Incidence and Risk Factors of *Toxoplasma gondii* in Workers that Occupationally Handle Animals: A Systematic Review

Maria Manuel Fernandes and Marcelo M. Ribeiro

Abstract *Toxoplasma gondii* is a parasite capable of infecting humans and other warm-blooded animals, which has chronically infected approximately a third of the world population. While mostly asymptomatic in immunocompetent patients, it is considered a serious disease in immunocompromised patients, with potentially fatal consequences. Workers that occupationally handle animals—such as farmers, butchers and veterinarians -, are under higher risk of being infected. Most common risk factors among these workers include contact with soil, improper hygiene, and consumption of undercooked meat and unwashed raw vegetables or fruits. There is also an increase in seropositivity with age. The authors conducted a systematic review of all available studies on the topic on the period between 2014 and June 2019 and included studies that detail *T. gondii* prevalence and risk factors. The information and data was collected from scientific databases—such as PubMed, Science Direct, Scopus and ISI Web of Science. The aim of this systematic review was to assess incidence and risk factors of *Toxoplasma gondii* in workers that are under exposure to animals in their line of work.

Keywords *Toxoplasma gondii* · Workers · Veterinarians · Risk factors · Occupational exposure

1 Introduction

With worldwide distribution, the obligate intracellular parasite *Toxoplasma gondii* has been documented in virtually every species of mammal and even on several species of birds. It is capable of infecting humans and other warm-blooded animals, which makes its associated infection—toxoplasmosis—one of the most common

M. M. Fernandes (✉) · M. M. Ribeiro
Department of Mining Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
e-mail: up201811553@fe.up.pt

P. M. Arezes et al. (eds.), *Occupational and Environmental Safety and Health II*, Studies in Systems, Decision and Control 277,
https://doi.org/10.1007/978-3-030-41486-3_37

[10]. It is estimated that, approximately, a third of the population worldwide is chronically infected with *T. gondii* [5].

Overall prevalence of *T. gondii* is dependent on eating habits, environmental conditions, and presence of and contact with the definitive hosts of this parasite. In developing and tropical countries, prevalence is influenced by environmental conditions and climate, as is generally higher in urban rather than rural areas, and in humid compared with dry climates. In Western Europe, overall prevalence is 30–50%. High prevalence (>80%) is observed in parts of Eastern/Central Europe, Latin America, the Middle East, Africa, and parts of Southeast Asia [19]. In the United States of America the overall seroprevalence among persons >6 years of age is 12.4% [7].

While mostly asymptomatic in immunocompetent patients, Toxoplasmosis is considered a serious disease in immunocompromised patients (such as HIV/AIDS patients, cancer patients, and organ transplant recipients). Because *T. gondii* may remain within the host through its life span—usually in a latent, subclinical infection -, there is a possibility of a spontaneous reactivation, which is more likely to occur in immunocompromised patients and can be fatal. Screening for *T. gondii* in generally only done in pregnant women, however, it is not mandatory in every country, as some have no prenatal program of surveillance [12, 13].

Given its ability to infect multiple animals—and not just cats, *T.gondii*'s definitive host-, it is likely that people that interact with animals on a daily basis, such as veterinarians, farmers, butchers and abattoirs workers, would be more susceptible to be infected.

T. gondii can be acquired through different routes. The most common routes are through ingestion of oocysts from the environment and contact with cat faeces, ingestion of tissue cysts in undercooked meat and under-washed raw vegetables and fruits, and by transplacental transmission [9].

Because it can be acquired through the consumption of food, primarily meat and vegetables—although contamination through water has been reported-, it is considered a food-borne infection. Given that large number of different possible vehicles of infection transmission (meat from small ruminants, pork, beef, and game meat, as well as fresh produce, seafood and dairy products), the process of controlling the incidence of this parasite is a challenge.

The objective of this systematic review is to assess incidence and risk factors of *Toxoplasma gondii* in workers that either handle or are under exposure to animals in their line of work.

2 Methodology

The current study is in accordance with the PRISMA-P statement for systematic review and meta-analysis protocols [17, 22].

For the identification of studies regarding incidence and risk factors of *T. gondii* in workers occupationally exposed to animals, online databases—PubMed, Science Direct, Scopus and ISI Web of Science—were browsed from 2014 until June 2019, for articles and articles in press written in English.

For this purpose, a search using a combination of the following keywords: "*Toxoplasma gondii*", "workers", and "employees" was conducted. In order to avoid missing any articles, after database searching, the reference list of the relevant papers were also screened manually. Were excluded articles that did not detail on the prevalence of *T. gondii*, and failed to specify if the population in study was under occupational exposure to animals.

The articles retrieved from this research were imported to Mendeley. After initial title screening and the removal of duplicated papers—given the small number of articles left that met the criteria-, all the remaining articles selected for full-text analysis (Fig. 1).

Data from relevant studies was compiled into a Microsoft Excel datasheet (Table 1):

- General information: first author, year of publication and country;
- Characteristics of the study: target, number of infected people, total number included in the study, percentage of *T. gondii* prevalence, risk factors.

Risk of bias was evaluated for each individual study analysed making use of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach to evaluate quality of evidence. Data acquired was analysed according to the intended objectives of this review; goals and objectives, evaluated variables, applied methods and equipment, evaluation procedure, and compliance with ethical standards were also under analysis. There was no observed risk of bias.

3 Results

Two thousand six hundred thirty-five articles were found in the initial key-word search before criteria insertion and duplicates removal. Of the 38 remaining articles, were excluded articles that had irrelevant abstracts, did not specify in the people included the study were under occupational exposure to animals, or failed to mention the parasite *T. gondii*. Fourteen articles met the inclusion criteria and were included in this review (Fig. 1).

For each selected study, the data was extracted as described in the methodology section and compiled into a table (Table 1).

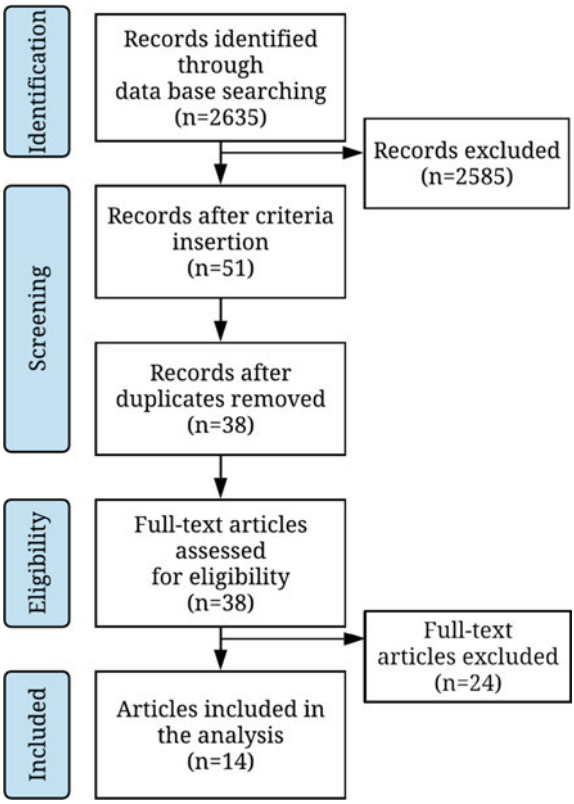

Fig. 1 Flow diagram. Adapted from Moher et al. [16]

Table 1 Data collected from the articles included in this review

Author	Year	Country	No of infected/ total no	% of Infection	Risk factors
Abu [1]	2015	Ghana	Fisherman: 33/35	94.29	Contact with soil Improper hygiene Increase in seropositivity with age Presence of cats
			Farmer: 42/43	97.67	
			Fishmonger: 45/46	97.83	
Alvarado-Esquivel et al. [3]	2014	Mexico	Livestock raiser: 2/51	3.9	Eat/drink while working Consumption of duck meat
			Veterinarian sciences: 10/139	7.2	
Anees et al. [4]	2014	Pakistan	Butchers: 5/50	10	Age $\geq$51 y Contact with the animals in abattoirs

(continued)

Table 1 (continued)

Author	Year	Country	No of infected/ total no	% of Infection	Risk factors
Brandon-Mong et al. [6]	2015	Malaysia	Vets: 7/38	18.4	Field work Animal surgery and cleaning Age $\geq$30 y Work >10 y
			Vet technicians: 15/45	33.3	
			Vet students: 29/194	14.9	
Doni et al. [8]	2015	Turkey	Female farmworkers: 399/684	58.3	Age >35 y Seasonal migratory farm work No of pregnancies
Ekanem [11]	2018	Nigeria	Livestock seller: 77/165	43	Exposure to poultry Work >5 y Contact with raw meat
			Butchers: 102/174	57	
Lassen et al. [14]	2016	Estonia	Vets: 73/158	46.2	n.a (High *T. gondii* prevalence in domestic cats may be a risk factor)
			Animal Caretakers: 279/375	74.4	
			Hunters: 94/144	65.3	
Mardani and Tavalla [15]	2015	Iran	Butchers: 46/ 110	41.8	Exposure to raw meat Proximity to slaughtered animals Consumption of undercooked meat
Rostami et al. [20]	2016	Iran	Farmers & Shepherds: 46/57	80.7	Age $\geq$50 y Consumption of undercooked meat and unwashed raw vegetables or fruits Using untreated water
Sang-Eun et al. [21]	2014	Korea	Vets: 40/299	13.4	Field work Using untreated water Contact with infected animals Ingestion of raw pork
			Lab Vets: 36/ 646	5.5	
Siponen et al. [24]	2019	Finland	Vets: 43/294	14.6	Age $\geq$40y Living in the country Tasting beef while cooking Large animal practice
Thiongo et al. [25]	2016	Kenya	Slaughterhouse workers: 34/87	39.1	Contact with chicken meat
Wójcik-Fatla et al. [27]	2018	Poland	Vets: 166/373	44.5	Age $\geq$61
Xing-Jun et al. [28]	2018	China	Pork processing industry employees: 36/ 200	18	Contact with animals

4 Discussion

Cats (and other members of the Felidae family) are *T. gondii* definitive hosts. Considering that small-practice veterinarians are likely to be in daily contact with various cats, it would be expected that contact with this animal would be considered a big risk factor among veterinarians. However, according to Shuhaiber et al. [23], contact with cats is a relatively low risk factor among veterinarians considering the lifecycle of *T. gondii* in the cat—cats excrete oocysts for only two weeks of their life, and those oocysts require 1–5 days to become infectious. It is common practice in veterinary clinics to clean cat litter within 24 h, which reduced probability of exposure. Higher standards of personal hygiene are also contributing factors to reduced risk.

It is important that veterinary schools continue to educate their students on the risks of this disease and on other standard precautions for zoonotic disease prevention in veterinary personnel as Brandon-Mong et al. [6] still determined as incidence of almost 15% among veterinary students in Malaysia [26].

The information collected for this review confirms this idea, as contact with cats is not considered a risk factor in articles that study *T. gondii* prevalence in veterinarians. It is however considered a risk factor with farmers [1], not necessarily by contact with the animal but by its common use in farms as a form of mice control and by the presence of its faeces in the cultivated fields.

For that reason, it is recommended that cats should not be allowed access to community gardens and any location where food is grown, as well as limit access to domestic cats to the outdoors in general [2].

The use of animal manure to fertilize fields and the use of wastewater for irrigation is also a source of possible contamination, and this is usually carried out without adequate personal protective equipment [29].

There is also an associated risk with contact with animal meat and tissue that affects veterinarians, butchers and slaughterhouse workers (as determined by Anees et al. [4], Brandon-Mong et al. [6], Ekanem et al. [11], Mardani and Tavalla [15] and Thiongo et al. [25]). This is because *T. gondii*'s cysts can be small and can be found randomly distributed among different organs and tissues.

To reduce this risk factor, extra precautions should be taken into account when performing necropsies or handling meat, given that meat, brain tissue, diaphragms and myocardial tissues are preferential location of cysts. Wearing protective gear such as gloves and lab coats or coveralls while handling carcasses, and proper hygiene habits during and after the removal of contaminated items before eating or handling not contaminated items [18].

This is particularly important to avoid possible cross-contamination because not only *T. gondii* but also many other zoonotic pathogens can be transmitted from animals to people directly or indirectly through the environment by hand-to-mouth contact. Transmission can occur directly during examination, treatment, and handling of animals, or indirectly through contact with contaminated objects such as cages, equipment and workplace surfaces [2].

5 Conclusion

The main goal of this review was to assess incidence and risk factors of *T. gondii* in workers that are under exposure to animals in their line of work.

In a general way, all the articles analysed present valid known risk factors given the line of work in question. However, even in similar conditions, not all risk factors hold the same importance in the infection route. This raises the question of how many other factors have to be taken into consideration and studied so we can better understand how to put a stop in the widespread nature of this parasite.

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