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Importance of toxoplasmosis for human and animal health, present condition, problems and solution proposals in Turkey and the World

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Abstract

Noting the fact that a major part of emerging diseases in humans are caused by animals, food security and sustainable food security can only be performed in a condition that animal health and welfare are secured and sustainable livestock raising is established. Taking into account the fact that animal health directly affects human health and animal products are undisputedly necessary in human nutrition, it is deduced that human health depends on animal health. According to the World Health Organization, more than 60% of infectious agents affecting humans and newly described in the last decade are caused by animals or products of animal origin. Toxoplasmosis is one of the most common zoonotic diseases in the world. *Toxoplasma gondii*, intracellular protozoan, is a food and water-borne parasite that has recently infected about 1 billion people in the world. In this context, in both humans and animals toxoplasmosis threatening health and causing important economic losses is known as a most important protozoan-related zoonosis. In the context of this presentation with the specified reasons, concise knowledge was given on presenting of knowledge belonging to present condition, concerns, sharing of preventive medicine/public health approaches in the prevention and control of infection, actions to be taken, and solution proposals related to *Toxoplasma gondii* important but yet ignored in many regions in Turkey and the world.

Keywords: Toxoplasmosis; Animal and human health; Concerns; Solution proposals

1. Introduction

Toxoplasma gondii (*T. gondii*), which is intracellular protozoan, is a food and water-borne parasite infecting about 1 billion people in the world [1]. *T. gondii* is a zoonotic protozoan that can infect all warm blooded animals including birds, farm animals, marine mammals, and humans [2-4]. Cats are definitive host and shed oocysts via feces for 1 to 2 weeks after a new infection [5]. Oocysts are sporulated in environmental condition in 1-5 days. Sporulated oocysts can remain infective for 1 year or for a long period of time in humid environment [4].

2. Present condition

2.1. Transmission of *T. gondii*

Transmission can occur via soil, water, undercooked meat, shellfish contaminated with cat feces, congenital way, breastfeeding, transfusion of body fluids, transplantation of tissues or organs [6], and inhalation of oocysts in dust particles [7]. The contamination of soil and underground water with oocysts is common [8]. The infection of ruminants, birds, wild herbivores, and pigs is likely to develop via environmental exposure to *T. gondii* oocysts [9].

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In Ordu city, in the drinking waters *T. gondii* DNA has not been detected but in the river waters *T. gondii* DNA has been detected by traditional PCR at 21.42%, and nested-PCR at %28.57 [10]. In Giresun city, *T. gondii* DNA has been detected in the environmental waters at 13.2% [11].

T. gondii oocysts can be ingested by intermediate hosts such as rodents, thus ingestion of the infected rodents is another transmission way [12]. Out of 68 snakes brains collected in Iran, 55 brains for *T. gondii* GRA6 gene have been positively detected by nested-PCR method. This study suggests that the prevalence of *T. gondii* is high among snakes [13].

Consuming unpasteurized milk is a risk factor for human toxoplasmosis. For example, in the Northeast region of Brazil, *T. gondii* DNA and its seroprevalence have been detected to be 6.05% (15/248) in milk and 22.58% (56/248) in sera in goats naturally infected with *T. gondii* [14]. In North-West Tunisia, *T. gondii* seroprevalence and *T. gondii* DNA in milk have been reported to be 31.2% in sera and 7.8% in milk in 77 goats, respectively. This suggests that the consumption of raw milk from goats naturally infected with *T. gondii* is a source for human infection [15].

Food and Agriculture Organization/World Health Organization estimates that *T. gondii* infections in humans are caused by meat at a rate of 22%. *T. gondii* prevalence has been reported to be higher in extensive farming system compared to intensive farming system in systematic meta-analysis of six farm animals in US [16]. It has been reported that humans are infected with *T. gondii* by ingesting undercooked horse meat comprising tissue cysts [17]. Dogs play a role as mechanical vector for humans by shedding oocysts via feces after eating infective oocysts [18].

2.2. Lifecycle of *T. gondii*

After humans and warm blooded animals ingest sporulated oocysts, parasite is transformed into the stage infecting intestine and moves to many tissues by blood vessels in the body [6,19]. Tachyzoites have a crescent shape. They occur in the active proliferation stage of *T. gondii* and in this phase they infect macrophages and monocytes. They are motile and are rapidly grown by endodyogeny. In the phase of chronic infection, there are bradyzoites in parasitophorous vacuole of cell. They slowly grow, are protected from host immune system and drugs, and remain in this form for months or years [20].

2.3. Epidemiology of *T. gondii*

The prevalence of *T. gondii* in humans and animals in Turkey and in the world is given in Tables 1-8.

Table 1 The prevalence of *T. gondii* in small animals in Turkey.

Province	Animal Species	Number of Samples	Prevalence (%)	Scientific Source
İzmir	Stray cat	1121	34.2	Can et al., 2014 [21]
Ankara and Kırıkkale	Cat	102	48.03	Duru et al., 2017 [22]
Niğde	Cat	72	76.4	Karatepe et al., 2008 [23]
Niğde	Domestic pigeon	105	0.95	Karatepe et al., 2011 [24]
	Wild pigeon	111	0.90	
Niğde	Squirrel	105	11.4	Karatepe et al., 2004 [25]
Kocaeli	Owned dog	116	69.8	Şimşek et al., 2006 [26]
Şanlıurfa	Shelter dog	80	97.5	Babür et al., 2007 [27]
Eskişehir	Stray dog	185	54.1	Doğan et al., 2014 [28]
Kars	Owned dog	179	96.1	Gıcık et al., 2010 [29]
Diyarbakır	Ownerless dog	100	94	İçen et al., 2010 [30]
Ankara	Stray dog	116	62.06	Aslantaş et al., 2005 [31]
Ankara	Stray dog	107	54	Şahal et al., 2009 [32]
İstanbul	Stray dog	100	19	Uysal et al., 2017 [33]
Sivas	Dog	120	95.8	Altay et al., 2013 [34]

Table 2 The prevalence of *T. gondii* in small animals in the world.

Country	Animal Species	Number of Samples	Prevalence (%)	Scientific Source
Estonia	Cat	306 Pet 184 Shelter	60.8	Must et al., 2015 [35]
Ethiopia	Cat	124	87.72	Gebremedhin and Tadesse, 2015 [36]
Brazil	Cat	348 Pet 247 Shelter	71.26 22.7	Magalhaes et al., 2017 [37]
Southern Spain and Northern Africa	Dog	769	30.6	Cano-Terriza et al., 2016 [38]
Czech Republic	Red Fox	80	100	Bartova et al., 2016 [39]
Southern China	Dog	364	51.9	Jiang et al., 2015 [40]
China	Raccoon Dog	1181	8.64	Zheng et al., 2017 [41]

In some regions of Turkey, prevalence of toxoplasmosis in shelter and ownerless dogs were very high. In the world, prevalence of toxoplasmosis in red foxes in Czech Republic and in cats in Ethiopia was rather high.

Table 3 The prevalence of *T. gondii* in livestock animals in Turkey.

Province	Animal Species	Number of Samples	Prevalence (%)	Scientific Source
Aydın	Cattle	487	45.2	Karagenç et al., 2005 [42]
Kars	Cattle	216	93.5	Akca and Mor, 2010 [43]
Samsun	Cattle	96	54.16	Acici et al., 2008 [44]
Adana	Cattle	132	56.06	Yücel et al., 2014 [45]
Afyon and Samsun	Water buffalo	131	87.79	Beyhan et al., 2014 [46]
Van-Siirt	Goat	275	72.7	Ataseven et al., 2006 [47]
Afyon	Sheep	186	98.92	Çiçek et al., 2011 [48]
Yalova	Sheep	63	66.66	Öncel et al., 2005 [49]
Şanlıurfa	Sheep	300	55.66	Sevgili et al., 2005 [50]
Kilis	Goat	105	95.24	Beyhan et al., 2013 [51]
Ankara	Horse	168	36.9	Gazyacı et al., 2011[52]
Ankara	Goat	137	81.75	Ural et al., 2009 [53]
Van	Goat	98	80.61	Karaca et al., 2007 [54]
Silopi	Sheep	100	97	Leblebici and Yıldız, 2014 [55]
Erzurum	Donkey	92	92	Balkaya et al., 2011 [56]

Table 4 Congenital toxoplasmosis in animal species in EU in 2012-2016 (EFSA, 2017) [57].

Sheep and Goat	2012	2013	2014	2015	2016
Sampled unit number	5,291	4,813	4,694	3,139	5,561
Positive rate %	28	42.4	26.8	38.8	18.7
The number of member countries reporting	10	12	12	11	12
Cattle	2012	2013	2014	2015	2016
Sampled unit number	1,348	1,078	1,000	1,177	451
Positive rate %	9.1	13.8	6.2	4.2	3.3
The number of member countries reporting	7	5	9	7	8

Table 5 The prevalence of *T. gondii* in livestock animals in the world.

Country	Animal Species	Number of Samples	Prevalence (%)	Scientific Source
Czech Republic	Cattle	546	9.7	Bartova et al., 2015 [58]
Ghana	Sheep	170	35.9	Bentum et al., 2019 [59]
	Goat	177	23.7	
Nigeria	Cattle	210	13.91	Onyiche and Ademola, 2015 [60]
Brazil	Pig	500	12.6	dos Santos et al., 2015 [61]
Brazil	Goat	248	22.58	Bezerra et al., 2015 [14]
	Goat milk		6.05	
India	Sheep	177	1.69	Kalambe et al., 2017 [62]
	Goat	223	1.34	
Nigeria	Pig	302	29.14	Onyiche and Ademola, 2015 [60]
Tunisia	Goat	77	31.2	Amairia et al., 2016 [15]
	Goat milk		7.8	
USA	Deer	142	56.3	Cox et al., 2017 [63]
China	Chicken	1173	30.36	Zhao et al., 2012 [64]
Portugal	Free range	178	5.6	Rodrigues et al., 2019 [65]
	Broiler chicken	170	0	
China	Goose	900	21.1	Tan et al., 2016 [66]
China	Horse	637	31.4	Wang et al., 2015 [67]
Mexica	Donkey	239	10.9	Alvarado-Esquivel et al., 2015 [68]
Mongolia	Goat	1078	32	Pagmadulam et al., 2019 [69]
	Sheep	882	34.8	
Brazil	Goat	580	40.5	Rego et al., 2016 [70]
	Sheep	374	48.7	

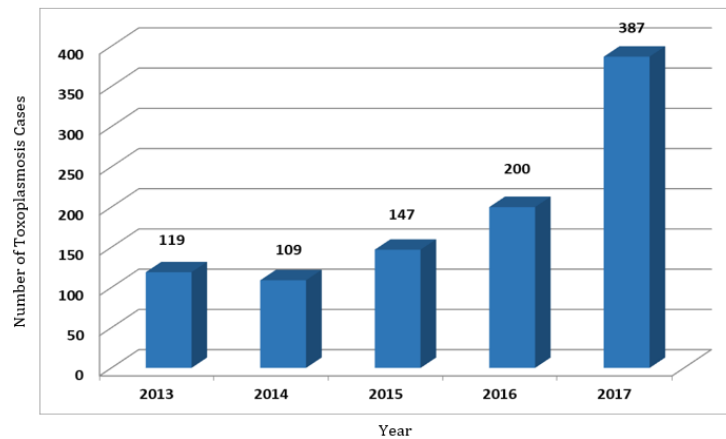
In Turkey, prevalence of toxoplasmosis in livestock animals was very high and reached 98.92% in sheep in Afyon. In EU, congenital toxoplasmosis prevalence was 42.4% in sheep in 2013 and 13.8% in cattle in 2013. In the world, prevalence of toxoplasmosis in livestock animals changed according to the regions. However, this rate was 48.7% in sheep in Brazil and 56.3% in deer in USA.

Table 6 The prevalence of *T. gondii* in humans in Turkey.

Province	Human	Number of Samples	Prevalence (%)	Scientific Source
Afyon	Pregnant	1284	23.4	Şimşek et al., 2016 [71]
Ordu	Pregnant	2791	27.6	Çalgın et al., 2017 [72]
İstanbul	Schizophrenia	300	60.7	Yuksel et al., 2010 [73]
	Anxiety and Depression patients	150	36.7	
	Healthy individuals	150	45.3	
Kayseri	Pregnant	1676	33.9	Kayman and Kayman, 2010 [74]
Van	0-18 years age	1562	8.4	Okur et al., 2012 [75]
Van	Pregnant	9809	37.6	Parlak et al., 2015 [76]
Ankara	Veterinary surgeons, Veterinary technician, Volunteer animal lovers	88	28.4	Çelebi et al., 2008 [77]
		25	16	
		14	50	
Kocaeli	Pregnant	1972	48.3	Tamer et al., 2009 [78]
Antalya, İskenderun	Pregnant	1652	52.1	Ocak et al., 2007 [79]
Adıyaman	Pregnant	455	48.4	Kölgeliev et al., 2009 [80]
Ankara	Pregnant	30.86	25.5	Çelen et al., 2013 [81]
Isparta	Pregnant	3140	28.4	Akpınar et al., 2017 [82]
İstanbul, Bursa, Adana, Kayseri Kocaeli	Childbearing women	17.751	24.61	Akyar, 2011 [83]
Kahramanmaraş	Pregnant	11.324	47.15	Bakacak et al., 2014 [84]
Muğla	Human	1162	2.4 20.6	Sankur et al., 2015 [85]
Uşak	Pregnant	1465	18.3	Toklu, 2013 [86]
İzmir	Pregnant	4651	39.9	Uysal et al., 2013 [87]
Amasya	Pregnant	1838	23.39	Kılınç et al., 2015 [88]
İstanbul	Pregnant	1737	24.2	Selek et al., 2015 [89]
Isparta	Childbearing women	794	24.4	Aynalı et al., 2016 [90]
Denizli	Pregnant	1102	37	Karabulut et al., 2011 [91]
Manisa	Human	2815	23.3	Bölük et al., 2012 [92]

Table 7 Human congenital toxoplasmosis cases in EU/EEA in 2012-2016 per 100.000 live birth (EFSA, 2017) [57].

Country	2012		2013		2014		2015		2016	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
Austria	-	-	-	-	-	-	-	-	-	-
Belgium	-	-	-	-	-	-	-	-	-	-
Bulgaria	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Croatia	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Cyprus	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Czech Republic	1	0.90	0	0.00	1	0.90	1	0.90	0	0.00
Denmark	-	-	-	-	-	-	-	-	-	-
Estonia	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Finland	0	0.00	0	0.00	0	0.00	0	0.00	1	1.80
France	104	12.70	179	22.00	216	26.40	246	30.76	-	-
Germany	20	3.00	10	1.50	6	0.80	15	2.03	10	1.36
Greece	-	-	-	-	-	-	-	-	-	-
Hungary	0	0.00	0	0.00	3	3.20	1	1.10	0	0.00
Ireland	1	1.40	1	1.50	0	0.00	1	1.50	0	0.00
Italy	-	-	-	-	-	-	-	-	-	-
Latvia	1	5.03	0	0.00	0	0.00	0	0.00	0	0.00
Lithuania	1	3.30	1	3.30	0	0.00	1	3.30	0	0.00
Luxemburg	1	16.50	0	0.00	0	0.00	0	0.00	0	0.00
Malta	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Netherlands	-	-	-	-	-	-	-	-	-	-
Poland	10	2.60	18	4.90	20	5.30	15	4.00	20	5.42
Portugal	-	-	-	-	-	-	-	-	-	-
Romania	0	0.00	0	0.00	1	0.50	0	0.00	0	0.00
Slovakia	0	0.00	2	3.60	0	0.00	0	0.00	2	3.60
Slovenia	0	0.00	0	0.00	0	0.00	1	4.80	1	4.84
Spain	0	-	0	-	0	-	0	-	5	-
Sweden	-	-	-	-	-	-	-	-	-	-
United Kingdom	5	0.60	2	0.30	11	1.40	7	0.90	8	1.03
EU Total	144	4.20	213	6.20	258	7.40	288	8.27	47	1.57
Iceland	-	-	0	0.00	0	0.00	0	0.00	0	0.00
Norway	-	-	-	-	-	-	-	-	-	-
Switzerland	-	-	-	-	-	-	-	-	-	-



* The data on February 6, 2018 are temporary.

Figure 1 The number of toxoplasmosis cases in humans in Turkey among 2013 -2017 (Ministry of Health, 2018) [93].

Table 8 The prevalence of *T. gondii* in humans in the world.

Country	Human	Number of Samples	Prevalence (%)	Scientific Source
Scotland	Human	1403	13.2	Burrells et al., 2016 [94]
Iran	Human	360	27	Khademi et al., 2019 [95]
Germany	Human	6564	55	Wilking et al., 2016 [96]

Toxoplasmosis prevalence in pregnant women reached 48.3% in Kocaeli region in Turkey. In Turkey, toxoplasmosis prevalence showed apparent increase in 2017 than 2013-2016 years. In EU, human congenital toxoplasmosis was significant rate in 2015. In Germany, human toxoplasmosis was significant level as 55%.

2.4. Clinical signs of *T. gondii*

In humans, three important clonal lineages of *T. gondii* are responsible for a major part of infections [97]. Atypical strains have been described to cause congenital toxoplasmosis [98] and symptomatic reactivation in immunosuppressive individuals [99]. The disease usually do not develop symptom but is an important problem in pregnant women, fetus and immunocompromised subjects. In individuals with adequate immune response severe toxoplasmosis infection such as myocarditis, pneumonia, encephalitis, and hepatitis rarely occurs [100].

Congenital toxoplasmosis occurs via ingestion of the causative agents during pregnancy. Infections in the first trimester of pregnancy are more severe than infections in the second and third trimester of pregnancy [9]. Hydrocephalus, intracerebral calcification, chorioretinitis, and mental retardation develop [100]. Toxoplasmosis causes posterior uveitis via the causative agents carried by blood circulation [100]. The reason of schizophrenia, character changes, dementia, and suicidal tendencies in toxoplasmosis is expressed by tropism of *T. gondii* toward brain [101]. *T. gondii* may cause endometritis, ovarian and uterus atrophy, adrenal hypertrophy, vasculitis, cessation of estrus cycle [102]. Test for *T. gondii* infection is required in some European Countries [9].

2.5. Diagnosis of *T. gondii*

The diagnosis of *T. gondii* in humans and animals is performed by isolation of parasites from various tissues, detection of specific DNA by PCR, or serological methods [103].

2.6. Treatment of *T. gondii*

Drugs used in the treatment of *T. gondii* infection include spiramycin, azithromycin, pyrimethamine-sulfadiazine, trimethoprim-sulfamethoxazole, pyrimethamine-clindamycin and traditional Chinese treatments. In a study regarding meta-analysis of efficacy of anti-*T. gondii* medicines in humans, the treatment of toxoplasma encephalitis with pyrimethamine-sulfadiazine, trimethoprim- sulfamethoxazole, and pyrimethamine-clindamycin has been determined to decrease clinical signs at the rate of 49.8%, 59.9% and 47.6%, respectively [104].

3. Problems

- Toxoplasmosis is a protozoan infection that is not among notifiable diseases by Ministry of Agriculture and Forestry, and is not routinely followed. According to the directive of notification system of contagious diseases in Ministry of Health, toxoplasmosis is in a list of notifiable diseases of Group C.
- Uncontrolled animal transportation among regions or foreign countries.
- Paying no attention for house hygiene and cleaning while cat is kept in house, going outside of cats in house [35] and feeding uncooked meat to cats [55].
- Not giving enough information to humans or not enough understanding the importance of the toxoplasmosis.
- Direct contamination of infected cat feces to fruits and vegetables growing on the ground and eating them without washing well.
- While children play with soil or in sand box, the contamination of their hands with infected cat feces and then moving their hands to their mouths without washing their hands.
- The consumption of unpasteurized milk; during preparing meal contacting of hands to raw meat and then moving hands to mucous membranes such as mouth and eye, and not washing hands and kitchen tools well.
- The consumption of a piece of undercooked meat while meat is cooked [60,92].
- Insufficient treatments of both owned and stray cats.
- The contamination of meals, and mouth and nares of humans by flying in wind of oocysts in infected feces that become dust by drying.
- That serious eradication has not yet been implemented in our country, and that the number of cats is rather high.
- Toxoplasmosis continues to be concern due to the fact that animals for slaughter are not properly killed, and that our community is not educated on the disease.

4. Solution proposals

- Taking precaution for stray cats in combating the disease.
- Preventing cats to eat organs with cyst; and feeding cats with well-cooked food or canned food [105,106].
- Amending abattoirs and checking them regularly.
- Disposing of organs with toxoplasmosis during slaughter in abattoirs under the control of veterinarian and under suitable conditions.
- Water should be drunk after boiled for killing *T. gondii* oocysts [8].
- All kinds of material such as cutting board and knife etc. used for meat after each use should be washed with hot water and soap; vegetables and fruits should be washed before consumption [8].
- Unpasteurized milk and raw eggs should not be consumed; moving hands to mucous membranes such as mouth and eye while contacting with hands to raw meat during preparing meal should be avoided; It should be waited until meat is cooked and the consumption of a piece of undercooked meat should be avoided.
- Risk of infection is substantially decreased by keeping meat for several days in deep freezer before cooking.
- Wearing gloves is necessary during contact of human waste or animal manure and hands should be washed; vegetables after washed well should be eaten when they are irrigated with human waste and animal manure [8].
- Gloves should be worn while gardening [105, 106].
- Paying attention for house hygiene and cleaning while cat is kept in house; avoiding going outside of cats in house.
- Pregnant women should be educated and serologically tested.
- Pregnant women should not contact with soil, raw meat, cat because toxoplasma poses a risk on fetus [105,106].
- Litter box of cat should be daily cleaned and not be emptied into toilet [105,106].
- Technicians involving animal care should wear mask and protective clothing while cleaning boxes of cats [105,106].

- Awareness should be created in the society by making public educations via related all foundations in order to combat toxoplasmosis (especially knowledge of disease should be given in schools in the manner that children can understand; children should be avoided playing with stray dogs) and preventive measures should be taken by society.
- Necessary regulations should be prepared on combating toxoplasmosis disease and follow-up according to fourth article regarding food and fodder law of plant health of veterinary services, with the number of 5996.
- One health approach is required including mutual scientific studies of physicians and veterinarians by looking into consumption of raw meat, vegetable and fruit, hand hygiene, habits of animal care according to socio-cultural structure of each country and region, in the reduction, control and prevention of zoonotic infections such as toxoplasmosis. Occupational groups of various specialization areas should be studied together in order that one health approach is succeed.
- Contact of cats with animals should be prevented; cats should be neutered; and populations of cats and rodents should be controlled [107].
- Feeds should be properly stored and cats entry to animal houses and feed storages should be prevented [107].

5. Conclusion

Toxoplasmosis is a common zoonotic parasitic disease in animals and humans in the world. This disease can be substantially decreased with knowing present problems and implementing the preventive measures.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There is no any conflict to declare by authors in this study.

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