

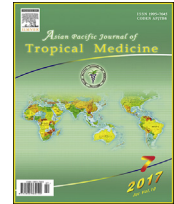
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Birds and poultries toxoplasmosis in Iran: A systematic review and meta-analysis

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ABSTRACT

Objective: To evaluate the overall prevalence of *Toxoplasma gondii* infection among birds and poultries in Iran.**Methods:** Data were systematically collected from 1983 to 2016 in Iran on the following electronic databases: PubMed, Google Scholar, Science Direct, Scopus, Web of Science, Magiran, Irandoc, IranMedex, and Scientific Information Database. Additionally, the abstracts of national scientific congresses and dissertations were included.**Results:** A total of 20 articles in the field of birds and poultries toxoplasmosis, totally examining 4563 cases with 754 positive results reporting the overall prevalence of infection from all parts of Iran could fulfill our eligibility criteria. The overall estimated prevalence included in chicken 20% (95% CI: 3%–38%) in chicken, pigeons 8% (95% CI: –17%–33%) and in sparrows 15% (95% CI: –25%–54%).**Conclusion:** Although there is a lack in data about poultries and birds toxoplasmosis in Iran, our meta-analysis revealed that infection rate is high among birds and poultries in Iran. More studies are needed to manage controlling programs and prevention strategies among poultries in Iran.

1. Introduction

Toxoplasmosis, a parasitic disease, can affect many mammals and birds as intermediate hosts [1]. Toxoplasmosis is one of the most prevalent parasitic infections in humans worldwide [2]. It has been estimated that 1/3 of the world population has antibody against *Toxoplasma gondii* (*T. gondii*) which is an indicator of parasite distribution all around the world [3]. Toxoplasmosis in human during pregnancy may lead to death of fetus or cause serious defects in fetus [4]. Infection in immunocompromised population causes serious problems and sometimes death [5]. Chickens, turkeys, ducks, sparrows and

other birds can be infected with *T. gondii* as intermediate host and acquire infection by digesting infective oocysts shed from the feces of definitive host. Domestic breeding birds and poultries are less infected than free-ranging or industrial breeding since they are not allowed to contact with infective oocysts or feline [6]. Infected birds are considered one of the best indicators for soil contamination with *T. gondii* oocysts because they feed on the ground. Human infection occurs via eating uncooked infected meat of birds and chicken. Besides the tissue of infected chickens is a source of infection in cats. Although there is no document about infection transmission by eggs, people are advised to avoid eating raw eggs so as to prevent other possible infections specially salmonellosis [7]. Considering the importance of birds and poultry in transmission of *T. gondii* to human and felids and also according to our knowledge, there is no documented data about the exact prevalence of toxoplasmosis in poultries and birds in Iran. Therefore, the present systematic review and meta-analysis was carried out to evaluate the exact prevalence of infection in this group of animals.

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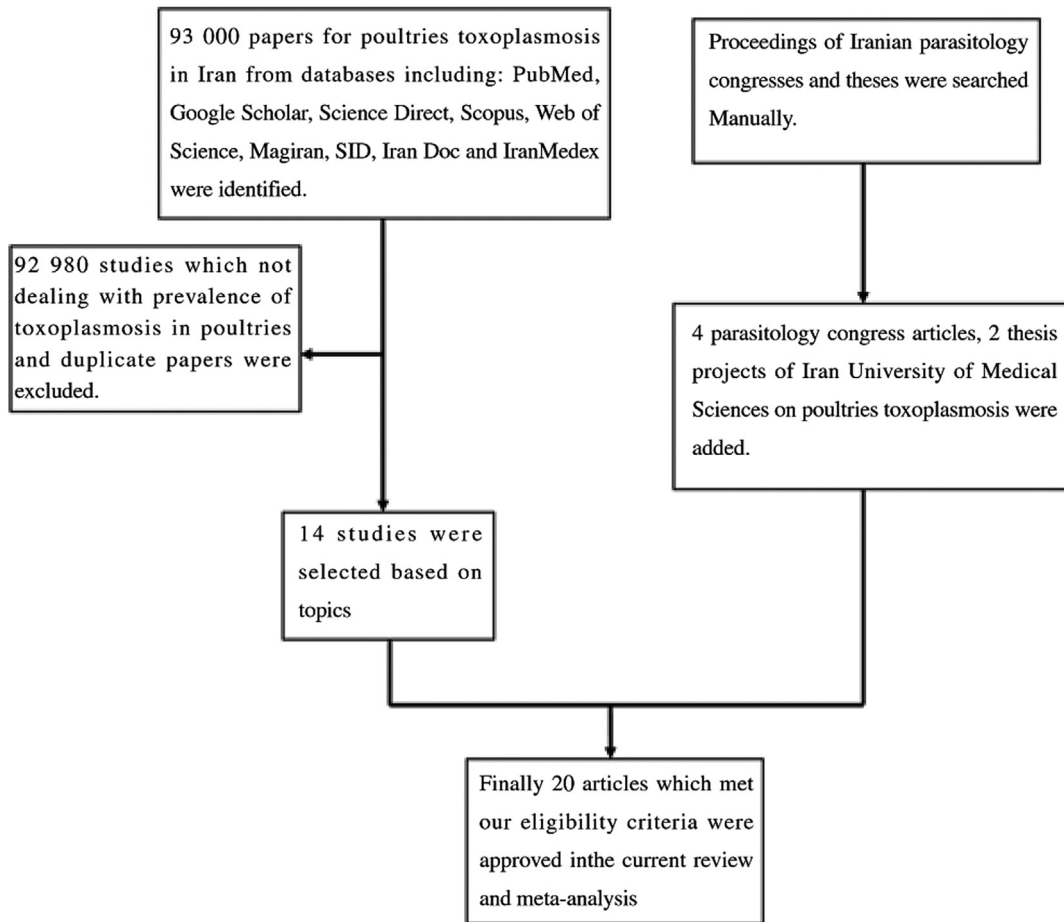


Figure 1. Flow diagram describing the study design process for poultry toxoplasmosis.

2. Methods

2.1. Data searching

Search was carried out in databases including PubMed, Google Scholar, Science Direct, Scopus, Web of Science, Magiran, Irandoc, IranMedex, and Scientific Information

Database. Dissertations, Congress summaries, and unpublished data were collected from 1983 to 2016. The process is shown in [Figure 1](#). All original descriptive studies in poultry toxoplasmosis were chosen. The search was done using such terms as “poultry”, “toxoplasmosis”, “birds”, “*Toxoplasma gondii*”, “prevalence”, “Iran”, “epidemiology” alone or in combination, both in Persian and English languages.

Table 1

Baseline characteristics of included studies.

No.	Year of publication	Province(s)/city(ies)	No. of animals	Positive	Percentage (%)	Lab method	Cutoff	References
1	1983	All parts of Iran	170	47	27.5	IHA	1:20	[8]
2	1990	All parts of Iran	162	46	28.4	IHA	1:20	[9]
3	1993	Ahvaz, Dezfool	203	55	27	IHA	1:20	[10]
4	1993	Kerman	332	27	8.13	DAT	1:60	[11]
5	1993	Zanjan	164	25	15.2	DAT	1:60	[12]
6	1997	Tehran	738	39	5.2	DAT		[13]
7	2000	Esfahan	365	19	5.2	IHA	1:20	[14]
8	2006	Ardebil	200	0	0	ELIZA		[15]
9	2006	Fars/Shiraz	122	44	36.1	IFA	1:16	[16]
10	2006	Fars/Shiraz	231	58	25.1	IFA	1:16	[17]
11	2007	Mazandaran	58	25	43.1	LAT	1:8	[18]
12	2007	Esfahan/Golestan	125	2	1.6			[19]
13	2008	Kerman	84	70	83.3	MAT	1:2	[20]
14	2008	Fars/Shiraz	697	70	10.04	IFA	1:16	[21]
15	2009	Fars/Shiraz	203	58	28.6	IFA	1:16	[22]
16	2011	Hamedan	100	9	9	DLAT	1:8	[4]
17	2013	Khozestan	249	39	16.2	RFLP PCR		[23]
18	2014	Fars/Shiraz	54	48	89.8	MAT	1:40	[24]
19	2014	Ahvaz	106	55	51.8	MAT	1:5	[25]
20	2015	Tehran	200	17	8.5	LAMP		[26]

Table 2Classified studies of *T. gondii* in different tissues.

No.	No. of birds/poulties	No. of seropositive (titer)	No. of isolates from tissues					No. of isolates from mice	No. of isolate by PCR	References
			Brain	Neck	Heart	Tongue	Liver			
1	106	55 (>1:5)						29	49	[25]
2	54	48 (>1:40)	18	16		17		6	33	[24]
3	249		13		28				41	[23]
4	203	58 (>1:16)			16					[22]
5	58	25 (>1:8)						7		[18]
6	332	27 (>1:60)	4							[11]
7	162	47 (>1:20)						12		[9]
8	231	58 (>1:16)	43		29			47		[17]

2.2. Data collection

For the present study, all databases and unpublished data were searched in order to eliminate duplicate and studies out of Iran or human-based studies. Totally 20 studies with epidemiological parameters of interest were considered to include to our systematic review and meta-analysis. The studies which reported the prevalence of toxoplasmosis in birds and poulties were eligible to include in our study (Table 1). The information extracted from studies were as first author, the year of publication, the year when study were carried out, total number of animals (Birds and poulties), number of infected animals and diagnostic tests. In some studies tissues were examined for detection of parasite (Tables 2 and 3).

2.3. Statistical analysis

Quality of meta-analysis was evaluated with STROBE checklist; a checklist with 22 items that were considered essential for good reporting of observational studies. These items were related to the title, abstract, introduction, methods, results and discussion sections of article and other information. Score under 7.75 is considered bad quality, between 15.76 and 15.5 low, between 15.6 and 23.5 moderate and more than 23.6 as high quality [27].

The obtained Mean score of STROBE checklist for our 20 analyzed articles was obtained 21.15. The prevalence and standard error of each study was estimated by respect of Binomial Distribution and studies were combined according to sample size and variance. The overall prevalence of toxoplasmosis was calculated. Forest plot was used to visualize the heterogeneity among studies. The heterogeneity was expected in advance, statistical methods, I^2 , and Cochran Q statistics (with significance of $P < 0.05$) were used to quantify the variations. For the purpose of meta-analysis, we assumed that the included studies are random samples from a population under study and a fix effects model was employed. Proportions of individual studies and overall prevalence were presented by forest plots. Begg's funnel plot (visual method) and Egger's regression test (quantitative method) were used to evaluate potential publication bias. The meta-analysis was performed with the Stata, version 11.0 (Stata Corp., College Station, TX, USA).

3. Results

Among all databases and unpublished data from 1983 to 2016, totally 20 studies were considered eligible with a total of

4563 animals and 754 positive cases. All of the chosen studies were designed as cross-sectional plot and evaluated the prevalence of *Toxoplasma* infection among birds and poulties in different parts of Iran. Although all studies were in range as shown in Figure 2, their scattering around the middle line of Begg's Funnel graph were not equal. Also the publication bias examination was statistically significant. It means that publication bias influences the prevalence of infection ($P = 0.022$) and probably some studies were not included in the study. Some reasons include unpublished data or inaccessible data other reasons. In our studies, 16 studies belonged to chickens and hens and overall prevalence of toxoplasmosis among them was evaluated 0.20 (95% CI = 0.03–0.38) ($I^2 = 0.0\%$, $P = 0.985$). The forest plot diagram of this review is shown in Figure 3. Also, the same analysis was performed for pigeons and sparrows. The results are shown in same figure (Figure 3). The

Table 3

Different kinds of birds with number of infected animals.

Birds	Prevalence [n/N (%)]	Year of publication	Reference
Chicken	47/170 (27.6)	1983	[8]
	20/74 (27)	1990	[9]
	22/87 (25.3)	1993	[10]
	27/332 (6.6)	1993	[11]
	19/365 (5.2)	2000	[14]
	44/122 (36)	2006	[16]
	58/231 (25.1)	2006	[17]
	23/45 (5.1)	2007	[18]
	70/84 (83.3)	2008	[20]
	70/697 (10)	2008	[21]
	58/203 (28.6)	2009	[22]
Duck	15/103 (14.6)	2013	[23]
	55/106 (51.9)	2014	[25]
	4/8 (50)	1990	[9]
	2/13 (15.4)	2007	[18]
	4/8 (50)	1990	[9]
	4/12 (33.3)	1990	[9]
	22/82 (64.7)	1993	[10]
	1/36 (2.8)	1993	[11]
	27/332 (6.6)	1993	[11]
	2/125 (13.3)	2007	[19]
Pigeon	13/35 (37.1)	1990	[9]
	11/34 (32.3)	1993	[10]
	25/149 (16.8)	1993	[11]
Sparrow	15/103 (14.6)	2013	[23]
	17/200 (8.5)	2015	[26]
	16/25 (64)	1990	[9]
Turkey	16/25 (64)	1990	[9]

The data are expressed as n/N(%), where, N = Number of total birds/poulties, n = Number of infected birds/poulties, (%) = Percent of infected birds/poulties.

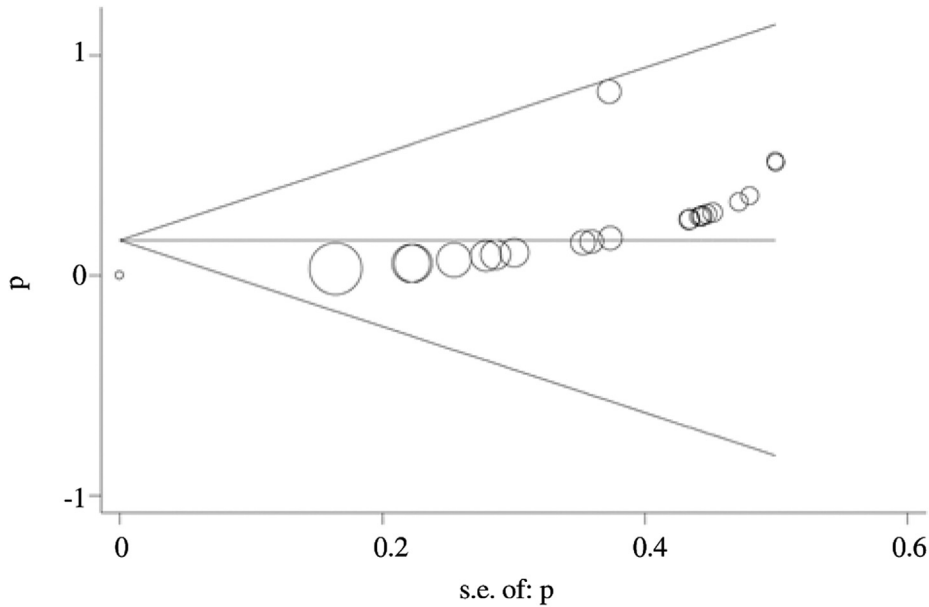


Figure 2. Funnel plot showing the prevalence of toxoplasmosis in birds (chickens, sparrows and pigeons). S.e. of = standard error of prevalence.

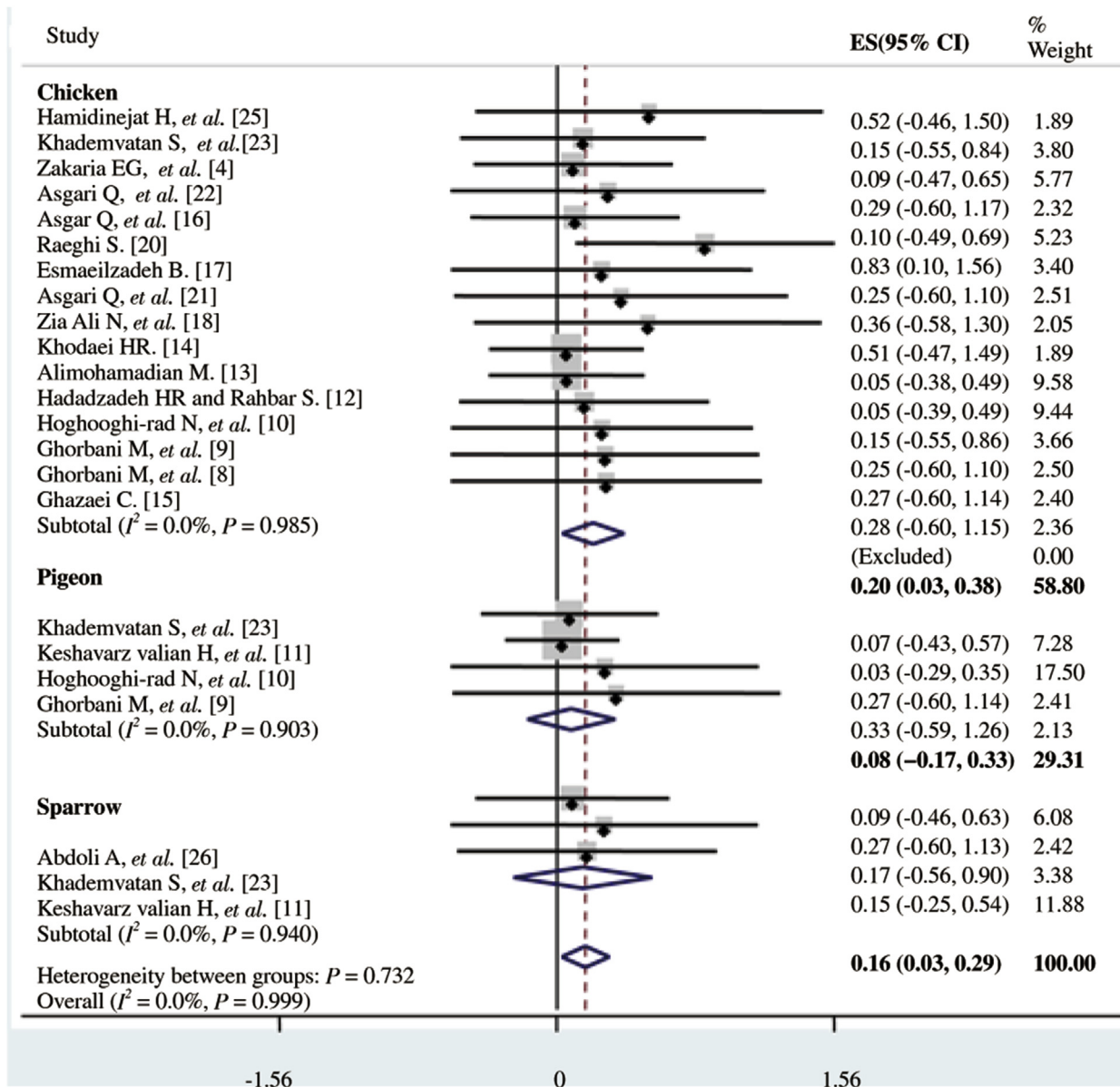


Figure 3. Forest plot for prevalence of infection in different types of birds.

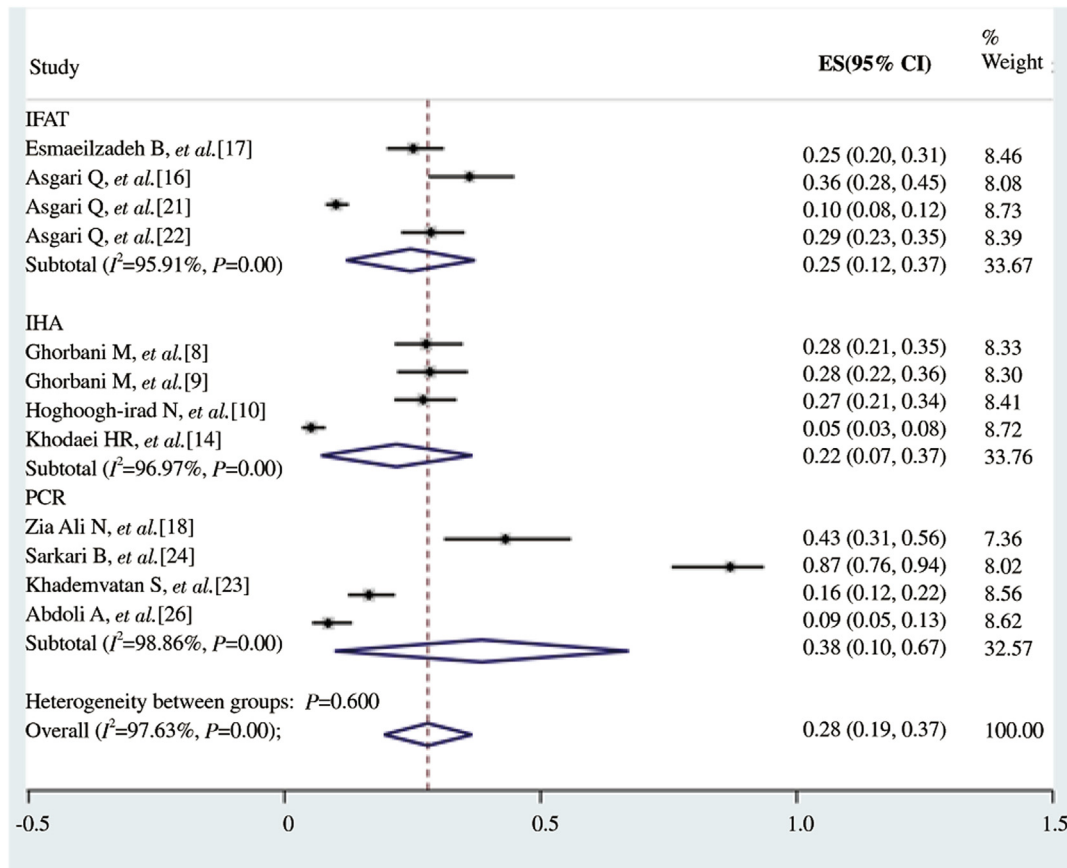


Figure 4. Forest plot for prevalence of infection in birds with different laboratory methods.

analysis revealed that minimum and maximum prevalence in chickens was 0.05 (95% CI = -0.38 to 0.49) and 0.83 (95% CI = -0.10 to 1.56), respectively. For pigeons, the minimum and maximum prevalence was 0.03 (95% CI = -0.29 to 0.35) and 0.33 (95% CI = -0.59 to 1.26), respectively. Meta-analysis in fix models for pigeons revealed the mean prevalence of 0.08 (95% CI = -0.17 to 0.33) ($I^2 = 0.0\%$, $P = 0.903$). Tree studies were carried out in sparrows and meta-analysis on them revealed the prevalence of 0.15 (95% CI = -0.25 to 0.54) ($I^2 = 0.0\%$, $P = 0.940$) for them. As studies were carried out with different methods, meta regression was performed for them. The I-square for methods and kind of birds was 0.00% and 0.000% and it shows homogeneity among all studies (Figure 4). Meta-analysis showed that although the prevalence rate in chickens is more than pigeons and sparrows, the difference was not statistically significant ($P = 0.59$). Also the results of meta-analysis for the methods revealed that although the prevalence by PCR is more

than other methods, the difference in tree methods is not significant ($P = 0.18$) (Figure 4, Table 4).

4. Discussion

Chickens are main sources of meat in Iran. Annual poultry meat production in Iran is 2.2 million tons and 900 000 eggs (FAO statistic book year 2014) with a rise of 12% per year has a small portion in the world poultry production of 94 million tons in 2015. The global poultry meat production will increase to 130 million tons in 2030. Egg production will also increase by 40%. Much of the growth will take place in developing countries (www.fao.org/ag/poortal/aga-index/en/).

On the other side, the developing countries (including Iran) faces tremendous challenges in the next quarter century, including feeding and improving hygiene of poultries and chickens and also managing protection programs. The consumption of poultry meat is 25.4 kg per capita annually in Iran with a 13% increase from 2007, so the importance of meat safety is crystal clear. As there was no exact estimation on pooled prevalence of birds sand poultries toxoplasmosis in Iran, the present study aimed to evaluate the estimated prevalence of poultries and birds toxoplasmosis from 1983 to 2016. A precise search was performed in electronic databases, unpublished data, abstracts of national scientific congress, and dissertations. Finally 20 studies with 4563 birds and 754 positive cases were investigated. Meta-analysis revealed the prevalence of infection in chickens (and hens) was 0.20 (95% CI = 0.03 to 0.38). The minimum of 0.05 (95% CI = -0.38 to 0.40) was achieved from the study carried out by Khodaei [14], and the maximum of 0.83 (95% CI = 0.010 to 1.56) reported by Raeghi [20]. Among

Table 4

Meta-analysis of different kinds of birds and methods.

Subject	Prevalence (95% CI)	I^2 (%)	Coefficient (standard error)	P
Animal				
Chicken	20.00 (3.00–38.00)	0.00	1.08 (0.88)	0.59
Sparrow	15.00 (-24.50–54.00)			
Pigeon	8.00 (-16.90–32.90)			
Lab methods				
IFAT	25.60 (12.00–37.20)	0.00	0.12 (0.08)	0.18
IHA	22.00 (7.00–37.06)			
PCR	38.80 (10.00–67.00)			

95% CI = 95% confidence interval.

pigeons the overall prevalence of 0.08 (95% CI = -0.17 to 0.33) ($I^2 = 0.00\%$, $P < 0.90$) was achieved. The minimum prevalence of 0.03 (95% CI = -0.29 to 0.35) related to the study carried out by Keshavarz and Ebrahimi [11] and the maximum of 0.33 (95% CI = -0.59 to 1.26) reported by Ghorbani *et al.* [9]. For sparrows, the overall prevalence of 0.15 (95% CI = -0.25 to 0.54) ($I^2 = 94.00\%$, $P < 0.0001$) was calculated with minimum prevalence of 0.09 (95% CI = -0.46 to 0.63) was reported by Abdoli *et al.* [26] and the maximum prevalence of 0.27 (95% CI = -0.60 to 1.13) was reported by Khademvatan *et al.* [23].

In addition, other kinds of birds were examined for infection. Some kinds of them are considered as meat source for human such as turkey, starling, duck, goose, ring dove and rooster. Few studies were carried out about them because of limitation in study numbers and sample size, and the mean prevalence among them were reported. In a study carried out by Khademvatan *et al.* on 39 starlings, only 5 (12.8%) of them were infected [23]. In another study by Eslami *et al.* on 125 rooks, the prevalence of 1.6% was reported [19].

Keshavarz and Ebrahimi in a study carried out on 332 birds in Kerman, showed that among 147 ring doves, 7 (4.8%) were infected with *T. gondii* [11]. Although Iranians are interested to consume the turkey meat, only two studies investigated the prevalence of toxoplasmosis among them. First study was carried out by Ghorbani *et al.* on 25 turkeys that 16 (64%) were infected [9]. Another study was performed by Sarkari *et al.* on 54 turkeys showed that 47 (87%) were infected with *T. gondii* [24]. It seems that turkey is more susceptible to *T. gondii* parasite than chicken or other kinds of birds but more studies should design for proper conclusion. In all studies carried out in Iran, only one study by Ghorbani *et al.* was done on goose and among 8 of these poultries, 4 (50%) were infected [9]. Amazing results achieved from the studies carried out by Ghorbani *et al.* and Zia Ali *et al.* on duck. Results of studies indicated that of 8 and 13 ducks examined for parasite, 4 (50%) and 2 (15.4%) were infected respectively. Studies carried out on roosters revealed that they could catch infection as chickens [9,18]. Ghorbani *et al.* examined 35 roosters and found that 13 (37.1%) had toxoplasmosis [9]. Also Hoghooghi-rad *et al.* examined 34 roosters and showed that 11 (32.3%) were infected [10].

Unfortunately there was no valid data about examined birds and poultries age and sex, so we could not evaluate the difference between male and female or among different age groups. Another fact in this study was industrial bred and free-range chickens. In some studies the difference was significant and industrial raising chickens were less infected than free-ranging as their food and water was free of oocysts of *T. gondii* parasite. Another important fact is that their habitat is enclosed and they don't have contact with cats or other animals in Felinae. Also owners don't let the cat enter the henry. A study carried out by Asgari showed that the infection rate in free-ranging chickens, semi-industrial and industrial henry was 27.1%, 12% and 2.02%, respectively [21]. The difference among them was statistically significant and elucidates the importance of raising chickens in industrial henry.

In Iran the poultry meat is cooked properly, but barbecued chicken is favorite food in all parts of the country and is used in camping, travels and almost in all ceremonies. A lot of people don't like the taste of well cooked chicken and prefer to have it uncooked, so the danger of toxoplasmosis will be lurking. Immuno-deficient individuals and pregnant women must be

aware of the importance of parasite transmission in consumption of uncooked chicken.

Comparing the results of all studies in Iran since 1983 indicate that infection rate in some provinces is more than other parts as the results of study carried out by Zia Ali showing the prevalence of 43.1% in Mazandaran province (north of Iran) [18]. Amazing results of studies in Fars province (Shiraz city) achieved. In studies carried out by Asgari *et al.* [16] the prevalence of 36.1% and by Esmailzadeh [17] the rate of 25.1% was reported. Shiraz is the central city in Fars province with semidry climate [16]. In previous studies among sheep and goat toxoplasmosis in this province, the prevalence of infection in sheep was 25.5% and 37.5% in 2006 [22] and among goats the prevalence of 22.7% was reported by Asgari *et al.* [21]. These results are very close to the results in chickens and indicate the proper climatic condition for oocysts survive in Fars province.

In Ahvaz, the central city of Khuzestan province, two studies were carried out. In the first study, Hoghooghi-rad *et al.* revealed that among 203 birds, a total of 55 (27%) were infected with *T. gondii* [10] and in another study, Hamidinejat *et al.* showed that 55 (51.8%) of 105 free-range chickens were infected [25,28]. An important point is the kind of feeding among chickens. As described previously, catching grain from ground is high risk of digestion sporulated oocysts of *T. gondii* and the infection is inevitable. Environmental controlling is hard work because of the large stray cat population, controlling is limited to prevention of infection in chicken raising place. Minimum prevalence of 1.6% was found in the study carried out by Eslami *et al.* on rooks [19]. It may be related to the manner of feeding as rook rarely take grain from ground so the probability of infection decreases. In some parts of Iran such as Ahvaz and other parts of Khuzestan, consuming sparrow meat is usual. Consistent to our study, the studies from other countries revealed amazing results. The results of a study on 107 turkeys in Iraq, western neighbor of Iran, showed the prevalence of 76.63% among them. Otherwise 82 out of 107 cases had antibody against *T. gondii* which was determined through latex agglutination test [29]. Another study carried out among 200 free-ranging and 200 industrial chickens as well as 50 ducks in Iraq showed that the prevalence of toxoplasmosis in free-ranging chicken, industrial chickens and ducks was 67%, 31% and 56%, respectively [30]. Also other study among 65 domestic chickens in Sulaimani Province, Iraq, revealed that 60% of them were infected [31]. It is clear that the prevalence of toxoplasmosis among chickens in Iraq is higher than Iran. Pakistan is our eastern neighbor and the study carried out there showed that 5.90% of 68 caged chicken and 20.70% of 468 free-ranging chickens were infected with *T. gondii* [32]. As in our study the rate of infection among free-ranging chickens is higher than that among caged chickens. Results from the other study carried out by Sadia *et al.* among 200 captive birds in Pakistan revealed that 16% of turkeys, 12% ducks, 8% pigeons and 4% of quails were infected [33]. Data from our neighbor countries were close to ours.

Unfortunately there is few data in birds and poultries toxoplasmosis in Middle East but what obtained from the studies in other parts of the world showed amazing results, as Dubey *et al.* described the infection rate among 61 of 225 free-ranging chickens in Portugal [34]. Also genotypes were described in the study. An exclusive study carried out by Dubey revealed that the prevalence of infection in the world differs from

minimum 0.01% in Czech Republic to 71.3% in Italy [7]. Also comparison of chickens and free-range chickens showed higher rate of infection in free-range chickens. This review was performed to evaluate the prevalence of toxoplasmosis among poultry and birds in Iran and it seems that infection is widespread in this country. This point indicated that more attention is needed for the prevention of toxoplasmosis in Iran. Some kinds of birds like pigeon, sparrow, starling and ding dove are hunted and the meat controlling is a hard task. Therefore, controlling programs should be managed in chicken rising in large scale because it is the largest source of bird meat in Iran.

There are some gaps in our systematic review and meta-analysis. First the number of studies is limit and more studies are needed for better estimation of infection among birds. Second, the number of other races of birds is less than what is needed for exact evaluation of infection among these races. This may be resulted from rare presence of these races in the study regions. Also, the sex and age were not considered in studies. Unlike the other birds, chickens feed on ground as they take oocysts from soil which contaminated with cat faces, so the infection among chickens is a good indicator of soil contamination and could consider valuable for preventing and controlling programs.

As expected, almost in all parts of Iran, prevalence of toxoplasmosis in poultries and birds is high. As in our previous studies in sheep, goats, cattle and cats in Iran, the situation for transmission of infection to human and also among animals is favorable for *T. gondii*. These data can help us manage prevention and controlling programs in animals and consequently in Iranian population.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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