites inactive (Williams et al., 2022).

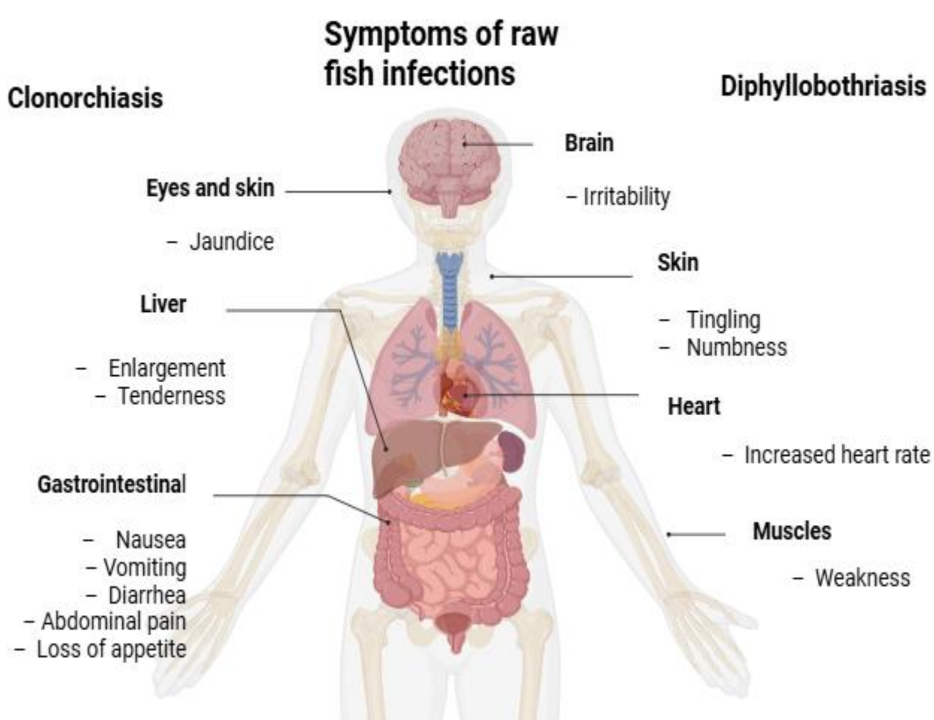


**Fig. 1:** The illustration of effects of two different diseases (Chlonorchiasis and Diphyllobothriasis) on different organs of human body

### i. Trematodes (flukes)

Fish-derived zoonosis are caused by a number of trematode (fluke). Cholangitis, choledocholithiasis, cholangiocarcinoma and pancreatitis as differentiated from healthy condition are among the serious clinical issues that can result from a high liver flukes and a chronic disease. These conditions can also cause swelling and impairment to the epithelial, which can lead to digestive issues (Choi et al., 2004).

After consuming freshwater crab or crayfish that contain fluke metacercariae, humans can contact paragonimiasis, a lung fluke infection (Tantrawatpan et al., 2013). In Southeast Asia, trematodiosis is a leading cause of mortality and is quite common throughout Asia. In northeastern Thailand and Laos, *Opisthorchis viverrini* is quite common (Prueksapanich et al., 2018). According to dos Santos & Howgate (2011) trematoda relevance are found in fish of freshwater, brackish and marine. In freshwater, trematode infections typically happen after consuming raw fish (Shamsi, 2019).

The Republic of Korea's freshwater fish samples included zoonotic trematode metacercariae (Sohn et al., 2021). The WHO lists zoonotic fish trematodes as an emerging infectious pathogen. Humans and other animals may be at danger from trematode infections and environmental contamination in aquaculture systems (Clausen et al., 2012). The prevalence of some parasites that infect humans in different countries of the world are mentioned in table 1.

**Table 1:** List of species of Trematodiases reported from humans

| Sr. Number | Specie | country | Prevalence | References |
|---|---|---|---|---|
| 1 | *Clonorchis sinensis* | China | 31.6% | (Yu et al., 2003) |
| 2 | *Opisthorchis viverrini* | Laos | 70.3% | (Chai et al., 2005) |
| 3 | *Opisthorchis felineus* | Ukraine | 5-40% | (Yossepowitch et al., 2004) |

These cutting-edge diagnostic instruments will assist in identifying the infectious stage (*metacercariae*) in humans that is challenging to identify (Caffara et al., 2020). Digenetic trematodes, especially the zoonotic species can be found in domestic cats and dogs. As a result, more preventative and control strategies that guarantee ongoing surveillance of fish parasites responsible for zoonosis in dogs and cats must be developed (Enes et al., 2010; El-Seify et al., 2021).

### ii. Cestodes (tapeworms)

Cestodes, or tapeworms, are another prevalent fish parasites. In contrast to trematodes, they can reach a maximum length of 20 meters. The order *Diphyllobothriidae* contains parasites that can cause diphyllobothriosis (Scholz & Kuchta, 2016). Approximately 50 species in the genus *Diphyllobothrium*, at least 14 have been known to infect humans (Jones, 2015). The most pathogenic species include *Diplogonoporus balaenopterae*, *Adenocephalus pacificus*, *D. dendriticum* and *D. nihonkaiense* (Anantawat et al., 2012).

The diphyllobothriosis is often a mild illness that poses no threat to life. Although most infected individuals do not have any symptoms, others may have diarrhea, stomach pain and deficiency of vitamin B12 (Dick, 2007; McConnaughey, 2014). Up to 20 million persons are thought to be infected globally (Anantawat et al., 2012). However, tapeworm infections in humans have decreased worldwide, with the exception of Japan and far eastern Russia.

### iii. Nematodes (round worms)

Few of the human diseases that are being reported worldwide are thought to be emergent diseases caused by fish-derived nematodes. There have been reports of human infections in a few countries, and the prevalence varies from one country to another. These infections are prevalent in areas where people eat a lot of seafood, and they are especially widespread on South America's western coast (Eiras et al., 2018a). The *Chrysophrys auratus*, a common table fish, was found to contain zoonotic nematodes from the *Anisakidae* family in samples taken from the oceans of Australia and New Zealand. If consumed raw as sashimi or in sushi, *Anisakis pegreffii*, which has been found in *Chrysophrys auratus*, will be extremely dangerous to people (Hossen et al., 2021). Furthermore, the edible fishes studied in Australia also contained zoonotic nematodes (*Contracaecum spp.*, *Anisakis spp.*, and *Hysterothylacium spp.*) of zoonotic significance (Suthar & Shamsi, 2021).

In their human-infectious larval stages, nematodes show limited host specificity. Thus, they may still be harmful to people's health. The *Anisakis spp.*, *Pseudoterranova spp.*, which cause anisakidosis and members of the *Gnathostomatidae* family, which cause gnathostomiasis, are some of the most prevalent fish nematodes that pose a health risk to humans. All of these nematodes are regarded as extremely important on a regional or worldwide scale (Salikin et al., 2020).

The most prevalent fish nematodes in the *Anisakidae* family are found throughout the world and belong to the genera *Anisakis*, *Pseudoterranova*, and *Contracaecum*. They are also among the most frequently reported marine parasite larvae and have significant zoonotic significance (Bao et al., 2019; Safonova et al., 2021). Numerous studies have been conducted to raise awareness of them, enhance their diagnostic methods, and comprehend various facts of their biology and pathogenicity (Shamsi, 2014). Members of the genus *Anisakis* are responsible for anisakiasis as mentioned in figure 2, however any member of the family *Anisakidae* can induce anisakidosis. The common cause of anisakidosis is members of the *Anisakis simplex sensu lato* species. Additional nematodes include *Contracaecum spp.*, *A. physeteri*, and *Pseudoterranova decipiens* (Eiras et al., 2018b).

Despite the fact that the salmon samples were positive for *Anisakis simplex*, the farmed Atlantic salmon samples showed no parasites, suggesting that the risk to farmed fish is minimal (Pardo-Gonzalez et al., 2020). To stop Anisakis from entering in farms, various tactics must be used. This involves employing nets to reinforce water access sites and freezing waste fish that are used to feed farmed fish in order to keep wild fish out (Ramos, 2020). Before eating, the whole raw fish should be thermally treated (>60 °C, >1 min or 20 °C, >24 h) to further lower the risk of anisakiasis (Pardo-Gonzalez et al., 2020).

The live larvae are typically responsible for anisakidosis, and when larvae reach the intestinal or gastric mucosa, they can induce symptoms of human gastroenteritis (Ramanan et al., 2013). The anisakids after its death can also produce illness (Audicana et al., 2002). Anisakidosis frequently mimics food poisoning and typically manifests as gastrointestinal symptoms. After the parasite is either surgically removed (Shimamura et al., 2016) or spontaneously eliminated from the body (regurgitation or excretion) (Shamsi & Butcher, 2011), symptoms usually go away. Hypersensitivity linked to anisakis is a serious issue. Because even extremely tiny dosages of exposure to well-prepared dead *A.*

*simplex* material can result in potentially fatal and quickly developing anaphylactic reactions to fairly persistently incapacitating circumstances, sensitive people exhibit great sensitivity (Aibinu et al., 2019). Despite being documented globally, the condition is more prevalent in Japan and Europe (Rahmati et al., 2020).

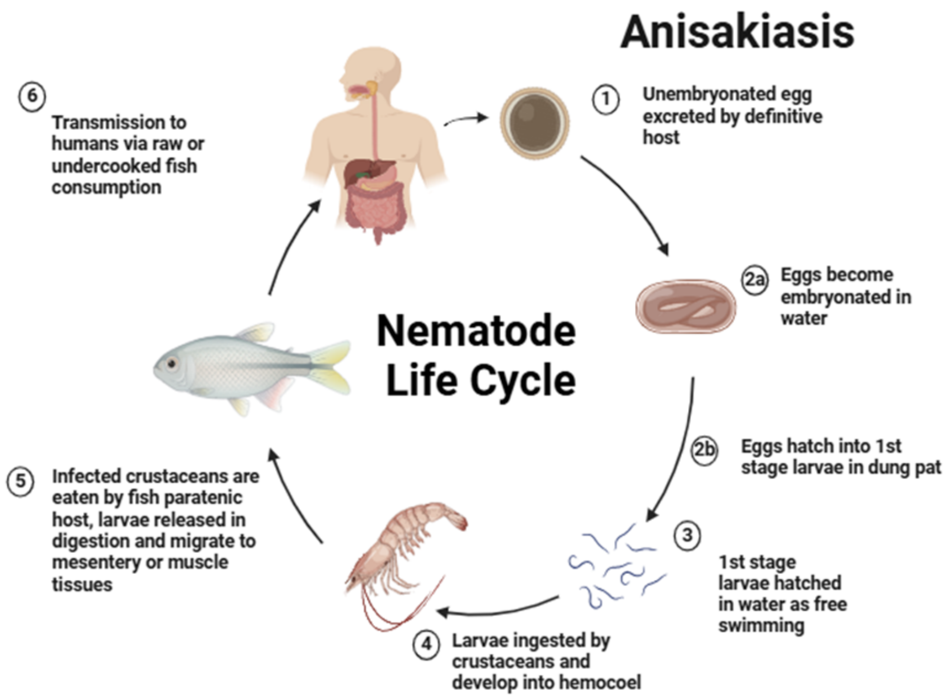


**Fig. 2:** Life cycle of Anisakis specie

Another significant nematode infection is gnathostomatidae, which is contracted by consuming raw or undercooked foods like sushi, ceviche made with fresh and brackish fish, and other freshwater creatures (eels, amphibians). When larvae (L3) of the family *Gnathostomatidae*, such as *Gnathostoma spinigerum* and *G. doloresi* are consumed, the parasites cause gnathostomiasis (Pinheiro et al., 2017; Shamsi et al., 2021).

In addition to hypoallergenic reactions, gnathostomiasis typically causes more severe clinical symptoms, including as nausea, vomiting, and abdominal discomfort, 24 to 48 hours after transmission (Anantawat et al., 2012). Infectious parasite larvae migrate through subcutaneous tissues, results in swellings. If they affect the nervous system, they can cause brain hemorrhage, paresis, or even death. *Gnathostoma spinigerum* has been identified as the causative agent of the majority of gnathostomiasis patients (Shamsi et al., 2021).

## 2. Prevention and Control

Public awareness of the risks of eating raw or undercooked fish is crucial because microbes in fish can exacerbate public health issues. Regular fish consumption monitoring and quality control procedures are necessary. This makes it possible to manage infections quickly and effectively and provide the knowledge needed to prevent and cure these diseases (Bibi et al., 2015).

Degradation of aquatic ecosystems is the primary cause of most fish illnesses and the environment has a big impact on fish health. Therefore, the implementation of suitable measures to prevent and manage diseases will be made possible by multidisciplinary tactics that include knowledge of potential fish pathogens, aspects of fish biology and a thorough awareness of environmental conditions (Toranzo et al., 2005). Some nematode species' intermediate hosts are reduced when ponds are cleaned and sterilized, which disrupts their life cycle. A substantial amount of intermediate hosts are more likely to remain in ponds that are not properly sterilized or sterilized before being refilled (Clausen et al., 2012; Tran et al., 2019).

The geographic location and availability of fresh seafood, as well as cleanliness, fish-handling methods, and dietary habits, can all be factors in the development of fish-derived diseases in communities. Social and personal conduct are also crucial (Chai et al., 2005). Fish-derived illnesses have become significant in industrialized nations due to factors like expanding global markets and its demand. To reduce the danger caused by zoonotic infections, there is a need to take some steps for harvesting, processing and storage. Government agencies and the seafood sector can help reduce the hazards associated with zoonotic fish-derived helminthes by implementing a number of initiatives, such as good manufacturing procedures (Shamsi, 2016).

Nonetheless, those who work with fish need to be aware of zoonotic diseases and prevention measures since antibiotics may be used to control certain zoonotic factors and are frequently used to treat bacterial zoonotic infections (Shin & Park, 2018). The greatest strategy to lower the potential hazards of these zoonotic illnesses may be prevention; specifically, it is not feasible to avoid contact with fish and water in the aquaculture sector. Humans can contract food-derived zoonosis by consuming tainted food that harbors multidrug-resistant animal diseases. Monitoring multidrug-resistant bacteria in both humans and animals as well as the consistent operation of communities is crucial to resolving this basic issue. Furthermore, it necessitates close collaboration between medical professionals, veterinarians, and environmental specialists (Chowdhury et al., 2021).

It's crucial to keep skin away from fish mucous and to wear disposable gloves. Even in cases when symptoms are vague, it is crucial to speak with the doctor. Frequent hand washing is the most effective method, particularly after coming into contact with the fish and water. Additionally, it's crucial to refrain from eating or drinking anything just before washing your hands. Additionally, direct or indirect contact with insects, vectors, inanimate item contamination, ingesting, and inhalation can all result in the spread of zoonotic infections (Boylan, 2011).

To avoid contaminating fish parasites, fishing vessels and technical industries must be handled appropriately. However, boiling fish for 15 seconds at 62 degrees celsius is sufficient to eradicate parasites. Freezing or heat-inactivation is one of the best ways to lower risk (Ahuir-Baraja et al., 2021). As a result, several essential tactics for zoonotic pathogen surveillance, management, and prevention must be taken into account. Furthermore, a sustainable and dependable method of managing any fish zoonotic or other possible disease epidemic is to integrate the One Health concept by enhancing several control mechanisms. The intricacy of the One Health approach and the participation of several components might make it difficult to follow. Nevertheless, there is no doubt that this can stop a community epidemic or any zoonotic illnesses in the future (Zorriehzahra & Talebi, 2021).

From tiny home aquariums to massive ponds spanning several hectares, aquaculture systems vary in size and design, but they always have nutrient-rich water that promotes the development of microorganisms. As a result, several research on the efficient chemical disinfection of polluted settings have been conducted; in order to successfully prevent fish zoonosis, it is important to address the duration of contact, the safe and appropriate handling of disinfectants, and the exact dosage of disinfectants. It's interesting to note that basic drying or desiccation has also been regarded as a successful disinfection method for zoonotic bacterial infections (Murrell, 2002). While the parasites are rendered inactive when imported edible fish are frozen, not all caught fish are frozen (Williams et al., 2022). Zoonotic transmission may be facilitated by customers' growing desire for seafood products (You et al., 2021). As a result, governments have to create stringent laws that keep an eye on the quality and safety for the use of aquatic food (Lehel et al., 2021). A significant human-fish interaction where zoonotic disease transmission may occur is the abrupt expansion of the aquatic ornamental fish business. The seriousness of this problem is demonstrated by observations of *Mycobacterium spp.* in ornamental fishes (Phillips et al., 2022). In order to effectively manage zoonotic fish infections, the One Health (OH) strategy has acquired significance and requires widespread implementation and strengthening. Increasing the close ties and involvement of stakeholders in addressing One Health issues for seafood safety is beneficial (Shamsi, 2019).

Furthermore, according to WHO, zoonotic diseases have proliferated as a result of globalization and cross-border movement of people, animals, and commerce. Furthermore, the viruses have spread further due to a lack of public health in distant communities, inadequate sample transportation infrastructure, and a lack of laboratory facilities for early illness identification. WHO publications state that the control, stoppage of transmission and diagnosis are main obstacles to controlling zoonotic illnesses and restricting the One Health system (WHO, 2021). Therefore, enhancing early illness and pathogen identification, encouraging infection treatment, managing vectors and rodents, and fostering efficient collaboration between human and animal health officials are the most crucial suggestions in this area. In order to control and prevent zoonosis, it is also essential to keep an eye on "One Health" approach and educating students, research teams, and international organizations to integrate multidisciplinary and cross-sectorial administrations (Aggarwal & Ramachandran, 2020).

**Conclusion and Future Prospects**

Numerous diseases, some are considered zoonotic and may infect humans, live in fish. Marine zoonotic research has increased as a result of the growing demand which has made zoonosis a serious concern for global health sectors. However, there is still a lack of information on the ecology, incidence, distribution, and biodiversity of illnesses originating from fish, especially with regard to parasites. This review was conducted in response to the dearth of information about the incidence and prevalence of zoonotic variables. Furthermore, in order to increase awareness as well as our knowledge of the infections' presence in their environment, a greater grasp of their morphological identification is required. Consuming raw or inadequately prepared fish is the primary way that humans contract the bulk of aquatic parasitic worms. Raw fish can be treated with heat or freezing before ingestion to lower the danger of parasitic tapeworms, roundworms, and flukes obtained from fish. In order to stop wild fish from entering the farm, preventative measures need also be put in place. To specifically identify zoonotic pathogens originated from fish, sophisticated molecular diagnostic methods should be created. This will make monitoring zoonotic infections in freshwater, farmed, aquatic, and ornamental fishes simple and affordable. Fish is therefore an important food source, but the expansion of aquatic diseases in humans has been caused by the presence of some likely zoonotic pathogens. Therefore, it is essential for public health and ought to be regarded as a significant component of human societies to have adequate knowledge about these dichotomies and to educate control and preventative techniques.

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