Vibrionaceae and Fish Zoonosis

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Mina Jamil[1*], Sajid Abdullah[1], Fatima Talib[1], Rabia Bashir[1], Naila Ghafoor[1], Khadija Javed[1], Umm E Ummara[1] and Ayesha Ghafoor[2]

ABSTRACT

Fish carry a wide variety of illnesses, some of which may be transmitted to humans (known as zoonotic diseases). There are primarily two sources of human illness included consuming raw fish (can be undercooked) or by the water contaminated with mucus or feces of already infected fish. The transmission of fish illnesses to people is complicated by a number of factors, including microorganisms (bacteria, viruses, parasites, fungus), host state (open sores on the body, spine penetration, immunocompromised), and environmental variables (unclean water). Gram-negative and Gram-positive bacteria are two broad types of zoonotic bacteria but the gram-negative is main agents of fish zoonosis. Members of the family Vibrionaceae are Gram-negative filaments causing various human, fish and shellfish infections come from a variety of their species. Humans may get diarrhoea, lesion infections, and sometimes extraintestinal infections as a result of certain vibrios. Vibrio (V.) cholerae (including V. cholerae O1/O139 strains responsible for cholera and additional V. cholerae strains associated with diarrhoea, wound infections, and septicemia) is responsible for the majority of the world's most severe diseases, followed by V. parahaemolyticus and V. vulnificus. Vibrios have been also linked to causing the condition known as vibriosis. Molecular identification is a key tool in clinical diagnostics. For species-level confirmation, real-time PCR and conventional PCR are both effective methods for detecting all major Vibrio spp. pathogens. To make disease management quick and efficient and to gives the knowledge required to stop and treat aquatic zoonotic pathogens, it is necessary to regularly examine and manage the quality of fish ingested. Thus, a multidisciplinary approach that takes into account the potential fish pathogens, features of fish biology, and a full understanding of environmental factors is necessary for the implementation of successful disease prevention and control approaches. The One Health (OH) concept should be enhanced and extended as it has become relevant in the treatment of zoonotic fish infections.

Keywords: Fish Zoonosis, Vibrionaceae, Zoonotic Agents, Zoonotic Detection, Antibiotic Resistance, Diagnosis, Prevention and Control

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[1]Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan
[2]Department of Zoology, Government College University, Faisalabad, Pakistan
***Corresponding author:** minajamil10@yahoo.com

1. INTRODUCTION

1.1. FISH ZOONOSIS

Increases in global population and per capita fish consumption have contributed to a surge in seafood demand in recent years. While the aquaculture sectors have demonstrated global expansion sustainably, but these are not without their share of risks (Shamsi 2019). Due to the importance of seafood as a protein source for people, there is always the chance of contracting a waterborne disease in addition to getting seafood poisoning. Environmental Health and Safety (EHS)/Occupational Health (2016) and Raissy (2017) report that many crucial components of fish and water may transfer illness to people. The immune system plays a significant role in determining the severity of aquatic zoonotic illnesses.
However, there are primarily two sources of human illness.

1- Consuming raw fish (can be undercooked) or by the water contaminated with mucus or feces of already infected fish is the primary risk factor for acquiring a fish-borne illness.

2- Transmission occurs when the infectious agent comes into contact with an open wound or abrasion/scratch on the skin (Raissy 2017).

3- Raissy (2017) reports that 46% of fish-derived zoonotic diseases are transmitted orally, while 15% of zoonotic illnesses originate in fish and may spread via more than one route. 24% of transmission occurs via direct skin contact with fish, and 19% occurs by ingestion of water containing infected organisms.

2. FISH ZOONOSIS CASE STUDY

Research found that eating contaminated fish in Americans causes around 260,000 illnesses each year. From the food groups causing outbreaks, most commonly reported is the fish meat. The Foodborne Disease Outbreak Surveillance System (FDOSS) of the Centres for Disease Control (CDC) gathers information on foodborne illness outbreaks. Additionally, according to Barrett et al. (2017), fish was implicated in about 857 outbreaks that resulted in 4,815 illnesses, 359 hospitalisations, and 59 deaths. These perilous fish-borne zoonosis outbreaks that have been recorded throughout the years highlight the need of keeping an eye on these diseases.
Emerging diseases are widespread in aquatic species. According to World Health Organization (WHO) "an emerging disease has appeared in a population for the first time, or may have existed before but is rapidly increasing in incidence or geographic range." The possibility for transmission from animals to humans is one aspect of emerging illnesses that is not well understood. The transmission of fish illnesses to people is complicated by a number of factors, including microorganisms (bacteria, viruses, parasites, fungus), host state (open sores on the body, spine penetration, immunocompromised), and environmental variables (unclean water). Bacteria, parasites, and viruses are the most significant infectious agents associated with fish (Meurens et al. 2021).

3. BACTERIAL ZOONOTIC AGENTS

Gram-negative and Gram-positive bacteria are two broad types of bacteria but the gram-negative is main zoonotic agents of fish. Even fish that seem healthy may have germs, especially in the kidneys and intestines (Meron et al. 2020).

4. THE FAMILY VIBRIONACEAE

Members of the family Vibrionaceae are Gram-negative filaments that may be straight or curled. They used polar flagella for the movement. Respiratory and fermentative metabolic processes are both used by facultative anaerobes. Some species including few strains of some species are bioluminescent, generally aquatic, often found alongside aquatic creatures and flora, and may be found in fresh, brackish, and saline water. Human infections come from a variety of species. Fish, eels, and other aquatic animals are harmed by some species. The Vibrionaceae family currently has 143 described species, which are grouped under the phylum Proteobacteria. The six genera *Aliivibrio*, *Enterovibrio*, *Grimontia*, *Photobacterium, Salinivibrio* and *Vibrio* make up the class Gammaproteobacteria (Farmer and Janda 2015).

5. HABITATS

According to Campbell et al. (1957), Baumann and Baumann (1981), Sakazaki and Balows (1981), Simidu and Tsukamoto (1985), members of the Vibrionaceae family occupy specific ecological niches. Humans may get diarrhoea, lesion infections, and sometimes extraintestinal infections as a result of certain vibrios. Infected wounds and widespread illnesses are caused by bacteria in aquatic animals. Aquatic settings are rich in vibrios and similar species. The distribution of these organisms is influenced by many variables, but the most important ones are probably specific human, animal, or plant hosts, readily accessible inorganic nutrients and carbon sources, temperature, salinity, dissolved oxygen, and, for aquatic species, depth below the surface.

6. REPRESENTATIVES OF VIBRIONACEAE

Members of the family Vibrionaceae are now a major concern to fish and shellfish infections (Fig. 1, 2, and 3). The resurgence of interest has led to the description of new species and a deeper knowledge of the biology of long-known taxa. Several species have been discovered so far as potential fish pathogens. Numerous species of vibrio have now been recognized. Ten of these creatures have been isolated from humans. *Vibrio (V.) cholerae* (including *V. cholerae* O1/O139 strains responsible for cholera and additional *V. cholerae* strains associated with diarrhoea, wound infections, and septicemia) is responsible for the majority of the world's most severe diseases, followed by *V. parahaemolyticus* and *V. vulnificus*. There are four more species of *Vibrio* that may be harmful to humans but often only cause less severe illness including *V. mimicus*, *V. fluvialis*, *V. furnissii*, and *V. alginolyticus*. As a consequence of recent taxonomic work, two closely related species that were formerly classified as members of the genus *Vibrio* have been reclassified as separate entities, *Grimontia hollisae* (previously *Vibrio hollisae*) and *Photobacterium damselae* subspecies *damselae* (previously *Vibrio damselae*). *V. metschnikovii, V. cincinnatiensis*, and *V. carchariae* have been the primary focus of case reporting, however it is yet unknown how these infections are significant to people. Their potential as human pathogens has been called into question (Morris 2013).

7. GENUS *VIBRIO*

Most commonly members of the genus *Vibrio* are capable of imitating widespread fish and human diseases. *Vibrio* is ubiquitous in estuarine and coastal marine environments and displays seasonal population changes. The pace at which organic matter is broken down in these habitats influences the amount of dissolved organic carbon at higher trophic levels in the marine food web. However, certain strains of Vibrio are opportunistic bacteria that may make humans and marine animals infectious (Austin 2010).

There is a lot of genetic and biological similarity amongst Vibrio species. Horizontal gene transfer and recombination, sometimes known as the "borrowing of genes from other species," shaped their two chromosomes, or genomes. There is genetic diversity among these illnesses, but they all originate in marine and aquatic environments. They thrive in somewhat salty, moderate water, and their numbers in

Fig. 1: Vibriosis-affected turbot with extensive surface bleeding (Photograph courtesy of Professor X.-H. Zhang)

Fig. 2: On the surface of olive flounder is an ulcer caused by *Vibrio sp*. (Photograph courtesy of Dr. D.-H. Kim)

Fig. 3: Hemorrhaging on the fins and around the opercula of a sea bass. The etiological agent was *V. anguillarum* (Photograph courtesy of Dr. V. Jencic)

the wild tend to increase as the temperature rises (Baker-Austin et al. 2017). *Vibrio spp*. are the most common pathogens in aquatic environments and seafood, contributing to human sickness. *V. cholerae, V. parahaemolyticus, V. vulnificus,* and *V. alginolyticus* are some of the most often seen pathogenic species. There is a distinct seasonal trend to infections caused by *Vibrio spp.,* with the majority of cases occurring in the winter. Infections caused by *Vibrio spp.* often manifest in people when they come into contact with contaminated water or consume seafood that has not been properly prepared (Table 1) (Oliver 2005).

8. CHOLERA AND NON-CHOLERA INFECTIONS

Cholera and other illnesses caused by the dangerous *Vibrio* bacteria may be roughly divided into two categories, which are cholera and non-cholera infectious groups. Cholera is a potentially fatal diarrheal sickness caused by ingesting contaminated food or water. Even purified water may harbor the cholera virus. Non-cholera *Vibrio spp*., such as *V. parahaemolyticus* and *V. vulnificus*, are the etiological agents of vibriosis, a group of disorders whose clinical manifestations vary based on the pathogen species, route of infection, and host susceptibility. Mild gastroenteritis or primary septicaemia (septicaemia caused by eating infected food that is raw or undercooked) may be caused by non-cholera bacteria, whereas wound

Table 1: Most important vibrio members behaving as human pathogens (Baker-Austin et al. 2018).

vibrio member	Infectious sources			Infectious route		Clinical demonstrations
	Sea food	Sea water	Fresh water	Oral contact	Wound contact	
V. cholera (O1 and O139 strains)	Rare	Rare	Yes	Yes	Rare	Cholera, gastroenteritis and rare wound infections
V. cholera (Remaining Strains)	Yes	Yes	None	Yes	Yes	Wound as well as ear infection and gastroenteritis with rare septicemia
V. vulnificus	Yes	Yes	None	Yes	Yes	Sepsis with gastroenteritis and wound infections
V. parahaemolyticus	Yes	Rare	None	Yes	Yes	gastroenteritis as well as wound infections with rarely sepsis occurrence
V. mimicus	Rare	Yes	None	Yes	Yes	Rare wound, ear as well as ear infection with gastroenteritis occurrence
V. fluvialis	None	Yes	None	Yes	Yes	Rare wound, ear as well as ear infection with gastroenteritis occurrence
V. alginolyticus	None	Yes	None	None	Yes	Common ear and wound infection with rare sepsis
V. hollisae	Yes	Yes	None	Yes	None	Gastroenteritis as well as wound infections in common and rare sepsis
V. metschnikovii	None	Yes	None	Probable	None	Common sepsis as well as gastroenteritis

infection and secondary septicaemia can be caused by exposure to contaminated water. Non-cholera *Vibrio spp*., found in seawater and shellfish, prefer moderate to high salinities. The most significant environmental human illnesses originating in aquatic and marine environments are caused by these bacteria (Thompson and Swings 2006).

9. *VIBRIO* IN MARINE FISH

The most prevalent *Vibrio* species in marine fish are *V. vulnificus* and *V. parahaemolyticus*, whereas *V. cholerae, V. vulnificus*, and *V. parahaemolyticus* are responsible for the bulk of human diseases. Fish infected with *Vibrio* often exhibit listlessness, skin lesions, exophthalmia, and ultimately death as clinical manifestations. Splenic enlargement, abdominal dropsy, intestinal inflammation, epidermal haemorrhage, scale exfoliation, pop-eye, and tail decay are among other signs that have been reported (Smith 2011).

10. *VIBRIO* SPECIES IN HUMANS

In humans, *V. cholerae, V. vulnificus,* and *V. parahaemolyticus* provide the most risk since they may cause gastroenteritis, wound infections, and septicemia, respectively. Other *Vibrio* species, such as *V. mimicus, V. fluvialis, V. furnissii,* and *V. alginolyticus*, have also been linked to human infections; however, their associated disorders tend to be milder (Baker-Austin et al. 2018). Regarding the environmental prevalence, the reports of the isolation of three species*, V. metschnikovii, V. cincinnatiensis,* and *V. carchariae,* may have been more indicative of asymptomatic colonization than infection (Morris Jr et al. 2003).

11. VIBRIOSIS

Several species of *Vibrio* and *Photobacterium* cause major infections in fish, crustaceans, mollusks, corals, and rotifers. These bacteria have been linked to causing the condition known as vibriosis (Gomez-Gil et al.

2014). The pathogen *Aliivibrio salmonicida*, formerly known as *V. salmonicida,* causes the Hitra disease or cold water vibriosis in Atlantic salmon (*Salmo salar*). These reclassifications are the result of recent developments in *Vibrio* taxonomy. Broadly speaking, vibriosis refers to any kind of septicemia brought on by these tiny organisms. According to the research Red limb illness was also called penaeid vibriosis, luminous vibriosis, and penaeid bacterial septicemia until it was renamed. An epizootic is a brief worldwide pandemic of a communicable illness in a constrained geographical region. Since then, it has been discovered in a wide variety of marine organisms and invertebrates around the globe. It was first seen in eels. Vibriosis has become a substantial economic influence on marine fish culture, significantly impacting many fisheries and other farmed animals, since all marine fish are vulnerable to at least one *Vibrio* species. Cell morphology, physiology, and biochemistry of a specific *Vibrio* species are commonly determined using biochemical tests and molecular approaches (Austin et al. 2012).

12. VIBRIOSIS THREE PRINCIPAL PHASES

Invasion (through skin, appendages, gills, or anus), tissue and host cell damage, and outflow (perhaps resulting in death) are the three primary phases of vibriosis. Siderophores, extracellular products (ECPs), hydrolytic enzymes, and poisons are all examples of the types of virulence factors that *Vibrio* may create. Although specific *Vibrio* species have been linked to a 100% fatality rate, resistance to vibriosis relies on how the infection, host, and environment interact (Hernández-Cabanyero and Amaro 2020).

13. HIGH-RISK *VIBRIO* SPECIES

- ***V. parahaemolyticus***

V. parahaemolyticus is the pathogen most often associated with food-borne gastroenteritis in a variety of countries, accounting for around 25% of cases. Rarely, eating infected raw or undercooked fish may be lethal, leading to invasive septicemia or acute gastroenteritis (Zarei et al. 2012).

- ***V. alginolyticus***

V. alginolyticus has the potential to greatly raise human morbidity and mortality rates. Exposure to saltwater has been linked to cases of gastroenteritis and significant extraintestinal infections such as otitis externa and traumatic wound infections. *V. alginolyticus,* which was formerly the third most prevalent *Vibrio* species to cause human illness, is now the second most common (Gomez et al. 2003).

- ***V. vulnificus***

Human septicemia, necrotizing wound infections, and gastroenteritis are largely brought on by *V. vulnificus*. Contrary to *V. parahemolyticus, V. vulnificus* produces septicemia with severe symptoms and a mortality rate of more than 50%. It is also very invasive (Tao et al. 2012).

14. ZOONOTIC DETECTION

Numerous facultative diseases with an environmental niche, which are usually difficult to differentiate between infections in common and strict zoonosis, are generally classified as fish zoonosis. It is essential to establish if human and fish illnesses are caused by the same organism before making any inferences given what is known about the characteristics of diseases produced by different bacterial agents in people and fishers, as well as their transmission mechanisms (Neogi et al. 2010). There is little data on whether illnesses in animals and humans are brought on by the same bacterial strains, serotypes, or in certain cases, species. Our capacity to identify whether human diseases have come from infectious fish, the environment, or briefly colonized or contaminated fish products has improved and thanks to the use of molecular tools (Di Pinto et al. 2005).

15. *VIBRIO* DETECTION IN DIETARY SAMPLES

Selective media, such as thiosulfate citrate bile salts sucrose (TCBS), are often used in conventional microbiological techniques for the detection of *Vibrio* in food samples. Isolating organisms from seafood and marine habitats may be challenging, time demanding, and less sensitive when utilizing standard phenotyping and biochemical testing procedures. New molecular techniques have developed as a response to these problems. *V. parahaemolyticus* was previously identified in seafood using the gyrB and toxR loci. *V. alginolyticus, V. vulnificus,* and *V. parahaemolyticus* collagenase gene sequences are genetic markers (Di Pinto et al. 2005; Neogi et al. 2010).

16. TRANSMISSION OF *VIBRIO* FROM FISH TO HUMAN

Food contamination continues to be an issue on a global scale. Recent changes in food consumption habits and improvements in food production and processing methods have brought up new risks. Summertime ingestion of unclean water and undercooked seafood is another epidemiological sign of *V. cholerae* spread (You et al. 2021).

Consequently, isolated species cannot be detected using traditional biochemical techniques. Molecular identification is a key tool in clinical diagnostics. PCR-based detection focuses on specific DNA sections to identify bacterial strains. Additionally, PCR amplified the 16S rRNA gene, generated positive findings, and allowed the identification of live but uncultivable isolates in the sample. Its usage among academics is expanding since it is less labor-intensive and considerably quicker than traditional approaches (Teh et al. 2010). *Vibrio* may be used to spread illnesses including lesions, septicemia, erythema, and tissue necrosis from fish to people. Increased customer preference for prepared seafood, such as fresh fish flesh segments, may result in diseases connected to *V. parahaemolyticus* (You et al. 2021). A crucial zoonotic pathogen that endangers the public's health is *V. vulnificus.* Consuming raw shellfish has been shown to cause primary septicemia in people. It may also cause secondary septicemia when exposed to saltwater (Carmona-Salido et al. 2021).

17. MAJOR INFLUENCE OF ANTIBIOTIC RESISTANCE ON ZOONOSIS

For more than 60 years, antibiotics have been regarded as a successful therapy for bacterial infections. Microorganisms, conversely, have evolved diverse resistance mechanisms to fight against the innovative drugs that are employed to kill them. Over 50,000 people die each year in Europe and the US alone as a consequence of infections brought on by resistant germs, which has rapidly grown in recent years. The mortality rate from this illness is noticeably greater in poor and impoverished countries (Mackey et al. 2014). Due to the massive use of various antibiotics in aquaculture to promote development and prevent bacterial infections, antimicrobial resistance has grown to be a severe threat to both human and veterinary health worldwide. Infected food may directly transfer antimicrobial-resistance genes to people, particularly those linked to mobile genetic elements (Shakerian et al. 2018).

The AMR pattern differs from nation to nation depending on the use of antimicrobial drugs. Between 2000 and 2015, the worldwide consumption of antibiotics rose by 36%, with notable regional variances. Gram-negative AMR pathogens are the most often used therapy for *Vibrio* species, notably *V. cholerae* (Wibisono et al. 2020). Antibiotic usage in India was 12.9×10^9 units per person per year on average in 2010. Antimicrobial drugs usually enable efficient surveillance of harmful microorganisms that cause infectious diseases. The incorrect use of antimicrobial treatments in society causes the emergence of bacteria that are resistant to the drugs, which might endanger human health (Riwu et al. 2020; Widodo et al. 2020).

18. DIAGNOSIS AND SCREENING

18.1. DIAGNOSIS OF CHOLERA

Cholera is a severe form of diarrhoea that causes fast fluid loss (dehydration) and is characterized by rice-water stools that must be forcibly evacuated (purged) at a speed of roughly 1 liter per hour. Nausea and vomiting are common symptoms of this severe diarrhoea. Most instances of *V. cholerae* infection are asymptomatic, accounting for around 75% (WHO 2016), whereas 5% are mild, 35% are moderate, and 60% are severe (Qadri et al. 2005; Harris et al. 2008). The incubation period for *V. cholerae* is normally five days, but may range from a few hours to several days. A person may be infectious (i.e., release live microbes in their faeces) for up to fourteen days, as stated by the World Health Organization (2017). When a patient checks into a healthcare facility, they often have a stool or blood sample obtained for microbiological identification (Azman et al. 2013).

18.2. DIAGNOSIS OF VIBRIOSIS

If a patient presents with watery diarrhoea and has recently consumed raw or undercooked seafood, especially oysters, or if a wound infection develops after being exposed to sea water, the doctor may suspect vibriosis (CDC 2017). The vast majority of *V. parahaemolyticus* infections are short-lived and not very severe. The incubation time for *V. parahaemolyticus* infections typically lasts between 12 to 24 hours after ingestion. Stomachache, diarrhoea, nausea, headache, fever, and chills are all common clinical manifestations. In situations of severe gastrointestinal vibriosis (such as *V. vulnificus* infection, where 90% of patients need hospitalization), obtaining the patient's exposure history is critical. Those with preexisting conditions like diabetes or liver disease are at a higher risk. The typical incubation period for *V. vulnificus* infections is 48 hours from ingestion to the onset of symptoms, and 16 hours when open wounds are involved. This highlights the need of prompt diagnosis. In extreme cases of *V. vulnificus* infection, severe necrotizing fasciitis might occurs. Microbiological confirmation of the diagnosis is performed by collecting the necessary clinical samples (faeces, blood, lesions, or ear secretions) (Baker-Austin et al. 2017).

18.3. MICROBIOLOGICAL DIAGNOSIS

Vibrio spp. are often easily cultured from clinical samples. Using TCBS agar, which consists of thiosulfate citrate, bile salts, and sucrose, is the gold standard for isolating and subculturing *Vibrio spp*. *V. cholerae* and *V. alginolyticus*, use sucrose for energy and produce yellow colonies on TCBS agar medium, whereas *V. parahaemolyticus, V. mimicus*, and *V. vulnificus*, utilize other sugars and produce green colonies. Several other media may be used to develop colonies that appear green on TCBS agar; for example, blood agar and CHROM agar can be used to isolate *V. parahaemolyticus*, while cellobiose-polymyxin B-colistin (CPC) medium can be used to isolate *V. vulnificus* (Croci et al. 2007). In the United States, *Vibrio spp.* are often initially isolated from clinical samples using blood agar. Samples that provide positive culture findings may be sent to specialist labs for confirmation testing, which often entails species-specific PCR methods. For species-level confirmation, real-time PCR and conventional PCR are both effective methods for detecting all major *Vibrio spp*. pathogens (Nordstrom et al. 2007).

Vibrio spp. are routinely identified by biochemical assays; however, these techniques have drawbacks. For example, the right serological testing to further classify isolates has constraints. These techniques, for instance, are expensive, time-consuming, labor-intensive, and need highly skilled employees to interpret the data (Martinez et al. 2006; Croci et al. 2007).

19. PREVENTION AND CONTROL

Microbial agents in fish may increase public health problems, hence it is crucial to inform the public about germs and the dangers of eating raw or undercooked fish. It is necessary to regularly examine and manage the quality of fish ingested. This makes disease management quick and efficient and gives the knowledge required to stop and treat aquatic zoonotic pathogens (Bibi et al. 2015).

As fish are raised in a system that depends on natural environmental conditions for production, it is challenging to control fish zoonotic agents. The deterioration of the aquatic environment, which is also a key element in determining fish health, is the primary cause of the majority of fish illnesses. Thus, a multidisciplinary approach that takes into account potential fish pathogens, features of fish biology, and a full understanding of environmental factors is necessary for the implementation of successful disease prevention and control approaches (Toranzo et al. 2005). Cleaning and maintaining a pond effectively reduces the amount of host species that might disrupt ecosystems and animal populations. Several studies have shown that ponds that have not been cleaned and sanitized prior to restocking increase the likelihood that pathogens would be retained (Clausen et al. 2012; Tran et al. 2019).

A community's risk for contracting a fish-borne disease may be affected by a number of variables, such as its location, access to raw seafood, diet, level of hygiene, and fishing practices. Behavior in one's personal and social life is equally crucial. Diseases caused by eating contaminated fish are prevalent not only in the developing countries but around the world (Chai et al. 2005). Growing international markets, increased consumer demand, improved transportation infrastructure, and demographic shifts all contribute to the prevalence of fish-related disorders in developed nations. There are steps that may be done to lessen the danger presented by zoonotic viruses throughout the harvest, storage, processing, and post-processing phases. The seafood sector and government agencies may help to reduce the hazards presented by zoonotic fish-derived diseases by implementing different initiatives, such as good manufacturing practices (GMP) systems. Antibiotic treatment is common in bacterial zoonotic infections, thus certain zoonotic factors may be controlled by the use of antibiotics (Shin and Park 2018). As a result, people who work with fish need to be aware of zoonotic illnesses and preventive measures. Although avoiding all interaction with water and fish in aquaculture systems is unrealistic, prophylaxis may be the best way to lower the risk of these zoonotic illnesses (Smith 2011).

Wearing disposable gloves and avoiding contact with fish fluids are vital. It is critical to see a doctor even if general symptoms appear. The best strategy is frequent hand washing, especially after coming into touch with fish or water directly. It's also important to avoid doing anything that can contaminate your clean hands, such eating or drinking. Vectors, insects, and other pathogens may spread zoonotic diseases to humans via a variety of routes, including ingestion, inhalation, contact with inanimate objects, and direct or indirect contact. Preventing the spread of fish parasites requires regular maintenance of fishing infrastructure and technological equipment. Parasites may be killed by frying fish for 15 seconds at 62 °C (however this may not be adequate to destroy all bacterial toxins) (Shamsi 2016). Methods for managing, preventing, and monitoring zoonotic pathogens are shown in Fig. 4.

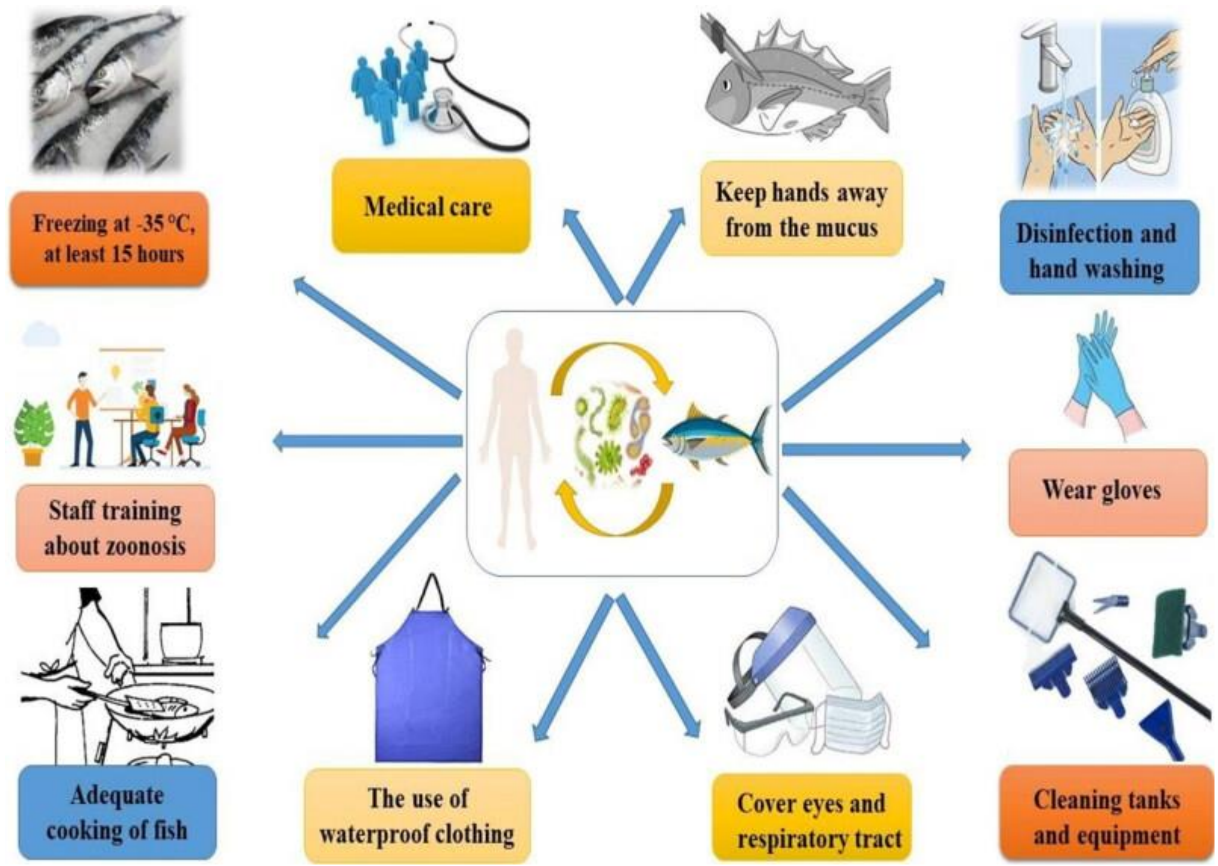

Fig. 4: Possible strategies for preventing and controlling zoonotic diseases.

20. ONE HEALTH (OH) APPROACH

The One Health (OH) concept should be enhanced and extended as it has become relevant in the treatment of zoonotic fish infections. Fish zoonosis epidemics can be stopped by having healthy fish, a healthy environment, healthy people, and a strong health care system. In order to solve One Health issues connected to seafood safety, it is advantageous to develop stakeholder relationships and involvement (Shamsi 2019).

The World Health Organization (WHO) asserts that international travel and trade have facilitated the spread of zoonotic illnesses. Inadequate sample transportation techniques and a lack of lab facilities for early sickness detection have also contributed to the spread of the illnesses in rural regions, where public health resources are few. Improving early sickness and pathogen detection, boosting infection treatment, and regulating vectors are among the most important suggestions in this area, as outlined by the World Health Organization (WHO) in 2021. A multidisciplinary and cross-sectoral approach is needed to manage and prevent zoonoses. It's important to keep an eye on the "One Health" strategy as you teach students, institutions, teams, and international organizations about it (Aggarwal and Ramachandran 2020).

21. CONCLUSION AND FUTURE PROSPECTS

Fish carry a wide variety of illnesses, some of which may be transmitted to humans (known as zoonotic diseases). Research into marine zoonotics has expanded in response to rising concerns about the spread of disease caused by zoonotic agents in the worldwide health and fishing industries. However, there is still a lack of variety in the ecology, incidence, and spread of fish-borne illnesses.

The medical community, food business, and biosecurity would all benefit from a heightened knowledge of disease morphological identification and environmental prevalence.

In order to accurately identify fish-borne zoonotic illnesses, novel molecular diagnostic approaches need to be developed. This will make it easier and cheaper to monitor fish for zoonotic diseases in freshwater, agricultural, marine, and ornamental settings. Aquatic diseases are unfortunately widespread among human's despite of the fact that eating fish may be economically beneficial. Therefore, it is crucial for public health and should be regarded a fundamental part of human civilization to have appropriate information about these and to educate control and preventative techniques. Any epidemic or possible breakout of a zoonotic disease in fish might be managed effectively and sustainably via the implementation of the One Health concept through the improvement of multiple control mechanisms.

REFERENCES

Aggarwal D and Ramachandran A, 2020. One health approach to address zoonotic diseases. Indian Journal of Community Medicine 45: S6-S8.

Austin B et al., 2012. Vibrionaceae representatives. Bacterial Fish Pathogens: Disease of Farmed and Wild Fish 2012: 357-411.

Austin B, 2010. Vibrios as causal agents of zoonoses. Veterinary Microbiology 140: 310-317.

Azman AS et al., 2013. The incubation period of cholera: A systematic review. Journal of Infection 66: 432-438.

Baker-Austin C et al., 2018. Vibrio spp. infections. Nature Reviews Disease Primers 4: 1-19.

Baker-Austin C et al., 2017. Non-Cholera vibrios: the microbial barometer of climate change. Trends in Microbiology 25: 76-84.

Barrett KA et al., 2017. Fish-associated foodborne disease outbreaks: United States, 1998-2015. Foodborne Pathogens and Disease 14: 537-543.

Baumann P and Baumann L, 1981. The marine Gram-negative eu-bacteria. In: Starr MP, Stolp H, Trüper HG, Balows A, Schlegel HG, editors. The Prokaryotes, a Handbook on Habitats, Isolation and Identification of Bacteria (1st Ed.): Springer-Verlag, New York; pp: 1352-1394.

Bibi F et al., 2015. Occurrence of Salmonella in freshwater fishes: a review. Journal of Animal and Plant Sciences 25: 303-310.

Campbell LL et al., 1957. Genus Beneckea. In: Breed, Murray, Smith, editors. Bergey's Manual of Determinative Bacteriology (7th Ed.): The Williams and Wilkins Co., Baltimore; pp: 328-332.

Carmona-Salido H et al., 2021. The widespread presence of a family of fish virulence plasmids in Vibrio vulnificus stresses its relevance as a zoonotic pathogen linked to fish farms. Emerging Microbes and Infections 10: 2128-2140.

Centers for Disease Control and Prevention (CDC), 2017. Cholera and Other Vibrio Illness Surveillance (COVIS), summary data, 2008-2012. Atlanta, GA: US Department of Health and Human Services.

Chai JY et al., 2005. Fish-borne parasitic zoonoses: status and issues. International Journal of Parasitology 35: 1233-1254.

Clausen JH et al., 2012. Prevention and control of fish-borne zoonotic trematodes in fish nurseries, Vietnam. Emerging Infectious Diseases 18: 1438-1445.

Croci L et al., 2007. Comparison of different biochemical and molecular methods for the identification of Vibrio parahaemolyticus. Journal of Applied and Microbiology 102: 229-237.

Di Pinto et al., 2005. A collagenase-targeted Multiplex PCR assay for identification of *Vibrio alginolyticus, Vibrio cholerae*, and *Vibrio parahaemolyticus*. The Journal of Food Protection 68: 150-153.

Environmental Health and Safety (EHS)/Occupational Health, 2016. Zoonotic Diseases–Fish. University of Colorado Denver/Anschutz Medical Campus.

Farmer III JJ and Janda JM, 2015. Vibrionaceae. Bergey's Manual of Systematics of Archaea and Bacteria 17: 1-7.

Gomez JM et al., 2003. Necrotizing fasciitis due to *Vibrio alginolyticus* in an immunocompetent patient. Journal of Clinical Microbiology 41: 3427-3429.

Gomez-Gil B et al., 2014. The Famlily Vibrionaceae. In: DeLong EF, Lory S, Stackebrandt E, Thompson F, editors. The prokaryotes. Springer, Berlin Heidelberg; pp: 659-747.

Harris JB et al., 2008. Susceptibility to Vibrio cholera infection in a cohort of household contacts of patients with cholera in Bangladesh. PLoS Neglected Tropical Diseases 2: e221.

Hernández-Cabanyero C and Amaro C, 2020. Phylogeny and life cycle of the zoonotic pathogen Vibrio vulnificus. Environmental Microbiology 22: 4133-4148.

Mackey TK et al., 2014. Emerging and re-emerging neglected tropical diseases: a review of key characteristics, risk factors, and the policy and innovation environment. Clinical Microbiology Reviews 27: 949-979.

Martinez UJ et al., 2006. Differences in the API 20E biochemical patterns of clinical and environmental Vibrio parahaemolyticus isolates. FEMS Microbiology Letters 255: 75-811 2006.

Meron D et al., 2020. Specific pathogens and microbial abundance within liver and kidney tissues of wild marine fish from the Eastern Mediterranean Sea. Journal of Marine Microbial Biotechnology 13: 770-780.

Meurens F et al., 2021. Animal board invited review: risks of zoonotic disease emergence at the interface of wildlife and livestock systems. Animal 15: 100241.

Morris JG, 2013. Minor Vibrio and Vibrio-like Species Associated with Human Disease.

Morris Jr JG et al., 2003. Cholera and other types of vibriosis: a story of human pandemics and oysters on the half shell. Clinical Infectious Diseases 37: 272-280.

Neogi SB et al., 2010. A highly sensitive and specific multiplex PCR assay for simultaneous detection of *Vibrio cholerae, Vibrio parahaemolyticus* and *Vibrio vulnificus*. Letters in Applied Microbiology 51: 293-300.

Nordstrom JL et al., 2007. Development of a multiplex real- time PCR assay with an internal amplification control for the detection of total and pathogenic *Vibrio parahaemolyticus* bacteria in oysters. Applied and Environmental Microbiology 73: 5840-5847.

Oliver JD, 2005. Wound infections caused by Vibrio vulnificus and other marine bacteria. Epidemiology and Infection 133: 383-391.

Qadri F et al., 2005. Enterotoxigenic Escherichia coli in Developing Countries: Epidemiology, Microbiology, Clinical Features, Treatment, and Prevention. Clinical Microbiology Reviews 18: 465-483.

Raissy M, 2017. Bacterial zoonotic disease from fish: a review. Journal of Food Microbiology 4: 15-27.

Riwu et al., 2020. A Review of Extended Spectrum β-Lactamase (ESBL) Producing *Klebsiella pneumoniae* and Multidrug Resistant (MDR) on Companion Animals. Systematic Reviews in Pharmacy 1: 270-277.

Sakazaki RI and Balows AL, 1981. The genera Vibrio, Plesiomonas, and Aeromonas. In: Starr, Stolp, Trüper, Schlegel, editors. The Prokaryotes. A Handbook on Habitats, Isolation, and Identification of Bacteria (Vol. 2): Springer-Verlag, New York; pp: 1272-1301.

Shakerian A et al., 2018. Antimicrobial resistance profile and resistance genes of Vibrio species isolated from giant freshwater prawn (Macrobrachium rosenbergii) raised in Iran. Journal of the Hellenic Veterinary Medical Society 68: 79-88.

Shamsi S, 2016. Seafood-borne parasitic diseases in Australia: how much do we know about them? Microbiology Australia 37: 27-29.

Shamsi S, 2019. Seafood-borne parasitic diseases: a “One-Health” approach is needed. Fishes 4: 9.

Shin B and Park W, 2018. Zoonotic diseases and phytochemical medicines for microbial infections in veterinary science: current state and future perspective. Frontiers in Veterinary Science 5: 166-169.

Simidu U and Tsukamoto K, 1985. Habitat segregation and biochemical activities of marine members of the Family Vibrionaceae. Applied and Environmental Microbiology 50: 781-790.

Smith SA, 2011. Working with fish, limiting zoonotic diseases. Global Aquaculture Advocate.

Tao Z et al., 2012. Prevalence and population structure of *Vibrio vulnificus* on fishes from the northern Gulf of Mexico. Applied and Environmental Microbiology 78: 7611-7618.

Teh CSJ et al., 2010. Simultaneous differential detection of human pathogenic and nonpathogenic Vibrio species using a multiplex PCR based on gyrB and pntA genes. Journal of Applied Microbiology 1086: 1940-1950.

Thompson FL and Swings J, 2006. Taxonomy of the vibrios. The Biology of Vibrios 3: 29-43.

Toranzo AE et al., 2005. A review of the main bacterial fish diseases in mariculture systems. Agriculture Aquaculture 246: 37-61.2

Tran AKT et al., 2019. Prevalence, species distribution, and related factors of fish-derived trematode infection in Ninh Binh Province, Vietnam. BioMedical Research International 30: 858-1379.

Wibisono FJ et al., 2020. CTX Gene of Extended Spectrum Beta-Lactamase (ESBL) Producing *Escherichia coli* on Broilers in Blitar, Indonesia. Systematic Reviews in Pharmacy 11: 396-403.

Widodo A et al., 2020. Extended-spectrum beta-lactamase (ESBL)-producing *Eschericia coli* from livestock. Systematic Reviews in Pharmacy 11: 382-392.

World Health Organization (WHO), 2016. 10 facts on cholera.

World Health Organization (WHO), 2017. Prevention and control of cholera outbreaks: WHO policy and recommendations.

World Health Organization (WHO), 2021. Zoonotic disease: emerging public health threats in the region.

You HJ et al., 2021. Tackling *Vibrio parahaemolyticus* in ready-to-eat raw fish flesh slices using lytic phage VPT02 isolated from market oyster. Food Research International 150: 110779.

Zarei M et al., 2012. Seasonal prevalence of Vibrio species in retail shrimps with an emphasis on *Vibrio parahaemolyticus*. Food Control 25: 107-109