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REVIEW ARTICLE

Human Parasitic Diseases in Northeast India: A comprehensive overview of Prevalence, Cultural Practices, Challenges and Role of ethnobotanical practices in the management of Parasitic Infections

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ABSTRACT

Human parasitic illnesses are the most pressing public health concern in North Eastern India. This article investigates the occurrence and distribution of zoonotic illnesses in the region, including common infections including malaria, dengue, toxoplasmosis, and leishmaniasis. Poverty, inadequate sanitation, high population density, and cultural habits all contribute to the spread of parasitic diseases. This review also examines the significance of traditional medicine, namely the use of indigenous botanicals, in parasite management. Many diseases and conditions are difficult to diagnose and treat due to limited healthcare infrastructure, antibiotic resistance, and cultural barriers. To address the disease load and its socioeconomic consequences, effective control strategies must be multidisciplinary, including increased healthcare access, enhanced diagnostic tools, focused public health initiatives, and community involvement.

Keywords: *Zoonotic illness, toxoplasmosis, indigenous botanicals, socioeconomic consequence.*

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INTRODUCTION

Zoonotic infections refer to infections which propagate from wildlife to human beings and are growing more widespread around the world. They offer growing hazards to human health and overall well-being, making public health systems very concerned [1]. Changes in the environment, cultural customs, and livestock production all influence the interactions between parasites, their hosts, and vectors. These variables determine the prevalence of diseases their mode of transmission, and the intensity of their effects on impacted populations [2]. Some of the most common infections are neglected tropical diseases (NTDs), which mostly impact the world's poorest people in tropical and subtropical areas. People who live in extreme poverty, where access to healthcare and sanitary facilities is limited, are disproportionately affected [3]. NTDs mostly impact the improvised globally, with about 40 million individuals affected and 750 million at threat [4].

India, the world's seventh largest and second most populated nation, is incredibly diverse in terms of geography, race, religion, food preferences, lifestyle choices, and standard of living. This diversity contributes to the country's unique cultural and social composition. More over 70% of rural families

raised cattle, and 72.2% of Indians lived in villages, according to the 2001 census. This illustrates the significance of cattle to the socioeconomic structure of India. Nonetheless, parasite zoonoses significantly impact both human and animal health, ultimately reducing cattle productivity. Although the prevalence varies by region, these parasite infections are widespread in India [5]. Poverty, poor hygiene, open defecation, a lack of clean water, stray animals, high human density, and unique food habits all contribute to India's expanding zoonotic disease burden. There are a number of reasons why infection rates differ by location. Common parasites include helminths like *Echinococcosis* and *Cysticercos*, as well as protozoa like *Cryptosporidium parvum*, *Toxoplasma gondii*, and *Lesihmania spp*. Prevention and control of new and re-emerging diseases, such leishmaniasis and cryptosporidiosis, are extremely difficult [6].

In North East India, the burden of parasitic zoonosis' is amplified by unique socio-cultural practices, challenging geography, and limited healthcare access. These factors create distinct patterns of disease prevalence and impact in the region [7].

This review discusses the major parasitic zoonotic diseases affecting North East India, emphasizing the region's specific challenges and the need for targeted prevention and control strategies.

Prevalence and Distribution of Human parasites in Northeast India

The ideal conditions for helminth parasite growth and spread are found in tropical or subtropical countries, and NE India, region in subtropical zone, has a large and diverse helminth fauna. The majority of parasites are known to infect human belongs to phyla: Nematoda (roundworms), Acanthocephala (spiny-headed insects), and Platyhelminthes, which include Monogenean, Trematodes and Cestodes worms. They are the cause of numerous fatal and chronic illnesses that affect both people and animals. In both developed and developing nations, parasitic zoonoses are a significant public health concern [8]. Cysticercosis is a parasitic disease caused by adult *Taenia solium*, a cestode, for which human act as adult host and pigs act as intermediate host. Borkataki *et al.,* (2011) [9] reported a high prevalence of *T. solium* in the pigs reared in Assam, which is known to contribute to Taeniasis or Cysticercosis in the region. Cats have also been reported to act as an intermediate and paratenic host for helminths from Aizawl [10].

Echinococcus spp. is the causative parasite of Hydatidosis, which is the infection of human liver and intestine by Echinococcus cysts. Deka *et al.,* (2008) [11] has reported the presence of *Echinococus granulosus* in stray dogs of the states of Assam, Meghalaya and Mizoram. Paragonimiasis is a human parasitic disease caused by lung flukes of the genus *Paragonimus*. 2 species of *Paragonimus* have been reported from Arunachal Pradesh and Manipur [12]. The prevalence of hookworm infections in the Khasi, Jaintia and Garo tribal population of Meghalaya has been linked to predisposition rather than chance due to social and cultural factors [13]. Nevertheless, Northeast India harbours a vast diversity of parasites, which are enlisted in Table 1.

Table 1: Common Parasitic Diseases of Northeast India.

Sl. No.	Disease Name	Causative agent	Vector	Mode of infestation	Reference
1	Malaria	*Plasmodium*	Anopheles Mosquito	Blood	[14]
2	Dengue	*Dengue virus* (DENV)	Aedes Mosquito	Blood	[15]
3	Japanese Encephalitis	*Japanese encephalitis virus* (JEV)	Culex mosquito	Blood	[16]
4	Toxoplasmosis	*Toxoplasma gondii*	Domestic cats	Infected food and water	[17]
5	Cysticercosis	*Taenia solium*	Infected human	Infected food and water	[18]
6	Paragonimiasis	*Paragonimus sp.*	Freshwater Snail, crab	Undercooked crustaceans	[19]
7	Hydatidosis	*Echinococcus sp.*	Dog, sheep, goat	Contaminated food and water.	[20]
8	Leptospirosis	*Leptospira*	Rodents	Direct exposure to infected urine	[21]
9	Scrub typhus	*Orientia tsutsugamushi*	Chiggers mite	Blood	[22]
10	Rabies	*Rabies virus*	Infected animals	Saliva	[23]
11	Fasciolopsiasis	*Fasciolopsis buski*	Freshwater Snail and aquatic edible plants	Consumption of infected plants	[24]
12	Cryptosporidiosis	*Cryptosporidium parvum*	Calves	Infected water	[24]
13	Gnathostomiasis	*Gnathostoma spinigerum*	Freshwater fish	Undercooked fish and water	[24]
14	Dirofilariasis	*Dirofilaria spp.*	Dogs and wild canines. Mosquito occasionally	Skin contacts and mosquito bites.	[24]

Parasitic infections: As a subgroup of Neglected Tropical Diseases

WHO defines neglected tropical diseases as a broad category of illnesses brought on by a range of pathogens, such as bacteria, fungi, viruses, and helminths, and they are linked to severe health, social, and economic repercussions. Therefore, parasitic infections can be regarded as a subgroup of NTDs, which are primarily found in tropical and sub-tropical areas among impoverished groups, albeit some have a considerably wider geographic range.

Global Burden of Disease Study 2010 [25] provided the most comprehensive attempt to quantify the burden of almost 300 diseases, injuries, and risk factors, including neglected tropical diseases (NTDs). The disability-adjusted life year (DALY), the metric used in the GBD 2010, is a tool which may be used to assess and compare the relative impact of a number of diseases locally and globally [26]. Malaria, lymphatic filariasis, soil-transmitted helminth infections, leishmaniasis, schistosomiasis, food-borne trematodiasis, rabies, dengue, African trypanosomiasis, Chagas disease, and cysticercosis are among the neglected tropical diseases (NTDs) that were included in the GBD study. In Northeast India, these parasite illnesses are prevalent. However, because they disproportionately impact the poorer segments of society, these diseases have been ignored globally [27].

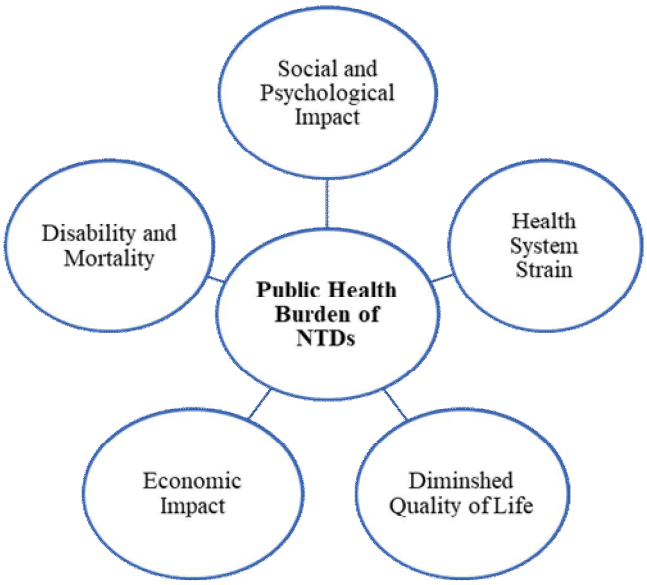

Fig 1: Public Health Burden of NTDs [28, 29].

A significant amount of the worldwide burden of NTDs is borne by India. In rural and underdeveloped urban regions with insufficient access to healthcare, sanitation, and education, NTDs are common. India has the highest incidence rates of Ascariasis, Hookworm Infection, Trichuriasis, Dengue Fever, Lymphatic Filariasis, Trachoma, Cysticercosis, Echinococcosis, and Visceral Leishmaniasis, according to data resources from the Global Burden of Disease Study 2016 (GBD, 2016). According to estimates, 162.5 million people in India reside in locations where malaria is highly contagious, which includes a large portion of the northeast, and tribal populations in mountainous areas are particularly vulnerable to the disease [30].

Sociocultural and environmental factors influencing the prevalence of human parasitic infections.

The disease known as kala-azar, or human visceral leishmaniasis (VL), continues to be a leading cause of death, especially in underdeveloped nations. In the interior parts of North-eastern India, where the climate is tropical or subtropical, the disease is prevalent. Eco-environmental factors that were found to be positively associated with the incidence of VL included waterbodies, woodland and urban built-up areas, fluvisol-type soil, air temperatures between 25.0 and 27.5°C, relative humidities between 66% and 75%, and an annual rainfall between 100 and less than 160 cm [31]. The prevalence of Kala-Azar is influenced by sociocultural variables such as poor housing, malnourishment, and poor sanitation, all of which complicate access to care, treatment results, education, and awareness [32]. Another human parasitic infection like malaria caused by *Anopheles baimaii* in Tripura, North-east India due to which thousands of positive cases and multiple deaths took place. Some of the environmental factors influencing the prevalence of this parasite is the Tripura's geographical region which is covered with forests. And the other is rainfall patterns appear to be more essential for *Anopheles baimaii* proliferation. *Anopheles baimaii* may once more be facilitated by sociocultural factors such as deforestation followed by

tree crop plantations. Members of the Dirus complex, such as *Anopheles baimaii*, have been thought to adapt to rubber plantations even better than their native tropical rain forests [33].

The direct use of untreated spring water in Sikkim presents a serious risk of parasitic infection because of the possible existence of waterborne pathogens. A large number of acute diarrheal illnesses and 104 and 158 cases of enteric fever were reported in Sikkim in 2017 and 2018, respectively [34]. Tribal populations of Northeast are known for eating boars, pigs and freshwater crustaceans, many of the parasitic infections occurs due to ingestion of undercooked and contaminated meat. Cysticercosis and paragonimiasis have been reported from Northeastern states and their prevalence is likely to be high since large numbers of people are eating pork as their main food and also consumption of crustacean is high in the region and their method of preparation is different from customary method [35]. Fishing is widely prevalent in rural areas of Northeast and holds a significant cultural relevance. A study carried out by [36] in Assam on total of 4520 freshwater fishes of 29 different species found the presence of larval helminths (India) in 1369 (30.28%) fishes over a period of one year. Thus, consumption of infested fish may be contributing to high number of helminth infections.

Ethnobotanical Practices to Control Parasitic Infections

Traditional preventions or medicines have been around for millennia and offer empirical approaches such as medication made from natural ingredients with an emphasis on total wellness [37]. One of the biggest public health issues facing many nations worldwide is malaria [38]. Malaria commonly *Plasmodium falciparum* is recorded in numerous Indian states, however each year, multiple epidemic-level mortality are reported from various regions of Northeastern India [39]. According to Chaturvedi and his co-workers, 2009 [40], the Vaidya (herbalists) and priests are involved in some traditional preventive. In order to prepare indigenous medicine and treat illnesses, the traditional Vaidya primarily use herbs. Ojha, or priests, are thought to "invoke the spiritual powers" of a god in order to diagnose and treat illnesses. They pray spiritually and offer animal or bird sacrifices in order to heal illnesses. This technique is still widely used in some indigenous societies and in isolated locations. The long-standing natural relationship between ethnic groups and the environment, particularly plants, has provided modern civilisation with access to a diverse spectrum of herbal medicines. Among the plants used for medicinal purposes are- *Acorus calamus* L., *Azadirachta indica*, *Cinnamonum bejolghota* (Buch. -Ham), etc., use to treat malaria (*Plasmodium falciparum* and *Plasmodium vivax*) and many more [41]. *Alstonia scholaris*, *Coptis teeta*, *Crotolaria occulta*, *Ocimum sanctum*, *Polygala persicariaefolia*, and *Vitex peduncularis* are six plant species that have been used to treat malaria. These species were either found in the northeast Indian jungle or close to tribal communities where they lived. Leaves accounted for 33% of the most used plant parts, followed by roots (31%), bark, and the entire plant (12%) [42]. Last but not the least below are some traditionally utilized medicinal plants by the tribes of Northeast India (Table 2).

Table 2: Medicinal plants used by the tribes of Northeast India against infections.

Sl. No	Medicinal Plant	Ethnomedical Uses	Tribe Name	State	Reference
1.	*Adhatuda vesica*	Diarrhea, Dysentery, Pneumonia and Malaria	Mishing	Assam	[43]
2.	*Adhatoda vesica Mill.*	Dysentery	Jaintia	Assam	[44]
3.	*Azadirachta indica* A.Juss.	Pox	Garo	Assam	[45]
4.	*Calotropis gigantia* (L.) Dryand.	Scabies	Garo	Assam	[45]
5.	*Cassia tora* L.	Ring Worms, Leprosy	Jaintia	Assam	[44]
6.	*Dichrocephala integrifolia* (Linn.f.)	Fungal infection	Mao Naga	Manipur	[46]
7.	*Eichornia crassipes* Solams	Pneumonia	Mishing	Assam	[43]
8.	*Nicotiana tabaeccum* Viv.	Skin Infections	Jaintia	Assam	[44]
9.	*Ocimum tenuiflorum* L.	Skin Diseases	Naga	Nagaland	[47]
10.	*Psidium guajava* L.	Dysentery	Naga	Nagaland	[47]
11.	*Papaver somniferum* L.	Dysentery And Typhoid	Naga	Nagaland	[47]
12.	*Pachystachys lutea*	Pneumonia	Mishing	Assam	[43]
13.	*Rhus semialata* Linn	Dysentery and Diarrhea	Mao Naga	Manipur	[46]

Challenges In Identifying and Curing Parasite Diseases.

In India, parasitic infections have a major impact on public health, particularly in rural and remote areas where the disease is more common due to a lack of access to treatment, poverty, and poor sanitation. The remoteness of the region, an inadequate healthcare system, and socio-economic inequalities all contribute to high prevalence of the disease. Most clinics in rural areas worldwide lack diagnostic instruments like PCR and ELISA, which are crucial for identifying low parasite burdens. The more widely used technique of microscopy frequently lacks accuracy [48].

The Northeast India's malaria incidence rate is declining, but the region is still at risk from the arrival and spread of artemisinin-resistant Plasmodium falciparum [49]. Thus, insecticide resistant vectors continue to pose challenges in the breakdown of transmission cycle. Sociocultural activities and lack of public awareness has also been contributing to the transmission of parasites. Extensive research is needed to identify and address key challenges specific to Northeast India for better management of parasitic infections. Table 3 highlights the common challenges faced by developing countries to address the NTDs including parasitic diseases. Most of the challenges holds true for Northeast India, as it encompasses mostly rural areas and unique geographic range which makes it remote within India (Fig 2).

Table 3: Challenges in the management of Parasitic Diseases in rural areas.

SL. No.	Challenges	Example	References
1	Lack of Infrastructure	Most rural clinics lack diagnostic instruments like PCR and ELISA, which are crucial for identifying low parasite burdens. The more widely used technique of microscopy frequently lacks accuracy.	[48]
2	Non-Specific Symptoms	Misdiagnosis occurs frequently due to overlapping symptoms (such as fever, diarrhea, and anemia) between bacterial and parasite illnesses.	[50]
3	Untrained Personnel	In rural healthcare facilities, a lack of qualified personnel results in incorrect sample collection and analysis.	[48]
5	Cultural Barriers	Conventional medical procedures cause late-stage diagnosis by delaying visits to official healthcare professionals.	[50]
6	Seasonality and Socioeconomic Barriers	Due to increased vector activity and waterlogging, parasitic illnesses are more common during the monsoon season; nevertheless, rural clinics are sometimes unprepared for outbreaks.	[48]
7	Drug Resistance	Resistance to anthelminthics like albendazole and antimalarial medications like artemisinin has become a serious problem.	[50]
8	Limited Access to Medications	Rural healthcare institutions frequently lack essential medications, and supply chains are hampered by remote locations.	[48]
9	Side Effects and Compliance	In marginalized groups, high rates of adverse effects, especially with leishmaniasis medications (such amphotericin B), result in low treatment adherence.	[51]
10	Stigma and Neglect	Diseases like lymphatic filariasis are associated with significant social stigma, discouraging individuals from seeking treatment early	[50]
11	Poor Sanitation	Open defecation and unsafe drinking water are major drivers of parasitic infections. Government programs like Swachh Bharat Abhiyan have improved sanitation but face challenges in remote areas	[48]
12	Seasonality	Monsoons exacerbate transmission of vector-borne diseases like malaria and filariasis	[50]

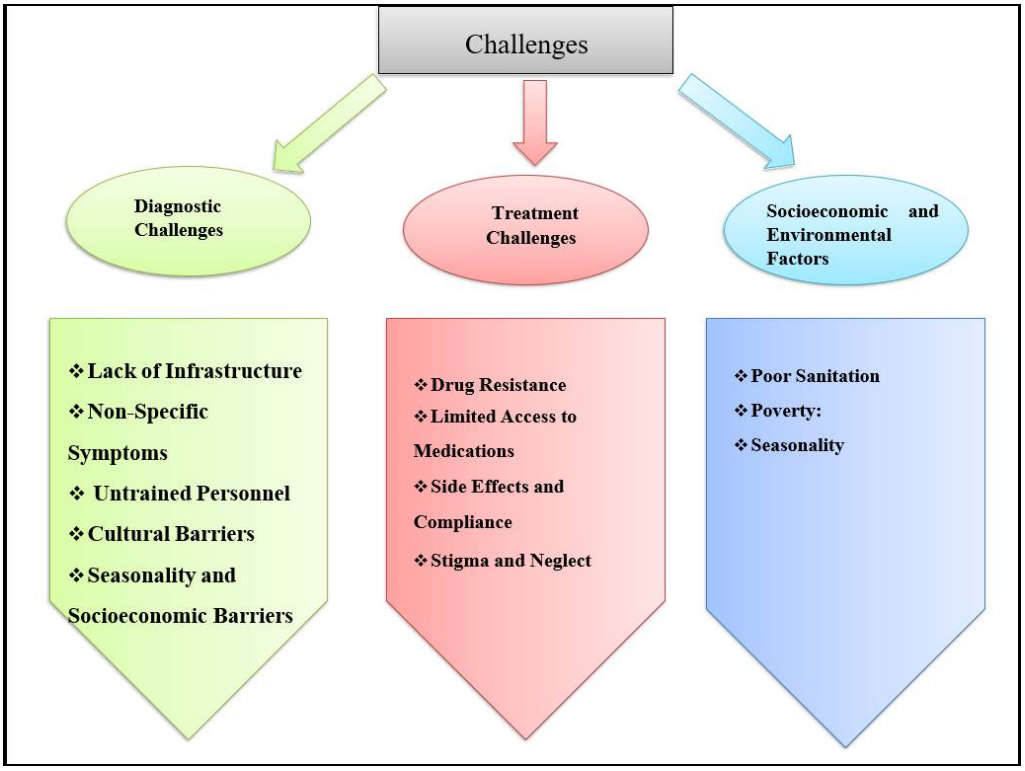

Fig 2: Key Challenges in management of parasitic disease.

CONCLUSION

Parasitic infections are one of the major health issues in community of rural India including Northeast region. Several factors contribute to the high incidence and high prevalence of parasitic diseases, which mainly includes environmental, geographical and societal factors. Residents of Northeast India has been silently coping up with huge burden of NTDs among which parasitic disease form a major sub-group. To measure the extent of these burden on the lives of commoners and economy of the region further research is needed. Certain parasitic infections have been showing rising trend in the region. Although different tribes of Northeast have been practicing use of plants and herbs against these illnesses, but this traditional knowledge is very limited and not specific for a particular infection. In regard to improve health services among deprived communities, a strong collaboration between government and non-profit organizations and regional research institutions is needed. Management of diseases causing by parasites in remote areas of India, mainly the Northeast, requires multi-skilled approaches like health service infrastructure, standard diagnostic treatment tools and MDA to break the transmission cycle.

Competing Interests

Authors have declared that no competing interests exist.

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