Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Introduction to Tropical Medicine

Priscilla Rupali, MD, DTM&H, FRCP

KEYWORDS

• Introduction • Classification • History • Tropical medicine • Fever • Diarrhea

KEY POINTS

- Tropical medicine is the practice of medicine in the tropics between the tropic of Cancer and Capricorn.
- It includes common infections, such as HIV, tuberculosis, malaria, and various other neglected tropical diseases, and noninfectious causes, such as snakebites, cancers, malnutrition, and nutrient deficiencies.
- It also deals with diseases that are indirectly or directly caused by climate change, air, water, and soil pollution.
- Access to medicines and health infrastructure impacts patient care in these areas leading to high mortality and morbidity.

INTRODUCTION

Tropical medicine is a branch of medicine that deals with communicable and noncommunicable diseases in the tropics. Most of the communicable diseases are infections that are endemic to the tropics contributing to significant morbidity and mortality. The three major infections in the tropics are human immunodeficiency virus (HIV)/AIDS, malaria, and tuberculosis. Tropical medicine involves rare and exotic parasitic and bacterial diseases but in addition involves variety of noncommunicable diseases, such as vitamin deficiencies, snakebites, scorpion stings, and toxin-related cardiac and neurologic manifestations. Hence this field involves not just microbiology, virology, parasitology, and epidemiology but also a fair bit of internal medicine.

HISTORY

Sir Patrick Manson (1844–1922) was a Scottish physician who graduated from the University of Aberdeen with degrees in surgery, medicine, and law. His medical career

The author has no financial conflicts of interests to declare and did not receive any funding to complete this article.
Department of Infectious Diseases, Infectious Diseases Training and Research Center, Ida Scudder Road, Christian Medical College Hospital, Vellore, Tamilnadu 632004, India
E-mail address: prisci@cmcvellore.ac.in

Infect Dis Clin N Am 33 (2019) 1–15
https://doi.org/10.1016/j.idc.2018.10.011 **id.theclinics.com**

spanned many decades in China, Hong Kong, and Taiwan (then called Formosa). He eventually came back to London where he lectured on tropical diseases at the St. George's hospital. He then became the chief medical officer to the Colonial Office. At this point he used his considerable influence to found a school for tropical medicine at the Albert Dock Seamen's Hospital. The London School of Hygiene and Tropical Medicine was formally inaugurated on October 2, 1899. He eventually went on to become the first president of the Royal Society of Tropical Medicine and Hygiene in 1907. He also made numerous contributions to parasitology, such as (1) the establishment of mosquito as the intermediate host of *Wuchereria bancrofti*, the causative agent of filariasis; (2) proposed the mosquito-malaria theory, which eventually spurred Sir Ronald Ross to discover that a mosquito was the definitive host for malaria; and (3) the discovery of a new species of *Schistosoma* (*Schistosoma mansoni*) and a new parasite, *Spirometra* or *Sparganum mansoni* and *Spirometra mansonoides*. A species of mosquito *Mansonia* spp and a filarial worm *Mansonella* spp were so named to honor him. He is hence known as the "Father of Tropical medicine."

PHYSICAL GEOGRAPHY

The tropics are regions of the earth that lie on either side of the equator between the tropics of Cancer and Capricorn (Fig. 1). The tropics include parts of Central and South America, Australia, Africa, India, and Oceania. The tropics account for 36% of the Earth's landmass, and are home to a third of the world's people.[1] The tropics are warm throughout the year with temperatures ranging from 25°C to 28°C (77°F–82°F) because they are close to the equator with direct sunlight most of the year. However, rainfall does vary remarkably from one area to another with the Amazon basin recording a high rainfall and North Africa being an arid area recording little to no rainfall most of the year. These climatic conditions often influence the flora, fauna, and insect wildlife in these areas.

ENVIRONMENTAL FACTORS

Tropical regions are dominated by equatorial climates with a mean temperature greater than 18°C, and arid zones are characterized by general lack of water, which

Fig. 1. Map of the tropics. (*From* WorldAtlas.com. Used with permission.)

harms plant and animal life. They host 80% of the world's biodiversity. Environmental factors include the following:

- Climate: Climate change has a wide-ranging impact on habitats, species distribution, human health, agriculture, sea levels, and the frequency/intensity of extreme weather events. Changing rainfall patterns and increased temperatures have also led to increase in vector borne diseases, such as dengue and malaria, because of increased vector distributions and decreased vector and parasite incubation periods.
- Air pollution: Among the tropical regions, Southeast Asia reported the greatest increase in CO2 emissions leading to a decreased air quality followed by South Asia and South America, which has significantly impacted the climate and led to higher weather-related mortality and morbidity, infectious disease rates, and respiratory illnesses.
- Land degradation: Although land productivity has gone up because of increased livestock and cereal production, land degradation caused by poor agricultural practices and deforestation has led to altered ecosystems and has not changed the fact that more people in the tropics experience undernourishment compared with the rest of the world.
- Water scarcity: The tropics have more than 54% of the world's renewable water sources, yet more than half of these areas are considered vulnerable to water stress because of the inequality of water distribution, with Southeast Asia having the highest pollution discharge in the world. Overexploitation of wild marine food resources has led to the coral reef systems to be at high or medium risk of damage.
- Biodiversity: Tropical biodiversity is being threatened across all taxonomic groups with a rapid loss of primary forests. Protection and maintenance of these fragile ecosystems will have a long-term impact on human health and requires cooperation at global, regional, and international levels.

SOCIAL CONDITIONS

Health is defined by the World Health Organization (WHO) as a "state of complete physical, mental and social well-being not merely the absence of disease or infirmity." However, there are many social determinants of health that affect a person's disease burden or longevity and these are often underemphasized or overlooked because the impact is often unmeasurable. Climate and other environmental factors and such social factors as poverty, overcrowding, undernutrition, and limited access to appropriate health care coupled with the lack of education and poor governance contribute to a higher prevalence of communicable and noncommunicable diseases.

According to the State of Tropics report 2014,[2] globally extreme poverty has declined by almost 50% since the 1980s but almost two-thirds of the poorest people in the world continue to live in the tropics. Poverty reduction has taken place mostly in Southeast Asia and Central America coupled with a rapid increase in urbanization in these areas. The urbanization rate in the tropics has increased disproportionately to almost 45% by 2010, in turn giving rise to large populations of slum dwellers as compared with the temperate regions, which in turn brings with it diseases of hygiene and sanitation.

POPULATION INDICES

About 40% of the world's population and 55% of children younger than age 5 also live in the tropics. By 2050, this is expected to increase to 50% and 60%, respectively.

Between 1950 and 2010, the life expectancy in the tropics increased by 22.8 years to 64.4 years and infant mortality reduced by 36%. Despite these enormous strides in the improvement of mortality, 6.9 million children younger than age 5 died in 2011, of which 99% were in low- and low-middle-income countries.

TRANSMISSION

Infectious agents and toxins are transmitted through water, soil, food, vectors, plants, and animals.

Water Sanitation and Hygiene

Freshwater constitutes only 2.5% of the total water resources on the planet. Of this only 0.3% is available as surface water, whereas the rest is in polar ice sheets, snow cover, and underground aquifers. Water scarcity is defined as less than 2000 cubic meters of water available per person per year. In the tropics the number of nations with water scarcity has tripled since 1962. This scarcity is most acute in South Asia, where 90% of the population is considered vulnerable, followed by North Africa and the Middle East at 62%.

Statistics gathered by United Nations show that 900 million people lack access to safe drinking water and 2500 million live without appropriate sanitation. Hence access to safe water and sanitation were recognized as human rights in 2010 by the United Nations General assembly.

Waterborne or water-related diseases[3] encompass illnesses resulting from indirect and direct exposure to water. The four main routes of transmission include (1) waterborne, (2) water washed, (3) water based/insect vector, and (4) water related.

Waterborne

These diseases are transmitted through the direct drinking of water contaminated with pathogenic microorganisms. Contamination of drinking water often occurs through fecal contamination, caused by poor sewage disposal and improper sanitation. If contamination levels are high, the young, the old, and the immunocompromised are at significant risk of diarrheal diseases and some others. Some of the pathogenic organisms and diseases they cause are as follows:

Protozoa
- *Entamoeba histolytica*: Amebic dysentery
- *Cryptosporidium* spp: Explosive watery diarrhea
- *Giardia lamblia*: Chronic diarrhea
- *Balantidium coli*: Persistent and occasionally invasive diarrhea
- *Naegleria fowleri*: Acute meningoencephalitis
- *Acanthamoeba* spp: Granulomatous amebic encephalitis

Bacteria
- *Salmonella typhi*, *Salmonella paratyphi* A, B, C: typhoid fever
- *Campylobacter jejuni*: acute invasive diarrhea
- *Shigella* spp: bacillary dysentery
- *Escherichia coli*: acute watery or invasive diarrhea
- *Leptospira interrogans*: leptospirosis
- *Vibrio cholera*: cholera

Viruses
- Rotavirus
- Hepatitis A
- Poliomyelitis

Waterwashed

These are also known as water-scarce diseases, which thrive in water scarcity and poor sanitation. This depends more on water quantity than quality.

a. Soil-transmitted helminths: Diseases of poor sanitation transmitted through contaminated soil. Most prevalent helminths include *Ascaris* spp, *Trichuris trichura*, *Ancylostoma duodenale*, or *Necator Americanus*.
b. Acute respiratory infections: They are responsible for 19% of the total child deaths every year and good hygienic practices including hand washing with soap can significantly reduce the transmission of acute respiratory infections.
c. Skin and eye diseases: Scabies, impetigo, trachoma, yaws, conjunctivitis, and skin ulcers.
d. Fleas, ticks, and lice: Typhus, scabies, relapsing fever.

Water-based diseases

These are infections caused by parasitic pathogens found in aquatic host organisms. Humans become infected either through skin penetration (schistosomiasis) or by ingesting the infective forms (dracunculiasis [ingestion of larvae in crustacean], paragonimiasis [metacercariae ingested in crab or crayfish], clonorchiasis [metacercariae ingested in fish]).

Water-related or vector-transmitted diseases

These are diseases caused by the insect vectors breeding in and around water bodies. Malaria is one of the water-related diseases endemic in 117 countries with 3.2 billion people at risk. About 59% cases occur in Africa, 38% in Asia, and 3% in Americas. Mosquito-borne diseases include malaria, yellow fever, dengue fever, and filariasis. Fly-borne diseases include onchocerciasis and loiasis.

Food Borne

Foodborne illnesses are defined by the WHO as diseases of infectious or toxic nature caused by the consumption of contaminated food or water. They are classified into two broad groups: intoxication and infection. Intoxication is caused by ingestion of toxin produced by pathogens, whereas infection is caused by ingestion of food containing viable pathogens. Intoxication is also possible by eating animals that have consumed toxin-producing organisms. Foodborne diseases result in considerable morbidity and mortality, and contribute to significant costs in tropical countries. Many of these are caused by bacteria, viruses, parasites, chemicals, and prions through contaminated food. The WHO estimates from 1990 to 2012 data that 582 million cases were caused by contaminated food resulting in 25.2 million DALYs (Disease adjusted life years).[4,5] Norovirus is a leading cause of foodborne illness (125 million) followed by *Campylobacter* spp with 96 million cases. In addition, nontyphoidal *Salmonella* diarrheal and invasive infections result in a high burden of 4.07 million DALYs in the African region followed by the Southeast Asian region in children less than 5 years.

The main pathogens of foodborne illnesses are bacteria (66%), viruses (4%), chemicals (26%), and parasites (4%). Bacteria cause 66% of the foodborne illnesses and botulism, *Clostridium perfringens* gastroenteritis, *E coli* infection, salmonellosis, and staphylococcal food poisoning. The most common clinical symptoms are diarrhea, vomiting, abdominal cramps, headache, and nausea.

Foodborne parasitic diseases excluding enteric protozoa cause an estimated 23.2 million cases and 45,927 deaths annually resulting in an estimated 6.64 million DALYs.[5] Among these foodborne ascariasis and toxoplasmosis were common

contributing to 12.3 and 10.3 million cases respectively. Human cysticercosis with 2.78 million, foodborne trematodiasis with 2.02 million, and toxoplasmosis with 825,000 DALYs resulted in a high burden of disease. Foodborne enteric protozoa resulted in an additional 67.2 million illnesses. Clinically foodborne pathogens can cause diarrhea, intoxications, and invasive enteric diseases.

Bacteria

Bacteria producing acute diarrheas include *Campylobacter*, *Salmonella* spp, *Shigella* spp, *Staphylococcus aureus*, nontyphoidal *Salmonella*, enteropathogenic *E coli*, and *V cholerae*.[6]

Bacteria causing intoxications include *Clostridium botulinum*, *C perfringens*, *Bacillus cereus*, and enterotoxigenic *E coli*.

Bacteria causing chronic diarrheas include *Brucella* spp, *Listeria* spp, and *Mycobacterium tuberculosis* in immunocompetent hosts and nontuberculous mycobacteria in immunocompromised hosts.

Viruses

Most of the burden of foodborne illness caused by viruses is transmitted by poor hygienic practices either during food handling or food production.[7] They are transmitted by the fecal-oral route infecting their host after ingestion, followed by invasion of cells in the epithelial lining of the gut and replication at the same site or elsewhere in the body.

Food handling and food contamination

Norovirus and hepatitis A are considered priority pathogens by the WHO and FAO (Food and Agriculture Organization of United Nations). Increasingly hepatitis E is a pathogen that is assuming increasing importance.

Zoonotic food borne viruses

Severe acute respiratory syndrome, monkey pox, and Nipah virus have been transmitted through various food-related incidents.

Parasites

Numerous parasites are transmitted by food including protozoa and helminths. However, some of these can also be transmitted by water, soil, or person to person contact. A wide variety of helminthic roundworms, tapeworms, and flukes are transmitted in foods, such as undercooked fish; crabs and mollusks; meat; raw aquatic plants, such as watercress; and raw vegetables contaminated by human feces.

Protozoa

Cryptosporidium spp, *Giardia intestinalis*, *Cyclospora cayetenensis*, and *Toxoplasma gondii*

Roundworms

Trichinella spp and *Anisakis* spp

Tapeworms

Diphyllobothrium spp and *Taenia* spp

Chemicals and toxins

Insecticides used in crops, alcoholic beverages containing methanol, poisonous plants (eg, mushrooms, raw cassava roots), oysters, mussels, and clams (which ingest dinoflagellates producing saxitoxin), large reef fish (which ingest marine algae producing ciguatera toxin), finfish spoiled by bacteria leading to scombroid poisoning, and ingestion of puffer fish containing tetrodotoxin all can contribute to significant morbidity.

Vector Borne

Vector-borne diseases impose heavy economic and health burdens leaving many people who survive the infection permanently debilitated, disfigured, maimed, or blind. Vectors thrive in conditions where housing is poor, water is unsafe, and environment is contaminated with filth exacting their toll on the poor in developing countries (**Table 1**).

Malaria is the vector-borne disease that causes the largest amount of morbidity and mortality. Dengue, yellow fever, and Zika are diseases that cause large outbreaks paralyzing health systems and contributing to considerable social and economic disruption. Onchocerciasis causes blindness, chikungunya severe arthritis, Japanese encephalitis permanent neurologic damage, Chagas heart failure and early death, and schistosomiasis poor nutritional status and school performance.

Other Tropical Diseases

Insect bites

Insect bites can cause problems and are venomous or nonvenomous. Venomous insects attack as a defense mechanism injecting painful toxic venom through their stings. Nonvenomous insects bite to feed on the blood of mammals (http://www.traveldoctor.co.uk/stings.htm).[8]

Snakebites and scorpion stings

Snakes are common in rural areas of tropical countries. Snakebites are a serious occupational hazard for agricultural laborers and fishermen. Generally, the two main families with maximum morbidity and mortality include Viperidae and Elapidae. Snakebites have now been included as a neglected tropical disease with one of the highest rates of mortality as demonstrated by the million deaths study.

Cancers

About 16% of cancers worldwide are caused by infectious agents in the developing world, and the most important cause after tobacco. If infections are controlled up to 1 in 10 cancers in the developing world can be prevented. Human papilloma virus is the most common infectious agent, followed by hepatitis B and Epstein-Barr virus contributing to cancers worldwide.

Table 1
List of common vectors and transmitted diseases

Vectors	Diseases Transmitted
Mosquitoes	
Aedes aegypti	Dengue, yellow fever, chikungunya, Zika
Aedes albopictus	Chikungunya, dengue, West Nile virus
Culex quinquefasciatus	Lymphatic filariasis
Anopheles spp	Malaria, lymphatic filariasis
Haemagogus spp	Yellow fever
Sandflies	Leishmaniasis
Triatomine bugs	Chagas disease
Ticks	Crimean-Congo hemorrhagic fever, tick-borne encephalitis, typhus, Lyme disease
Fleas	Plague, murine typhus
Flies	Human African trypanosomiasis, onchocerciasis

Malnutrition and related nutrient deficiencies

Protein energy malnutrition and micronutrient deficiencies of vitamins and minerals are common in tropical countries and these often contribute to delayed childhood growth and poor child health indices. Although universal immunization and nutrient supplementation at child care centers through mid-day meal schemes have played a major role in mitigating this problem, these are often encountered in many poverty-stricken or famine-ridden countries.

CLASSIFICATION OF TROPICAL DISEASES

Tropical diseases are classified as communicable and noncommunicable diseases. Communicable diseases by definition include diseases that are transmitted to humans and in turn are further classified as those caused by bacteria, viruses, protozoa, parasites, and fungi. Noncommunicable diseases are diseases caused by genetic and lifestyle factors, such as cancers, cardiovascular diseases, diabetes, and chronic respiratory diseases. In addition, snakebites, scorpion stings, and marine and terrestrial envenomations are also management dilemmas. It is important to note that because of constraints of poverty in the tropics, often unsafe food practices are condoned leading to high morbidity among individuals. Air and water pollution can lead to a myriad of respiratory, gastrointestinal, skin, and neurologic disorders along with serving as carriers of infectious pathogens. Although it is impossible to list all the causative pathogens of disease in the tropics, a syndromic approach and a region-wise probability of common tropical diseases is most helpful when dealing with a patient in the tropics or even a returned traveler.

Fever in the Tropics

Each area of the world is unique and endemic for specific tropical diseases. There is now through the Geosentinel network a large amount of data about the causes of fever in travelers in contrast with data from the tropical regions. Studies that are available use inconsistent definitions about “acute undifferentiated febrile illnesses” and diagnoses are not often confirmed. Fever in the tropics is often syndromic and in the absence of appropriate and accurate diagnostics, common diseases are vastly overdiagnosed, such as malaria in Africa and typhoid fever in South Asia. The advent of rapid diagnostic testing has led to the recognition of other important causes of acute febrile illnesses in the tropics (**Table 2**).

Neurologic Syndromes

Neurologic diseases in the tropics, although rare, are a cause of considerable morbidity and mortality. A history of travel including geographic locale and activities indulged in, possible exposures encountered, vaccines, prophylaxis and protective measures taken, along with the immune status of the host could help determine the etiologic organism of a particular neurologic syndrome. The neurologic syndromes are divided into global and focal syndromes (**Table 3**).

Dermatologic Syndromes

Skin lesions are a common problem in the tropics and they could be a primary problem or secondary to an underlying systemic condition. It is important to focus on infections that are treatable, transmissible, and have a high morbidity or mortality. The history must include details of previous travel, previous skin lesions, activities indulged in, immune status of the host, vaccinations, and prophylaxis. Exposures to fresh or sea water, animals, arthropods, plants, breaks in skin including tattoos, sexual activities, and

Table 2
Classification of common causes of fever by geographic area

Syndrome	Causative Pathogen	Disease	Region Where it Is Common
Acute undifferentiated fever	*Orientia tsutsugamushi*	Scrub typhus[13]	South and Southeast Asia North Asia Africa Oceania
	Plasmodium falciparum and *vivax*	Malaria[14]	Africa and the Middle east South and Southeast Asia Oceania South and Central America
	Dengue virus	Dengue	Southeast Asia India Oceania Central and South America Central Africa
	Leptospira spp	Leptospirosis[15]	Southeast Asia South and Central America Africa India
	Salmonella typhi	Typhoid fever[16]	South and Southeast Asia South Central Asia Oceania Africa
	Bartonella bacilliformis	Oroya fever	South America
Prolonged fever syndromes	*Burkholderia pseudomallei*	Melioidosis	Southeast Asia India Oceania Western Australia
	Brucella spp	Brucellosis	India Parts of Africa Mongolia Syria Peru Central America
	Leishmania donovani	Visceral leishmaniasis	India Africa South America
	Penicillium marneffei	Penicilliosis	Southeast Asia Southeast India
	Histoplasma capsulatum	Histoplasmosis	Southeast India Southeast Asia Parts of North America South and Central America
	Paracoccidiodes brasiliensis	Paracoccidiodomycosis	South America

Data from Refs.[13–16]

Table 3
Predominant neurologic syndromes and its clinical presentation

	Clinical Presentation	Etiologic Organism
Global syndromes	Febrile confusion or encephalopathy	Malaria, typhoid, scrub typhus, leptospirosis, dengue
	Meningitis Acute Chronic	*Streptococcus pneumoniae*, *Haemophilus influenzae*, *Neisseria meningitidis*, herpes simplex, *Enterovirus*, mumps, *Naegleria fowleri* *Mycobacterium tuberculosis*, *Brucella*, *Treponema pallidum, Borrelia burgdoferi*, *Cryptococcus* spp, *Histoplasma capsulatum*, *Toxoplasma gondii*, *Taenia solium*
	Encephalitis	Herpes simplex, *Enterovirus* 70,71, poliovirus, measles, varicella zoster, HIV, rabies, Lassa fever, Lyssa virus, Nipah, West Nile virus, Western equine encephalitis, Eastern equine encephalitis
	Cognitive decline	Subacute sclerosing panencephalitis, *T pallidum*, HIV
	Movement disorders	*Streptococcus pyogenes*, Japanese encephalitis, scrub typhus, rabies
Focal syndromes	Hemiparesis/seizures	*T gondii*, *M tuberculosis*, *C neoformans*, bacterial abscess, JC virus
	Paraparesis Spastic Flaccid	Human T-cell lymphotropic virus type 1, HIV, *Campylobacter*, lathyrism, polio
	Polyneuropathies	Diphtheria, snakebite, botulism

medications are important. Time of onset of skin lesions, their evolution, and associated symptoms, such as itching, pain, or fevers, are important clues to the diagnosis. Although tropics are often considered exotic locations skin problems can often be from cosmopolitan causes. Sunburn, scabies, and prickly heat are common and chronic skin problems, such as atopic dermatitis, may exacerbate in a tropical environment. Tropical biodiversity also results in a wide variety of plants and hence hypersensitivity to plants, plant products, and drugs may also occur. It is important not to forget mundane causes, such as pyoderma and folliculitis. Because skin manifestations are myriad a syndromic approach does help to narrow down a definite diagnosis (**Table 4**).

Diarrheal Syndromes

Diarrhea as a syndrome in the tropics has been described as "Montezuma's revenge" and "Delhi belly" because of the associated morbidity. It also is the second most important cause of child deaths younger than the age of 5 years contributing to almost 500,000. In the Global Burden of Disease Study[9] diarrhea was a leading cause of death among all ages contributing to 1.31 million deaths. Most of the deaths in children and adults were attributable to *Rotavirus*, *Shigella* spp, and *Salmonella* spp. However, deaths on the whole have been reduced by 20.8% from 2005 to 2015. In the Global Enteric Multicenter Study[10] done in children younger than age 5, interventions to reduce deaths should be directed against five pathogens: stable enterotoxigenic *E coli*, enteropathogenic *E coli*, *Cryptosporidium* spp, *Rotavirus*, and *Shigella* spp. Different clinical syndromes of diarrhea have been defined, each reflecting different etiology and pathogenesis. These are briefly described in **Tables 5** and **6**.

Table 4
Dermatologic syndromes and etiology

Syndrome	Important Points	Differential Diagnoses
Fever with rash	Duration of fever, associated symptoms, type and pattern of rash, exposure to sick contacts, mosquitoes, geographic area	Dengue fever, chikungunya, measles, rubella, mumps, typhoid, Katayama fever
Migratory rashes	Exposures, travel, and eosinophilia	Cutaneous larva migrans, gnathostomiasis, Larva currens
Fever with papules	Systemic symptoms, immunocompromise	Histoplasmosis, penicilliosis, nocardiosis, coccidiodomycosis, paracoccidiodomycosis
Nodules	Geographic locale, occupation, exposures	Myiasis, onchocercomas, cutaneous leishmaniasis
Vascular nodules	Immune status, exposure to brackish water and sandfly bites	Rhinosporidiosis, chronic bartonellosis
Ulcers, cutaneous and mucosal	Vaccination and nutrition status, exposures to cattle or pets, occupation, proximity to the jungle	Buruli ulcer, cutaneous leishmaniasis, cutaneous diphtheria, tropical ulcer, atypical mycobacteria, paracoccidiodomycosis, sporotrichosis
Eschars	Insect bites painful or painless, surrounding induration, exposures, systemic symptoms	Scrub typhus, anthrax, *Loxosceles* spider bite, trypanosomiasis, plague, tularemia, African tick typhus
Nodules with sinuses	Occupation, trauma, color of grains	Mycetoma, actinomycetoma, botryomycosis

DIAGNOSTIC CHALLENGES IN THE TROPICS

Various challenges exist in the diagnosis of tropical infections. The challenges are multiple and are divided as discussed next.

Disease Related

The burden of disease and the kind of setting where the disease is being diagnosed often determines the need of an appropriate diagnostic test. In a high-prevalence, low-resource setting a test that is low cost, point of care, requiring little technical expertise, with a high positive predictive value is required. In contrast in a low-prevalence, low-resource setting, additional tests may need to be performed to confirm the diagnosis. Subclinical and asymptomatic manifestations of a tropical disease may also make it difficult for a diagnostic test to distinguish between clinical disease and the former. In addition, if a test is serology-based in an endemic setting it may be difficult to establish causality for the clinical manifestations of the disease if baseline antibody titers is high.

Test Related

Although there are obvious infrastructural and financial challenges in low-resource settings there are also impediments with the lack of trained laboratory staff and quality assurance of available laboratory diagnostics. In addition, an ideal laboratory test needs to be rapid, point of care, requiring minimal technical expertise, following norms

Table 5
Etiologic classification of diarrhea based on stool appearance

Stool Appearance	Small Bowel	Large Bowel
Appearance and volume	Watery and large volume	Mucoid or bloody and small volume
pH and reducing substance	<5.5 and positive for reducing substances	>5.5 and negative for reducing substances
Serum and stool WBC	No bandemia and WBCs in stool <5/hpf	Bandemia and WBCs in stool >10/hpf
Organisms	*Rotavirus*, *Astrovirus*, *Calicivirus*, *Norovirus*, adenovirus	*Escherichia coli* (EIEC, EHEC), *Shigella*, *Salmonella*, *Campylobacter*, *Aeromonas*, *Yersinia*, *Plesiomonas*

Abbreviations: EHEC, Enterohaemorrhagic *E coli*; EIEC, Enteroinvasive *E coli*; hpf, high-powered field; WBC, white blood count.

of good clinical laboratory practice and health and safety measures in the workplace. The advent of molecular techniques has made this a reality and the need of the hour is an accurate rapid diagnostic test. Today the high burden diseases, such as tuberculosis, HIV infection, and malaria, all have rapid diagnostic tests, which has been a revolution with regard to appropriate case management of these diseases. A definite challenge has been to find similar easy diagnostic test strategies for diagnosis and epidemiologic surveillance for other tropical infections associated with high morbidity and mortality.

Table 6
Etiologic classification based on symptomatology

Symptoms and Signs	Pathophysiology	Possible Etiology
Large watery stools	Secretory small bowel	ETEC, EPEC, *Salmonella*, *Vibrio parahemolyticus*
Large volume watery	Enterotoxin mediated	*Vibrio cholera*, ETEC, *Cryptosporidium* spp
Many small volume stools	Large bowel irritation	*Shigella*, *Salmonella*, *Campylobacter*, *Yersinia enterocolitica*, *Entamoeba histolytica*, *Clostridium perfringens*
Tenesmus, fecal urgency, dysentery	Colitis	*E histolytica*, EIEC, EHEC, *Shigella*, *Campylobacter*, *Y enterocolitica*, *Clostridium difficile*
Diarrhea and vomiting	Toxin-mediated gastroenteritis	*Calicivirus*, *Rotavirus*, *Bacillus cereus*, *Staphylococcus aureus*
Fever and diarrhea	Mucosal invasion	*E histolytica*, EHEC, EIEC, *Shigella*, *Salmonella*, *C difficile*, *Campylobacter*, *Norovirus*
Persistent diarrhea	Secondary malabsorption, invasion	*Giardia*, *Cryptosporidium*, *E histolytica*, *Aeromonas*, *Isopsora belli*, *Microsporidium*

Abbreviations: EHEC, Enterohaemorrhagic *E coli*; EIEC, Enteroinvasive *E coli*; EPEC, Enteropathogenic *E coli*; ETEC, Enterotoxigenic *E coli*.

ACCESS TO MEDICINES

The WHO constitution dictates, "All people share the right to the highest attainable standard of health." Huge advances are being made toward internationally agreed global health targets, some of which include a reduction in child mortality by 50% between 1990 and 2013 and a 48% decline in AIDS related deaths since the peak of the HIV/AIDS epidemic in 2005 with at least half the infected people being able to access antiretroviral therapy. Many international agencies, such as the WHO and UNAID (Joint United Nations Programme on HIV/AIDS), pharmaceutical companies and Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator and the Global Antibiotic Research and Development Partnership have incessantly campaigned for increased access to medicines leading to an achievement of many of the health-related millennium development goals.[11]

NEGLECTED TROPICAL DISEASES

Controlling, eliminating, and eradicating neglected tropical diseases has been a major focus for the WHO since 2003 as it moved away from specific diseases to the health needs of poor communities. Over the years many disease conditions that were believed to require a concerted effort by the WHO were included. These were identified as follows (**Table 7**)[12]

This has led the WHO to adopt five major strategies to combat these diseases:

1. Preventive chemotherapy: Optimum large-scale use of safe, single-dose medicines against four different helminthiasis: lymphatic filariasis, onchocerciasis, schistosomiasis, and soil-transmitted helminthiasis. Azithromycin administration for treatment of trachoma.
2. Intensified disease management: Improved case detection and decentralized clinical management of human African trypanosomiasis, Chagas disease, leishmaniasis, and Buruli ulcer.
3. Vector and intermediate host control: Integrated vector and intermediate host management uses efficient, ecologically sound, and sustainable interventions to control vector-borne and intermediate host-mediated neglected tropical diseases.
4. Veterinary public health at the human animal interface: An integrated human and animal health approach is required for such diseases as cysticercosis, echinococcosis, and rabies, which involve vertebrate hosts.
5. Provision of safe water, sanitation and hygiene: Better sanitation and improved safe water supply coupled with vector control is being looked at for long-term economic growth and food production.

Table 7
List of neglected tropical diseases – WHO 2017

Dengue	Rabies	Trachoma	Buruli ulcer
Yaws	Leprosy	Chagas disease	Echinococcosis
Human African trypanosomiasis		Cysticercosis	Schistosomiasis
Soil-transmitted helminths		Foodborne trematodiasis	Onchocerciasis
Lymphatic filariasis		Snakebite envenoming	Mycetoma
Chromoblastomycosis and other deep mycoses			Scabies

SUMMARY

Tropical medicine is an amalgamation of infectious and noninfectious diseases and deals with many important issues, such as water, hygiene, and sanitation, which is out of reach for many low- and middle-income tropical countries. As a result, the health indices for these countries often suffer necessitating global and local public health interventions. Research, development, global support, and funding along with access to major health interventions has empowered many of these countries to overcome the challenges faced by them while combating tropical diseases.

REFERENCES

1. Tropics. Available at: https://www.nationalgeographic.org/encyclopedia/tropics/. Accessed May 24, 2018.
2. 2014 Report. State of the Tropics. James Cook University. Available at: https://www.jcu.edu.au/state-of-the-tropics/publications/2014. Accessed May 24, 2018.
3. Forstinus NO, Ikechukwu NE, Emenike MP, et al. Water and waterborne diseases: a review. IJTDH 2016;12(4):1–14.
4. Kirk MD, Pires SM, Black RE, et al. World Health Organization estimates of the global and regional disease burden of 22 foodborne bacterial, protozoal, and viral diseases, 2010: a data synthesis. PLoS Med 2015;12(12): e1001921.
5. Torgerson PR, Devleesschauwer B, Praet N, et al. World Health Organization estimates of the global and regional disease burden of 11 foodborne parasitic diseases, 2010: a data synthesis. PLoS Med 2015;12(12):e1001920.
6. Addis M, Sisay D. A review on major food borne bacterial illnesses. J Trop Dis 2015;3:176.
7. Institute of Medicine. Improving food safety through a one health approach. Washington, DC: The National Academies Press; 2012.
8. Insect bites and stings. Available at: http://www.traveldoctor.co.uk/stings.htm. Accessed June 25, 2018.
9. GBD Diarrhoeal Diseases Collaborators. Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Infect Dis 2017; 17:909–48.
10. Kotloff KL, Nataro JP, Blackwelder JC, et al. Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. Lancet 2013;382: 209–22.
11. Access to Medicine index 2018 –methodology report. Available at: http://apps.who.int/medicinedocs/documents/s23336en/s23336en.pdf. Accessed June 25, 2018.
12. WHO. Accelerating work to overcome the global impact of neglected tropical diseases. A roadmap for implementation. Available at: www.who.int/neglected_diseases/en. Accessed June 25, 2018.
13. Xu G, Walker DH, Jupiter D, et al. A review of the global epidemiology of scrub typhus. PLoS Negl Trop Dis 2017;11(11):e0006062.
14. World malaria map. Available at: https://www.cdc.gov/malaria/travelers/about_maps.html. Accessed June 25, 2018.

15. Costa F, Hagan JE, Calcagno J, et al. Global morbidity and mortality of leptospirosis: a systematic review. PLoS Negl Trop Dis 2015;9(9):e0003898.
16. Mogasale V, Maskery B, Ochiai RL, et al. Burden of typhoid fever in low-income and middle-income countries: a systematic, literature-based update with risk-factor adjustment. Lancet Glob Health 2014;2:e570–80.