Cats and *Toxoplasma gondii*: A systematic review and meta-analysis in Iran

*Toxoplasma gondii* is a cosmopolitan zoonotic intracellular coccidian of the phylum Apicomplexa infecting warm-blooded animals and human beings. This protozoan causes a significant public health problem in humans and imposes considerable economic losses and damages to husbandry industries. The final host, cats, accounts for all of these significant burdens. Hence the present study was designed to analyse and review the overall prevalence rate of *T. gondii* infection in cats in Iran for the first time. In the present study data collection (published and unpublished papers, abstracts of proceedings of national parasitology congresses and dissertations) was systematically undertaken on electronic databases including PubMed, Google Scholar, Ebsco, Science Direct, Scopus, Magiran, IranMedoc, IranMedex and Scientific Information Database. A total of 21 studies from 1975 to 2013 reporting prevalence of Toxoplasma infection in cats from different areas in Iran met the eligibility criteria. The pooled proportion of toxoplasmosis using the random-effect model amongst cats was estimated at 33.6% (95% confidence interval [CI] 22.05–46.41). The prevalence rate of cat toxoplasmosis in various regions of Iran ranged from 1.2% to 89.2%. Firstly, this study establishes a crude prevalence rate of *T. gondii* infection in cats. Secondly, it discusses the role of significant risk factors including sex, age and being either household or stray cats, in the epidemiology of the disease. Furthermore, the current study determines gaps and drawbacks in the prior studies that are useful to keep in mind to assist in designing more accurate investigations in future.

**Introduction**

*Toxoplasma gondii*, the causative agent of toxoplasmosis, is an obligate intracellular parasite which belongs to the phylum Apicomplexa that infects all species of warm-blooded animals (Flegr et al. 2003). In humans it is considered to be one of the most common parasites, based on serological investigations that estimate that up to a third of the world’s population has been exposed to this widespread zoonotic agent. The overall seroprevalence rate of toxoplasmosis amongst the general population in Iran is 39.3% (95% confidence interval [CI] 33.0% – 45.7%) (Bahrami et al. 2011; Daryani et al. 2014; Dubey & Jones 2008; Sharif et al. 2007).

Even though the majority of toxoplasmosis cases in immune-competent individuals are either asymptomatic or mild, first exposure to *T. gondii* during pregnancy can lead to transplacental transmission to the embryo, with serious pathological signs including hydrocephalus, microcephaly, blindness, abortion and death of the foetus (Dunn et al. 1999; Havelaar, Kemmeren & Kortbeek 2007). In addition, *T. gondii* is considered to be an opportunistic and life-threatening parasite in immune-compromised groups, encompassing those with HIV and AIDS, cancer and organ transplant recipients who receive immunosuppressive drugs (Tenter, Heckerlooy & Weiss 2000).

Felids play a pivotal role for *T. gondii* as definitive hosts, and interestingly are known as the only final hosts that produce oocysts in their faeces, contaminating soil, food and water (Cenci-Goga et al. 2011; Dubey 2004). Even though the final host excretes oocysts for a short period of time (only 1–2 weeks), millions of oocysts may be excreted. Oocysts can survive in the environment for several months and are noticeably resistant to freezing, drying and disinfectants, whereas they are not heat-resistant and are destroyed at 70 °C for 10 min (Dubey & Beattie 1988; Dubey & Jones 2008).

Infection both in the definitive and the intermediate host usually occurs either through ingestion of infected tissue cysts or oocytes. Felids are more likely to shed oocysts followed by ingestion...
of tissue cysts rather than oocysts. Surprisingly, a cat must ingest at least 1000 oocysts in order to develop an infection, although ingestion of just one bradyzoite is enough for a cat to acquire T. gondii infection (Dubey 2008).

Clinical manifestations of cats infected with T. gondii include depression, anorexia and fever, followed by peritoneal effusion, hyperthermia, icterus and dyspnoea. Moreover, some other symptoms of toxoplasmosis are diarrhoea, weight loss, muscle hyperaesthesia, fever, anorexia, seizures, ataxia, pancreatitis and anterior or posterior uveitis (Dubey & Lappin 2006). Furthermore, the coccidian phase of the entero-epithelial cycle is seen solely in the definitive feline host. The extra-intestinal development of T. gondii is the same for all hosts, including all warm-blooded vertebrates (Dubey 2005). The disease is important both in the medical and veterinary fields. Toxoplasmosis causes significant economic losses and damages to animal husbandry due to stillbirths and neonatal mortality in sheep and goats (Dubey & Beattie 1988; Hartley & Marshall 1957).

In spite of the need, currently there is no effective vaccine, even though many efforts have been conducted to develop a vaccine and are ongoing. Furthermore, no approved treatment exists for clinical toxoplasmosis in cats. Drugs including pyrimethamine, sulphonamides, trimethoprim and clindamycin, either alone or in combination, that have been prescribed to treat cats with clinical toxoplasmosis have shown varied results (Dabritz et al. 2007).

Cats have a key and crucial role in the epidemiology of toxoplasmosis, so expanding the basic knowledge about T. gondii infection in cats is a matter of importance. It is worth mentioning that epidemiological investigations are still the most useful method for evaluating the status of T. gondii infection. Despite the multitude of publications on toxoplasmosis in cats from Iran, there is no systematic review and meta-analysis that can describe the status of toxoplasmosis in the final host in this country. Therefore the objective of the current systematic review and meta-analysis was to determine the weighted prevalence of T. gondii infection and describe the epidemiological features of infection in cats in Iran.

**Research method and design**

**Database search**

To gather information a precise and comprehensive search was performed on all scientific publications (full texts and abstracts) from February to April in 2013 (Figure 1). The following nine databases were included: five English databases (PubMed, Google Scholar, Ebsco, Science Direct and Scopus) and four Persian databases (Magiran, IranDoc, IranMedex and the Scientific Information Database [SID]). In addition to published articles, dissertations and all proceedings of national parasitology congresses held in Iran from 1975 to 2013 were carefully evaluated. In order to avoid missing any articles, whole references of papers were also meticulously checked.

The search terms used alone or in combination were ‘Toxoplasma gondii’, ‘toxoplasmosis’, ‘Toxoplasma infection’, ‘animal toxoplasmosis’, ‘cat’, ‘feline’, ‘epidemiology’, ‘prevalence’, ‘Iran’ and ‘anti-Toxoplasma antibodies’. Data collection was limited to items in English and Persian.

**Data collection**

All cross-sectional studies carried out to estimate the prevalence of toxoplasmosis, diagnosed by different methods using serological, molecular and parasitological tests on cats, were included. Repetitive papers were excluded. The data that were collected for the current study were as follows: year of publication, first author, study areas, sample size, number of males and females, prevalence rate, age of samples, diagnostic tests, time of the study, and involving either domestic or stray cats. For this purpose a data extraction form was used.

The quality of the meta-analysis was evaluated using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist, which included 22 items that we considered essential for good reporting of observational studies. These items were related to the article’s title, abstract, introduction, methods, results and discussion sections. Scores under 7.75 were considered to indicate bad quality, of 7.76–15.5 low quality, 15.6–23.5 moderate and more than 23.6 high quality (Von Elm et al. 2007).

**Statistical methods**

The crude and the weighted prevalence estimates as well as the 95% CI for each study that was included were calculated. A forest plot was used to visualise the heterogeneity amongst
During a period of 39 years, nine different types of diagnostic methods were employed to evaluate *T. gondii* infection in cats, as follows: the modified agglutination test (MAT), direct agglutination test (DAT), indirect immunofluorescent assay (IFA), latex agglutination test (LAT), immunochromatography test (ICT) and Sabin and Feldman Test (SFT), wet smear, flotation and polymerase chain reaction (PCR). The most frequently used diagnostic method for *T. gondii* assessment in cats in Iran was the IFA (5 studies), followed by flotation (4 studies), MAT (3 studies), LAT (2 studies), DAT (2 studies), ICT (2 studies), SFT, PCR and wet smear (1 study for each). The pooled proportion of toxoplasmosis, using the random-effect model, amongst cats in Iran over the 39-year period was estimated at 33.6% (95% CI 22.05–46.41) and a forest plot diagram of the current study was drawn (Figure 2). A wide variation was observed in the prevalence estimates of different studies (Q statistic = 742.3, df = 20, p < 0.0001 and I² = 99%).

The prevalence rate of cat toxoplasmosis in various regions of Iran was between 1.2% and 89.2% in Khorasan and Tehran respectively. The prevalence rate of toxoplasmosis in cats in different parts of Iran is shown in Figure 3. Amongst the studies included, only three studies compared stray cats with domestic cats for toxoplasmosis (Akhtardanesh et al. 2010; Haddadzadeh et al. 2006; Raeghi & Sedeghi 2011). They found a statistically significant difference in the number of positive stray cats and domestic cats. The results based on

### TABLE 1: Publications on cat toxoplasmosis included for meta-analysis.

| City          | Province          | Diagnostic method | Cut-off | Total individuals | Positive individuals | Prevalence (%) | Year | Authors                  |
|---------------|-------------------|-------------------|---------|-------------------|----------------------|----------------|------|--------------------------|
| Tehran        | Tehran            | IFA               | 1:80    | 100               | 40                   | 40%            | 2007 | Hooshvar et al.          |
| Isfahan       | Kerman            | IFA               | 1:80    | 100               | 40                   | 40%            | 2007 | Nasiroohiyan et al.     |
| Sari          | Mazandaran        | LAT               | ≥ 1:1   | 100               | 100                  | 100%           | 2009 | Sharif et al.           |
| Isfahan       | Isfahan           | IFA               | 1:80    | 100               | 100                  | 100%           | 2007 | Rezaei et al.           |
| Tehran        | Tehran            | ICT               | -       | 65 domestic       | 65                   | 65%            | 2010 | Soks-Rezaie             |
| Kerman        | Kerman            | MAT               | ≥ 1:20  | 70 domestic, 70 stray | 70                   | 70%            | 2010 | Akhtardanesh et al. 10  |
| Shiraz        | Fars              | LAT               | -       | 100               | 100                  | 100%           | 2011 | Parse et al.            |
| Shiraz        | Fars              | PCR               | -       | 20                | 20                   | 20%            | 2011 | Raeghi et al.           |
| Urmia         | West Azerbaijan   | LAT               | 1:20    | 100               | 100                  | 100%           | 2011 | Raeghi et al.           |
| Kerman        | Kerman            | ICT               | -       | 198 domestic      | 198                  | 99%            | 2011 | Mozallanejad et al. 11  |
| Kerman        | Kerman            | LAT               | ≥ 1:16  | 108               | 108                  | 100%           | 2012 | Derakhshah and Mousavi  |

Note: Please see the full reference list of the article, Rahimi, M.T., Daryani, A., Sarvi, S., Shokri, A., Ahmadpour, E., Mizani, A. et al., 2015; ‘Cats and Toxoplasma gondii: A systematic review and meta-analysis in Iran’, Onderstepoort Journal of Veterinary Research 82(1), Art. #823, 10 pages. http://dx.doi.org/10.4102/ojvr.v82i1.823, for more information.

LAT, latex agglutination test; DAT, direct agglutination test; SFT, Sabin and Feldman Test; IFA, indirect immunofluorescent assay; ICT, immunochromatography test; MAT, modified agglutination test; PCR, polymerase chain reaction.

### TABLE 2: Studies of cat toxoplasmosis included for meta-analysis based on stool examination.

| City          | Province          | Diagnostic method | Total individuals | Positive individuals | Prevalence (%) | Year | Authors                  |
|---------------|-------------------|-------------------|-------------------|----------------------|----------------|------|--------------------------|
| Tehran        | Tehran            | Wet smear         | 170 domestic      | 21                   | 12%            | 1975 | Saatara                  |
| Khorasan      | Khorasan          | Flotation         | 82 stray          | 1                    | 1.2            | 2000 | Razmi                    |
| Zanjan        | Zanjan            | Flotation         | 100 stray         | 42                   | 42             | 2009 | Esmailzadeh et al.       |
| Tabriz        | East Azerbaijan   | Flotation         | 100               | 43                   | 43             | 2010 | Farhang                  |
| Urmia         | West Azerbaijan   | Flotation         | 100 domestic, 30 stray | 3                   | 2.3            | 2011 | Raeghi and Sedeghi       |

Note: Please see the full reference list of the article, Rahimi, M.T., Daryani, A., Sarvi, S., Shokri, A., Ahmadpour, E., Mizani, A. et al., 2015; ‘Cats and Toxoplasma gondii: A systematic review and meta-analysis in Iran’, Onderstepoort Journal of Veterinary Research 82(1), Art. #823, 10 pages. http://dx.doi.org/10.4102/ojvr.v82i1.823, for more information.
FIGURE 2: Forest plot diagram of the current systematic review and meta-analysis.

| Study Details | Proportion (95% confidence interval) |
|---------------|-------------------------------------|
| Saatara, H., 1975, Tehran, Wet smear | 0.1235 (0.0781, 0.1826) |
| Ghorbani, M., 1983, Iran*, LAT | 0.1712 (0.1063, 0.2543) |
| Sayyed Tabaee, J., 1992, Tehran, DAT | 0.8922 (0.8152, 0.9449) |
| Hoghooghi-Rad, N., 1993, Khozestan, DAT | 0.5941 (0.4918, 0.6907) |
| Jamali, R., 1996, Tehran, SFT | 0.3600 (0.2664, 0.4621) |
| Razmi, G.R., 2000, Khorasan, Flotation | 0.0122 (0.0003, 0.0661) |
| Haddadzadeh, H., 2006, Tehran, IFA | 0.6300 (0.5276, 0.7244) |
| Hooshyar, H., 2007, Isfahan, IFA | 0.8600 (0.7326, 0.9418) |
| Tahmtan, Y., 2008, Fars, IFA | 0.1100 (0.0562, 0.1883) |
| Esmaeilzadeh, M., 2009, Zanjan, Flotation | 0.4200 (0.3220, 0.5229) |
| Sharif, M., 2009, Mazandaran, LAT | 0.4000 (0.3033, 0.5028) |
| Saljoghiyan, H., 2010, Isfahan, IFA | 0.3200 (0.2302, 0.4208) |
| Skoeizade, K., 2010, Tehran, ICT | 0.0308 (0.0037, 0.1068) |
| Farhang, H., 2010, East Azerbaijan, Flotation | 0.4300 (0.3314, 0.5329) |
| Akhtardanesh, B., 2010, Kerman, IFA | 0.3200 (0.2302, 0.4208) |
| Pirzad, R., 2011, Fars, MAT | 0.8276 (0.6423, 0.9415) |
| Pirzad, R., 2011, Fars, PCR | 0.6897 (0.4917, 0.8472) |
| Raeghi, S., 2011, West Azerbaijan, MAT | 0.2077 (0.1416, 0.2876) |
| Raeghi, S., 2011, West Azerbaijan, Flotation | 0.0231 (0.0048, 0.0660) |
| Mosallanejad, B., 2011, Khozestan, ICT | 0.2475 (0.1890, 0.3136) |
| Derakhshan, M., 2012, Kerman, IFA | 0.0278 (0.0058, 0.0790) |
| Combined | 0.3369 (0.2206, 0.4642) |
A significantly higher prevalence rate of *T. gondii* was observed in older animals as compared with younger ones. Regarding sex, just two studies reported a significant difference, with male cats showing a higher prevalence rate of toxoplasmosis than females (Farhang 2010; Raeghi & Sedeghi 2011). The source of faeces in all the studies was the rectum of the examined cats.

Results of heterogeneity of meta-analysis for two groups (stray and domestic cats) showed that they were not homogeneous (*p* < 0.0001). Overall seroprevalence rates for stray and domestic cats were 0.38 (95% CI 0.22–0.55) and 0.33 (95% CI 0.19–0.47) respectively, and the pooled estimate was 0.36 (95% CI 0.25–0.47) (Figure 4).

There was a significant difference between sub-groups of sexes (*p* < 0.0001), and random meta-analysis showed that seroprevalence rates of toxoplasmosis in males and females were 0.21 (95% CI 0.23–0.59) and 0.31 (95% CI 0.19–0.43), respectively, and the pooled estimate was 0.36 (95% CI 0.25–0.47) (Figure 5).

Differences between sub-groups of ages (juvenile and adult) were significant (*p* < 0.0001) in only two studies, and random meta-analysis showed seroprevalence rates of toxoplasmosis in juveniles and adults to be 0.545 (95% CI 0.540–0.550) and 0.392 (95% CI 0.286–0.562) respectively. The pooled estimate was 0.481 (95% CI 0.386–0.788) (Table 3).

Egger’s regression test and a funnel plot were carried out for assessment of publication bias, and results showed that publication bias was significant (Figure 6).

Five studies employed stool examination on 582 cats and 110 cases (18.9%) were reported as positive.

**Discussion**

The current study is the first systematic review and meta-analysis of cat toxoplasmosis in Iran. It provides valuable data about the prevalence of toxoplasmosis in cats from 1975 to 2013. The overall prevalence rate of toxoplasmosis amongst cats in Iran was estimated to be 33.6%. The worldwide seroprevalence of toxoplasmosis in domestic cats (*Felis catus*) was estimated to be 30% – 40% (Dubey & Beattie 1988), and our findings roughly correspond to this range. Besides, previous studies have shown that the prevalence rates of *T. gondii* antibodies in cat populations vary greatly,
from 0% to 100%, and depend on particular criteria including age, method of survey, number of animals studied and geographical area (Dubey 2005; Dubey & Beattie 1988).

Several surveys have been performed on cat toxoplasmosis in Iran’s neighbouring countries. An investigation on anti-
*T. gondii* antibodies in 99 cats in Ankara, Turkey, using SFT and IFA showed prevalences of 40.3% and 34.3% respectively (Özkan et al. 2008), which is in close alignment with the present study. In another survey in Nigde, Turkey, the prevalence of antibodies to *T. gondii* employing SFT in stray cats was reported to be 76.4% (Karatepe et al. 2009).

In Saudi Arabia the prevalence rate of *T. gondii* antibodies in cats was determined to be 15.2% using the indirect haemagglutination (IHA) test (Hossain et al. 1986). A study on stray and domestic cats using LAT in Lahore, Pakistan, showed that 56% of cases were seropositive for *T. gondii* (domestic cats 48% and stray cats 64%) (Shahzad et al. 2006). In addition, the seroprevalence rate of *T. gondii* infection in cats was reported to be 60% in Faisalabad, Pakistan using LAT (Ahmad et al. 2001). The infection rates in cats in Lebanon and Iraq were reported to be 78.1% and 100%, respectively (Deeb, Sufan & Digiacomo 1985; Khairy, Alaa & Ahmad 2010). The findings of the current study are in agreement with those of Dubey (1998), who reported a 30%–80% seroprevalence rate in cats in the United States of America (USA).

A high prevalence of toxoplasmosis of cats in some areas may be due to the following factors: humid and temperate climate; absence of routine treatment for feline toxoplasmosis; and a considerable abundance of cats. It was confirmed that there is conformity between climate and the prevalence rate of toxoplasmosis, and regional prevalence varied in conformity with different climates. It is usually more prevalent in warm, humid climates and at lower altitudes compared to cold or dry districts. This fact is associated with longer viability of *T. gondii* oocysts in a warm and humid environment (Tutuncu et al. 2003). Sporulated oocysts of

| Study | ES (95% CI) | Weight |
|-------|-------------|---------|
| Stray |             |         |
| [Saftaa, 1975] | 0.12 (0.07, 0.17) | 4.86 |
| [Ghorbani, 1983] | 0.17 (0.10, 0.24) | 4.81 |
| [Sayyed Tabaei, 1992] | 0.89 (0.83, 0.95) | 4.83 |
| [Hoghooghi-Rad and Afraa, 1993] | 0.59 (0.50, 0.69) | 4.72 |
| [Razmi, 2000] | 0.01 (-0.01, 0.04) | 4.90 |
| [Haddadzadeh et al., 2006] | 0.63 (0.54, 0.72) | 4.73 |
| [Hooshayr et al., 2007] | 0.86 (0.76, 0.96) | 4.72 |
| [Tahmant, 2008] | 0.11 (0.05, 0.17) | 4.83 |
| [Saljoghiyan, 2010] | 0.32 (0.23, 0.41) | 4.74 |
| [Skoeizade, 2010] | 0.03 (-0.01, 0.07) | 4.87 |
| [Akhtardanesh et al., 2010] | 0.32 (0.23, 0.41) | 4.74 |
| [Pirzad, 2011] | 0.69 (0.52, 0.86) | 4.38 |
| [Mosallanejad et al., 2011] | 0.25 (0.19, 0.31) | 4.83 |
| Subtotal (I-squared = 99.0%, p = 0.000) | 0.38 (0.22, 0.55) | 61.97 |
| Domestic |             |         |
| [Jamali, 1996] | 0.36 (0.27, 0.45) | 4.73 |
| [Esmailizadeh et al., 2009] | 0.42 (0.32, 0.52) | 4.72 |
| [Sharif et al., 2009] | 0.40 (0.30, 0.50) | 4.72 |
| [Farhang, 2010] | 0.43 (0.33, 0.53) | 4.72 |
| [Pirzad, 2011] | 0.83 (0.69, 0.97) | 4.54 |
| [Raeghi and Sedeghi, 2011] | 0.21 (0.14, 0.28) | 4.81 |
| [Raeghi and Sedeghi, 2011] | 0.02 (-0.00, 0.05) | 4.90 |
| [Derakhsh and Mousavi, 2012] | 0.03 (-0.00, 0.06) | 4.89 |
| Subtotal (I-squared = 97.8%, p = 0.000) | 0.33 (0.19, 0.47) | 38.03 |
| Overall (I-squared = 98.7%, p = 0.000) | 0.36 (0.25, 0.47) | 100.00 |

Note: Weights are from random effects analysis.

**FIGURE 4:** Prevalence of seropositivity in terms of type of cats (stray or domestic).
T. gondii can persist in the environment (particularly in moist shaded soil or sand) for several months owing to their resistance to variable environmental conditions (Dubey & Beattie 1988; Webster 2001).

In the USA the prevalence rate in the drier southwest, including New Mexico, Utah and Arizona, was lower (16.1%) than in humid climates such as Hawaii (59.2%), in accordance with the abovementioned climate template for T. gondii infection (Dubey & Jones 2008). In contrast, in some areas of Iran, such as Mazandaran province, the findings are not in accordance with that climate template.

Iran’s climate ranges from arid or semi-arid to subtropical along the Caspian coast and in the northern forests. In the north of the country temperatures seldom decrease below freezing in winter, and the area usually remains humid for the rest of the year. In summer the temperature rarely
exceeds 29 °C (84.2 °F) (Modarres & De Paulo Rodrigues Da Silva 2007).

In the past different diagnostic tests were used in T. gondii surveys in cats. IFA was the most frequently employed test for the diagnosis of cat toxoplasmosis. This test was introduced in 1992 and considered a more reliable test than other serological diagnostic methods due to its significant sensitivity and specificity. This method is a relatively simple assay for evaluating the infection of animals, and also is particularly useful for screening a large number of specimens, which may explain why most studies used this method (Chejfec 1999; De La Luz Galvan-Ramirez et al. 2012; Silva et al. 2002).

In this systematic review and meta-analysis sex, age and type of cat (stray or domestic) can be probable causes of homogeneity, as well as publication bias. The role of risk factors including sex, age and being stray or domestic in the prevalence of toxoplasmosis is undeniable. In the current review there was a statistically significant difference between sexes (p < 0.05), and a higher infection rate of toxoplasmosis was seen in male cats compared to females. This may be related to lifestyle, as male cats have more of a tendency to wander and thus more access to contaminated sources; spending more time outdoors may increase their exposure to infection.

The age of animals is another major factor in prevalence of toxoplasmosis. Since young animals were less infected than older ones, it is expected that with increasing age exposure to T. gondii infection also increases (Miró et al. 2004). In Iran a significant relationship was observed between age at sampling and prevalence rate of toxoplasmosis amongst cats. These findings were in accordance with the results of some studies in other countries, which reported an increased prevalence of toxoplasmosis in older compared to younger cats (Frenkel et al. 1995; Maruyama et al. 2003; Volllaire, Radecki & Lappin 2005). It has been mentioned that newborn kittens are more dangerous than adult cats for transmission of this infectious disease, since they excrete oocysts for 1–2 weeks. On the other hand, kittens infected transplacentally or via milk exhibit more severe symptoms and frequently die due to pulmonary or hepatic disease (Buxton & Rodger 2008).

In the present study, Haddadzadeh et al. (2006), Akhtardanesh et al. (2010) and Raeghi and Sedeghi (2011) showed that the prevalence of toxoplasmosis in stray cats was noticeably higher than in domestic cats. In general, stray cats are more prone to T. gondii infection compared to household cats. The findings confirmed that stray cats have a tendency to have a higher prevalence rate than cats kept indoors. An acceptable justification for this fact might be that stray cats could acquire the infection through catching wild rodents, birds and reptiles, raw food scraps and so on. Cat owners can decrease their cats’ exposure risk of acquiring T. gondii infection by keeping their cats indoors and also not feeding them uncooked meat and milk. In addition, the food source of the animal is significant in transmission and also for completion of the lifecycle of the parasite (Dubey et al. 2006). Integrated control strategies and measures should be considered to prevent and control toxoplasmosis in both stray and household cats, which will have important implications for the control of toxoplasmosis in humans and other important intermediates such as sheep, goats and cattle.

Limitations of the study

The collected data are limited just to 10 out of 31 provinces, and there is a paucity of data for cat toxoplasmosis in the majority of provinces of Iran. Although many efforts have been made to determine the prevalence of toxoplasmosis in cats in different parts of Iran, some gaps in prior studies were evident.

Recommendations

Not enough attention was paid during sampling to the role of major factors including sex, age, and being stray or companion cats, despite their key role in the epidemiology of the disease. Therefore, considering all of the abovementioned parameters is necessary in order to overcome these shortcomings in future. The present study will form the basis of further studies that will enable us to deepen our knowledge of the epidemiology of T. gondii.

Conclusion

Based on the current results, stray cats are probably the major source of T. gondii infection in Iran. This study accentuates some valuable and interesting points: the prevalence rate of toxoplasmosis in cats in Iran is high (33.6%), and this considerable infection rate of final hosts can be considered a potential danger to public health and animals due to high contamination of the environment by oocysts.

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Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors’ contributions

M.S. (Mazandaran University of Medical Sciences), A.D. (Mazandaran University of Medical Sciences) and M.T.R. (Mazandaran University of Medical Sciences) designed the study, S.S. (Mazandaran University of Medical Sciences), A.S. (Mazandaran University of Medical Sciences), E.A. (Tabriz University of Medical Sciences) and A.M. (Mazandaran University of Medical Sciences) collected the data, and S.H.T. (Hormozgan University of Medical Science)
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