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Toxoplasmosis: Public health importance and its status in Ethiopia

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Abstract

Toxoplasmosis is one of the most important worldwide zoonotic diseases caused by the protozoan parasite known as *Toxoplasma gondii*. Felines and humans are the only definitive host intermediate hosts for the parasite respectively. Humans get infections after ingesting raw or undercooked meat, by ingesting cat-shed oocysts via contaminated soil, food or water. One-third of the world population is infected *with T. gondii*. Encephalitis is the most important manifestation in immunosuppressed individuals. Good hygienic practicing measures are the best option to minimize transmission of *T.gondii* to humans. Several measures are presented for public health protection, especially in developing countries like in Ethiopia. Generally, the community needs to be recommended about the disease as to how they can keep themselves and their animals healthy particularly by keeping their cats indoor and keeping environmental hygiene.

Keywords: Abortion, Cat, Ethiopia, Food, Public Health, Toxoplasmosis, Women, Zoonosis

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1. INTRODUCTION

Toxoplasmosis is one of the most important world wide zoonotic disease caused by the protozoan parasite known as *Toxoplasma gondii* (Pal,2007; Dubey *et al*.**,** 2013), which is an obligate single-celled, intracellular protozoan parasite belonging to phylum Apicomplexa, which can infect wide-ranging warm-blooded vertebrates, such as humans as well as other warm-blooded domestic and wild animals (Pal, 2007; Fenta, 2019). It is caused by an intrauterine infection with Toxoplasma gondii. Infection in early stages of pregnancy may cause intrauterine death or chorioretinitis, brain lesions with intracranial calcifications, hydrocephalus, microcephaly, convulsions, hepatosplenomegaly, jaundice, rash, fever that may be apparent immediately at birth or shortly thereafter. Infection of the pregnant woman at a more advanced stage of pregnancy can cause mild or subclinical fetal disease with late manifestations such as recurrent or chronic chorioretinitis.

Felines are the only definitive host while all other warm-blooded animals including humans are intermediate hosts for the parasite with particular characteristics (Pal, 2007; Dubey, 2010; Zemene *et al*.**,** 2012; Oliveira *et al*.**,** 2019).

Humans get infections with *T. gondii* after ingesting raw or undercooked meat, by ingesting cat-shed oocysts via contaminated soil, food, or aquatic environments (Pal, 2007). It is mentioned that housefly, cockroach may also transmit the infective oocysts from cats feces to human food and to animal feed (Pal, 2007). Globally, it is estimated that about one-third of the population is infected with *T. gondii* (Feleke *et al*.**,** 2019).

Moreover, in human and animal *T. gondii* infections are asymptomatic, and only non-specific clinical signs of toxoplasmosis are usually present (Fenta, 2019). Immunocompromised humans or animals may develop ophthalmic or neurological alterations. Encephalitis is the most important manifestation in immunosuppressed groups (Torgerson, 2011).

The diagnosis of toxoplasmosis can be established by serologic tests, amplification of specific nucleic acid sequences by PCR, histologic demonstration of the parasite and/or its antigens by immune peroxidase stain, or by isolation of the organism (Hurley and Taber, 2012).The action to mititigate health risks from later disease applying proper hygienic practicing measures and antibiotic drugs after a meeting with a medical doctor like pyrimethamine and sulfadiazine plus the B vitamin folic acid (Pleyer *et al*.**,** 2019; Barakat, 2012). Avoidance should exist in direct or indirect contact with a cat by pregnant women as well as young girls. Also, stray cat should be eliminated, meat and vegetable should be thoroughly cooked, drinking water should be of clean source and meat should not be included in the feed of food animals. Climatic factors are affecting the survival of oocysts in the environment (Ertug *et al*.**,** 2005).

Higher prevalence has been observed at tropical countries where humid, warm climatic conditions, and conversely, lower prevalence is found for arid countries or colder countries, while several anthropogenic factors include several variations in human seroprevalence, like dietary habits (method of cooking meat, hand washing, kinds of meat or vegetables consumed, and vegetable cleaning; economic, social, or cultural habits; quality of water; and sanitation coverage. Seroprevalence increases with age, but the rate of acquisition of infection to age varies according to the country and socio-economic level (Robert-gangneux and Dardé, 2012).

The incidence of toxoplasmosis became increasing last years in Ethiopia (Gebremedhin and Tadesse, 2015). Despite *T.gondii* being an important zoonotic pathogen, there is no as much awareness in the community that addressed the multiple disorders it causes in humans, its impact on animal production, its temporal and spatial distribution, and the associated disease risk factors in Ethiopia.

Hence, the objective of this article paper is to review the available documents on the public importance and status of toxoplasmosis with particular reference to Ethiopia taking proper measures for public health protection.

2. LITERATURE REVIEW

2.1 History

*Toxoplasma gondii*is an obligate intracellular protozoan pathogen that was first discovered by Nicollae and Manceaux, who in 1908 isolated it from the African rodent Chenodactylus gundi, then in 1909 differentiated the disease from leishmania and named it *Toxoplasma gondii*. The genus name is derived from the Greek word *toxon*, meaning ªbowº and referring to the crescent shape of the organism. In 1948, a serological dye test was created by Sabin and Feldman, which became the base for particular diagnostic tests (Ibrahim, 2017).

2.2 Etiology

Toxoplasma gondii is the causative agent of toxoplasmosis. It contains many genera of intracellular parasite like *Eimaria,Babesia, Theileria, Cyclospora, Isospora, Plasmodium,*etc. , which are known to cause severe disease in animals and human (Mulisa, 2014) *Toxoplasma*. *gondii* presents the next three infective stages namely tachyzoite, bradyzoite, and oocyst. Tachyzoite is a rapidly multiplying and invasive stage found in tissues of the intermediate host (Paquet*et al***.,** 2013). Conversion of tachyzoite result in bradyzoites, which is slowly dividing into tissue cysts in the muscle of the intermediate host which would infect the cat and the third stage an environmental stage,

Oocysts developed in the intestinal wall of the cat and shed with its feces., which known as tissuecyst (Black and Boothroyd, 2000). Bradyzoitesare resistant to the acid pepsin allows their transmission through ingestion. Mature oocysts, containing Sporozoites, are 12 to13 micrometers in length and ovoid shape that after sporulation contain two sporocysts, each containing four sporozoites.

The oocyst wall protecting the parasite from chemical and mechanical damages. It enables the parasite's survival for a long period, in amoist environment (Muralikrishna *et al***.,** 2017).

2.3 Life Cycle and Transmission Ways

The oocyst ingested by humans, herbivores, and chickens release sporozoites, several research studies have been made about relative infections from a cat with contaminated environments and ingestion of bradyzoites infected flesh transplacentally, tachyzoites infect fetus in pregnant women (Robert-Gangneux and Darde, 2012; Mahmoud*et al***.,** 2015; Black and Boothroyd, 2000;

However, cats begin the shedding of oocysts 3 to 7 days after the ingestion of tissue cysts and may continue for up to 20 days. About more than 100 million oocysts can be released in feces-infected cats infecting a wide range of animals (Mahmoud *et al***.,** 2015; Torgerson and Mastroiacovo, 2013).

After ingestion, sporozoites are liberated from the oocyst. Tachyzoites are converted to a tissue cyst (bradyzoite) in a week approximately and some days post-infection and may remain throughout life in most hosts, predo minantlyin the brain or musculature (Robert-Gangneux and Darde, 2012).

2.4 Pathogenesis

In humans, clinical disease is common to immunocompromised individuals or resulting from an acute infection of the expectant mother. The severity of congenital infections depends on the stage of pregnancy when the acute infection occurred, and spontaneous abortions or neurological disorders (Pleyer *et al***.,** 2019).

Within this latter patient group, toxoplasmosis is a frequent cause of intracerebral focal lesions resulting in toxoplasmic encephalitis. If left untreated, toxoplasmic encephalitis can be fatal. A therapy is needed for long-term period as drug therapy will effectively kill the tachyzoite stage, such treatment does not remove the chronic bradyzoite stage. The toxic side effects of these drugs, combined with their inability to eliminate the infection, make the need for safer and more effective treatments critical (Paquet *et al***.,** 2013).

2.5 Clinical Signs in humans

Most persons infected by *T. gondii* after birth are asymptomatic unless immune suppression occurs and the organism reactivates, however, proper measures should be taken for the avoidance of disease or chronic infections (Singh, 2016).

Congenital toxoplasmosis generally occurs when a woman is newly infected with *T. gondii* during pregnancy and encephalitis is the most common clinical presentation of toxoplasmosis among persons with AIDS (Pleyer *et al***.,** 2019).

2.6 Clinical Signs in Animals

Clinical toxoplasmosis in pigs is rare but there are cough, lack of coordination, tremors, and diarrhea (Rouatbi *et al.*, 2020). However, toxoplasmic chickens show clinical signs like encephalitis, chorioretinitis, peripheral neuritis, torticollis (Robert-gangneux and Dardé, 2012). In sheep and goat, *T. gondii* causes abortion and neonatal mortality. (Tenter*et al*., 2000).

2.7 Toxoplasmosis and Wildlife

Toxoplasmosis found in all habitats and regions, from the Arctic to the tropics in terrestrial, aquatic, and marine settings affecting all homeotherms with several infections may occur (Sibley, 2003). Several pathways for wildlife infection include consumption of infected felids, particulat contaminated environments should be monitored properly avoiding associated health risks (Dubey *et al*., 2004). Environmental transmission to carnivores and omnivores, such as polar bear (Ursusmaritimus), grizzly (Ursusarctos), and black bears (Ursusamericanus) can be driven by either consumption of infected meat in prey species or direct ingestion of oocysts (Oksanen *et al*., 2009).

Particular studies (Conrad, 2015) have demonstrated the critical role of invisible polymers in the transmission of *T. gondii* in food webs increasing the retention of the parasite in snails grazing on kelp (Miller, 2002).

2.8 Diagnosis

Several studies about the diagnosis of *T. gondii* infection, toxoplasmosis have been made (Jilo and Adem, 2016; Remington et al., 2004; Hill and Dubey, 2002).

Diagnosis can take place based on Laboratory testing for children with suspected congenital toxoplasmosis includes serology, PCR, and other tests to help confirm and assess the extent of infection and obtain baseline values before initiating antimicrobial therapy. Diagnosis of congenital infection in neonates is usually made serologically, but interpretation of the results can be complicated because: IgG in the neonate may indicate either previous or acute maternal infection as IgG crosses the placenta Fetal IgM antibodies may disappear before birth Antenatal treatment may affect the serological profile of the infant.

However, IgM is rarely present in infants treated with intrauterine pyrimethamine and sulfadiazine Neonatal antibody response to Toxoplasma gondii may be delayed for months Transplacental leakage of maternal IgM and IgA may result in low positive IgM and IgA titers being found in the unaffected newborn immediately after birth For an accurate serological diagnosis it is necessary to check both the mother and the child. Immunocompetent mothers with acute infection during pregnancy usually have positive IgM and IgG. The diagnosis in the newborn is based on the presence of specific IgM, which can appear within the first days of life or at various times after birth (depending on the time of the mother's infection). Thus the absence of IgM does not exclude congenital infection. When the IgM titers, in the infant, are negative or doubtful, IgA and IgE should be tested by ELISA, which is a more sensitive method (~90% vs. 75-80%) but without guaranteed specificity. Repeat testing at 10 days of age may aid diagnosis. IgM and IgA titers in an uninfected infant (ie, an infant with low positive IgM and IgA titers, as a result of placental leakage) decline rapidly, whereas they remain positive for weeks or months in an infant with intrauterine infection.

Moreover, regular serological tests during the first year of life are essential for diagnosis when initial results are equivocal. IgG titers derived from the mother transplacentally usually fall to undetectable levels between 6-12 months, whereas in infants with congenital infection they remain elevated beyond the age of one year. The best prenatal diagnosis of fetal infection is the detection of T. gondii DNA by PCR or RT-PCR (more sensitive) in the amniotic fluid after amniocentesis, but the sensitivity of the method is lower in early than in an advanced pregnancy. Ultrasound examination of the fetus (with usual findings: sonographic intracranial foci, calcifications and dilatation of the ventricles) is useful in providing prognostic information and in making the decision to terminate the pregnancy in a fetus with congenital infection.

Susceptibility to Toxoplasma gondii infection is general but if acquired immunity is present many infections are asymptomatic. The duration and level of immunity is not known but it is speculated that it may be long-lasting or permanent, the antibodies

persisting for years possibly for life. Patients who are immunosuppressed or with HIV infection have a higher risk of developing disease from resurgence of infection.

Furthermore, the use of serologic tests for the demonstration of specific antibodies to *T. gondii* is the initial and primary method of diagnosis. A combination of serologic tests is required to measure different antibodies that possess unique patterns of rising and fall with time after infection. Toxoplasma Serological Profile (TSP) and ELISA are used to determine infection acquired in the recent or more distant past (Remington *et al*., 2004). PCR amplification is very important for the detection of *T. gondii* DNA in body fluids and tissues PCR enables early detection of *T. gondii* DNA in brain tissue, cerebrospinal fluid (CSF), Vitreous and aqueous fluids, bronchoalveolar lavage (BAL) fluid, and blood (Rouatbi *et al*., 2020).

IFA and ELISA, to determine the presence of IgM antibodies, which appear and disappear before the IgG Abs. Since IgM does not cross the placenta, the presence of this Abs in the serum of newborns is reliable evidence that the fetus developed them in utero and that the infant was born with the infection (Remington *et al*., 2004).

Also evolution of IgG Abs titers and if the titers increase after more than three dilutions, it may be speculated that the patient's immune system is responding actively to the parasite and therefore that individual must be in the active phase of the infection (Acha and Szyfres, 2003).

2.9 Treatment

Pyrimethamine is tolerated to be appropriate for relative treatment in addition with alternative drugs like sulfadiazine and vitamin B (Serranti *et al*., 2011; Wallon *et al*., 1999).

For pregnant and infected with toxoplasmosis, treatment may vary depending on where you receive medical care. If infection occurred before the 16th week of pregnancy, you may receive the antibiotic spiramycin (Dunay *et al*., 2018). Use of this drug may reduce your baby's risk of neurological problems from congenital toxoplasmosis (Kravetz and Federman, 2015). Spiramycinis routinely used in Europe but is still considered experimental in the United States. If infection occurred after the 16th week of pregnancy, or if tests show that your unborn child has toxoplasmosis, you may be given pyrimethamine and sulfadiazine, and folinic acid (leucovorin). Your doctor will help you determine the optimal treatment (Wallon *et al*., 1999). Pyrimethamine should be used at areas that exist malaria taken the relative measures so as to prevent epidemics (Koliopoulos et al. 2019).

2.10 Prevention Measures – Control

Among the prevention measures is to control of epidemiological effects to population in developing countries like in Ethiopia and the associated sociological economic effects with the monitoring in infection in agricultural animals and reduce the risk of human disease associated with the consumption of infected meat especially meat of domestic animals. On farms, control of toxoplasmosis is more difficult, but where possible animal feed should be covered to exclude access by cats and insects (Aguirre *et al*., 2019). Live vaccine consisting of tachyzoites attenuated by a repeated passage in mice is now available for sheep.

Congenital infection can be prevented by preventing primary infection during pregnancy. Therefore it is recommended: Primary prevention 1. Informing pregnant women regarding the following preventive measures: Consuming well-cooked meat or alternatively keeping it at -200C for 24 hours. Through washing vegetables, good cleanage with fresh water before consumption. Infected pregnant women should avoid contact with feces from stray cats. It is a good idea to wear gloves when tending to the garden and to wash your hands thoroughly after work and especially before eating. Also, knives and other items that have come into contact with raw meat should be thoroughly washed before reuse 2. Cats should be fed dry food, canned food and well-cooked meat and kept domesticated. Their droppings must be removed on a daily basis or buried deep in the soil to prevent the spread of oocysts. 3. Drinking water only from a tested network Secondary prevention Identification of infected pregnant women with serological testing. Treatment during pregnancy results in a 50% reduction in the incidence of infant infection. Therapeutic abortion prevents the birth of a newborn suffering from congenital toxoplasmosis but

should only be considered in cases of maternal infection during the first or second trimester of pregnancy. Control of cases, vectors, close environment Declaration of the case to the competent health authorities Isolation of patients not applicable Quarantine not applicable Simultaneous disinfection not applicable Vaccination of contacts not applicable Investigation of contacts and source of infection: In congenital infection, determination of the antibody titer in the mother and the infant. Special treatment: in confirmed infection of the pregnant woman after the first 6 weeks, spiramycin is administered which reduces the risk of transmission of the infection to the fetus until the end of the pregnancy. After the 20th week, the amniotic fluid is tested with PCR and simultaneous ultrasound monitoring of the fetus. In case of confirmed fetal infection, sulfadiazine-pyrimethamine is administered to the mother from the 30th week of pregnancy until delivery. In confirmed congenital toxoplasmic infection of the newborn, a sulfadiazine-pyrimethamine combination is given until the age of one year unless toxicity occurs, in which case spiramycin is given. In case of ocular involvement, steroids are administered. Because pyrimethamine causes neutropenia, folinic acid is co-administered (4)

The strain used has lost the capacity to form oocysts in cats. The vaccine consists of 10000-1000000 tachyzoites and it is given as a single dose IM at least 3 weeks before tupping or lambing (Ibrahim, 2017). The public must therefore be made aware of preventative actions such as washing hands after handling mud, washing raw vegetables before eating, avoiding eating raw or rare meat, and serological monitoring of pregnant women during the prenatal period as well as keeping clean cats in clean environments. (Lopes-Mori *et al*., 2011; Oliveira *et al*.**,** 2019).

2.11 Toxoplasmosis in Ethiopia – Actions to mitigate Risks

In Ethiopia, drinking water supply in the rural communities and climatic conditions is favoring the survival of parasites. A continuous screening program should exist for *T. gondii* , as it does not exist a proper monitoring scheme because of facility limitations and cases are mostly diagnosed by exclusion. *Toxoplasma* seroprevalence is variable, with higher prevalence being observed in warm and moist areas than in cold or hot dry areas. Apart from this, variation may also be related to the age of the animals and husbandry practices (Gebremedhin and Tadesse, 2015).

The overall prevalence recorded in sheep in Ethiopia and other African countries is 54.7% (Deconinc *et al*.**,** 1996). The overall seroprevalence of 26.7% was recorded in goats from Ethiopia. The prevalence rates ranging from 11.5% to 39% have been recorded in various African countries including Ethiopia (Bekele and Kasali, 1989).

Some studies conducted in several locations in Ethiopia presenting high infection in sheep, goats, and pigs, where has been reported that overall seroprevalence betweeen 19.5% and 24.1% based on particular tests methodology of *Toxoplasma* antibodies that has been found in goats (Negash and co-investigators, 2004), while another study for southern Ethiopia found a high percentage indicated 74.9% (Teshaleet al., 2007) as well as a study by Gebremedhin and Gizaw, 2014, found a 26.09% for particular regions in Ethiopia. In definitive host, cat, a study conducted in Addis Ababa found that there were 33 seropositive cats (which are 91.6%) out of 36 randomly sampled cats (91.6%) (Dubey *et al*.**,** 2013).

A former serological study in Ethiopia showed 68.8% to 92.6% prevalence in the central part and 83.6% in the Southwest part of the country (Gebremedhin *et al*.**,** 2013). Human case was reported fromButaJira with highest prevalence (95.1%) from patients found in 15-49 age groups ,and from Tiku Anbessa Specialized Hospital, HIV/AIDS patients was reported with 94% prevalence, while minimum prevalence is reported from Adama (Gebremedhin and Tadesse, 2015).

Seroprevalence of *T. gondii* in Jima town was 83.6% also reported (Zemene *et al*.**,**2012). Anti-*T. gondii* IgG antibodies were detected in 81.4% of the samples of which 78.4% were positive for only IgG and 3.06% positive for both IgG and IgM antibodies in central Ethiopia (Jula *et al*.**,**2018).

Seroprevalence of *T. gondii* in pregnant women was 23.9% in southern Ethiopia.The overall seroprevalence of T.gondii infection in pregnant women at Bonga Hospital, Southwestern Ethiopia was 75.7%. (Tesfahuneygn and Gebreegziabher, 2019). *T.gondii* infection was higher in pregnant women between age ranges of 36–44. Associated risk factor was observed in those eating raw meat, in those eating

raw vegetables, in those who have a history of abortion, in women who drink river/streams water and in those who did not handle raw meat (Negero*et al*.**,** 2017).

As Tesfahuneygn and Gebreegziabher, 2019 stated that from a total of 270 HIV-infected women within the reproductive age group of study participants, 255 (94.4%) were found to be seropositive for *T. gondii* anti-immunoglobulin G (IgG) antibody, and 6 (2.2%) for anti-immunoglobulin M (IgM). The proper monitoring schemes at water supply networks, associated infrastructures as well as relative presented preventive measures should be applied properly in order to mitigate the associated risks from toxoplasmosis. However, several education programmes should exist for population inn Ethiopia or other similar conditions at other developing countries. Proper additional measures should be taken for the prevention and control of toxoplasmosis as they are described below in other section.

Therefore, proper monitoring schemes should exist for the sources, pathways and receptors. Good facilities and infrastructures should exist for fresh water as well as for cleaning spaces. Based on epidemiological studies a dense surveillance monitoring scheme network for the safety of social health in particular human or animal population under risk. Also proper prevention statistical measures should exist for the water supply networks, food security and relative infrastructures for public health protection and taking relative safe measures in clean indoors, outdoors spaces in emergencies (Babatsikou et al. 2017; Koliopoulos et al. 2020a, b). Clean food should be safely exist following proper maintence monitoring at water supply networks, for safe dietary histories and food frequency for safe nutritional epedimiological results, nutritritional dietary status and biomarkers (Naska, A. et al. 2017).

2.12 Public health importance of Toxoplasmosis

Congenitally, the disease occurs in children if a pregnant mother suffers from primary infection or acts as a carrier of chronic infection (Sonar and Brahmbhatt, 2010). The cysts in latter cases may revert to tachyzoites cycle under pregnancy stress or cortisone therapy and infect the fetuses. The mother might remain symptomless. Transmission occurs during late pregnancy. In severe cases, there is abortion and organisms can be detected in all aborted materials **(**Blanchard *et al***.,** 2015**)** as well as for pregnant women particular infections could be presented including neurologic, neurocognitive deficits, chorioretinitis, child disability, others (Bigna *et al.*, 2019).

If the child is born alive, it shows a fever, adenopathy, splenomegaly, hepatomegaly, hydrocephalus, microcephaly, psychomotor disturbances, chorioretinitis, and cerebral calcification are also seen (Abamecha and Awel, 2016). Delayed manifestations of congenital toxoplasmosis in children are congenital contact chorioretinitis, anemia, and serious mental retardation. In mild cases, the symptoms are few and difficult to recognize (Praveen *et al***.,** 2016).

Congenital toxoplasmosis is an infection caused in utero or at birth by the parasite Toxoplasma gondii. According to Clinical Manifestations, the severity of the manifestations depends on the gestational age at which the infection occurs. Fetuses affected earlier in pregnancy are more likely to develop severe disease (66% for 1st trimester, vs 5-10% for 3rd trimester). If the fetus is affected during the 1st trimester it can result in intrauterine death, birth of a stillborn neonate or a neonate with severe congenital disease with microcephaly, hydrocephalus, intracranial lesions (calcifications and ventricular dilatation), mental retardation, chorioretinitis, lymphadenopathy, hepatosplenomegaly and jaundice. Intracranial calcifications and neurological disorders are more likely to occur the earlier in pregnancy seroconversion occurs, which does not appear to occur with chorioretinitis. Stillbirth or neonatal death is rare. Congenital cataract, diarrhea vomiting, rash, pneumonitis and hemorrhagic manifestations are also reported. On the contrary, the consequences of an attack at the end of pregnancy are very small and the newborn is asymptomatic or shows only chorioretinitis that progresses if no treatment is given. Many newborns, while initially asymptomatic, may develop some manifestation and usually chorioretinitis as they age. Congenital toxoplasmosis has even been implicated as a cause of congenital deafness. Analysis of 24 series studies of 550 infants infected and detected by prenatal or birth screening showed that 19% (105/550) had clinical manifestations in infancy (<1 year): 14% (79/550) had chorioretinitis and 9 % (49/550) had intracranial calcifications. About 5% of

infected infants identified by prenatal or birth screening had severe neurological disorders (infantile convulsions, microcephaly, valve placement, or death). Congenital toxoplasmosis is caused by the intracellular parasite Toxoplasma gondii, necessary preventive and treatment measures must be taken to avoid health risks. Pathogenesis Congenital toxoplasmosis occurs after parasitaemia resulting from an acute infection of an immunocompetent mother or, more rarely, by reactivation of a latent infection in an immunocompromised mother, hematogenous spread to the placenta, and transmission to the fetus either via the placenta or after normal delivery. In rare cases, an infection that occurred within 6 months before conception has been transmitted to the fetus from an apparently immunocompetent mother. The possibility of transmission of the parasite to the fetus is greater the more advanced the pregnancy. According to a relative analysis, the probability of transmission was estimated at 15% for maternal seroconversion at 13 weeks of gestation, 44% at 26 weeks, and 71% at 36 weeks. According to epidemiological studies, it is caused by intrauterine infection with Toxoplasma gondii. Infection in early stages of pregnancy may cause intrauterine death or chorioretinitis, brain lesions with intracranial calcifications, hydrocephalus, microcephaly, convulsions, hepatosplenomegaly, jaundice, rash, fever that may be apparent immediately at birth or shortly thereafter. Infection of the pregnant woman at a more advanced stage of pregnancy can cause mild or subclinical fetal disease with late manifestations such as recurrent or chronic chorioretinitis (CDC, 2020; Desmonts G, et al. 1974).

Acquired toxoplasmosis remains asymptomatic in 25% of cases. The disease is severe, particularly in immune-suppressed persons. Symptoms may vary from mild fever and body pain to fatal encephalitis. Fever lymphocytosis, eye lesions, abortion, obstructive history, myocarditis, and meningoencephalitis are some of the common manifestations. (Parlog*et al*., 2015, Torgerson and Mastroiacovo, 2013).

3. RECOMMENDATIONS

Toxoplasmosis is an important parasitic disease in animals including man and birds. Women are frequently exposed to domestic animals and garden soil. Hence, screening of pregnant women for *T. gondii* infection during their Maternal and Child Health (MCH) service is not only of the benefit of the women but also of benefit the next generation.

Studies conducted indifferent geographical locations of Ethiopia from 2007 to2020 indicated a high seroprevalence of *T. gondii* infection in humans, sheep, goats, and pigs. Hydrocephalus, retinochoroiditis, convulsion, and intracerebral calcifications in fetus and lymphadenitis and encephalitis in immunocompromised groups are the major findings of toxoplasmosis.

In figure 1 are presented relative measures that should be taken place for public health protection. Such measures include surveillance, epidemiological assessment for injured human population by toxoplasmosis, support to population drugs and vaccines.

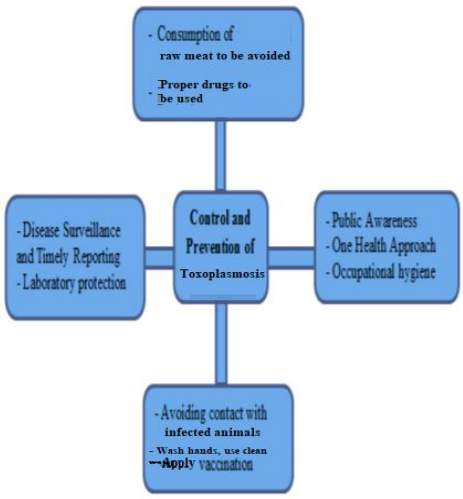

Figure 1. Measures to be taken for the prevention and control of toxoplasmosis

In general, toxoplasmosis is highly important in its high-risk groups, and in order to reduce its means of transmission, the following recommendations are forwarded:

1. Avoidance to drink contaminated water and to consume raw meat. More monitoring schemes, epidemiological studies should exist in Ethiopia or in similar cases in developing countries so as to estimate true prevalence in a different geographical area using sophisticated diagnostic tools.
2. Education of women of age 15-44 years, especially pregnant women, about the transmission, prevention, and control of toxoplasmosis is required.
3. Domestic and barn cats should be prevented from nesting and defecating in the hay, straw mows, grain

stores or other loose piles of the commodity of livestock feeds present in the farms.

4. Veterinarians, slaughterhouses, and abattoir workers should take care when faced with the sources of *T. gondii* to minimize its transmission.

5. Individuals should always wash their hands thoroughly after contact with cat stool, litter or litter box and there should be carried out health education for livestock holder's and people who are at risk.

4. CONCLUSIONS

Based on the above the relative surveillance measures should take place at regions that toxoplasmosis exist in Ethiopia or other similar developing countries. Proper infrastructures are needed to be installed with continous support to the populations that are under public health risk. Also proper monitoring schemes and epidemiological studies should exist for safe agricultural units in food production in terms of soil health, water contamination and public health contamination.

Special educational and training seminars should take place for pregnant women so as to follow the right guidelines in terms of hygiene and public health protection.

Surveillance actions and proper measures are necessary to be taken and to be followed by interesting population. Special information activities to public are essential that should be taken place via e-mails, social media information, webinars, sms to populations that have been injured or are under probable risk by toxoplasmosis or associated tropical diseases. Clean water should be used avoiding contaminated water as well as avoidance to eat fresh meat. Proper remediation projects should exist for soil health, environmental protection, air pollution control and mitigation of risks from particular chemical hazards. Proper pre-constructed sustainable designed green facilities could be used for the rapid installations of integrated community health infrastructures with proper openings, indoor, outdoor space, foundations and drainage designs due to climate change (Koliopoulos et al. 2020a, b).

Proper infrastructures and services should exist for medical supply services, warehouse, safe logistics and shipment of goods to populations that are under risk. Moreover, monitoring schemes should exist so as to mitigate associated risks at places with malaria or other tropical diseases. Renewable resources and clean technologies should be preferred not only for environmental and public health protection but also to create new jobs for unemployed people.

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Contribution of authors

All the authors contributed equally. They read the final version, and approved it for the publication.

Conflict of interest

The authors declare that they do not have conflict of interest.

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