A Review of Toxoplasmosis in Humans and Animals in Libya

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Keywords: Toxoplasmosis, Cats, T. gondii, Libya

ABSTRACT

Toxoplasmosis is a widely distributed zoonotic infection, caused by an obligate intracellular protozoan parasite Toxoplasma gondii in both humans and animals. The review summarizes published data on mode of infections, prevalence, life cycle, clinical aspects diagnosis, and risk factors of T. gondii in Libya. There is no adequate information exists on the mode of T. gondii transmission in Libya. Presence of stray cats and rodents in the houses and farms in different Libyan cities, probably play an important role in the maintaining the life cycle of T. gondii in the region. Libyan people might be also getting infection of T. gondii either by ingesting raw and undercooked grilled meat of lamb on festive occasions and sacrifice feasts or by handling contaminated meat. Handling of infected meat by abraded hands at home might be transmitting toxoplasmosis to some extent through blood from broken skin especially among women in Libya. Diagnosis of T. gondii infection in Libya is based on serological detection of specific anti-Toxoplasma immunoglobulin, using different serological tests which have varied sensitivity and specificity in place to place. Various serological tests showed that toxoplasmosis is prevalent in eastern and western regions compared to southern parts of different Libyan localities from past few decades without any health education and control programmed. Prevalence of anti-Toxoplasma IgG was more than anti-Toxoplasma IgM among pregnant women and patients. Variations in seroprevalence of T. gondii in Libya seem to correlate to lifestyle of cats (stray vs. pet), serological test utilized, climatic conditions, category of patients the with eating and hygiene habits of a population and other undefined factors. Little is known on the seroprevalence of toxoplasmosis in livestock. The sheep showed high seroprevalence and are suitable host for T. gondii in Libya.

مراجعة لداء المقوسات في الإنسان والحيوان في ليبيا

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الكلمات المفتاحية: داء التكسوبلازما، القطط، T. gondii، ليبيا

الملخص

تقدم هذه الورقة ملخصًا لمراجعة حول التكسوبلازما جوندي في ليبيا، بما في ذلك معلومات عن عوامل الخطر، وأسباب العدوى، وانتشارها، ودورات الحياة. يعد داء المقوسات، الذي يصيب البشر والحيوانات على حد سواء، مشكلة كبيرة في عدة أجزاء من ليبيا. ولعل مدى العقود القليلة الماضية، ظهرت هذه العدوى في ليبيا، ولكن الأسف، لم يكن هناك قدر كبير من التثقيف الصحي أو برامج التحكم. لقد لوحظ أن النساء الحوامل والمرضى الأخرين لديهم معدل أشجار أعلى لمضادات التكسوبلازما من نوع IgG مقاومة baja IgM من المعتقل أن يكون وجود الخطط والمخاطر الضارة في المسكن، والمساكن والمزارع في مختلف المدن الليبية أمرًا حيويًا يساعد على إكمال دورة T. gondii في المنطقة. وبالتالي، قد تكون القطط هي المصدر الرئيسي لانتقال العدوى إلى الإنسان والحيوانات الأخرى في ليبيا. من غير المألوف أن ينتقل الاءطعمة غير المطبخة التكسوبلازما T. gondii مع ذلك، قد يصاب الأفراد بالتكسوبلازما جوندي عن طريق تناول لحم الخرافة غير المطبوخ الذي تم شوته في الاحتفالات وأعمال الرقصة، وكذلك في المطاعم على جانب الطريق. بالإضافة إلى ذلك، قد يؤدي التعامل مع اللحوم أو الطععه أو المشروبات الملوثة بالبويضات المسافقة عن طريق السلالات إلى انتقال المرض. قد يؤدي التعامل مع اللحوم الملوثة بالأيادي، خاصة بين النساء في ليبيا، إلى انتشار داء المقوسات إلى حد ما عن طريق الدم. من الجملة المجرح، بالإضافة إلى ذلك، فإن الممارسات التي بها خطأ عرضة للإصابة بداء المقوسات في مواسما.

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1. Introduction

Toxoplasma gondii infects a wide range of mammals and birds. It is one of world’s most common zoonotic parasitic infections (Dubey, 2010; 2017 and Younis et al, 2015). It is capable of infecting almost any cell type within an exceptionally broad host range - across humans, livestock, birds, companion animals and wildlife, making it one of the most ‘successful’ protozoan parasites on earth. Toxoplasmosis is an important health problem worldwide. It has been estimated that one third of the world population has been exposed to this parasite (Hill et al, 2005; Hill and Dubey, 2013, Dubey et al, 2014 and Rouatbi et al, 2019).

T. gondii has a complex life cycle (Dubey,2009). The felines, can host both sexual and asexual reproduction of T. gondii. Essentially, domestic cats are considered as definitive host of T. gondii and are the natural reservoir host of this parasite. Cats of the family Felidae are the key animal species in the life cycle of this parasite by excreting the environmentally resistant oocysts. In intermediate hosts, where asexual reproduction occurs are consist of all warm-blooded animals, including more than 30 species of birds and 300 species of mammals, with T. gondii being most common in sheep (Dubey, 2010).There are three different infective stages of T. gondii, which are (i) a rapidly dividing invasive tachyzoites, present during the acute or early infection in intermediate hosts as pseudocysts, (ii) a slowly dividing bradyzoites, present during the chronic or late stage of the disease in intermediate hosts persist as tissue cysts for protracted periods, and (iii) sporulated oocysts containing procysts, shed as non-sporulated oocysts by the final hosts with feces. Sporulation occurs outside of the body to form sporulated oocyst containing four sporozoites. These oocysts are environmentally robust, and can retain infectivity in a cool damp environment for months (Dubey, 2010 and Subasinghe et al, 2011).

T. gondii has three dominant clonal classes of strains named as Type I, II and III. These genotypes are clonal in their structural features (Dubey, 2010). Different strains of the parasite induce different cytokine responses, triggering development of various clinical and biochemical disturbances in the host (Araujo and Slifer, 2003). Different genotypes of the parasite show great diversity in pathogenicity and drug sensitivity. Type I causes infection in rodents. Type II established as the infectious agent in small ruminants while Type III has yet not been proved as infectious strain. Recently, a genotype (Type IV) has also been reported mostly in wildlife (Ahmed et al, 2015). So far in Libya, Ali et al (2018) reported evidence of Type I strain of T. gondii in the city of Benghazi among patients clinically suspected of ocular toxoplasmosis.

The aim of our review is to describe actual knowledge on the prevalence of T. gondii in humans and animals in different Libyan cities. It also discusses aspects of transmission, life cycle, clinical manifestations, and diagnosis and on potential risk factors favoring infections of humans and livestock with T. gondii. Knowledge on potential risk factors is prerequisite to implement effective biosecurity measures in farms to prevent T. gondii infections.

2. Transmission of T. gondii

Different modes transmissions of T. gondii are shown in Figure 1. The cats are the primary source of infection to human beings for toxoplasmosis. Human infection is acquired by consuming food or drink contaminated with oocysts of T. gondii shed by cats, or by accidentally ingesting oocysts from the environment or handling infected cats. Ingestion of tissue cysts containing bradyzoites or psuedocysts and tachyzoites from raw or undercooked meat (Macra et al, 1996 and Dubey and Jones, 2008).Congenital transmission could result in the infection of the placenta by tachyzoites which may cross the placenta and enter fetal tissues or the bloodstream (Pardini et al, 2018). T. gondii infection can also rarely be transmitted by tissue or organ transplants (Robert-Gangneux, and Darde, 2012). Transmission of the parasite can also occur by blood transfusion (Yazar et al, 2006 and Alshibani, 2017) and bone marrow transplantation (Edvinsson et al, 2008) all ofgenetic stem cell transplantation (Fricker-Hidalgo et al,2009) sputum (Laibe et al, 2006) and breast feeding milk (Hiramoto et al, 2001 and Camossi et al, 2011). Animals get infection by the ingestion of oocysts contaminated in grasses, feed and water or by transmission from mother to fetus. Therefore toxoplasmosis in animals is significantly associated with presence of cats in the farms (Dubey, 2010). The definitive host cats, acquired infection of toxoplasmosis by eating infected meat of warm-blooded animals (cattle, buffaloes, sheep, goats, camels, rostens, pigs and birds) containing tissue cysts or pseudocysts or both. Handling of meat at home from infected animals, increases the possibility of contact with tissue cysts, particularly if no protective equipment, such as gloves, is worn. Additionally, tissue cysts may be ingested during hand-to-mouth contact after handling undercooked meat (Markell et al,1992). It can also be transmitted by containers, knives or other utensils, cutting boards or other preparation surfaces contaminated with raw meat. Prevalence of T. gondii infection is high in Libya but the main reason yet unclear as no adequate studies regarding availability of modes of transmission (Alkateb et al, 2007).

In Libya, there are plenty of stray cats (so called domestic cats) which are roaming freely indoor and outdoor would be increasing more risk of T. gondii infection to both humans and domestic livestock (Mahmoud et al, 2019 and Rouatbi et al, 2019). Soil contaminated with cat’s faeces may play role in transmitting infection through consumption of contaminated raw vegetables or water or fruits and poor hand hygiene are important risk factors in transmission of Toxoplasma infection (El-sayed and Almannoni, 2016. Alshaibani, 2017 and Mahmoud et al, 2019). Moreover, domestic cats usually defecate in open areas and contaminate the soil near by houses and exposure of children playing in sandpits and geophagia resulting infection of T. gondii(Flegr et al, 2014 and Rouatbi et al, 2019). Therefore, presence of cats in a region posing an important risk factor for toxoplasmosis. Sheep, goats and camels are the traditional source of meat in this region. Libyan peoples usually slaughter domestic livestock on festive occasions. Peoples may be acquiring infection of T. gondii by eating raw and undercooked meat of infected animals (Kassem and Morsy, 1991, Al-Mabruk et al, 2013, Gashout et al, 2016, Mahmoud et al, 2019 and Elgodwi 2020). Moreover, at homes in Libya, handling of infected meat of animals or chicken might be playing role in the transmission of toxoplasmosis as bradyzoites or tachyzoites or both of T. gondii may enter into blood stream through broken skin. Ali et al (2019) have identified some important risk-factors contact with farm animals, unfiltered water-sources are supposed to be risk-factors of toxoplasmosis in Asabieh city.

3. Life cycle of T. gondii

T. gondii is a coccidian parasite and has both asexual (schizogony) and sexual (sporogony) cycles in the same host that is felids (Figure.1). Since sporogony (schizogony) does not occur in any host and therefore, cats are considered as definitive host of T. gondii. In cats, non-sporulated oocysts are developed in gut and passed out in feces which get matured (sporulated) in the soil and are infective stage to both humans and herbivores. Intermediate hosts are a variety of livestock, and birds. In human beings asexual or schizogony cycle of parasite completed. At some frequency within the host, especially in immunodeficient patients (HIV/AIDS) there is apparently a low rate of spontaneous reactivation (reactivation of latent infection of T. gondii) whereby bradyzoites differentiate back to tachyzoites. Normally, the immune response efficiently prevents the dissemination of these tachyzoites. However, in immunocompromised hosts, reactivation may be unchecked and/or more frequent, leading to the provocative suggestion that the parasites might actively detect a lowered immunity against them (Gazzinelli et al, 1993 and Gross and Pohl, 1996). The result, in either case, can be a massive and potentially fatal recrudescence.
Fig. 1: Transmission pathways of *T. gondii* (Attias et al, 2020)

Life cycle of *T. gondii* is not known in Libya. The population of small rodents in Libya is high and they may play a significant role as intermediate hosts for the final host, and play role in the spreading of the Toxoplasma infection (El-Gomati et al, 2010). Mahmoud et al (2019) found that presence of cats at home was significantly associated with seroprevalence of toxoplasmosis among pregnant women in Sebha and Tripoli city respectively. In Libya atmospheric conditions in various cities are probably favorable for the survival and spreading of oocysts shed by the definitive hosts, leading to higher contamination rates of intermediate hosts (El-Gomati et al, 2010 and Al-Mabruk et al, 2013). In such areas, the number of different herbivore species is also high creating further favorable conditions for *T. gondii* transmission in the region (Kassem and Morsy, 1991. Gashout et al, 2016 and Rouabi et al, 2019).

4. Clinical features of Toxoplasmosis

The primary infections of *T. gondii* are usually subclinical and the vast majority of significant morbidity and mortality in certain groups. This includes encephalitis, chorioretinitis, congenital infection and neonatal mortality (Weiss and Dubey, 2009).

4.1. Acquired Toxoplasmosis

Acquired infections are common and approximately 80% to 90% remain asymptomatic. In acute toxoplasmosis, patients may develop hepatomegaly, splenomegaly, fever, lymphadenopathy, meningoencephalitis and usually unilateral retinchoroiditis, blurred vision and rarely may turned to blindness (Murat and Michael, 2019). In chronic toxoplasmosis patients remains asymptomatic or there is low grade fever, lymphadenopathy, unilateral retinchoroiditis, myocarditis, myalgia and arthralgia (Murat and Michael, 2019).

4.2. Congenital Toxoplasmosis

Congenital infection results from a primary infection of the mother during pregnancy. Primary infection during pregnancy poses a risk of abortion or severe birth defects or dis carriage of the fetus. This vertical or congenital transmission could result in the invasion of the placenta by tachyzoites which may cross the placenta and enter fetal tissues or the bloodstream (Mahmoud et al, 2015 and Pardini et al, 2018). Congenital toxoplasmosis may cause abortion, neonatal death, or stillbirth and fetal congenital abnormalities develop mainly in the neuromuscular system and eyes (Remington et al, 1995 and Hayde and Pollak, 2000). This is most severe when maternal infection occurs early in pregnancy. Approximately 15-55% of congenitally infected children do not have detectable *T. gondii*—specific IgM antibodies at birth or early infancy. Approximately 67% of patients have no signs or symptoms of infection (Murat and Michael, 2019). Usually, in congenital infections there is bilateral retinchoroiditis occurs in about 15% of patients, which may persist to bilateral blindness and intracranial calcifications develop in about 10%. Cerebrospinal fluid (CSF) pleocytosis and elevated protein values are present in 20% of patients. Infected newborns developed anaemia, thrombocytopenia, and jaundice at birth. Microcephaly has been reported. Affected survivors may have mental retardation, seizures, visual defects, spasticity, hearing loss or other severe neurologic sequelae.

*T. gondii* has emerged as one of the most common opportunistic infections in patients with AIDS. Toxoplasmosis in AIDS patients is considered to be a result of reactivation of latent infection, but the mechanism of reactivation is unknown. The clinical features of toxoplasmosis in immunocompromised patients, such as HIV patients are not specific and may likely mimic other signs that can lead to an erroneous outcome. The usual signs are fever with neurological imbalance (Nimri et al, 2013). In immunosuppressed (HIV, organ transplant or cancer) patients, the infection can lead to life-threatening cerebral toxoplasmosis (Akanmu et al, 2010 and Addebbous et al, 2012). In pregnant animals, primary infection can lead to abortion, hence causing high economic losses. In ewes, if the infection occurs between 50 and 120 days of pregnancy, it induces abortion, expulsion of mummified fetuses, or the birth of stillborn and weak lambs (Buxton et al, 1991 and Al-Mabruk et al, 2013). Most of the acquired infections of *T. gondii* in herbivores (sheep, goat, cattle, camel and equine) are subclinical. However, fever, ataxia and retinal degeneration and encephalomyelitis may develop. Severity of toxoplasmosis in ovine is associated with the stage of pregnancy (Kadle, 2014 and Younis et al, 2015). *T. gondii* in ovine are the most devastating impact on their performance and useful organs, especially in pregnant sheep, which is important to the ovine industry.

5. Diagnosis of *T. gondii*

Diagnosis of toxoplasmosis in humans is performed using different techniques including serological testing, histological identification, and isolation in tissue culture as well as, molecular methods using the Polymerase Chain Reaction (PCR). Acute and latent *T. gondii* infections are mostly diagnosed by serological tests including increased antibody levels such as IgG, IgM, IgA and IgE. Various serological techniques have been established to determine recent and previous exposures to *T. gondii* infection: namely Sabin-Feldman dye test (SFDT) (Sabin and Feldman, 1948), Latex agglutination tests (LAT) (Dubey, 1997., Dubey and Jones, 2008., Robert-Gangneux and Dardé, 2012 and Liu et al, 2015), indirect fluorescent assay (IFA) (Rorman et al, 2006 and Saraei et al, 2010), and enzyme-linked immunosorbent assays (ELISA)(Dubey, 2010., Ben Abdallah et al, 2013., Liu et al, 2015., Gashout et al, 2016., Pardini et al.2018 and Elamrani et al, 2021), or a combination of these methods (Rorman et al, 2006., Dubey and Jones, 2008 and Robert-Gangneux and Dardé, 2012). ELISA is still considered as one of the most commercially available techniques with high sensitivity and specificity in the quantitative detection of antibodies and all antigenically active molecules (Doskaya et al, 2014 and Liu et al, 2015). Worldwide, prevalence of the toxoplasmosis is measured by detection of specific anti-Toxoplasma IgG antibodies varies between 1% and 100 depending on different factors such as serological tests used for diagnosis, types of anti-Toxoplasma antibodies geographical location, age, habit of eating raw meat or unwashed fruit and vegetables, sociocultural and nutritional habits, general level of hygiene and contact with domestic cats (Al-Nahari and Al-Tamimi, 2010., Al-Jebouri et al, 2013., Alzaidy, 2007., Elazzzy et al, 2014.).

In Libya, both qualitative (Latex Agglutination Test) and quantitative (Indirect Hemagglutination Test, and Enzyme Linked Immunosorbent Assay) have been used for the serodiagnosis of toxoplasmosis (Khadre and El-Nageh 1987., Kassem and Morsy, 1991., Azwai et al, 1993., Alrzaid, 2007., El-Gomati et al 2008., Al-Mabruk et al, 2013., Gashout et al, 2016., Younis and Elamrani, 2018 and Elamrani et al, 2021). Gashout et al (2016) for the first time in Libya described establishment, optimization, and application of diagnostic PCR assay to amplify SAG2gene of *T. gondii* infection from Libyan HIV patients, women who have had spontaneous abortions, leukemia, and ocular infection patients who were sero-positive for specific Toxoplasma antibodies. They also found PCR has ability to diagnose active toxoplasmosis in immunocompromised and congenital toxoplasmosis when serological techniques fail to diagnosed the disease. Moreover, Haq et al (2016) applied PCR for high frequency detection of *T. gondii* DNA in human neonatal tissue indicating a high level of congenital toxoplasmosis in the city of Misrata from Libya.

6. Infection of *T. gondii* in Libya

*T. gondii* is prevalent among humans (10.4 to 69.4%) as well as animals (7.5 to 75.1%) in North Africa (Rouabi et al, 2019). Worldwide, prevalence of the toxoplasmosis is mostly measured by detection of specificity-Toxoplasma IgG antibodies using ELISA. IgG seropositivity determined the chronic stage of disease, which is also
the latent toxoplasmosis and reflects previous exposure to the infection. Secondly, the immunoglobulin M (IgM) level determines the acute stage of the T. gondii infection and may indicate recent exposure to the disease. The majority of the studies have focused on the seroprevalence in pregnant women followed by patients with disorders frequently using serological tests were the ELISA, latex agglutination test (LAT), and IFAT (Elsaid et al, 2014, Gashout et al., 2016, Alshaibani, 2017 and Rouabti et al, 2019).

Table1: Seroprevalence of Toxoplasmosis among pregnant women in different Libyan cities/localities

<table>
<thead>
<tr>
<th>City</th>
<th>Technique</th>
<th>Prevalence (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benghazi</td>
<td>LAT</td>
<td>45.6</td>
<td>Legnain and Prawecka (1983)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kassem and Morsy (1991)</td>
</tr>
<tr>
<td>El Beida</td>
<td>ELISA</td>
<td>44.0</td>
<td>Maghni et al (2003)</td>
</tr>
<tr>
<td>Tripoli</td>
<td>LAT</td>
<td>25.6</td>
<td>Alzaidy (2007)</td>
</tr>
<tr>
<td>Zawia</td>
<td>ELISA</td>
<td>74.0</td>
<td>Aljabali (2008)</td>
</tr>
<tr>
<td>Surman</td>
<td>ELISA</td>
<td>68.8</td>
<td>Aljabali (2008)</td>
</tr>
<tr>
<td>Sabrata</td>
<td>ELISA</td>
<td>58.1</td>
<td>Aljabali (2008)</td>
</tr>
<tr>
<td>Benghazi</td>
<td>ELISA</td>
<td>44.8</td>
<td>Mousa et al (2011)</td>
</tr>
<tr>
<td>Fezzan</td>
<td>ELISA</td>
<td>23.6</td>
<td>Ebrahim (2013)</td>
</tr>
<tr>
<td>Benjawad</td>
<td>ELISA</td>
<td>37.1</td>
<td>Salima and Kassem (2015)</td>
</tr>
<tr>
<td>Tripoli</td>
<td>ELISA</td>
<td>30.7</td>
<td>Boshapor and Kassem (2015)</td>
</tr>
<tr>
<td>Sebha</td>
<td>ELISA</td>
<td>25.8</td>
<td>Ramadan (2015)</td>
</tr>
<tr>
<td>Al Khoms</td>
<td>ELISA</td>
<td>39.3</td>
<td>Gamal and Jaroud (2015)</td>
</tr>
<tr>
<td>Sebha</td>
<td>ELISA</td>
<td>36.8</td>
<td>El-Sayed and Almannouni (2016)</td>
</tr>
<tr>
<td>Msallata</td>
<td>LAT</td>
<td>41.0</td>
<td>Zeglam and Shugi (2017)</td>
</tr>
<tr>
<td>Tarhuna</td>
<td>ELISA</td>
<td>33.0</td>
<td>Elyadi et al (2017)</td>
</tr>
<tr>
<td>Tripoli</td>
<td>Immunoassay system</td>
<td>41.0</td>
<td>Elgodwi (2020)</td>
</tr>
<tr>
<td>Sebha</td>
<td>Immunoassay system</td>
<td>36.0</td>
<td>Elgodwi (2020)</td>
</tr>
<tr>
<td>El Beida</td>
<td>ELISA</td>
<td>26.8</td>
<td>Elammar et al (2021)</td>
</tr>
</tbody>
</table>

The first serological study of T. gondii on human infections in Libya was done by Legnain and Prawecka (1983) in Benghazi among pregnant women. Four years later, Khadre and El Nageh (1987) carried out seroprevalence of toxoplasmosis on women in childbearing age pregnant women and non-pregnant, adult males and schoolchildren. Several seroprevalence studies have been conducted in pregnant women in different Libyan cities and results showed differences from region to other(Table 1). Most of studied seropositivity data presented in Table 1, were based on detection of anti-Toxoplasma IgG using ELISA, which varies from 23.6 to 74.0% among pregnant women (Aljabali, 2008 and Ebrahim, 2013). However, IgM seropositivity was low, and varies from 0.0 to 17.6% in different cities among the pregnant women using ELISA. Recently, Haq et al (2016) used PCR for the diagnosis of congenital toxoplasmosis and detected T. gondii DNA in 9.8% of the umbilical cord of neonates, indicating a high level of congenital toxoplasmosis and detected T. gondii DNA in 9.8% of the umbilical cord of neonates, indicating a high level of congenital toxoplasmosis.

Table2: Seroprevalence of Toxoplasmosis among general population and patients in different cities of Libya.

<table>
<thead>
<tr>
<th>City</th>
<th>Category of patients</th>
<th>Assay</th>
<th>Prev. (%)</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Adult Males</td>
<td>LTA</td>
<td>51.6</td>
<td>Khadre and Ebrahim (2013)</td>
</tr>
<tr>
<td></td>
<td>Adult Females</td>
<td></td>
<td>43.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>School Children</td>
<td>LTA</td>
<td>45.7</td>
<td>Nageh (1987)</td>
</tr>
<tr>
<td>Tripoli</td>
<td>Psychiatric Patients</td>
<td>ELISA</td>
<td>50.3</td>
<td>Elsaid et al (2014)</td>
</tr>
<tr>
<td></td>
<td>Patients with Leukemia and Lymphoma</td>
<td>LTA</td>
<td>61.7</td>
<td>(2014)</td>
</tr>
<tr>
<td>Tripoli</td>
<td>Infants with</td>
<td>ELISA</td>
<td>66.7</td>
<td>Gashout et al (2016)</td>
</tr>
</tbody>
</table>

In Libya, results of several studies showed high prevalence of toxoplasmosis in the eastern and western regions compared to the southern region of the country. This can be attributed to the difference environmental conditions, such as the high rainfall, and high humidity, making it an environment suitable for the sporulation and surviving of oocysts. However, hot and dry environment as such in the southern regions of the country could be unfavoring the development and surviving of the parasite which may explain the moderate to low incidence of T. gondii in the southern regions (Boshapor and Kassem, 2015).

Seroprevalence of toxoplasmosis among non-pregnant women, psychological patients, school children, immunocompromised patients(leukemia, lymphoma and patients with HIV/AIDS), children with ocular infection, diabetic patients, patients with epilepsy and patients attending hospital is shown in Table 2. Higher seroprevalence 60.7% and 88.5% of T. gondii was estimated among psychiatric and HIV/AIDS patients respectively in Tripoli. The authors explain this as a causal relationship between toxoplasmosis infection and psychiatric diseases (Elsaid et al, 2014). Moreover, most of the time, psychiatric patients have a high risk of exposure to T. gondii infection due to lack of good personal hygiene, self-care skills, and a tendency to pica (Achaw et al, 2019). These habits frequently expose people to infections.

Livestock (sheep, goats, cattle, buffaloes, camels, and poultry) play an important role in food security, which provides a source of nutrients to other animals and humans in the region. Some animals may carry the bradyzoite cyst within tissues of their bodies and can subsequently be transmitted to other respective hosts through consumption of raw or undercooked portion of this infected tissue (Polley and Thompson, 2009). So far, there are only few studies in Libya related to seroprevalence data on T. gondii infection in animal species. Seropositivity in livestock is shown in Table 3. Indirect hemagglutination testing (IHA) was used to serologically determine the species of the infection in cattle, sheep, goats and horses sampled from different parts of Libya by Azawi et al (1993). El-Gomati et al (2010) used Toxocell latex test for the detection of Toxoplasma antibodies and found 35% positivity. A higher seroprevalence (71%) was reported in sheep from the western region to the central region using latex agglutination testing (Al-Mabruk et al, 2013). They consider sheep are suitable host for T. gondii in Libya. Research on the rodent intermediate host is scarce in Libya, and only a single report was documented (El-Gomati et al, 2010).
7. Risk factors associated with T. gondii
Prevalence of the toxoplasmosis is measured by detection of specific-anti-Toxoplasma IgG antibodies depending on different factors such as geographic allocation, age, habit of eating raw and undercooked meat or unwatched fruit and vegetables, sociocultural and nutritional habits, general level of hygiene and contact with domestic pets (Krvavetz and Federman, 2005. Al-Nahari and Al-Tamimi, 2010. Al-Jebourietal., 2013 and Idawela et al., 2017). Farm management is a major risk factor. For example, in Algeria, sheep are reared in extensive systems and fed on fresh bulk feed or pasture, which is a greater risk as sources of contamination (Dahmani et al., 2018). Afghanaei and Abdulsalam (2019) summarized data on possible risk factors related to T. gondii infection in Libya. Risk factors could be:

(i) A higher seroprevalence of T. gondii is associated with geographical location such as humid areas, which are suitable for sporulation of oocysts. Humidity and sufficient rainfall conditions increased viability of oocysts and can survive for more than one year (Jimenez-Coello et al., 2012 and El-sayed and Almannoni, 2016). Results of studies in Libya showed higher prevalence of toxoplasmosis in eastern and western regions compared to southern parts of country, where incidence of T. gondii is moderate to low (Boshapoor and Kassem, 2015).

(ii) Meat of warm-blooded animals and birds has been considered a major source of Toxoplasma infection especially in countries that consumed raw or undercooked meat. Besides the consumption of T. gondii tissue cysts contained in meat, meat-derived products, or offal can be an important source of infection in humans (Jiménez-Coello et al., 2012 and El-sayed and Almannoni, 2016). Consumption of undercooked meat is significantly associated with T. gondii infection (Tenter et al., 2000; Dubey, 2010, Mousa et al., 2011, and Alshaibani, 2017). T. gondii cysts may persist in the tissues of the host for years (Dubey, 2010). Meat is predominantly consumed cooked in sauce, but undercooked grilled lamb is consumed during the Muslims’ sacrifice feast, and very often in restaurants at the side of the road (Uhl, 2001). Therefore tissue bradyzoites consumed from infected meat precipitates infection of T. gondii in humans. Livestock (cattle, buffaloes, camels, sheep, goats, and poultry) play an important role in food security, nutrition, and the economies of North African countries by supporting rural livelihoods and employment, and ensuring access to animal source foods (FAO, 2016). Gamal and Jaroud (2015) reported significantly higher seropositivity rate (70.0%) among women consuming sheep meat compared to those (54.0%) consuming camel meat in Al Khoms city. Transmission of T. gondii infection through undercooked meat in Libya is uncommon because most people preferred to eat well cooked meat (Swalem and Feturi, 1994. Abu Setta and Yamani, 2008 and El-sayed and Almannoni, 2016). Ali et al. (2019) reported that way of meat cooking was a significant risk factor associated with T. gondii infection as 80% of the population ate well-cooked meat where 20% of them ate undercooked meat in the city of Asabieh. Women are at high risk of contracting Toxoplasma infection (Yue et al., 2010 and Pinto et al., 2017). Hana et al. (2021) reported that Toxoplasma infection was higher in female (55.6%) than male patients (35.9%) in city of Sirte. This can be explained by the fact that women are more exposed to risk factors and as a result of the risk factors are in a longer exposure period (frequently having contact with cats as pets at homes, spend more time for cooking and handling of raw meat). Therefore, women have more frequency of infection than males.

(iii) Contact with domestic cats is primary source of infection in humans and major risk factor for toxoplasmosis (Dubey and Jones, 2008. Jones et al., 2009 and Hatam-Nahavandi et al., 2021). Cats are essential in the life-cycle of T. gondii because they are the only hosts that can excrete the environmentally resistant oocysts in nature. Felids can shed millions of oocysts that can spread the infection to environmental conditions and contaminating flours of houses, soil nearby homes and residential areas, water, fruits and vegetables in farm houses in the region. Several studies conducted in Libya, showed association between the Toxoplasma infection and contact with cats (Kassem and Morsy, 1991., Abu Setta and Yamani, 2008., Ramadan, 2015., Gamal and Jaroud, 2015., Bohsapoor and Kassem, 2015., Younis and Elamami, 2018 and Mahmoud et al., 2019). On the contrary, other studies found no association between seroprevalence of toxoplasmosis and contact with cats. (Magri et al., 2003., AlKhunfas, 2008., Mousa et al., 2011., Elsaid et al., 2014., El-sayed and Almannoni, 2016). However, the acquisition of cats as pets is not common practice in Libya. Stray cats are found in farms, gardens, or may enter houses from time to time to obtain their food from remains of raw meat thrown in the garbage (Afghanaei and Abdulsalam, 2019). This could increase the chance of infection especially for children living in houses with soil floor or playing in farms during picnics (Mousa et al., 2011 and El-sayed and Almannoni, 2016). Moreover, the population of small rodents in Libya is high and they may play a significant role as intermediate hosts for the final host (cat), and plays role in the spreading of the Toxoplasma infection (El-Gomati et al., 2010). Several risk factors for toxoplasmosis in Asabieh city were identified, direct contact with farm animals were at increased risk compared with those who did not have regular contact with them. Consumption of unfiltered water was also identified as a risk factor for toxoplasmosis in Libyan city of Asabieh (Ali et al., 2019). In addition, contact with dogs showed significant associated with infection; therefore dogs might be an important route of T. gondii transmission (Elsaid et al., 2014 and Hatam-Nahavandi et al., 2021).

8 Conclusion
In this review we concluded, that anti-Toxoplasma gondii IgG antibodies were significantly more prevalent than anti-Toxoplasma gondii IgM antibodies among pregnant women in Libya, but little is known on clinical congenital toxoplasmosis. In addition, little is known on the seroprevalence of toxoplasmosis in livestock, particularly sheep destined for human consumption in this region. The
disease is widespread in all parts of the country with variable prevalence rates. Presence of cats in houses and farms playing a significant role in the epidemiology of toxoplasmosis in different localities of Libya. Higher Toxoplasma antibodies (IgG and IgM) were found among pregnant women and immunocompromised/immunosuppressive patient in different Libyan cities. Obstetricians appear to provide more appropriate counseling of pregnant women about risk factors, such as avoid contact with cats, having a pet cat at home or in living area, eating raw or undercooked meat and eat properly washed vegetables and fruits may reduce the risk of congenital toxoplasmosis. Veterinary data of toxoplasmosis show that this can be achieved by controlling rodent pests and keeping cats out of sheds of animal or farm houses. Moreover, the population of small rodents in Libya is high and they may play a significant role as intermediate hosts for the final host. High IgM seropositivity among pregnant women necessitates systematic measures to prevent acute toxoplasmosis infection during pregnancy in Libya.

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