Review

Toxoplasmosis in humans and animals in Saudi Arabia: A systematic review

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Abstract
Introduction: The causative agent of toxoplasmosis is Toxoplasma gondii (T. gondii); an intracellular obligate parasite causes abortion in humans and animals. The review aims to clarify the situation of the disease in humans and animals in different parts of the country so that data will be available for any future work regarding the control of the disease. Methodology: All humans and animal research studies published in the last 18 years between 2000 and 2018 in Saudi Arabia were targeted, including prevalence or seroprevalence of T. gondii infection or antibodies. The searched strategy included human or pregnant women or children as well as animals or any particular species. Results: The result showed that approximately one-third of the population in Saudi Arabia had IgG seropositivity, and 6.4% had IgM seropositivity. Moreover, the disease was widespread in almost all the regions except AL - Jouf, where no data published. The prevalence of the chronic infection was high in sheep in Riyadh 68%, and the prevalence of acute was found in Najran 19% in sheep, goats, and camels. Conclusions: The current article showed the importance of the disease in Saudi Arabia for both humans and animals. The educational programs should be established to impart people to avoid the infection by the parasite.

Key words: Toxoplasmosis; prevalence; risk factors; Saudi Arabia.

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Introduction

The causative agent of toxoplasmosis is Toxoplasma gondii (T. gondii) an intracellular obligate parasite causes abortion in human and animals [1]. During different periods of the parasite life cycle, individual parasites convert into various cellular stages. These stages include the sporozoites, bradyzoites, and tachyzoites [2]. The parasite’s life cycle consists of two stages: a sexual stage that appears in cat and asexual stages which occur in all warm-blooded animals, including humans [3]. The parasite can affect both humans and animals, including camels, cattle, sheep, goats, poultry, and wild animals [4]. Lymphadenitis is the most common clinical form of the disease [5-8].

In contrast, the effect of the disease during pregnancy depends on the time of infection; for example, a pregnant woman infected in the third trimester often there will be asymptomatic diseases to new-born [9]. The effect of the parasite in animals may lead to economic impact; in sheep, the infection may cause fetal death and mummification, early embryonic death and resorption, neonatal death, stillbirth, and abortion [10]. The parasite does not pass from person to person with direct contact, but vertical transmission may appear from mother to her fetus. Intermediate hosts can get the infection via horizontal transfer, including different routes such as contaminated water or food [11].

As in the case of most other protozoa, the prevalence of T. gondii is higher in developing areas of the world. However, T. gondii is one of the few protozoans, which has maintained a significant prevalence in developed countries such as the United States [12].

The diagnosis of toxoplasmosis still depends on the detection of different types of antibodies, which each of them has a different interpretation. Detecting IgM in the blood sample of the patient using the ELISA technique means the infection in the acute phase while found IgG means past infection [13].

In pregnant women, several procedures should be followed to prevent them from getting the infection, mainly contacting a cat or the area where it lives. The crucial thing is washing hands and good personnel hygiene [14].

In Saudi Arabia, there were numerous studies done to estimate seroprevalence, and the majority of the studies were conducted among pregnant women. The current work implemented to clarify the situation of the disease in Saudi Arabia besides explaining which the target group of people needs to look for them and to
know where and how the plan should be conducted to fight the disease.

**Prevalence of toxoplasmosis in human**

The estimation is done by WHO confirmed that approximately 30% to 50% of people worldwide had an infection with *T. gondii* [15]. Most of the more than one-third of the world's human population who are infected with *T. gondii* remain asymptomatic because the immune system usually keeps the parasite from causing illness. Chronic, typically lifelong, infection with *Toxoplasma* that is not accompanied by overt clinical symptoms of toxoplasmosis disease is termed latent toxoplasmosis. In contrast, chronic infection associated with continuous or recurrent clinical symptoms is termed chronic toxoplasmosis [16]. The prevalence of toxoplasmosis in the US was declining, although 14% of people still seropositive [17] with one million new cases each year, resulting in about twenty thousand cases of retinal infection [18] and 750 death cases [19]. The highest prevalence is found in Latin America, parts of Eastern/Central Europe, the Middle East, and parts of South-East Asia and Africa [20].

Low seroprevalence (10 to 30%) has been observed in North America, in South East Asia, in Northern Europe, and Sahelian countries of Africa. Moderate prevalence (30 to 50%) has been found in countries of Central and Southern Europe, and high prevalence has been found in Latin America and tropical African countries [21].

The prevalence rate of toxoplasmosis in Asian countries was found to be between 23 to 45% in pregnant women in Malaysia, 1.4 to 21.7% in Thailand, and up to 17.2% in Singapore [22]. Even though toxoplasmosis is a disease distributed worldwide, there is rare information on the prevalence and epidemiology of the disease in the Arabian Peninsula countries [23]. In UAE, the seropositivity was the lowest in the Arabian Peninsula (22.9 %) [24]. In Qatar, a study that examined seropositivity in the general population demonstrated a rate of 29.8 % [25]. In Kuwait, as one of the Arabs peninsula countries, the seropositivity rate was highest (45.7 %) [26].

**Prevalence of toxoplasmosis in animals**

The disease of toxoplasmosis is critical in meat-producing animals because these animals are still the primary source of infection to humans. The infection can be reduced by following some hygienic procedures and intensive farm management. The seropositivity of the disease in sheep in Europe may reach 77% [28]. Infection of *T. gondii* in cattle and the prevalence still was the kind of debate, but the recorded data confirmed that the prevalence rate might reach 92% in Europe [1].

**Risk factors associated with toxoplasmosis**

**Age** some studies associated the infection of *T. gondii* with the age of the target groups, particularly in Arab countries [29,30]. One study in Egypt found that the disease increased with age [31]. Opposing these studies, some studies in pregnant women in China found no relationship between infections with *T. gondii* and age [32].

**Gender** National population based-surveillance done in the USA found that the prevalence of toxoplasmosis in men was higher than in women [33]. Some other studies showed no gender-related with the *T. gondii* infection [34, 35].

**Location** In the Arabic countries’ area and the Middle East countries, the prevalence of toxoplasmosis was different according to the area. Previous studies were done in the Arabian Peninsula area, shown different seropositivity of toxoplasmosis, which ranges between 22.9% to 58.2% [36-38]. In the Sham area, the prevalence of toxoplasmosis ranges between 23.4 % to 62% among pregnant women [39,40]. In the Wadi-Al-Nile area, the seroprevalence toxoplasmosis in Egypt in pregnant women showing the highest prevalence in this region, which ranges between 46.1% and reached 62.1% [41,42] In Sudan, the seroprevalence in pregnant women was 34.1% reported in 2003, while the prevalence rate reached 58.3% in aborted women [43,44]. In the Maghreb area, the prevalence of toxoplasmosis was higher compared with other regions. The record showed prevalence between 47% to 64% in Tunisia, Algeria, Morocco, and Libya [45-47].

**Contact with Cats** Cats play a crucial role in transmitting the infection as the definitive host. In the literature, there was colossal work done. Some of these workers found a strong relationship between direct contact with a cat and the infection; other studies found no association between direct contacts with a cat and get an infection [44,48]. In general, living with domestic cats and exposure to their feces may increase the chance of getting the disease.
Raw Meat
In the majority of the epidemiological studies, researchers found that eating raw or undercooked meat, maybe the first source of the infection by *T. gondii* [49-51]. Some other studies found an association between getting an infection with *T. gondii* and cutting meat [52].

Contaminate Hands
Transmission can be done via contamination of hands by exposure to the feces of cat containing oocysts when cleaning the cat’s litter or exposure to bradyzoites when cutting the raw meat [53]. Therefore, contaminated hand plays a significant role in the transmission of the parasite by different forms.

Drinking Unboiled Milk
Consumption unboiled milk or milk products containing tachyzoite of *T. gondii* still play the role of infection as the tachyzoite of the parasite resistant the trypsin and pepsin [54,55].

Contact with other Animals
Some animals such as goats, sheep, and pigs are more susceptible to infection by *T. gondii* and may harbor the bradyzoite of the parasite for life [56,57]. Thus, the infection will transmit to humans by eating the raw meat extracting from these animals or by direct contact of raw meat contains the tissue cyst.

Contact with Soil or working in the garden
The oocyst of *T. gondii* can survive in the soil for life. An individual who in direct contact with soil or children who are playing in the earth may get the infection via contaminated or dirty hands [58].

Blood transfer and organ transplantation
This is another example of a person-to-person route for transmission besides congenital toxoplasmosis. Although the parasite survival in the bloodstream for a short period but the transmission via blood still can be happened even is rare [59,60].

Socio-economic Impact
The effectiveness of infection with *T. gondii* to mother and fetus during pregnancy may be stiff. For instance, there was no effective vaccine available and no strategic plan to control the disease in pregnant women or children in developing countries. The socio-economic impact of the disease in these countries will be at high cost in humans and animals, mainly when the abortion occurs [61].

Methodology
Related data and studies on prevalence and risk factors of *T. gondii* infection and toxoplasmosis in humans and animals were researched in Saudi Arabia using Pub-med, Scholar-Google, ProQuest Central, Science Direct, Web of Science, Scopus, Springer, and Taylor & Francis as seen in Table1 between 2000 and 2019.

The critical fundamentals used for reviewing included humans or animals for review questions and the prevalence of *T. gondii* for the outcome. The probable elements used for searching included: (1) Prevalence of *Toxoplasma gondii* infection in human or pregnant women or children in Saudi Arabia. (2) Seroprevalence of *Toxoplasma gondii* infection in human or pregnant women or children in Saudi Arabia. (3) A cross-sectional study of *Toxoplasma gondii* in human or pregnant women or children in Saudi Arabia. (4) Detection of *Toxoplasma gondii* in human or pregnant women or children in Saudi Arabia. (5) Prevalence of *Toxoplasma gondii* infection in Farm animals or slaughterhouse animals in Saudi Arabia. (6) A cross-sectional study of *Toxoplasma gondii* in animals or farm animals or slaughterhouse animals in Saudi Arabia. (7) Detection of *Toxoplasma gondii* in animals or farm animals or slaughterhouse animals in Saudi Arabia.

| Serial No. | Publisher             | 2000-2004 | 2005-2009 | 2010-2014 | 2015-2019 | Total |
|-----------|-----------------------|-----------|-----------|-----------|-----------|-------|
| 1         | Pub-Med               | 0         | 0         | 5         | 1         | 06    |
| 2         | Google Scholar        | 2         | 2         | 14        | 8         | 26    |
| 3         | ProQuest central      | 0         | 0         | 5         | 1         | 06    |
| 4         | Science Direct        | 0         | 0         | 0         | 2         | 02    |
| 5         | Web of Science        | 1         | 0         | 5         | 1         | 07    |
| 6         | Scopus                | 0         | 0         | 6         | 3         | 09    |
| 7         | Springer              | 0         | 0         | 1         | 0         | 01    |
| 8         | Taylor and Francis    | 0         | 0         | 1         | 1         | 02    |
| 9         | Others                | 0         | 1         | 7         | 2         | 10    |
| **Total** |                       | **03**    | **03**    | **44**    | **19**    | **69** |
All human and animal research studies published in the last 18 years between 2000 - 2018 in Saudi Arabia were targeted, including prevalence or seroprevalence of *T. gondii* infection or antibodies. The searched strategy included human or pregnant women or children as well as animals or any species in particular. Different excluded criteria were approved to select suitable studies. These criteria included: 1) Descriptive studies, short commination, reviews, case-report, letter to the editor, or other studies did not show original data. 2) Studies did not include our target group. 3) Studies limited to the use of experimental infection by *T. gondii*. 4) Studies not done in Saudi Arabia.

**Results**

**Prevalence of toxoplasmosis in KSA**

The seroprevalence of toxoplasmosis was estimated in different populations in Saudi Arabia between 2000 and 2019, according to previous publications done. Various studies have shown that IgG seropositivity of toxoplasmosis in Saudi Arabia about 29.52%, while the IgM seropositivity of toxoplasmosis about 6.4%. The IgG seropositivity of the infection in various regions, ranging from 9.13% in the Hail region to 39.43% in the Eastern region (Figure 1). The IgM seropositivity in the various regions ranging from 0.44% in the northern region to 17.7% in the eastern region (Table 2). Both IgG and IgM seropositivity increased in northern areas to the southern areas.

**Seroprevalence of toxoplasmosis in pregnant women**

Toxoplasmosis is a significant disease, particularly in pregnant women and their infants. Therefore several studies are done in this target group. The IgG seropositivity of toxoplasmosis in pregnant women in Saudi Arabia, ranging from 8.57% in Hail to 51.4% in Al Ahsa. The overall IgG seropositivity of toxoplasmosis in pregnant women about 29.6%;
however, the overall IgM seropositivity of toxoplasmosis in pregnant women about 3.0% (Table 3).

**Seroprevalence of toxoplasmosis in other groups**

Other groups, including women other than pregnant, men, students, and blood donors, were being targeted for several research studies to clarify the situation of the diseases in these target groups. The results obtained from different studies shown that the IgG seropositivity of toxoplasmosis ranging from 4.7% in students in Jeddah to 41.9% in women, men, and infants in Jazan (Table 4). Whereas the prevalence of IgM seropositivity of toxoplasmosis ranging from 0% in different target groups, particularly in women and students in different areas to 46.3% in women in Al Ahsa, as shown in Table 4.

**Toxoplasmosis as an opportunistic infection**

The parasite of *T. gondii* plays an opportunistic infection in different patients of other diseases, particularly disease caused immunosuppression such as cancer, AIDS, and so on. In Saudi Arabia, several studies were done; aim to study the prevalence of toxoplasmosis among these target groups. The result recorded showed a high IgG seropositivity found in some patients in Jeddah 61.4%, and the less prevalence rate observed patients with AIDS in Makkah 21.3% (Table 5). The IgM seropositivity recorded a high in AIDS patients in Makkah 12.5% and no positive results recorded in diabetic patients in Makkah or patients with major depression disorders in Makkah area (Table 5).

### Table 4. Seroprevalence of Toxoplasma gondii infection among other populations.

| City     | Target group                   | Sample size | Assay                      | Prevalence rate IgG % | Prevalence rate IgM % | References |
|----------|--------------------------------|-------------|----------------------------|-----------------------|-----------------------|------------|
| Tabuk    | Student                        | 180         | ELISA IgG and IgM          | 9.4%                  | 0%                    | [92]       |
| Najran   | Male, Female, and Children     | 210         | ELISA IgG                  | 31.9%                 | -                     | [93]       |
| Najran   | Women                          | 96          | IHA and ELISA IgG and IgM | 29.2%                 | 3.1%                  | [94]       |
| Jazan    | Women, men, and infants        | 124         | LAT, IHA and ELISA        | 41.9%                 | 5.65%                 | [95]       |
| Jeddah   | Student                        | 127         | ELISA IgG and IgM         | 4.7%                  | 0%                    | [96]       |
| Makkah   | Blood donors                   | 220         | ELISA IgG and IgM         | 19.5%                 | 0%                    | [97]       |
| Makkah   | Male and female                | 924         | ELISA IgM                 | 24.8%                 | 0.3%                  | [98]       |
| Rafha    | Women                          | 162         | ELISA IgG and IgM         | 12%                   | 0%                    | [99]       |
| Rafha    | Women                          | 508         | ELISA IgG and IgM         | 14.6%                 | 0%                    | [100]      |
| Al Ahsa  | Women                          | 160         | ELISA IgG and IgM and IgG avidity | 27.5% | 46.3% | [101] |
| Eastern  | Male and female                | 1464        | MEIA IgG and IgM          | 25.0%                 | 5%                    | [102]      |

### Table 5. Seroprevalence of Toxoplasma gondii as an opportunistic infection.

| Region   | City     | Target group                                      | Sample size | Assay                      | Prevalence rate IgG % | Prevalence rate IgM % | References |
|----------|----------|---------------------------------------------------|-------------|----------------------------|-----------------------|-----------------------|------------|
| Qassim   | Qassim   | Cancer patient and control                         | 137         | ELISA IgG and IgM          | 29.9%                 | 0.7%                  | [103]      |
| Makkah   | Makkah   | AIDS patients and control                          | 80          | ELISA IgG and IgM          | 21.3%                 | 12.5%                 | [104]      |
| Makkah   | Makkah   | Diabetic patients                                  | 90          | ELISA IgG and IgM          | 43.3%                 | 0%                    | [105]      |
| Makkah   | Jeddah   | Patients                                          | 70          | ELISA IgG and IgM and PCR  | 61.4%                 | -                     | [106]      |
| Jazan    | Jazan    | Neuropsychiatric patients                          | 162         | ELISA IgG and IgM          | 35.8%                 | 6%                    | [107]      |
| Riyadh   | Riyadh   | Glucose-6-Phosphate dehydrogenase deficiency       | 53          | ELISA IgG and IgM          | 58.8%                 | 1.9%                  | [108]      |
| Makkah   | Makkah,  | Schizophrenia and major depression disorder        | 177         | ELISA IgG and IgM          | 31.75%                | 4.8%                  | [109]      |
| Jeddah,  | Taif     |                                                   |             |                           | 24.64%                | 0%                    |           |
Risk factors related to toxoplasmosis and source of infection

Risk factors were studied in different parts of Saudi Arabia, but there is still a lack of information regarding the exact source of infection in different locations. The majority of the research studies in Saudi Arabia targeted women. Age as a risk factor detected in different areas, as shown in Table 6. According to a significant relationship between age and infection with *T. gondii*, different categories of age groups were found to be significant including 20-30 years, 30-40 years, 40-84 years, and 50-56 years. Resident in an urban area as a risk factor was recorded in two areas: AD-Dawadimi in the central and Rafha in the north. In contrast, resident in the rural area was detected in Al-Ahsa. Illiterate increased the infection with *T. gondii* found in one study in Al-Ahsa. In the same studies, researchers found that housewives and students and people in the lowest income were more appropriate for getting the infection. The race was detected to be significant with infection with *T. gondii* in one study in Makkah in blood donors.

Table 6. The risk factors increase the infection in different areas and different target groups.

| City              | Target group          | Risk factor(s)                                      | ELISA                      |
|-------------------|-----------------------|-----------------------------------------------------|----------------------------|
|                   |                       |                                                     | IgG positive (%) | IgG negative (%) | P - value | References |
| AD-Dawadimi       | Pregnant women        | Resident in urban                                  | 129 (46.5%)  | 148 (53.5%)  | 0.001     | [78]       |
|                   |                       | Age group ≥ 41 years                                | 4 (57.1%)     | 3 (42.9%)     | 0.048     | [80]       |
|                   |                       | Increased number of pregnancies ≥ 5                 | 67 (46.2%)    | 78 (53.8%)    | 0.05      | [80]       |
|                   |                       | Increased number of parity number of parity ≥ 5    | 29 (44.6%)    | 36 (55.4%)    | 0.46      |            |
| Khamis Mushait and | Pregnant women        |                                                     |                           |               |           |            |
| Abha              |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
| Makkah            | Pregnant women        |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
| Al Ahsa           | Pregnant women        |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
| Tabuk             | Student               | Ownership of cat                                   | 3 (33.3%)     | 6 (66.7%)     | 0.023     |            |
| Najran            | Women                 | Consumption of raw, unwashed fruit or vegetables    | 10 (19.3%)    | 42 (80.7%)    | 0.007     | [92]       |
|                   |                       |                                                     |                           |               |           |            |
| Makkah            | Blood donors          | Race                                                | 9 (52.9%)     | 8 (47.1%)     | 0.001     | [97]       |
| Rafha             | Women                 | Residency (urban)                                  | 51 (13.0%)    | 337 (87.0%)   | 0.0001    |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       | Direct contact with cat                             | 17 (25.4%)    | 50 (74.6%)    | 0.007     | [100]      |
|                   |                       |                                                     |                           |               |           |            |
| Qassim            | Cancer patients       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
| Makkah            | Diabetic patients     |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
| Jeddah            | Women                 |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |
|                   |                       |                                                     |                           |               |           |            |

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The relationship between the increased number of pregnancies and an increased number of parity found to be increased the opportunity to get an infection with *T. gondii*. The correlation between infection with *T. gondii* and abortion, stillbirth, and infertility were detected.

Contact with cat or ownership cat as a risk factor to get an infection with *T. gondii* recorded in four different studies, as shown in Table 6. Consumption of raw or undercooked meat or raw fruits or vegetables were also observed. Also, contact with soil or eating mud as a risk factor to get an infection with *T. gondii* was found, as shown in Table 6.

**Molecular detection of toxoplasmosis**

Detection was done in five studies using different types of PCR in different parts of Saudi Arabia from the north to the central areas and in the south. The sample size of the study ranged between 43-226 samples. The prevalence rate of toxoplasmosis by molecular technique was a range between 0.6% in Rafha and 41% in Aseer, as shown in Table 7.

**Genotyping of toxoplasmosis in human**

Genotyping of toxoplasmosis was done in three different areas in Riyadh, Jazan, and Al Madinah. The sample size varied and ranged between 91-226 samples. The methods used were different types of PCR. One study in Jazan detected the only type I strain while the study in Riyadh found type II and III strains. In addition, in Al Madinah all the types of strains were found Table 8.

**Seroprevalence of toxoplasmosis in animals**

The majority of the studies conducted in Riyadh, the capital, and a few studies were done in Najran, Al-Ahsa, Qassim, and the central area. The studies targeted different types of animals and different assay methods to detect the presence of IgG and IgM antibodies.

### Table 7. Detection of the prevalence of *T. gondii* in Saudi Arabia using molecular techniques.

| Region | No. of samples | Method      | Prevalence rate | References |
|--------|----------------|-------------|-----------------|------------|
| Rafha  | 162            | B1 and RE PCR | 0.62%           | [99]       |
| Riyadh | 203            | PCR         | 22.2%           | [110]      |
| Jazan  | 226            | PCR-RFLP    | 3.5%            | [81]       |
| Aseer  | 137            | PCR         | 41%             | [82]       |
| Jeddah | 43             | PCR         | 37.2%           | [106]      |

### Table 8. Genotyping of *T. gondii* in Saudi Arabia.

| Region    | No. of samples | Method    | Type of strain | References |
|-----------|----------------|-----------|----------------|------------|
| Riyadh    | 203            | Nested-PCR| Type II (80.6%)| [110]      |
| Jazan     | 226            | PCR-RFLP  | Type III (19.4%)| [81]       |
| Al Madinah| 91             | RFLP      | Type I (100%)  | [111]      |

### Table 9. Prevalence of *T. gondii* infection in different kind of animals in Saudi Arabia.

| Region     | Type of animals                          | Sample size | Assay      | Prevalence rate IgG % | Prevalence rate IgM % | References |
|------------|-----------------------------------------|-------------|------------|-----------------------|-----------------------|------------|
| Najran     | Sheep, goats and camels                  | 236         | IHAT and ELISA | 22.4%                 | 19.0%                 | [112]      |
| Riyadh     | Camels                                  | 412         | IFAT       | 13% total antibodies  | -                     | [113]      |
| Riyadh     | Sheep                                   | 291         | IHAT and ELISA | 68%                   | -                     | [114]      |
| Riyadh     | Goats                                   | 87          | IHAT and ELISA | 58.6%                 | -                     | [115]      |
| Al-Ahsa    | Cats, dogs, sheep, goats, cattle, and camels| 1148      | ELISA      | 21.4%                 | -                     | [116]      |
| Riyadh     | Chicken                                 | 200         | ELISA      | 32%                   | -                     | [117]      |
| Riyadh     | Rats                                    | 200         | ELISA      | -                      | 13.5%                 | [118]      |
| Qassim     | Chicken                                 | 244         | DAT        | 11.9% total antibodies | -                     | [119]      |
| Riyadh     | Cats                                    | 200         | ELISA      | 26%                   | -                     | [120]      |
| Central    | Camels                                  | 713         | LAT        | 13% total antibodies  | -                     | [121]      |
| Riyadh     | Sheep, goats, and camels                 | 1628        | IFAT       | 34.6% total antibodies| -                     | [122]      |
ruminant animals included sheep, goats, and camels. One study aimed at cattle and other animals such as chicken, cat, dog, and rat. The majority of studies used the ELISA technique to detect IgG, and a few studies used IgM. The IgG seropositivity was high in sheep in Riyadh (68%), and the IgM seropositivity was found in Najran (19%) in sheep, goats, and camels. The prevalence was less in chicken in Qassim (11.9%) as shown in Table 9.

Discussion

The main outcome obtained from the current article was to determine the national prevalence rate of toxoplasmosis in Saudi Arabia, according to previous studies. Thus, the result received approximated that; one-third of the population in Saudi Arabia had antibodies against T. gondii infection. That means two-thirds of the people at risk of getting an infection by this parasite and one-third may suffer from a latent parasite reactivation. The researchers confirmed that about one-third of the people worldwide had been infected by T. gondii [62,63], resulting in the present study counterpart with this fact. Although the infection is subclinical and asymptomatic still, the risk is existing mainly in pregnant women, children, and immunocompromised individuals as the disease caused abortion in pregnant women and malformation in children and being fatal in immunocompromised individuals.

The results also showed that the IgG seropositivity would be higher in the south of the country, and gradually reduced towards the north. In the Al-Jouf region, there is no data published regarding the prevalence rate throughout the previous twenty years. However, the acute infection found higher in the eastern area, and less case was detected in the north area. The variation in infection rate by T. gondii was different according to climate change, including different humidity, varying temperatures, and the various areas [64]. A similar study was done in the same target group in Iran; the results were higher in Iran than in KSA [65,66].

Reactivation of chronic T. gondii infection in HIV-infected persons is most often connected with encephalitis with focal neurological abnormalities, sometimes with fever, defects of the visual field, and defects of cerebellum function, with neuropsychiatric symptoms. The extra cerebral form can also occur, mostly presented as chorioretinitis with multifocal and bilateral lesions of the optic nerve [67]. Therefore, study the disease as an opportunistic infection is critical. Several studies done in Saudi Arabia targeted people suffer from different diseases such as cancer patients, AIDS patients, diabetic patients, people who are suffering from glucose-6-phosphate dehydrogenase deficiency, neuropsychiatric patients, and schizophrenia and major depressive disorder. The results showed that the IgG seropositivity found high in a patient suffering from different diseases, and the IgM seropositivity found higher in AIDS patients. The result was logic, as in AIDS patients; the immunity will be less than usual. Human immunodeficiency virus (HIV) infection encompasses an acute phase that lasts for months, followed by a clinically latent phase that typically lasts for a few years and, ultimately, by the collapse of the immune system that characterizes acquired immunodeficiency syndrome [67,68].

Age as a risk factor to increase the infection with T. gondii was studied in several studies. In conclusion, there are contrasting results in different parts of the world. The main idea was that, the infection increased by time, people who live a long time will be more susceptible to get the infection. Moreover, these results showed that, the infection by T. gondii in Saudi Arabia could infect almost all people of all ages, although no results available regarding teenaged children. These results matched with several results published around the world [69-71].

Prevalence of T. gondii infection in rural and urban was recorded in Saudi Arabia; a similar result was found in Chile. They found a high prevalence rate in both rural and urban areas [72]. The results confirmed that people who live in urban or rural have the same chance of getting an infection.

The level of education can increase the infection with T. gondii; in the current study, uneducated people were more suspected than educated people. A similar result was detected in southern Brazil [73]. The result will help health educators when they establish an educational program to control the disease.

Unemployed people or housewives in this study were found more infected than others; the same result was also found in southern Brazil [73]. It was logical as unemployed people or housewives may be more exposed to the source of the infection.

Association between exposures to T. gondii and abortion, stillbirth, and infertility had noticed in several studies. Abortion happened in the severe infection with high virulence parasite and mainly in the first trimester of pregnancy [74,75].

The main risk factors knew increased T. gondii infection, including contact with a cat, eat raw or undercooked meat, and contact with soil. In Saudi
Arabia, all these factors were detected in different places as risk factors.

Molecular techniques didn’t become widespread as diagnostic or routine tests in Saudi Arabia. However, some research studies were done by using these techniques but, still we need more effort to establish these methods and transfer and settled the technology. In few genotyping studies done in Saudi Arabia, all the strains of *T. gondii* were recorded in different areas.

The prevalence of chronic *T. gondii* in sheep was higher in Saudi Arabia, and most of the people depend on their food from sheep meat (Kabssa). Bradyzoite of *T. gondii* latent in the muscles, this will be of high risk, particularly in insufficiently cooked meat.

**Conclusion**

The results obtained confirmed that the disease was found in Saudi Arabia, although the recent infection was not high but the disease was recorded in almost all the regions. The prevalence rate was not apparent in one region, where it needs to be screened and showed the important of the disease there. A research study should be conducted to determine the main source of infection in the country. The education program should be raised and should study the socioeconomical impact of the disease to the people in KSA.

The prevalence rate of the disease in animals was not clear enough and needed more study research at national level to explore the situation in different animals.

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