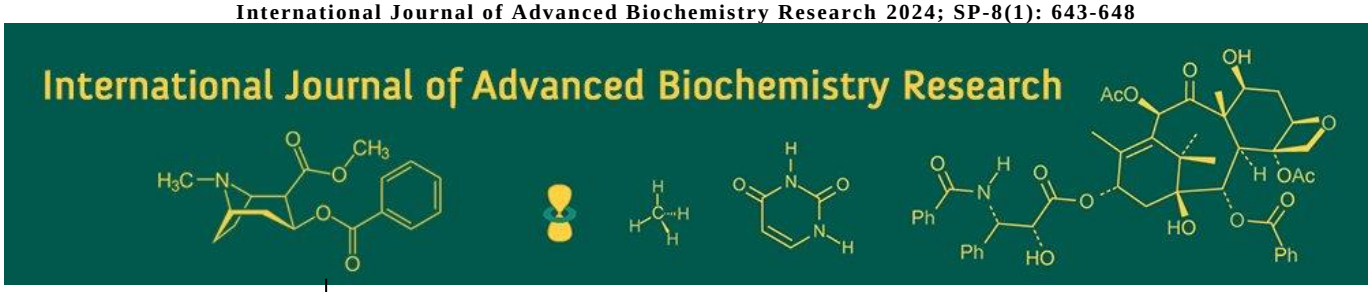

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Diseases of freshwater fishes in India and its treatment: A review

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Abstract
India stands as one of the leading countries in aquaculture production, providing crucial economic support to many people in the country. However, the occurrence of diseases has emerged as a primary hindrance to the sustainable production and trade of aquaculture products. Various stress factors, including inadequate physicochemical and microbial quality of culture water, poor nutritional status as well as high stocking density, can lead to infections by opportunistic pathogens. The presence of different opportunistic bacterial pathogens and parasites poses a significant threat, causing substantial losses to the fish industry in terms of heightened morbidity and mortality, diminished growth, and increased expenses on the use of chemicals for preventive and control measures. Therefore, the present review sheds light on the common freshwater fish diseases in India and their treatment, aiming to promote sustainable aquaculture.

Keywords: Aquaculture, chemical, pathogens, treatment and control measures

Introduction
Aquaculture is a fast-growing food production sector with 122.5 million tonnes (MT) total of production globally in 2020 (SOFIA, 2022). In which, Indian aquaculture production is pegged at 8.64 MT in 2020 (SOFIA, 2022). The surging demand for fish, coupled with a decline in marine catches, has exerted significant pressure on the aquaculture industry, driving the need for intensified operations. Various organisms suitable for cultivation are reared in different types of culture systems. There are three main types of cultures: open, semi-closed, and closed cultures. Open culture systems include cage culture, pen culture, rack culture and raft culture. Semi closed culture system includes pond and raceway culture and closed culture system include Biofloc system and Recirculating aquaculture system (RAS). Fish are highly susceptible to various pathogens, especially when they are cultivated under controlled conditions. Disease outbreaks occur due to inadequate cultural conditions, stress, the suppression of the host's immune system, high stocking densities with improper management, and the virulence of pathogens (Kennedy *et al*., 2016). Ponds that are well-managed typically remain disease-free, but a serious problem arises from carelessness in stocking, feeding and management practices. As they say, prevention is always preferable over the treatment, so it is essential to take measures to prevent the entry of pathogens into the culture pond. Although several treatment methods are available, they can be difficult and often impracticable for ponds containing a large number of fish. The most efficient technique to prevent the spread of disease is the removal and extermination of infected fish from the pond. Whenever possible, disease-resistant fish should be selected for cultivation.

Types of diseases in aquaculture
Occurrence of diseases in aquaculture is a result of complex interaction of host, pathogen and environment. There are three types of diseases Infectious diseases which include bacterial, viral, fungal and parasitic.

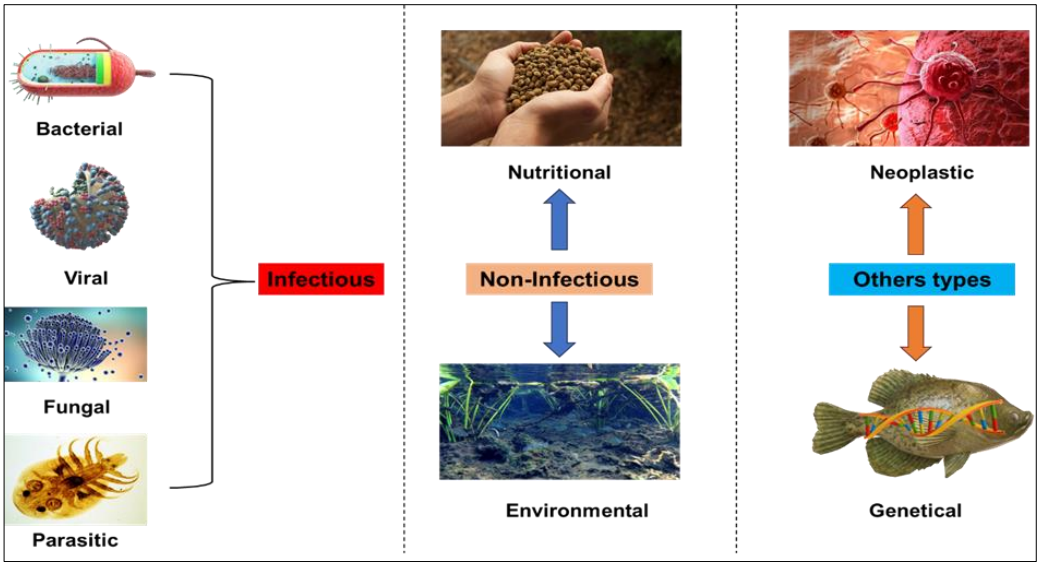

Fig 1: Different types of disease occur in aquaculture practices

Non infectious diseases which include environmental and nutritional diseases and other types which include genetic and neoplastic diseases. The World Organization for Animal Health (WOAH) or Office International des Epizooties (OIE) have listed major diseases in fish aquaculture (OIE, 2021) *viz*., Epizootic ulcerative syndrome, Carp edema virus, Epizootic haematopoietic necrosis diseases, Gyrodactylosis, Infection of covert mortality nodavirus, Infection with infectious salmon anaemia virus, Infection with tilapia lake virus, Infectious haematopoietic necrosis, Koi herpesvirus diseases, Red sea bream iridoviral diseases, Salmonid alphavirus infection, Spring viraemia of carp, and Viral hemorrhagic septicemia which cause substantial economic losses worldwide.

Bacterial diseases

Fish diseases caused by bacteria are widespread and present a formidable challenge in terms of health management. These bacteria are generally saprophytic in nature and turning pathogenic only under conditions where the fish's physiological equilibrium is disrupted, nutritional deficiencies occur, or when various stressors like poor water quality and overstocking create opportunities for opportunistic bacterial infections to take hold (Sandeep *et al*., 2016) [18]. Bacterial infections have commonly been observed in fish eggs, fry, and fingerlings, leading to significant mortality rates. These microorganisms primarily act as opportunistic pathogens, invade the tissues of fish hosts that have become vulnerable to infection due to the presence of stress-inducing factors. Several significant bacterial diseases, such as motile aeromonad septicaemia, edwardsiellosis, Pseudomonas septicaemia, flexibacteriosis, Vibriosis, bacterial gill disease, mycobacteriosis, and enteric septicaemia, have been frequently reported in carp culture in India (Mukherjee, 2002; Mohanty and Sahoo, 2007) [14, 13]. The detail of common bacterial diseases and there treatment reported in India are present in table 2.

Fungal diseases

Only a few numbers of fungal species are recognized as fish pathogens. These organisms are primarily found in water, and they tend to exploit unfavourable circumstances to target fish, resulting in skin lesions. Most fungal infections recorded in carp culture are those caused by species belonging to the oomycete fungi, *Saprolegnia*, *Achlya* and *Aphanomyces*. Diseases caused by these fungi are collectively called "saprolegniasis" (Das and Mishra, 2014) [7]. The oomycete fungi, which are frequently found in aquatic environment, are considered as primary pathogens. They are more commonly acknowledged as saprophytic entities, opportunistic secondary pathogens that readily colonise the damaged tissues infected by bacteria or parasites (Mukherjee, 2002) [14]. Fungal growth on the skin or fins manifest as patches resembling white to whitish-grey cotton-like growths. These formations primarily consist of numerous fungal hyphae, which become evident when examined through microscopic analysis. Saprolegniasis is particularly prominent in over-wintering ponds characterized by high stocking densities, such as in cage culture or intensive aquaculture settings. While reports of saprolegniasis abound, it is more prevalent in cage culture systems, with occurrences typically lower in pond culture systems, except in cases of significant mismanagement. Alongside Saprolegnia, diseases in pond aquaculture can also arise from *Branciomyces* and *Aphanomyces fungi*. Another crucial fungal-induced disease with substantial economic implications in fish culture is Epizootic Ulcerative Syndrome (EUS). The detail of common fungal diseases and their treatment reported in India are present in table 2.

Parasitic diseases

The productivity of aquaculture systems is hindered by the presence of diverse fish parasites. Among various diseases, parasitic diseases have emerged as a prominent and concerning issue, leading to substantial setbacks for freshwater aquaculture in India (Sahoo *et al*., 2013) [16]. Fish parasites proliferate swiftly under favourable circumstances, consequently impacting the well-being of fish and frequently resulting in elevated mortality rates. These parasites intrude upon the hosts nutrition, disturb metabolic processes, affect the secretory functions of the alimentary canal, and inflict damage on the nervous system (Sandeep *et al*., 2016) [18]. Primarily, protozoan ciliates such as *Ichthyophthirius sp*. and *Trichodina sp.*, along with monogenetic trematodes like *Dactylogyrus* spp. and *Gyrodactylus sp.*, as well as larger crustacean ectoparasites including *Lernae* spp., *Argulus* spp. and Ergasilus, contribute significantly to the economic losses within fish

culture systems in India (Sahoo *et al*., 2013, Das and Mishra, 2014) [17, 7]. The detail of common parasitic diseases and their treatment reported in India are present in table 2.

Viral diseases

Over 125 distinct viruses have been recognized in fish worldwide, and fresh discoveries continue to emerge. However, only a limited number of accounts exist regarding viral diseases impacting finfish in India. Viral diseases such as Cyprinid Herpesvirus-2 (CyHV-2), Koi Rana Virus (KIRV), Carp Edema Virus (CEV), Megalocytiviris, and Goldfish hematopoietic virus necrosis herpes have been reported in ornamental fish culture (Sahoo *et al*., 2017) [16]. There are some reports of occurrence of Tilapia Lake Virus (TILV) in some region of India (Suresh *et al*., 2023) [19]. The detail of common viral diseases and there treatment reported in India are present in table 2.

Diseases diagnosis

The latest disease diagnosis guidelines can be categorized into three levels of infection identification:

Level I: This encompasses farm/production site observations, record-keeping, and health management. This contextual information significantly aids in confirming the diagnosis of infections through level II and level III diagnostics.

Level II: This involves specialized techniques such as histopathology, which are typically not feasible to perform directly at the farm site.

Level III: Encompasses advanced techniques that demand a high level of infrastructure investment, trained personnel, and substantial expenditure for conducting the tests.

Table 1: External signs observed during level I diseases diagnosis

Clinical signs	Types of diseases
Gills with excess mucus	Bacterial, parasitic, environmental or nutritional
Gills necrotic	Bacterial, parasitic, fungal
Gills pale	Viral, bacterial, nutritional
Skin with excess mucus	Parasitic, environmental
Re-pigmented areas in skin	Bacterial or parasitic
Dark skin pigmentation	Viral, bacterial, nutritional, eye parasite
Haemorrhage, erythemia	viral, bacterial, parasitic
Frayed, eroded, erythemia in fins	Bacterial, parasite, mechanical, physiological disorder
Exophthalmia, haemorrhaged opaque eyes	Viral, bacterial, parasitic, gas super saturation
Ulceration, necrotisation	Bacterial, parasitic
Dropsy	Bacterial, viral, metazoan parasite
Enlarged abdomen (fluid accumulation)	Viral, bacterial, parasitic
Growth, nodules, raised spot on skin	Viral, parasitic, neoplasmic, fungal.

Table 2: Common fish diseases in India their symptoms and treatment

Bacterial Diseases				
Disease Name	**Causative Agent**	**Clinical Symptoms**	**Treatment**	**References**
Furunculosis	*Aeromonas salmonicida*	Appearance of boillike lesions, stomach filled with mucus, blood and sloughed epithelial cells, and fusion of gill lamellae	Oxytetracycline 50-75 mg/kg fish weight/day for 10 days Sulfamerazine 150-220 mg/kg fish weight/day for 10-14 days	Ravi and Jithender, 2007 [15]
Dropsy	*Pseudomonas punctata*	Bloating of the body, accumulation of yellow coloured fluid inside the body cavity	5 ppm potassium permanganate for 2 minutes dip bath 250 mg oxytetracyclin in 20 l water for 2 to 3 days	Vajargah, 2022; Ravi and jithender, 2007 [20, 15]
Fin and tail rot	*A. hydrophila, Pseudomonas* spp	Erosions, discoloration and disintegration of fins and tails	Tetracycline 3-4 gm/100 l for 2-3 days 1 minute dip treatment in 500ppm copper sulphate solution	Mishra *et al*., 2017; Ravi and jithender, 2007 [12, 15]
Columnaris	*Flexibacter columnaris* or *Cytophaga columnaris*	whitish or greyish plaques are seen over head and back giving a saddle back like appearance	Oxytetracycline 220 mg/kg/day for 10 days Potassium permanganate 500mg/100l for 1 hour Malachite green 10mg/100l for 30-96 hours copper sulfate bath at 37 mg/L for 20 min copper sulfate to pond water at 0.5 mg/L	Davis, 1992 Mishra *et al*., 2017; Ravi and jithender, 2007 [8, 12, 15]
Motile aeromonas septicaemia	*Aeromonas hydrophila*	Haemorrhagic and ulcerative lesions on skin fins, head, exopthalmia	Oxytetracycline 50 to 75 mg/Kg of fish per day for 10 days Trimethoprim-sulphamethoxazole at 10 g/t of pool water for 3 days Ciprofloxacin at 5 ppm for 5 days potassium permanganate at 2 to 4 mg/L	Cipriano *et al*. 1984, Adanir and Turutoglu, 2007, Chirila *et al*. 2008 [6, 2, 5]
Eye disease	*Aeromonas liquifaciens*	Cataract of eyes, affect cornea,	Chloromycetin 8-10 mg/liter bath	Mishra *et al*., 2017 [12]

		eyeball gets putrefied	for 1 hour for 2-3 day	
Vibriosis	*Vibrio parahemolyticus*, *Vibrio salmonicida* and *Vibrio harveyi*	Red spots on the ventral and lateral area of fish, swollen and dark skin lesions that ulcerate	Sulfamethazine 2 gm/100 pounds of fish / day Terramycin3 - 4 gm/100 pounds of fish/day for 10 days	Mishra *et al*., 2017; Ravi and jithender [12, 15]
Fungal disease				
Saproligniasis	*Saprolegnia parasitica*	Appearance of fluffy tufts of cotton-like material, haemorrhage, exposure of jaw bones, blindness and inflammation of liver and intestine	1-3 ppm malachite green for one hour 1:500 formalin for 15 minutes 3 to 5 mg/1 methylene blue as a preventative measure after the eggs are laid NaCl 5-10 ppt H_2O_2 500 ppm for 15 minutes	Lipton, 2006; Ravi and jithender, 2007 [10, 15]
Branchiomycosis	*Branchiomyces sanguinis* and *Branchiomyces demigrans*	Respiratory distress, fungus develops on or in gill tissue, or penetrates the blood vessels causing obstruction, congestion and necrosis or gill tissues.	0.3 ppm Malachite green for 24h Dip in 3-5% NaCl for 5 to 10 min. 0.05 g/kg grisin mini antibiotic feed for 3 days 5 ppm potassium permanganate bath for 5 to 10 minutes	Abduhalilova *et al*., 2023; Ravi and jithender, 2007 [1, 15]
Epizootic ulcerative syndrome	*Aphanomyces invadans*	Red spot, blackish burn like mark or deeper ulcer with red centres and white rims	Calcium hydroxide at 375kg/Ha NaCl is applied at 1250-1875 kg/ha CIFAX at 1 liter/ha Bleaching powder at 5- 10 kg/ ha Oxytetracycline at 60- 100 mg/ kg with feed for 7 days	Manna at al., 2023; Ravi and jithender, 2007 [11, 15]
Parasitic diseases				
White spot disease	*Ichthyophthirius multifilis*	characterised by the presence of small white spots on the skin or gills	1.5 to 2.5% of Sodium chloride for 10 to 30 minutes/ 7 days Potassium permanganate at 2 to 5 ppm Malachite green at 0.1 ppm for 3 to 4 days	Lipton, 2006; Ravi and jithender, 2007; Mishra *et al*., 2017 [10, 15, 12]
Whirling disease	*Myxobolus cerebralis*	characterized by whirling movement of the affected fish, malformations of the skeleton & black coloration of the posterior part of the body	There is no treatment of this disease if fishes are infected it should be destroyed by applying quicklime at the rate of 2t/ha	Ravi and jithender, 2007; Mishra *et al*., 2017 [15, 12]
Costiasis	*Ichthyoboda necator*	Characterized by bullness of the skin, and respiratory manifestation	Formalin bath for 1 hour at 250mg/l sodium chloride for 20 to 30 min at 10-20gm/l Acriflavine bath for 10 hour for 10 mg/l 5mg/l potassium permanganate	Ravi and jithender, 2007; Mishra *et al*., 2017 [15, 12]
Hole in head disease	*Hexamita. salmonis, H. truttae* and *H. intestinalis*	Characterized by anorexia, emaciation and abdominal distension	Metronidazole 5mg/1 liter for 3 hours, Magnesium sulfate 0.2-0.3% of the diet for 3 days	Buchmann, 2022; Ravi and jithender, 2007; Mishra *et al*., 2017 [4, 15, 12]
Dactylogyrosis	*Dactylogyrus sp*	Mostly affects gills, destroying the gill filaments, gills with clumps of white masses. Parasites can be observed under microscope in sample from gills	10 ppm potassium permanganate bath for 1-2 hour sodium chloride 2.5% for 1 hour by bath Mebendazole 1mg/liter for 24 hour by bath method	Buchmann, 2022; Ravi and jithender, 2007; Mishra *et al*., 2017 [4, 15, 12]
Gyrodactylosis	*Gyrodoactylus sp.*	These parasites which grow on and destroy the skin, gills with clumps of white masses, frequently associated with secondary infections.	10 ppm potassium permanganate bath for 1-2 hour sodium chloride 2.5% for 1 hour by bath Mebendazole 1mg/liter for 24 hour by bath method	Buchmann, 2022; Ravi and jithender, 2007; Mishra *et al*., 2017 [4, 15, 12]
Argulosis	*Argulus*	Loss of scales and presence of red spots, damage of gills	500 ppm of ammonium chloride 0.25 ppm of dylox, Ivermectin 50g/kg of body weight	Buchmann, 2022; Ravi and jithender, 2007; Mishra *et al*., 2017 [4, 15, 12]
Lernaeasis	*L. chackoensis*	Body unsegmented with its anterior part deeply embedded in host tissue with the help of a hold fast organ, infect nostril, skin, fin, and gills	250 ppm formalin for 30 to 60 minutes. 0.2 ppm gammexane for 72 hours, 2 ppm of lexone potassium permanganate at 5mg/L	Buchmann, 2022; Ravi and jithender, 2007; Mishra *et al*., 2017 [4, 15, 12]
Viral diseases				
Spring viraemia of	Spring viraemia of carp	Exophthalmia, pale gills,	No treatment is available	Mishra *et al*., 2017;

carp	virus	haemorrhages on the skin, base of the fins and the vent, and abdominal distension or dropsy		Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]
Infectious haematopoietic necrosis	Infectious haematopoietic necrosis virus	Darkening of the skin, pale gills, ascites, distended abdomen, exophthalmia, and petechial haemorrhages internally and externally	No treatment is available	Mishra *et al*., 2017; Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]
Carp edema virus disease	Carp edema virus	Swollen gills or gill necrosis, enophthalmos, skin lesions at the base of the fins or around the mouth and inflammation of the anus	No treatment is available	Mishra *et al*., 2017; Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]
Lymphocystis	lymphocystivirus	Small moderate wart-like nodules over the external body surfaces like fins, skin or gill and pop eye.	No treatment is available	Mishra *et al*., 2017; Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]
Koi herpesvirus disease	Koi herpesvirus	Loss of epidermis, irregular patches of pale colouration or reddening, excessive or reduced mucous secretion and sand paper like skin texture	No treatment is available	Mishra *et al*., 2017; Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]
Viral nervous necrosis	Nervous necrosis virus	Erratic swimming behaviour including spiral, whirling or belly up swimming with inflation of swim bladder	No treatment is available	Mishra *et al*., 2017; Ravi and jithender, 2007; Lipton, 2006 [12, 15, 10]

Disease management practices

Preventive measures

Following aspects are useful to prevent diseases at fish farm

- Prevent the entry of wild aquatic animals into the ponds.
- Construct reservoirs for storing water without directly taking from the natural water bodies.
- Treat reservoir water before use into pond
- Water exchange should be minimum
- Use of closed or semi-closed recycle system
- In case of a disease outbreak, disinfect contaminated water before discharge.
- Maintain good pond preparation by drying pond bottom and removing top layer of the sediment.
- Avoid over stocking
- Maintain good water quality ideal water quality parameters are mention in table 3.
- Feed nutritionally balanced diet at the required quantity avoiding excess feed.
- Early and effective detection of pathogens using improved diagnostic methods to screen and quarantine infected fishes to prevent the spread of the pathogens.
- Always use specific pathogen free (SPF) or specific pathogen resistant (SPR) fish larvae
- Avoid importing of larvae. This could increase accidental introduction of potential pathogens across the borders.
- Avoid feeding trash fish to fishes

Chemotherapy

Successful aquaculture currently relies on the use of chemicals. Most countries involved in aquaculture have established mechanisms for approving veterinary drugs for use in aquaculture. Some of the FDA-approved drugs used in aquaculture include chloramine-T, formalin, hydrogen peroxide, oxytetracycline hydrochloride, tricaine methanesulfonate, chorionic gonadotropin, florfenicol, oxytetracycline dihydrate, sulfadimethoxine, and ormetoprim. However, it is essential to be cautious about the use of antibiotics and antimicrobial compounds in aquaculture. The Marine Products Export Development Authority (MPEDA) in India, for instance, has issued a list of banned antibiotics and antimicrobial compounds in 2001. This list includes substances such as Chloramphenicol, Dimetridazole, Nitrofurans, Metronidazole, Neomycin, Onidazole, Nalidixic Acid, Ipronidazole, Sulphamethoxazole, Nitroimidazoles, Aristolochia, Clenbuterol, Chlorpromazine, Diethylstilbestrol, Colchicine, Sulfonamide, Apsone, Fluoroquinolones, Chloroform, and Glycopeptides. Strict adherence to approved and safe chemicals is crucial for sustainable and environmentally friendly aquaculture practices. This ensures that the aquatic ecosystems remain healthy, and the products from aquaculture are safe for consumption and export.

Table 3: Ideal water quality parameter for fish farming

Water quality parameter	Optimum range
Depth	1-2 meter
Turbidity	30-60 cm
Temperature	28- 32 °C
Dissolved oxygen	>5 ppm
pH	7 - 8.5
Alkalinity	80 - 200 ppm
Hardness	75 - 150 ppm
Salinity	0 ppt
Ammonia	0.01 ppm
nitrite	0.01 ppm
Nitrate	0 - 200 ppm
Phosphorus	0.02 - 0.05 ppm

Conclusion

Disease prevention and mitigation in aquaculture is crucial for increasing productivity, diminishing economic loss by maintaining the health of aquatic organisms. Several strategies are employed for prevention and control of infectious diseases in aquaculture such as biosecurity, stress management, good management practices (GMP), efficient usage of vaccine, antibiotics, chemical therapeutants, immunostimulant, pre/post biotics. The present review emphasis numerous preventive steps as well as water quality parameters for ideal aquaculture practices, treatment

available for bacterial, fungal and parasitic disease except viral disease in freshwater fishes. Hence, there is urgent need to develop therapeutic to combat the viral infections.

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