Vector-Borne Zoonotic Diseases

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ABSTRACT

The global health program of the World Health Organization recognizes zoonoses as a significant threat, encompassing around 250 diseases transmissible from animals to humans. Zoonotic diseases, often vector-borne, pose a dual threat by causing severe illnesses in humans and endangering animal health, leading to substantial economic losses in the livestock industry. Vector-borne zoonoses, transmitted by creatures like mosquitoes and ticks, have far-reaching consequences for public health and the environment. These diseases, including West Nile virus, Malaria, Lyme disease, and dengue fever, contribute significantly to global morbidity and mortality. Vectors act as bridges, facilitating the transmission of infectious agents between animals and humans, potentially sparking epidemics or pandemics. The environmental impact is profound, influenced by factors like temperature changes and ecological disruptions, altering the dynamics of these diseases. The economic toll is substantial, with higher medical expenses, lost productivity, and reduced agricultural output in affected regions. The interdependence of human, animal, and environmental health necessitates a collaborative One Health approach for effective management and prevention. Vector-borne zoonoses remain a concern due to urbanization, climate change, and globalization, posing challenges to surveillance, diagnosis, and control. Vectors, such as mosquitoes, ticks, flies, fleas, and lice, play a crucial role in transmitting infectious agents actively or passively. Mosquito-borne diseases, influenced by complex interactions between the environment and population dynamics, present a serious global health challenge. This chapter explores various aspects of vector-borne zoonoses, emphasizing their significance and the need for collaborative strategies to address emerging threats.

Keywords: Zoonotic diseases, Vector-borne diseases, One Health, Global health program, Mosquito-borne diseases

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1. INTRODUCTION

The World Health Organization's global health program includes zoonosis as a significant component. 250 zoonotic ailments can be contracted by humans either directly or indirectly from a wide range of animal species. Primary health systems prioritize the treatment and control of zoonotic diseases. Zoonosis is primarily considered an animal disease and human acts as an aberrant host (Bezerra-Santos et al. 2021). Zoonosis functions as a two-edged weapon. One by spreading deadly diseases to people, and the other by endangering the health and production of animals and generating significant financial losses to the livestock industry (Judson and Rabinowitz 2021). Throughout the world, numerous infections caused by viruses, bacteria, or parasites are recognized as zoonosis transmitted by ticks, and diseases caused by them are referred to as vector-borne diseases (VBDs). In other words, these infections are transmitted especially from animals to humans (Springer et al. 2021). The importance of vector-borne zoonosis is seen in its effects on the environment and public health.

Following are some crucial details emphasizing the significance of vector-borne zoonosis:

1-Zoonotic disorders transmitted by vectors are a serious hazard to human health on a global level. A notable portion of morbidity and mortality worldwide is brought on by these illnesses, which include West Nile virus, Malaria Lyme disease, and dengue fever.

2-Infectious agent transmission between animals and people, including the transfer of viruses, bacteria, and parasites, is greatly aided by vector-borne zoonosis. By acting as a bridge, they enable infections to get across species boundaries and may even start epidemics or pandemics.

3-Environmental Impact: Environmental factors are directly related to vector-borne zoonosis. The distribution and behavior of vectors can be impacted by changes in temperature, land use, and ecological disruptions, which can change the dynamics of zoonotic illnesses.

4- Economic Effects: Vector-borne zoonosis has significant negative economic effects. These illnesses can result in higher medical expenses, lost productivity, and lower agricultural output in the afflicted areas. In regions where these diseases are endemic, the financial burden might be very high.

5- Vector-borne zoonosis brings attention to the interdependence of human, animal, and environmental health. Public health professionals, veterinarians, ecologists, and other stakeholders must collaborate to manage and prevent these diseases using a One Health strategy.

6-Vector-borne zoonosis continues to represent a concern because of things like urbanization, climate change, and globalization. The introduction of novel illnesses via vectors into new geographical areas might provide difficulties for surveillance, diagnosis, and control (Hassall et al. 2023).

2. VECTORS AND THEIR TYPES

A vector, which is a living creature, transmits an infectious agent from an infected animal to a human or another animal. Vectors include arthropods such as mosquitoes, ticks, flies, fleas, and lice (Swei et al. 2020). Infectious diseases can be transmitted actively or passively via vectors:

Some biological vectors, such as ticks and mosquitoes, can carry illnesses that multiply within them and transfer to new hosts via biting.
Mechanical vectors, such as flies, can pick up infectious pathogens and distribute them through direct physical contact.
Some vectors can go long distances. This may have an impact on the range of zoonotic diseases spread by vectors (Combs et al. 2022).

3. MOSQUITO-BORNE DISEASES

Mosquitoes-borne diseases are one the serious health problem around the globe and their transmission rely upon perplexing interactions between the environment and the sensitivity, vulnerability, and versatile capacity of populations (Colón-González et al. 2021). When we talk about the list of these diseases there are a number of diseases and in this chapter we will discuss a few as given below.

4. WEST NILE FEVER

This disease is spread by arbovirus i.e. West Nile Virus belongs to the *"flaviviridae" family*. It is spherical, enveloped, and has approximately 40-60 nm diameter according to the electron microscope. For perpetuation in nature, this virus depends on a taxonomically diverse host viz. Mosquitoes and Birds. These hosts differ evidently in their response to infection. Some ways of transmission include hematophagy, ingestion, aerosol and direct contact (Habarugira et al. 2020). According to CDC, transmission of West Nile Virus is shown in Fig. 1.

5. SIGNS AND SYMPTOMS

Partial paralysis, head pressing, weight loss, weakness particularly in hind legs, muscle twitching, impaired vision, stumbling, grinding teeth, an inability to swallow, circling and convulsions are typical signs of WNF in horses (Cantile et al. 2000 and WOAH).

6. DIAGNOSIS

Diagnosis is performed by serological testing for detection of Ig M antibodies in the serum of infected person via ELSIA test (Clark and Schaefer 2019).

7. TREATMENT AND CONTROL

The treatment of this virus is mainly supportive care along with symptoms management. For its control in horses, vaccines are available. Moreover, key to prevent west Nile Fever is to control mosquito population and surveillance programs to educate people regarding severity of this disease (Castillo-Olivares and Wood 2004; WOAH).

8. MALARIA

Millions of people around the world are afflicted with malaria, a potentially fatal infectious disease spread by mosquitoes that is most prevalent in tropical and subtropical areas. It has been brought on by the Plasmodium parasite. Despite enormous attempts to combat it, this disease has long been a major cause for public health concern and still poses a significant threat to global health (Zambare et al. 2019).

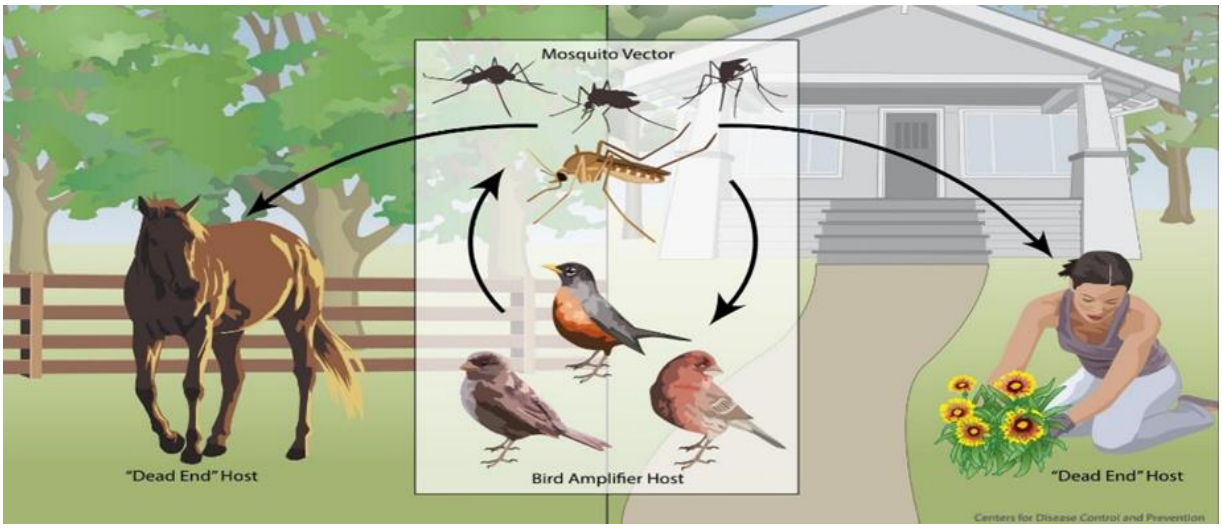

Fig. 1: Transmission of West Nile Virus (CDC).

9. CAUSATIVE AGENT OF MALARIA AND ITS LIFE CYCLE

There are five species of Plasmodium known to infect human beings and are the causal agents of malaria*: Plasmodium falciparum, Plasmodium malariae, Plasmodium Knowles and Plasmodium vivax* (Talapko et al*.* 2019). Majority of fatal cases of malaria are brought on by *Plasmodium falciparum*, which is the most threatening for all species.

10. LIFE-CYCLE

Plasmodium has a wildly complex life cycle consist of three stages shown in Fig. 2.

10.1. GAMETOCYTES STAGE 1

The male gametocytes (microgametocytes) and female gametocytes (macrogametocytes) are transmitted by an anopheles mosquito during a blood meal. Inside the mosquito, these gametocytes develop into a sporozoite. The male and female gametocytes then mate within the mosquito's gut, forming a parasite known as a sporozoite after about 15 to 18 days (Kuehn and Pradel 2010; Deshmukh 2023).

10.2. SPOROZOITES STAGE

When the infected mosquito bites a human, the sporozoites are transmitted through the mosquito's saliva into the human's bloodstream. Inside the liver cells, the sporozoites mature into schizonts. These schizonts then rupture, releasing merozoites (Deshmukh 2023).

10.3. MEROZOITES STAGE 3

Over the next one or two weeks, each schizont multiplies, giving rise to several merozoites. These merozoites exit the liver, entering the bloodstream once again, where they attack the red blood cells. As they grow and multiply, they destroy the blood cells. Some merozoites develop into gametocytes, which

are ingested by a mosquito during a blood meal, restarting the whole cycle. When the red blood cells are destroyed by the merozoites, they release a toxin that causes severe chills and fever. Extreme cold chills and high fever are classic symptoms of malaria in humans (Deshmukh 2023).

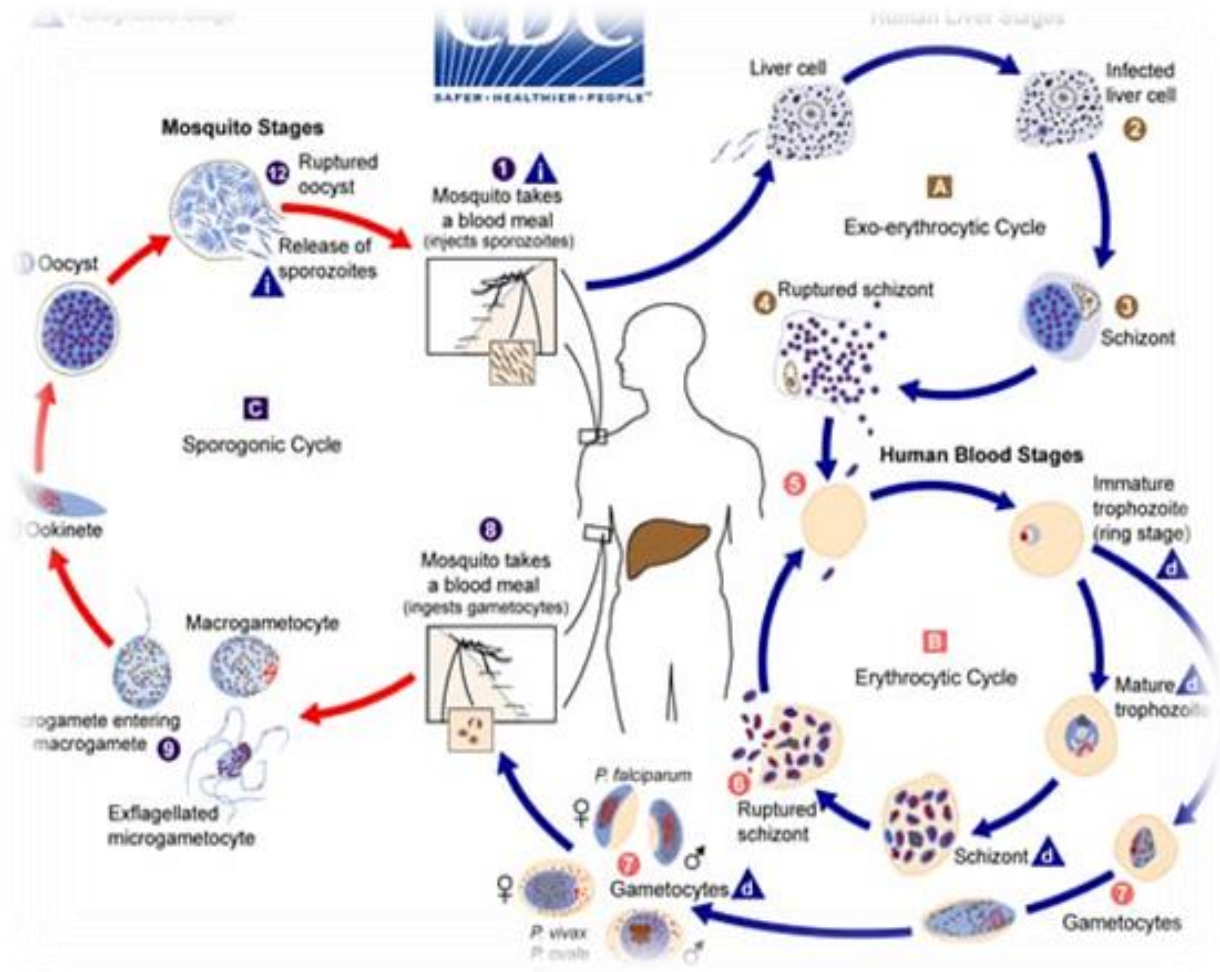

Fig. 2: Plasmodium life cycle (CDC) http://www.cdc.gov/.

11. PATHOGENICITY AND CLINICAL SIGNS OF MALARIA

The attack of malaria is called Paroxysm. Liberation of merozoites and malarial pigment and merozoites; RBC debris into the bloodstream. -*P.vivax*. Attack occurs once after every other day (48 hours). *P.falciparum* attacks 36/48hours. They show a lead of 3 stages 1. The cold stage (having chill), lasting for 30 min to 1 hour. 2. The hot stage (having fever), 1 to 4 hours. 3.Sweating stage that lasts 1 to 2 hours (Schiess et al. 2020).

12. SPLENOMEGALY AND ANEMIA

Rupture of infected RBCs and destruction of normal RBCs increase phagocytosis, causing phagocytes to multiply and function better, eventually leading to anemia and spleen enlargement.

13. RELAPSE

A unique attack that occurs months or even years after the initial strike. The bradysporozoites in the liver relax and slumber for months or even years before developing into exoerythrocytic and erythrocytes stages. At this point, the patient experiences paroxysm, displaying recurrent fever similar to the main bouts; this is known as relapse.

14. MALIGNANT MALARIA

P. falciparum malaria is more severe than malaria produced by other plasmodia. Cerebral malaria (involvement of the brain), Blackwater fever (massive hemoglobinuria), acute respiratory distress syndrome, severe gastrointestinal symptoms, shock, and renal failure may result in mortality (Batte et al. 2021).

15. LABORATORY DIAGNOSIS

Under microscopic examination, the demonstration of malarial parasites in the blood film (Thin or Thick) is the gold standard test for malaria diagnosis. (Gitta and Kilian 2020).

16. TREATMENT

Anti-erythrocytic stage drugs like Chlorquine and quinine. Anti-exoerythrocytic stage drug like Pyrimethamine. Primaquine for all stages of all species (Hanboonkunupakarn and White 2022).

17. PREVENTION AND CONTROL

Chemoprophylaxis, which includes chloroquine and pyrimethamine, is used to prevent malaria. Chemotherapy should be started one week before entering the endemic area and continued for four weeks after returning.Mosquito control. Reconstruction of the environment: eliminate mosquito breeding sites. Insecticides such as DDVP and others should be sprayed. To protect yourself from mosquito bites, use mosquito netting, screens, or repellents. (Tegegne et al. 2019).

18. DENGUE FEVER

It is vector borne diseases prone by dengue virus and transmitted by mosquitos of Aedes genus particularly *Aedes Aegypti.* It is RNA virus and a member of family Flaviviridae and have four interlinking serotypes. Approximately, 50-100 million people annually affected by this disease. Currently, this disease become a major health problem and endemic in almost 112 countries of the world (Ullah et al. 2018).

19. TRANSMISSION

It is transmitted from the bite of mosquitoes, mother to fetus and rarely by blood transfusion, organ transplantation etc.

20. LIFE CYCLE

This life cycle of Aedes Mosquitoes consists of following stages as shown in shown Fig. 3.

20.1. EGGS

Female mosquitoes lay their eggs on wet container walls. These eggs can survive for 8 months even if they dry out. Even a little water can attract them.

20.2. LARVA

After eggs are covered by water, larvae come out. They eat tiny living things in the water and change their skin three times before becoming a pupa.

20.3. PUPA

Pupa is a stage where a young mosquito develops inside the water until it becomes an adult.

20.4. ADULT

After becoming an adult, male mosquitoes drink flower nectar, while females need blood to lay eggs. Aedes aegypti mosquitoes are attracted to people and can be found near homes and buildings where there are no screens or open doors.
Eggs look like dirt, larvae and pupae are in the water, and when they grow up, female mosquitoes bite people for blood (Day 2016).

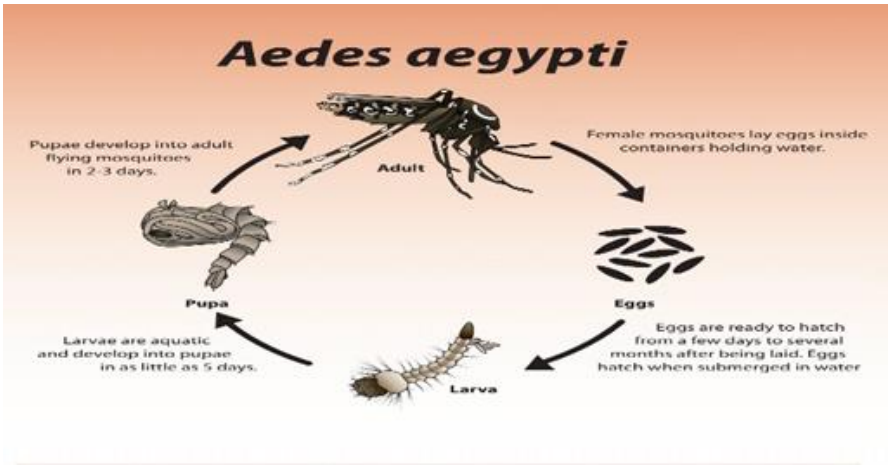

Fig. 3: Life cycle of Aedes Mosquitoes (CDC) http://www.cdc.gov/.

21. SIGNS AND SYMPTOMS

Fever, headache, retro orbital pain, rash, low white blood cell count and myalgia's are common signs. Due to severe pain in muscles, bones and joints, it is also known as "break-bone fever" (Li and Wu 2015). Repeated infection of this disease results in lots of complications including Hepatitis, Encephalopathy, ARDS, Dengue Hemorrhagic Fever and Dengue Shock syndrome (Ullah et al. 2018).

22. DIAGNOSIS

Diagnosis is performed by serological testing for detection of Ig M antibodies in the serum of infected person via ELIZA test (Raafat et al. 2019).

23. TREATMENT AND CONTROL

Supportive and symptomatic treatment are predominant therapeutic approach. Antiviral drugs are widely used for its treatment but its role is limited (Wiwanitkit, V. 2010). For its control, there is no specific vaccine available in market. However, Tetra valent vaccine has been reported against this virus. Proper sanitation conditions and control of the population play a significant role in its control (Li and Wu 2015). Moreover, educating people regarding the usage of mosquito control chemicals on their breeding sites also plays a vital role in the prevention of this virus (Wiwanitkit 2010).

24. YELLOW FEVER

It is historically dangerous infectious RNA viral disease belong to *Flaviviridae family*. It is transmitted to human through an *Aedes*, *Sabethes* and *Heamogogus* mosquitoes genera and monkey (Douam and Ploss 2018).

25. TRANSMISSION

This virus have 3 transmission cycles *viz*. Jungle (sylvatic) cycle in which none human primates (monkey) involve, virus transmitted from mosquitoes to monkey to human when human jungle; Intermediate (savannah) cycle, in which virus transmitted mosquitoes to monkey and monkey to human and human to human through mosquitoes; urban cycle In which infection transmit from urban mosquitoes to to human through mosquitoes; urban cycle in which infection transmit from urban mosquitoes to human (Monath and Vasconcelos 2015).Transmission of Yellow Fever to human through an *Aedes*, *Sabethes* and *Heamogogus* mosquitoes genera and monkey as shown in Fig. 4.

26. SIGNS AND SYMPTOMS

After contraction, virus incubates 3-6 days in body and then prone infection in one or two phase. First one is acute phase elucidates fever, muscle pain, loss of appetite, nausea, vomiting, headache and backache. This phase usually last 2-3 days and that symptom disappear. Nevertheless, 15% patients face toxic phase after 24 hours of acute phase. In this phase, patient suffers with high fever, jaundice, blood ooze out from mouth, nose, ears and stomach. Most of the organs affected, kidney functions deteriorate and death occurs usually 10-15 days. If organs arenot affected in the toxic phase the patient recovers from this phase as well (WH0-2014).

27. DIAGNOSIS

It is diagnosed by several laboratory tests. For instance, for molecular detection RT-qPCR and serological tests MAC- ELISA were performed to detect IgM antibodies (Silva et al. 2020).

28. TREATMENT AND CONTROL

Supportive and symptomatic treatment area used for this fever. Vaccines are available for its prevention which are cheap and affordable. Additionally, insecticides are used to control mosquitos' population for the control of this infection. Furthermore, prompt detection of this virus and vaccination campaign play significant role for the control of this viral fever (WH0-2014).

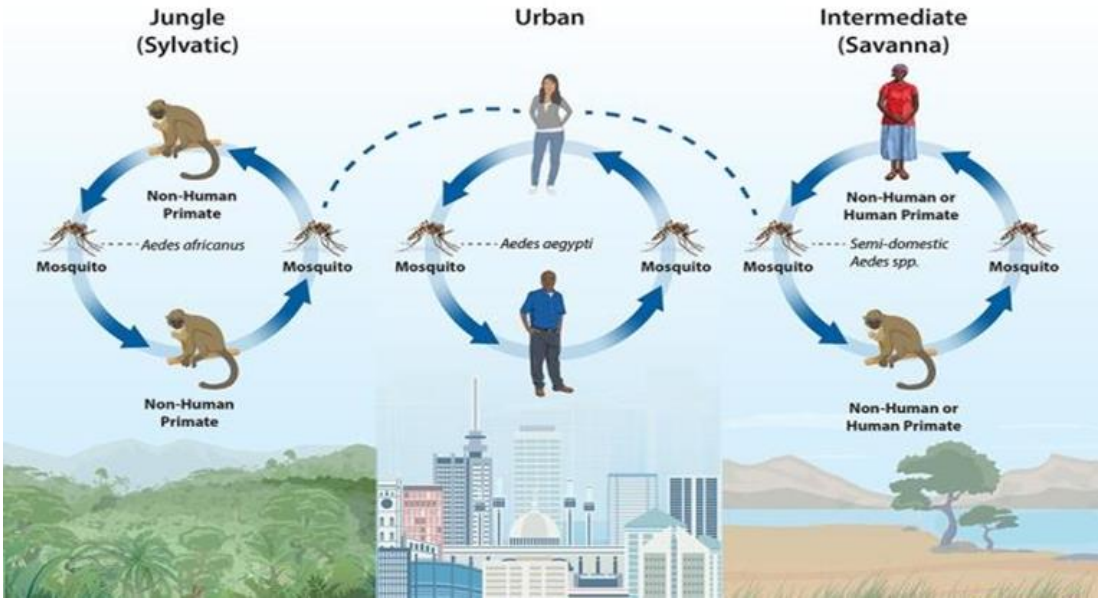

Fig. 4: Transmission of Yellow Fever (CDC) http://www.cdc.gov/.

29. ZIKA VIRUS

It is positive sense RNA virus belong to *Flaviviridae family*. This virus first isolated from Zika Forest of Uganda therefore its name is Zika Virus (Noorbakhsh et al. 2019)

30. TRANSMISSION

It is transmitted to human via bite of *Aedes Mosquitoes* particularly *Aedes Agypti*. It is also transmitted person to person while sexual intercourse, by blood transfusion, mother to fetus during pregnancy and during breast feeding (Rawal et al. 2016). Life cycle of Zika Virus according to CDC are shown in Fig. 5.

31. SIGNS AND SYMPTOMS

Low grade fever with maculopapular rash, conjunctivitis and arthralgia (involve small joints of hands and feet) are the common signs of this virus. It prone various complication include abortion, congenital microcephaly and Guillain–Barré syndrome (Rawal et al. 2016).

32. DIAGNOSIS

Zika virus is diagnosed by different serological tests against Ig M antibodies, by autopsy tissues, from flow cytometry of whole blood, by RT-PCR and from aptamer- based ELISA assay against NS1 protein (Noorbakhsh et al. 2019).

33. TREATMENT AND CONTROL

There is no antiviral therapy or vaccine available for this virus. Symptomatic and supportive treatment is used. For the control, doctor advice avoidance of sexual intercourse by using barrier methods i.e. condoms and taking environmental control measures to control mosquito breeding (Rawal et al. 2016).

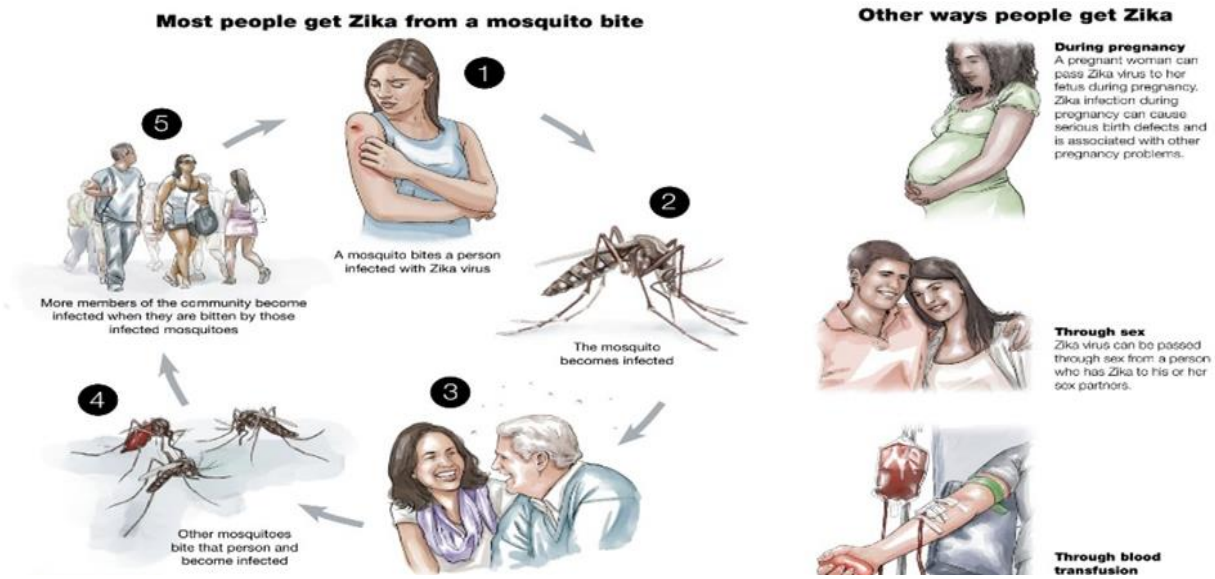

Fig. 5: Life cycle of Zika Virus (CDC) http://www.cdc.gov/.

34. JAPANESE ENCEPHALITIS VIRUS

It is mosquito-borne virus that belongs *Culex species*, and is a member of the *Flaviviridae family*. The most significant viral encephalitis in the world is called Japanese encephalitis (JE), which is brought on by infection with the Japanese encephalitis virus (JEV). With a death rate of 10,000–15,000 per year, JE affects about 35,000–50,000 persons annually (Zheng et al. 2012).

35. TRANSMISSION

Japanese encephalitis (JE) is a virus that spreads through the bite of infected mosquitoes, particularly *Culex tritaeniorhynchus* (Fig. 6). These mosquitoes pass the virus between animals like pigs and wading birds, which are natural carriers as shown in 6. Humans can get infected too, but they can't pass the virus to other mosquitoes. The virus is mostly found in rural areas with rice fields and flooding. In some parts of Asia, this can also happen near cities. In cooler parts of Asia, JE occurs more in summer and fall, while in warmer areas, it can happen all year, especially during the rainy season (Mackenzie-Impoinvil 2014).

36. SIGNS AND SYMPTOMS

The typical febrile disease of JE appears as anorexia, headache, backache, myalgia, and a sudden onset of fever. These symptoms last for a week. Following this are changes in mental state, speech, gait, and other motor function problems. In children, it may cause gastrointestinal symptoms like nausea and stomach pain (Unni et al. 2011).

37. DIAGNOSIS

Virus isolation, molecular tests, plaque reduction neutralization test, the haem- agglutination test, the complement fixation test, the immunofluorescence assay, and the enzyme-linked immunosorbent assay are some of the traditional diagnostic methods used to identify JEV. Biosensors, a new diagnostic instrument designed specifically for viruses, will be applied (Roberts et al. 2022).

Fig. 6: Transmission of Japanese Encephalitis Virus (CDC) http://www.cdc.gov/.

38. TREATMENT AND CONTROL

JEV vaccinations were created as early as 1930. There are various vaccinations on the market, and more are being developed. Currently, there are three different vaccination forms (cell-culture-derived live-attenuated, inactivated derived from mouse brain and SA 14-14-2 JE vaccination is used in Asian countries with some degree of efficacy. Alarmingly, flaviviral infections are spreading to new regions, demanding management measures. In general, the flavivirus control schemes involve human vaccination, pig immunization, and mosquito control by spraying pesticides and using impregnated mosquito nets (Unni et al. 2011).

39. CHIKUNGUNYA VIRUS

The chikungunya virus (CHIKV) is an arthropod-borne virus that is primarily responsible for acute and chronic articular symptoms and is spread by Aedes mosquitoes. An alphavirus called the chikungunya virus (CHIKV) is spread by mosquitoes, primarily *Aedes aegypti* and *Aedes albopictus.*

40. TRANSMISSION

Chikungunya virus is mostly spread by mosquitoes that bite infected people as shown in Fig. 7. However, it can also be spread through blood, like when healthcare workers handle infected blood or through a pregnant woman to her baby. But it's not commonly found in breast milk, so breastfeeding is still recommended even if the mom has the virus. The chances of passing the virus to a mosquito or through blood are highest during the first week of being sick (Diallo et al.1999).

41. SIGNS AND SYMPTOMS

High fever, back pain, arthralgia's, and headache are the most common signs. Antipyretics have a poor response to fever, which is usually high. In adults, Intense fatigue, myalgias, anorexia, nausea, and vomiting are common, in adults, while older patients may also experience transient confusion, and

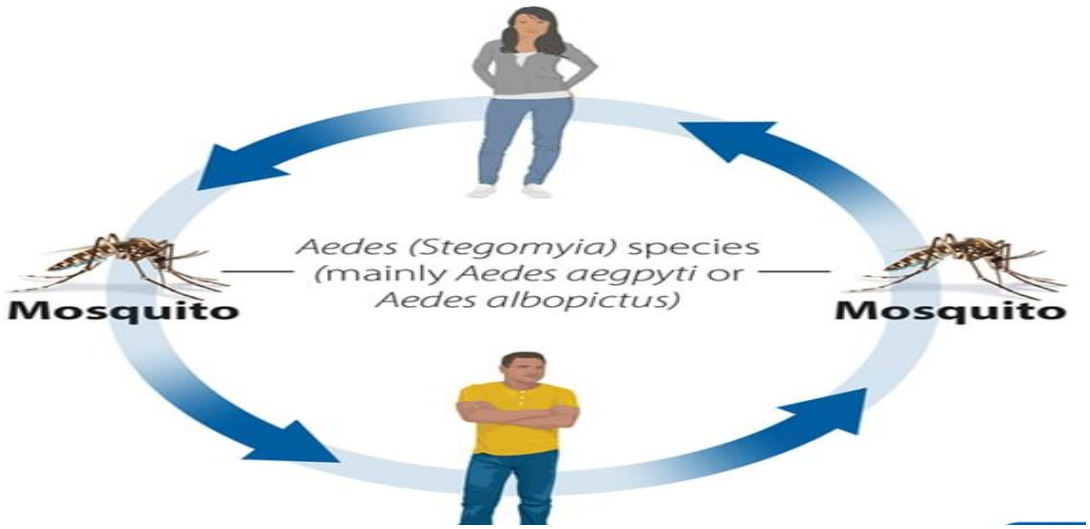

Fig. 7: Transmission cycle of Chikungunya virus (CDC) http://www.cdc.gov/.

symptoms on the GIT, skin, and mucosa are frequent. After the short-lived recovery following the acute stage, the life of the patient recently infected with CHIKV can be adversely affected by early exacerbation, long-lasting rheumatism, inflammatory relapses, and a significant loss in the quality of life (Simon 2011).

42. DIAGNOSIS

CHIKV can be diagnosed by virus isolation, nucleic acid amplification, or serology, depending on the timing of the patient's blood specimen collected in relation to the onset of symptoms. The most specific test and gold standard test is the viral culture in Vero. The sample should be taken within the first three days of illness for the best chance of effective isolation. Cell culture also offers the possibility of virus isolation, making it helpful for obtaining novel or unexpected agents. Since reverse transcription-PCRl 5 is a potent method that can identify nucleic acid from non-viable viruses, blood samples collected more than three days ago may be used (Sam 2006).

43. TREATMENT AND CONTROL

Treatment for CHIKV is mostly supportive, with rehydration and analgesics as necessary. Clinically, no antivirals have been used. Chloroquine was found to improve signs of chronic arthritis patients following CHIKV infection in an open trial. The United States Army developed a live CHIKV vaccine that was found to be immunogenic and safe in Phase II studies, but not further tested. Similar to dengue, control and prevention of outbreaks has been targeted on community education and vector control techniques like spraying of insecticides and eradication of breeding sites'. Surveillance is also crucial for early detection of outbreaks (Sam 2006).

44. FLY-BORNE DISEASES

44.1. LEISHMANIASIS

Leishmaniasis is caused due to sand flies and is a parasitic disease. It is present in Found in 88 different countries (Mann et al. 2021). There are three types of Leishmaniasis. Cutaneous refers to skin damage

caused by the bite of sand-fly. While viscera mostly affects the liver, the spleen, and specially bone marrow. Lastly Mucocutaneous affecting the nose and mouth mucous membranes as a result of dissemination from a neighboring cutaneous lesion (extremely rare). The most prevalent species in the Middle East are these two (L. major and L. tropical). Skin infection is due to L. major. While L. tropical leads to skin and visceral infection, as well as mucocutaneous infection in rare cases. Incidence rate of cutaneous Leishmaniasis is 1.5 million per year while 500 000 /year for visceral Leishmaniasis worldwide. In Desert Storm soldiers, 20 instances for cutaneous Leishmaniasis (L. major/L tropical) and twelve instances for visceral infection (L. tropical) were documented. (Abadías-Granado et al. 2021).

45. CUTANEOUS LEISHMANIASIS

The most common type is distinguished by a number of papules, nodules, or skin lesions. Sores are sometimes described as mimicking a volcano with an elevated perimeter and core crater because they can alter in size and shape over time. Even though sores are typically not painful, they might become so if they develop into secondary infections. Near the lesions, there may be swollen lymph nodes. The majority of sores develop within a few weeks of a sand-fly bite, yet they can take months to manifest.

46. VISCERAL LEISHMANIASIS

The most intense form of this illness can be fatal if remain untreated. Weight loss, pyrexia and an enlarged liver or spleen are common symptoms. Anemia manifesting (low red blood cells), leukopenia manifesting (low white blood cells), and thrombocytopenia manifesting (low platelets) are all prevalent. Lymphadenopathy is possible. Visceral Leishmaniasis in the Middle East is typically milder and has less particular findings (Martins et al. 2021).

47. LIFE CYCLE

Visceral Leishmaniasis completes its life cycle in following steps as shown in Fig. 8. Leishmania, a tiny germ, spreads through the bite of infected sand flies. When a person is bitten, the germs enter the body and change into a different form. They multiply inside the body and can be passed on to more sand flies when they bite. Inside the sand fly, the germs transform back to their original form and can infect another person when the fly bites again (Sachdeva 2016).

48. CLINICAL SIGNS AND SYMPTOMS

Typically accompanied by a pyrexia, weight loss, and enlargement of the spleen and liver. If Thrombocytopenia (low platelets), Anemia (low RBC), and leukopenia (low WBC) are all prevalent conditions. Lymphadenopathy is a possibility. If a sore appears on the face, it may leave behind painful scars and be disfiguring ((Chakravarty et al. 2019).

49. DIAGNOSIS

The diagnosis requires a biopsy. If local medical staffs are qualified and there is a Leishmania diagnostic capability, a biopsy can be performed. Special laboratories will perform microscopy, culture, and PCR. Sores that still not heal must be sent for further identification, even if they are not "typical" of Leishmaniasis. People experiencing high temperatures, weight loss, GIT problems, and unusual liver tests needs to be evaluated (Castelli et al. 2021).

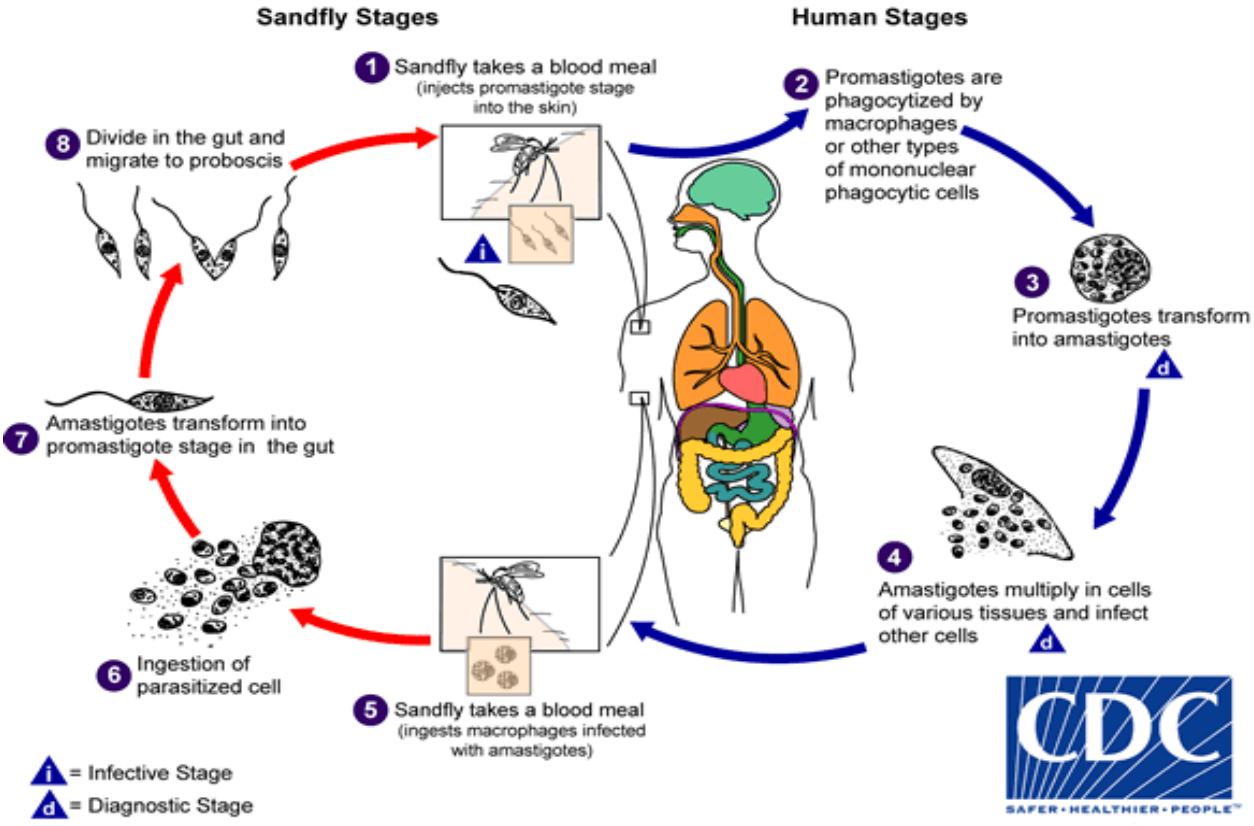

Fig. 8: Life Cycle of Visceral Leishmaniasis (CDC) http://www.cdc.gov/.

50. PREVENTION AND CONTROL

The reservoir is suppressed using dogs, gerbils rats, and several other small animals and rodents. Remove the vector: Sand-fly, essential for disease prevention in stagnant troop populations. Prevent sand-fly bites by doing the following: Personal defense at night, use sleeved-down, repellents for insects including DEET, permethrin-treated uniforms, and permethrin-treated sleeping nets (Ibiapina et al. 2023).

51. TREATMENT

51.1. CUTANEOUS LEISHMANIASIS

The drug of choice is antimony (Pentostam®, Sodium stibogluconate), which is administered intravenously for 20 days. Fluconazole may shorten the healing time after an L. major infection. To determine species, it requires a biopsy and culture, while Six weeks of therapy are required (Azim et al. 2021).

51.2. VISCERAL LEISHMANIASIS

The drug of choice is liposomal amphotericin-B (AmBisome®), with a dosage rate of 3 mg/kg per day on days 1-5, 14, and 21. Pentostam® is a complementary therapy. A total of 28 days of therapy are necessary (Mazire et al. 2022).

52. TICK BORNE DISEASES

52.1. ANAPLASMOSIS

A contagious and transmittable ailment called anaplasmosis is characterized by increasing anemia as well as other recognizable signs. Cattle are affected by this disease, which is spread by ticks (Rajan and George 2021). Although it can infect humans, it primarily affects animals, particularly domesticated livestock and pets. Many places of the world are affected by the disease, especially those where tick populations are enormous (Villar et al. 2023).

53. ETIOLOGY

Humans are susceptible to anaplasmosis due to the bacterium *Anaplasma phagocytophilum.* Other species of Anaplasma are accountable for the disease's occurrence in animals like cattle and dogs. Ticks, especially those of the *Ixodes genus* (often called deer ticks or black-legged ticks), are the main vectors for spreading the bacteria to hosts.

54. LIFE-CYCLE

Anaplasmosis spreads through tick bites as shown in Fig. 9. When an infected tick bites a cow or a deer, it passes the Anaplasma bacterium to them. The bacteria then multiply in the animal's blood, causing weakness and anemia. Other ticks can get infected by biting these sick animals, continuing the cycle (Dantas-Torres and Otranto 2017).

55. SIGNS AND SYMPTOMS

Anaplasmosis symptoms that are frequently observed are listed. It is crucial to remember that not everyone will experience all of the symptoms, and that each person will experience a unique set of symptoms (Shaukat et al. 2019). Anaplasmosis symptoms among humans typically start to show up 1 to 2 weeks after a tick bite Sigs in Fever, chills, rigors, Severe headache, Malaise, Myalgia, Gastrointestinal symptoms (nausea, vomiting, diarrhea, anorexia), Rash (<10%).

56. GENERAL LABORATORY FINDINGS

Typically seen within the first week of clinical illness onset, mild anemia, thrombocytopenia, and leukopenia are all symptoms of leukopenia. Hepatic transaminase increases range from mild to high.

57. DIAGNOSIS

Blood smear testing is insensitive and shouldn't ever be used to rule out anaplasmosis completely. However, the presence of morulae in the cytoplasm of granulocytes during blood smear analysis is extremely suggestive of a diagnosis. DNA detection in whole blood using PCR. This method's sensitivity is highest in the first week of an infection; after taking tetracycline-class antibiotics, sensitivity may decline (Mahmoud et al. 2023). Using the indirect immunofluorescence antibody (IFA) assay on paired serum samples, it was shown that the IgG-specific antibody titer had increased by four times. First sample should be collected within the first two weeks of illness, and second sample should be collected between two and four weeks afterwards. Organisms from skin, tissue, or bone marrow biopsies are stained using immunohistochemistry (Jamil et al. 2023).

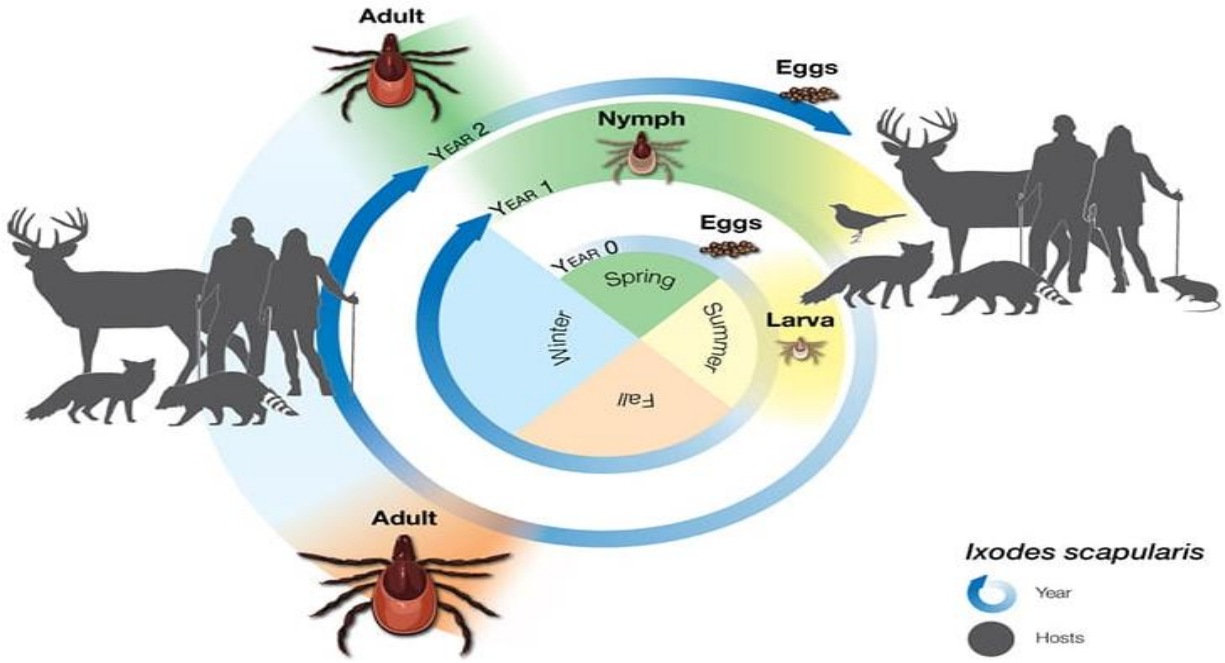

Fig. 9: Life Cycle of Anaplasmosis (CDC) http://www.cdc.gov/.

58. TRANSMISSION OF DISEASE

The Northeastern and Upper Midwest regions of the United States, which coincide with the known geographic distribution of Lyme disease and other Ixodes scapularis-transmitted infections, are where anaplasmosis cases are most frequently reported from. Co-infection with A. phagocytophilum and B. burgdorferi, Babesia microti, or Powassan virus is possible as a result of the shared vector. A phagocytophilum is primarily spread through the bite of an infected tick, although it can also be contracted through organ or blood transplants (Jiménez et al. 2019).

59. PREVENTION AND CONTROL

The risk of anaplasmosis must be reduced by avoiding tick bites. The risk of infection can be reduced by taking precautions including wearing protective clothes, using insect repellents, and properly checking for ticks after outdoor activity (Reppert 2019).

60. TREATMENT

If anaplasmosis is detected, it is critical to seek medical care right away because, if untreated, the condition can result in serious complications. Use of antibiotics like doxycycline, which is typically successful in battling the infection, is part of the routine treatment (Sarli et al. 2021).

61. TICK- BORNE ENCEPHALITIS

Three genera—*flavivirus, hepaciviruses*, and *pestiviruses*—represent the family of viral diseases known as *Flaviviridae*. Numerous human diseases are caused by *flavivirus*. Common *Flavivirus* infections are caused

by the *Japanese encephalitis virus* (JEV), *Dengue virus* (DENV), *West Nile virus* (WNV), *Yellow fever virus* (YFV), and *tick-borne encephalitis virus* (TBEV). Since ticks and mosquitoes are the primary vectors for the majority of flaviviruses to infect humans, and is also referred to as Arboviral infections (Unni, et al. 2011). The tick-borne encephalitis virus, which is mostly transmitted to people by tick bites, causes an infection of the central nervous system (Bogovic and Strlex 2015).

62. LIFE CYCLE

When a tick feeds on an infected animal, it can catch the infection. This can happen at any stage of the tick's life. The virus can also spread between young ticks feeding on the same host. TBEV in the host's blood infects the tick through its belly, then moves to its spit glands and can be passed to the next animal it bites (Fig. 10). In young ticks, the virus spreads as the tick grows, so it stays infectious for its whole life. Adult ticks that are infected can produce infected eggs, passing the virus to the next generation (Pulkkinen et al. 2018).

63. SIGNS AND SYMPTOMS

Tick-borne encephalitis is more prevalent in adults than in children. Clinically disease extends from mild meningitis to the severe meningoencephalitis specifically with or without paralysis (Bogovicand Strle 2015).

64. DIAGNOSIS

The diagnosis of TBEV is simple: typically, when CNS symptoms appear in the second phase of the disease, TBEV-immunoglobulin M (IgM) and typically TBEV-IgG antibodies are found in the initial serum samples collected. Additionally, multiplex PCR and haemagglutination inhibition and ELISA are widely used (Lindquist and Vapalahti 2008).

65. CONTROL AND TREATMENT

Tick-borne encephalitis cannot be treated with a specific antiviral medication. People who live in or travel to places where tick-borne encephalitis is endemic should consider getting the vaccine since it can successfully prevent the illness. Non-specific preventive strategies include pasteurization of milk, personal protective procedures, and reduction of the tick population (Bogovic and Strle 2015).

66. ROCKY MOUNTAIN SPOTTED FEVER

Rocky Mountain spotted fever (RMSF) is a major life-threatening disease that is caused by *Rickettsia rickettsii*, an obligatory intracellular bacterium and is spread to human beings by infected ticks.

67. TRANSMISSION

Rocky Mountain spotted fever spreads through tick bites (such as those from the lone-star tick, American dog tick, or lone-star tick) or contact with tick faeces or blood on the skin. There is no human-to-human transfer.

68. SIGNS

Patients with RMSF shows a wide range of systemic, cardiac, cutaneous, pulmonary, renal, ocular, neurological, gastrointestinal and skeletal muscle manifestations.

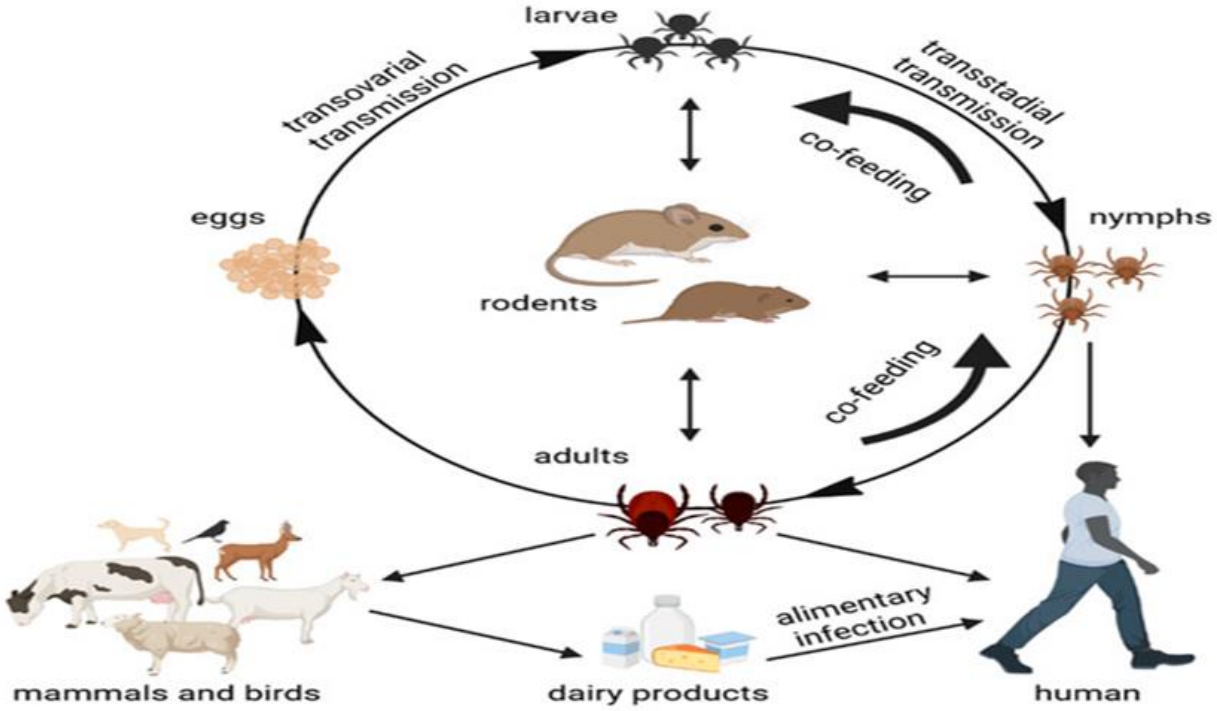

Fig. 10: Life Cycle of Tick- Borne Encephalitis (CDC) http://www.cdc.gov/**.**

69. DIAGNOSIS

The diagnosis of RMSF is done by physical examination of the patient and recent epidemiological data. Quantitative PCR assay, (new PCR-based method) have developed for the quantification and detection and of R rickettsia.

70. CONTROL AND TREATMENT

The only effective drugs for the treatment of RMSF are Tetracyclines and chloramphenicol. Because of the development of safe and effective antibiotics, the development of vaccines remains a low priority against rickettsial diseases.
Thus, it is best way to emphasize on control of tick-infested habitats like heavily wooded areas to prevent RMSF (Dantas-Torres 2007).

71. LYME BORELIOSIS

Borrelia burgdorferi sensu lato, often known as Lyme Borrelia, is a family of related spirochetes that causes Lyme disease or Lyme boreliosis and is transmitted by certain *Ixodes spp*. Ticks (Stanek 2012).

72. LIFE CYCLE

Blacklegged ticks have a life cycle of 2 to 3 years and go through four stages as shown in Fig. 11. These stages are egg, larva, nymph, and adult stage. They need blood meals to advance to the next stage and for egg production. Lyme disease bacteria can infect ticks when they feed on infected animals, and they

can transmit the bacteria to humans during their next blood meal. Deer are essential for the survival and movement of ticks but do not carry Lyme disease bacteria. Ticks usually need to be attached for 36 to 48 hours before they can transmit the disease, so prompt removal can reduce the risk of infection. In the eastern US, Lyme disease risk is high from spring to fall. Nymphs, being tiny and abundant, are hard to detect and pose a significant risk. Adults are more noticeable but can also transmit the bacteria. Many Lyme disease cases occur without the person realizing they were bitten by a tick (Burn et al. 2023).

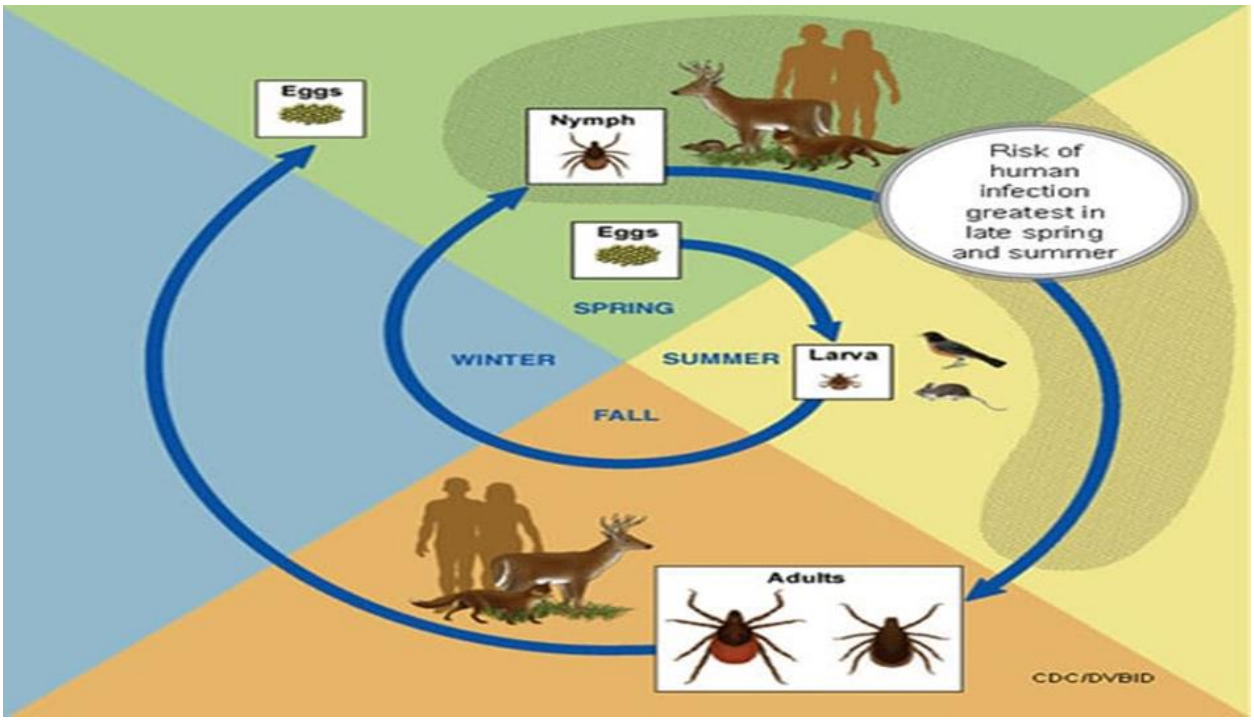

Fig. 11: Life Cycle of Lyme boreliosis (CDC) http://www.cdc.gov/.

73. SIGNS AND SYMPTOMS

Skin lesion, musculoskeletal, cardiac, nervous system, ocular manifestations are major signs in this disease (Stanek 2011).

74. DIAGNOSIS

Skin biopsy samples from erythema migrans lesions, as well as PCR-based and ELISA testing for Borrelia burgdorferi, are routinely used procedures. However, PCR is not a reliable test for current infection. Serological testing is the only generally available and practicable tool for confirming Lyme boreliosis diagnosis (Steere 2016).

75. CONTROL AND TREATMENT

Personal preventive measures are the main focus of interposition for the prevention of Lyme boreliosis. Avoiding tick-infested regions, wearing protective clothes, using acaricides and insect repellents, checking for ticks, and altering the landscape around residential areas to make them less tick-friendly are all

examples of preventative strategies. However, according to research carried out in the United States, most people can avoid developing Lyme boreliosis by taking one tablet of doxycycline if it is taken within 72 hours of a tick bite. NSAIDs are effective with antibiotic treatment. Neither North America nor Europe currently manufactures a human Lyme boreliosis vaccine (Steere 2016).

76. CRIMEAN-CONGO HEMORRHAGIC FEVER CCHF

The most common disease transmitted by ticks is Crimean-Congo hemorrhagic fever (CCHFV), which is brought on by the CCHFV. (Nasirian 2020).

77. LIFE CYCLE

The CCHFV GN and GC proteins play a role in the early stages of the CCHFV replication cycle (Fig. 12). GC helps the virus attach to cellular receptors and merge with the cell in endosomes. CCHFV relies on the cell's structure for internalization, assembly, and release. Although the specific receptors for CCHFV haven't been found, there seems to be a connection between CCHFV GC and cell surface nucleolin. After CCHFV attaches to the cell's outer layer, it gets pulled inside through a process called clathrin-mediated endocytosis. Cholesterol and low pH levels seem to be important for this. The virus then moves to early endosomes and later to multivesicular bodies where the CCHFV membrane fuses with the endosome's membrane. This releases the genetic material of the virus into the cell, which then starts the replication process. The L protein and N are essential for this replication. As CCHFV is a type of virus that carries its genetic information in a negative strand of RNA, this genetic material is used to produce capped mRNA. This mRNA is then used for making proteins and new viruses. The process continues with the production of more viral proteins and the final maturation of the virus. The assembly and release of CCHFV likely happen similarly to other bunyaviruses (Watts et al. 2019).

78. SIGNS AND SYMPTOMS

The majority of CCHF cases are unprovoked or moderate. Mild cases might show a variety of clinical signs or nonspecific symptoms, including headache, joint pain, fever, myalgia, nausea, and vomiting. However, a small percentage of cases possessed sudden onset, rapid bruising, and severe hemorrhage (Temur et al. (2021).

79. DIAGNOSIS

Diagnosis can be done by examining epidemiologic factors, clinical manifestations, and the abnormal laboratory tests. The laboratories involved with CCHFV diagnoses must conduct quality control assays. There is a need for high sensitivity and specificity testing as well as standardized assays. In this case, PCR is more sensitive than ELIZA. The use of early diagnosis in therapeutic and preventative strategies are helpful (Nasirian 2020).

80. CONTROL AND TREATMENT

The main way to stop tick bites and control CCHF is to use tick repellents. Acaricides are a good option for tick management in well-run animal production operations. Light clothing that covers the arms and legs should be worn to stop tick exposure and attachment, and skin and clothes should be checked often for ticks to avoid coming into touch with infected cells or blood. Permethrin can be applied to the sleeves and legs of clothing, and tick repellent must be applied directly to the skin. Regular CCHF awareness programs

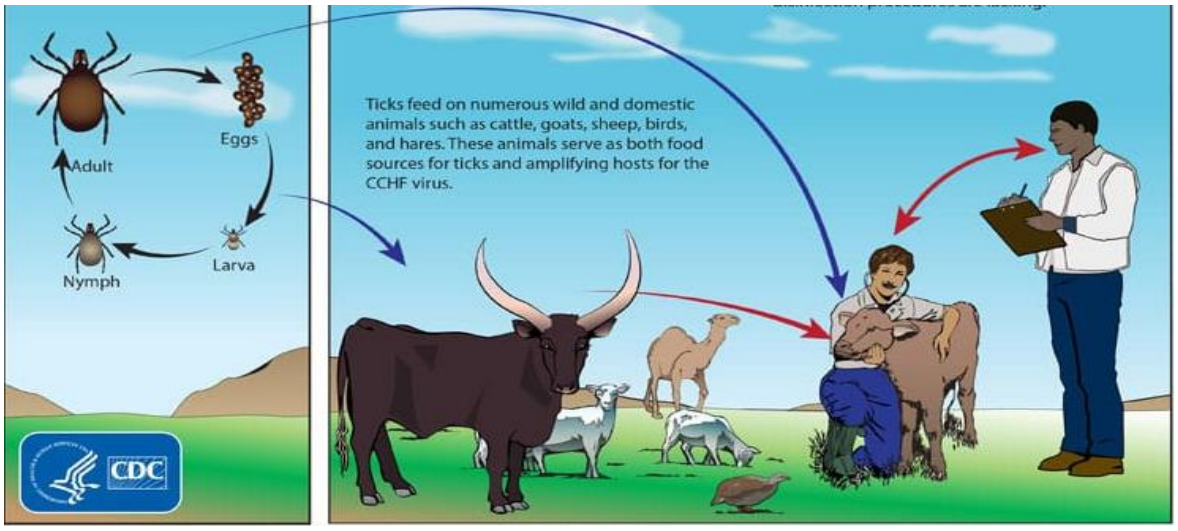

Fig. 12: Life Cycle of Crimean-Congo hemorrhagic fever (CDC) http://www.cdc.gov/.

are required at the country level by various communication channels for health workers, animal handlers, working housewives, and other people at risk since the cases rise during Eid-al-Adha. In CCHF treatment, majorly intravenous ribavirin has been suggested, whereas oral ribavirin has been suggested for post-exposure prophylaxis. Symptomatic and supportive treatments are usually done as there is no approved vaccine for CCHF is available yet (Nasirian 2020).

81. FLEA- BORNE DISEASES

81.1. PLAGUE

Yersinia Pestis, the pathogen that causes plague, is not frequently seen in hospitals, despite the fact that there are many natural plague foci all over the world. It has been determined that *Y. pestis* is a category A bioterrorism agent. A missed diagnosis will have serious consequences.

82. TRANSMISSION

Plague bacteria mostly spread through flea bites. When many rodents die from plague, the fleas that fed on them look for other blood sources. If people or animals go to these areas, they can get infected from flea bites (Fig. 13). Dogs and cats can also bring infected fleas home. Flea bites can cause bubonic or septicemic plague (Barbieri 2021).

83. SIGNS AND SYMPTOMS

The early signs of plague are similar to those of flu, an elevated temperature (up to 39 to 40°C), malaise, chills, and headache. Contact history with wild animals in natural plague foci or with other plague patients is an important clue for suspecting the plague. In an area where plague is endemic, if a patient develops an instant high fever after close contact with dead animals like (rodents or other wild animals) may indicate serious concerns. These symptoms include bubonic plague (regional lymph node swelling), and septicemic plague (sudden high fever and chills) or pneumonic plague (severe coughing and pneumonic signs by X-ray) (Yang 2018).

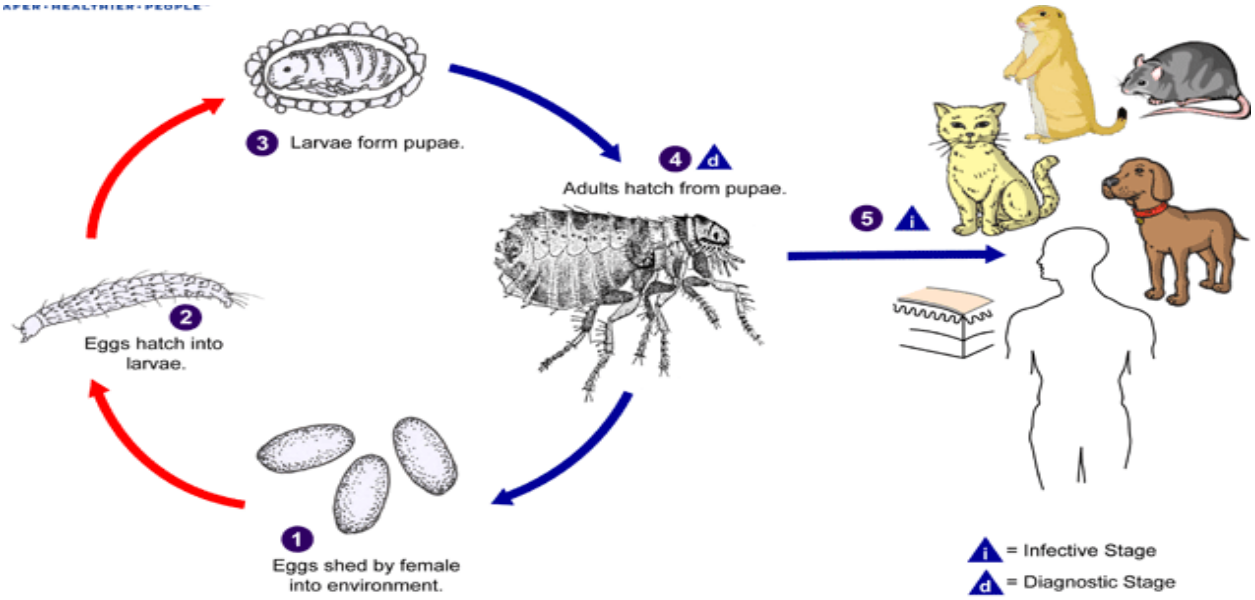

Fig. 13: Transmission cycle of PLAGUE (CDC) http://www.cdc.gov/.

84. DIAGNOSIS

According to the WHO guidelines, plague should be interpret as a suspected, presumptive, or confirmed case (World Health Organization 2006). The gold standard test in case of plague diagnosis is the isolation and identification of the plague pathogen from clinical samples in the laboratory.

85. PREVENTION AND CONTROL

Aside from physical prevention, antibiotic prophylaxis using streptomycin, tetracycline and chloramphenicol are recommended by the WHO Expert Committee on Plague (1970). In bioterrorism attack setting or a large-scale plague outbreak, to treat the plague for both adult and child patients, oral doxycycline and ciprofloxacin are recommended (Yang 2018).

86. FLEA BORNE TYPHUS

The rickettsial zoonosis known as flea-borne typhus, also called endemic or murine typhus, is primarily found in warm, coastal regions of the world, including some portions of the United States (Azad 1990). Flea-borne typhus, caused by *Rickettsia typhi* and *R. felis*, is an infection that can cause serious illness or death and manifest as fever, headache, rash, and multiple organ complaints. Humans can contract flea-borne typhus by being bitten by a flea, getting an abrasion on their skin, scratching their mucous membranes, or being bitten by a flea (Anstead 2020).

87. TRANSMISSION

Flea-borne typhus comes from bacteria in flea droppings. Scratching the droppings into a bite or wound, or getting them in your mouth or eyes, can cause the infection as shown in Fig. 14. Pets like cats, dogs, and wildlife can carry the infection without looking sick. Fleas need animals to survive and are always

around in Orange County. Giving pets flea medicine all year helps stop the disease from spreading. Flea-borne typhus can come from fleas on lots of animals like cats, dogs, opossums, rats, and more. Any animal with fleas can spread the disease (Eisen and Gage 2012).

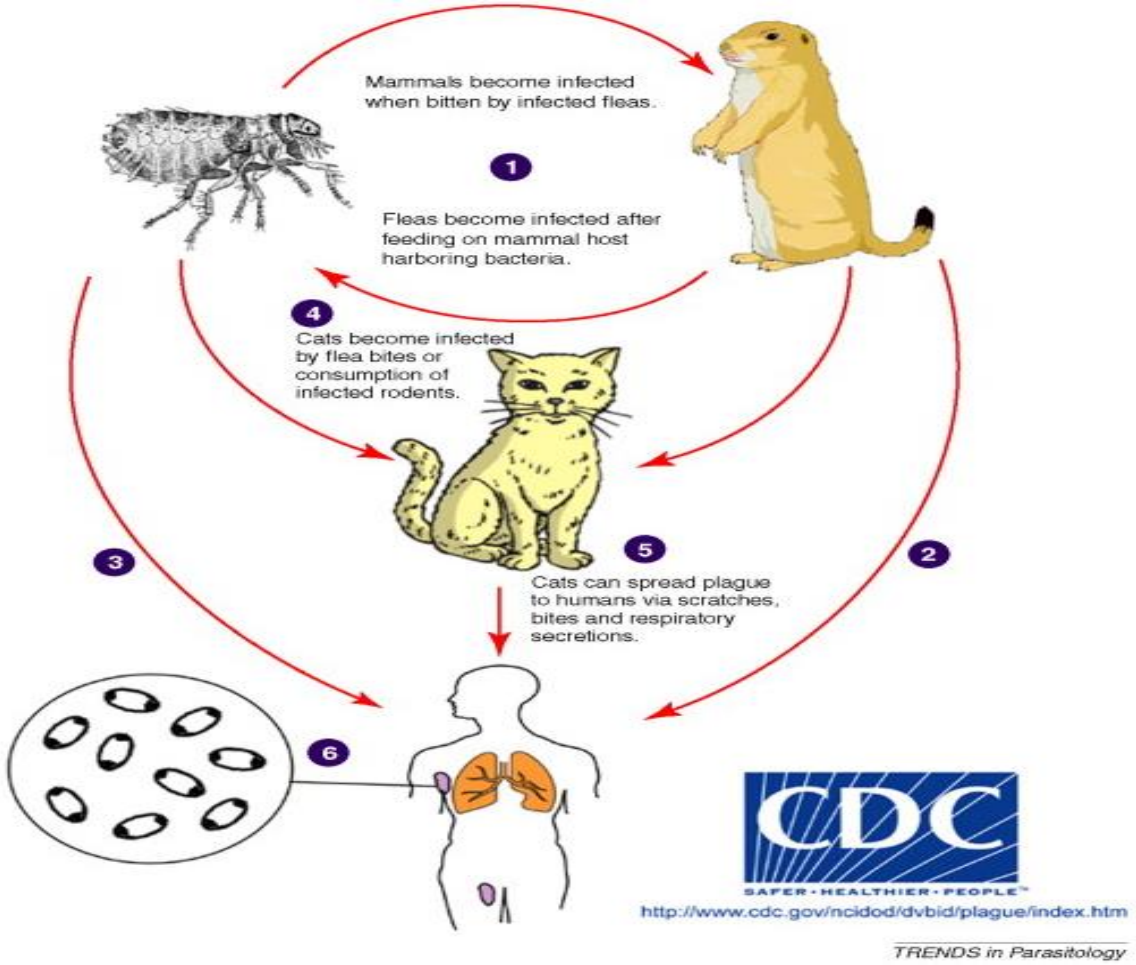

Fig. 14: Transmission cycle of Flea borne typhus (CDC) http://www.cdc.gov/.

88. SIGNS AND SYMPTOMS

The advanced level of disease that patients reported at initial hospital presentation may have been a confounding factor in the frequency of respiratory and neurologic signs identified in this group. The risk of ailments is thought to increase with age, according to previous research. Therefore, patients above the age of 50 may be more likely to experience negative results. (Pieracci et al 2017).

89. DIAGNOSIS

Tetracyclines, which are effective antibiotics for FBT, first entered clinical use in the late 1940s. The Weil-Felix test, the original diagnostic method for FBT, was reported to show inadequate specificity and sensitivity and was then replaced by complement fixation and the indirect fluorescent antibody test. R. felis, a second organism that causes FBT, was identified in 1990 (Anstead 2020).

90. PREVENTION AND CONTROL

"FBT is treated in the same way as other acute infectious condition. About all that can be advised is complete bed rest, attentive nursing, adequate nourishment, plenty of fluids, and treatment of symptoms as they arise. For nervous symptoms and headaches, opiates are usually needed. While sulfa medications first appeared in the American Pharmacopoeia in the 1930s, this class of medications had negative effects on the treatment of rickettsial infection and it was later advised to avoid them for FBT.

To prevent the spread of this disease, manage crowded, unhygienic environments and vectors in those places (Anstead 2020).

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