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Seroprevalence of *Toxoplasma gondii* in South Asian countries

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Summary

Toxoplasmosis, a cosmopolitan zoonosis, is caused by an apicomplexan, obligate, intracellular protozoan parasite, *Toxoplasma gondii*. Nearly all animals, including humans, are at risk owing to its broad geographical distribution. The authors searched published data related to *T. gondii* in databases, including Google Scholar, PubMed and Science Direct for South Asian countries, and retrieved a total of 113 articles fulfilling the criterion of seroprevalence investigation. *Toxoplasma gondii* infection in livestock and humans was investigated using various serological tests. In these studies, a total of 14,431 samples from domestic animals and 53,899 samples from humans were screened for anti-*T. gondii* antibodies in all South Asian countries. Among the animals, cattle (*n* = 1,981), goats (*n* = 3,285), buffaloes (*n* = 1,695), sheep (*n* = 1,747), cats (*n* = 1,480), camels (*n* = 435), elephants (*n* = 45), pigs (*n* = 920), dogs (*n* = 1,604) and poultry (*n* = 1,206) were tested. This comprehensive review will be useful to biologists, public health workers, physicians and veterinarians and provides a better understanding of the distribution of *T. gondii* in this region. Furthermore, this knowledge will support efforts to find and apply effective prevention measures to better manage this zoonosis in South Asian countries.

Keywords

India – Pakistan – Seroprevalence – South Asian Association for Regional Cooperation – *Toxoplasma gondii* – Toxoplasmosis.

Introduction

The intracellular protozoan parasite *Toxoplasma gondii* is found worldwide and causes toxoplasmosis in a variety of hosts, including nearly all mammals and birds (1). It has the potential to infect every nucleated cell of an individual and is one of the most successful eukaryotic pathogens. It is of major medical and veterinary importance (2), being associated with huge economic losses worldwide (1, 3). The medical importance of the parasite was first identified in 1939 when *T. gondii* was diagnosed in a congenitally infected newborn baby (4). Many studies have shown that one in three people is seropositive for this infection, indicating that chronic infection is common (1). The parasite has three infective stages: tachyzoites, bradyzoites (5) and sporozoites. Tachyzoites are the rapidly dividing stage transmitted congenitally or through blood transfusion (4), while bradyzoites are transmitted by ingestion of meat or organs from an infected animal (6). Oocysts are shed in the faeces of infected felids (definite hosts) and sporulated oocysts are transmitted via contaminated food or water to intermediate hosts (7, 8).

In this review article, the authors summarise the results of sero-epidemiological studies of *T. gondii* in the South Asian Association for Regional Cooperation (SAARC) countries.

South Asian countries are bound in an organisation called SAARC, which was established on 8 December 1985: SAARC comprises Afghanistan, Bhutan, Bangladesh, India,

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Maldives, Nepal, Pakistan and Sri Lanka. The policies of SAARC aim to promote advancements in economic, social and cultural development within the South Asian region, to allow better cooperation with other developing countries.

Studies to determine the seroprevalence of *T. gondii* are not only important for human health but also highly valuable for the livestock industry. Many studies from SAARC countries have reported cases of ocular, congenital and cerebral toxoplasmosis (9, 10, 11). This article presents a comprehensive review of serological studies to detect infection with *T. gondii* in SAARC countries, as summarised in Figure 1.

The authors searched published data related to *T. gondii* in databases, including Google Scholar, PubMed and Science Direct for South Asian countries. Specific terms were searched alone or in combinations, including '*Toxoplasma* & Seroprevalence' and 'Toxoplasmosis & Animals', 'Epidemiology & *Toxoplasma*', 'Animals & Toxoplasmosis', 'Bovine & Toxoplasmosis', 'Human & Toxoplasmosis', 'Cattle', 'Buffalo', 'Sheep', 'Goats', 'Dogs', 'Cats', 'Afghanistan', 'Bangladesh', 'Bhutan', 'India', 'Nepal', 'Pakistan', and 'Sri Lanka', for all South Asian countries. Finally, a total of 113 articles were retrieved that fulfilled the criterion of seroprevalence investigation (Fig. 2). Specific anti-*T. gondii* antibodies in domestic animals and humans were investigated by various serological tests such as enzyme-linked immunosorbent assay (ELISA), latex agglutination test (LAT), direct agglutination test (DAT), indirect fluorescent antibody test (IFAT), modified direct agglutination test (MDAT), indirect haemagglutination (IHA) and modified agglutination test (MAT). Overall, a total of 68,330 animal (n = 14,431) and human (n = 53,899) samples were screened for anti-*T. gondii* antibodies in all South Asian countries. A wide variety of animals, including cattle (n = 1,981), goats (n = 3,285), buffaloes (n = 1,695), sheep (n = 1,747), cats (n = 1,480), camels (n = 435), elephants (n = 45), pigs (n = 920), dogs (n = 1,604) and poultry (n = 1,206), were included in the review (Fig. 3).

The seroprevalence studies highlighted the extent of infection in these countries and helped to identify the risk factors for infection with *T. gondii*.

Pakistan

In Pakistan, estimation of *T. gondii* seroprevalence in humans indicates variation among geographical zones and age groups. Prevalences of 63%, 48% and 38% in Punjab, Azad Kashmir and Khyber Pakhtoon Khwa (KPK), formerly known as North-West Frontier Province (NWFP), have been reported, respectively (12). In Islamabad, the capital of Pakistan, the prevalence of *T. gondii* was 17.4% in school-age children, based on an immunoglobulin G (IgG) ELISA (13).

Besides its prevalence in humans, *T. gondii* seroprevalence has been estimated in livestock in all major cities of Pakistan, with a seroprevalence of 19% in small ruminants (sheep and goats) in Rahim Yar Khan. The prevalence was higher in goats (25.4%) than in sheep (11.2%) (24). In Multan, *T. gondii* seroprevalence was significantly higher in beetle goats (57.14%) than in teddy goats (46.03; $p < 0.05$) (14). On testing of 400 and 422 serum samples from cattle and buffaloes, respectively, by IgG and IgM ELISA, 19.75% of cattle and 15.16% of buffalo serum samples were found to be positive for *T. gondii* (15). The overall number of positive samples included both IgG- and IgM-positive cases: IgG antibodies were found in 75 (18.75%) cattle and 58 (13.74%) buffaloes, while IgM antibodies, suggesting more recent infection, were found in 9 (2.25%) cattle and 10 (2.37%) buffaloes (15). Five cattle and four buffaloes were positive for both IgG and IgM antibodies. Seroprevalence was significantly higher in females and in older animals of both species ($p < 0.05$) (15).

The seroprevalence in cats and dogs was reported to be 26.43% (111/420) and 28.43% (116/408), respectively (16). Seroprevalence studies (17, 18, 19, 20, 21, 22, 23, 24, 25) from many regions of Pakistan are summarised in Table I.

Ramzan *et al.* (2009), who compared the infection rate in different sexes of sheep and goats, found that the prevalence was significantly higher ($p < 0.01$) in ewes and does (24%) when compared with rams and bucks (19%) (24).

The infection is widespread and has been reported from various geographical regions of Pakistan, with a higher prevalence in warm regions such as Multan and the cold zone of Malakand Agency (25). Overall, in Pakistan, *T. gondii* seroprevalence was significantly higher in humans (65% to 71%) than in rats (58.57%), goats (52%), mice (36.66%), dogs (28.43), cats (26.43%), cattle (25%) and sheep (2.5%).

Bangladesh

Domestic animals used for meat and other products from the Mymensingh District of Bangladesh had a seroprevalence of anti-*T. gondii* antibodies of 12%, 32% and 40% in cattle, goats and sheep, respectively (26). In the same study, a total of 15 women were tested and all were negative for anti-*T. gondii* antibodies (26). In another study, sera from 205 cattle, 17 sheep and 306 goats were tested for *T. gondii* antibodies using a LAT (27). Diagnostically significant titres (≥1:64) were detected in 16.10% of cattle, 17.65%

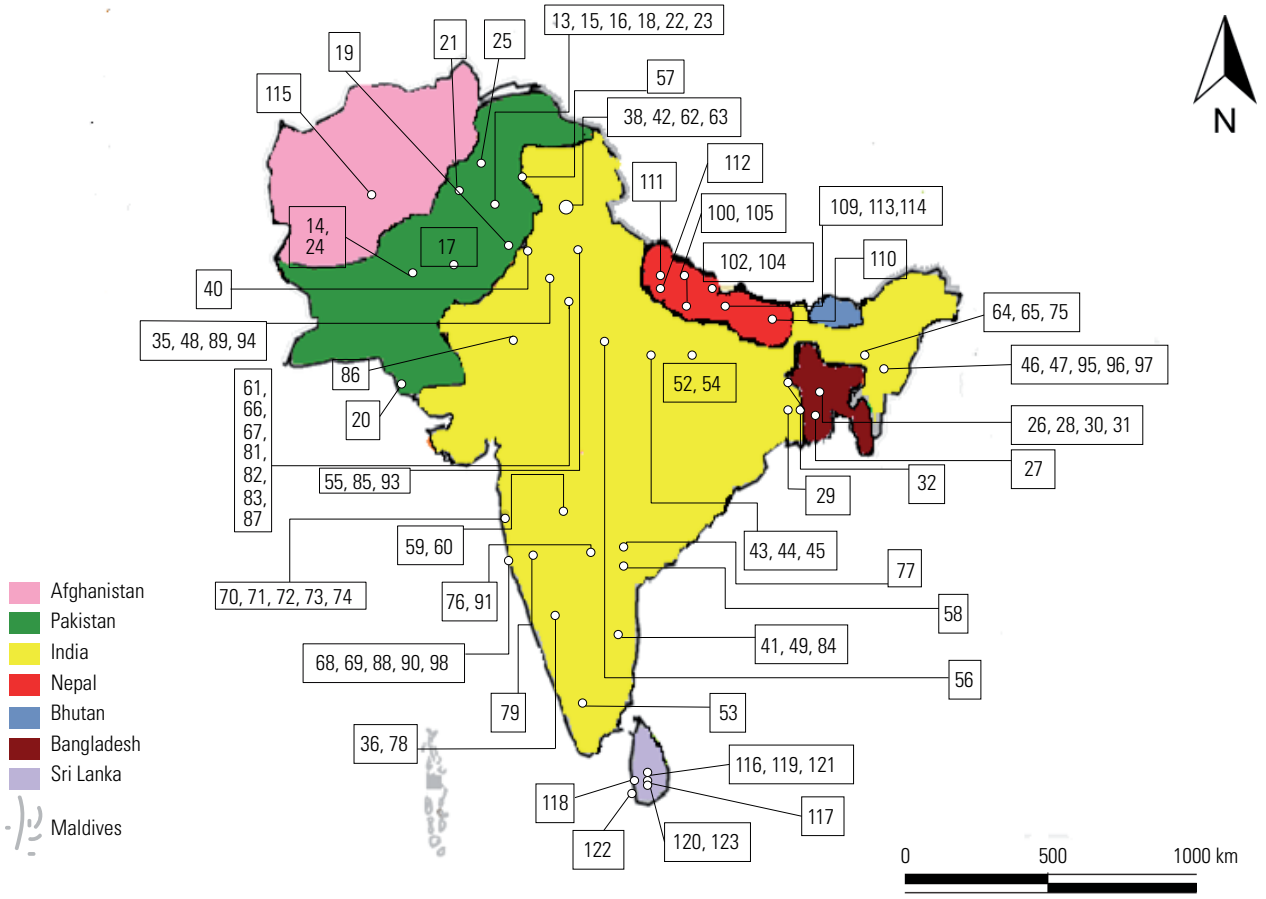

Fig. 1

Map of the seroprevalence studies of *Toxoplasma gondii* in both humans and livestock included in this review

Each allotted number demonstrates the site of the study on the map. The same number on the map represents the reference numbers in the tables and text

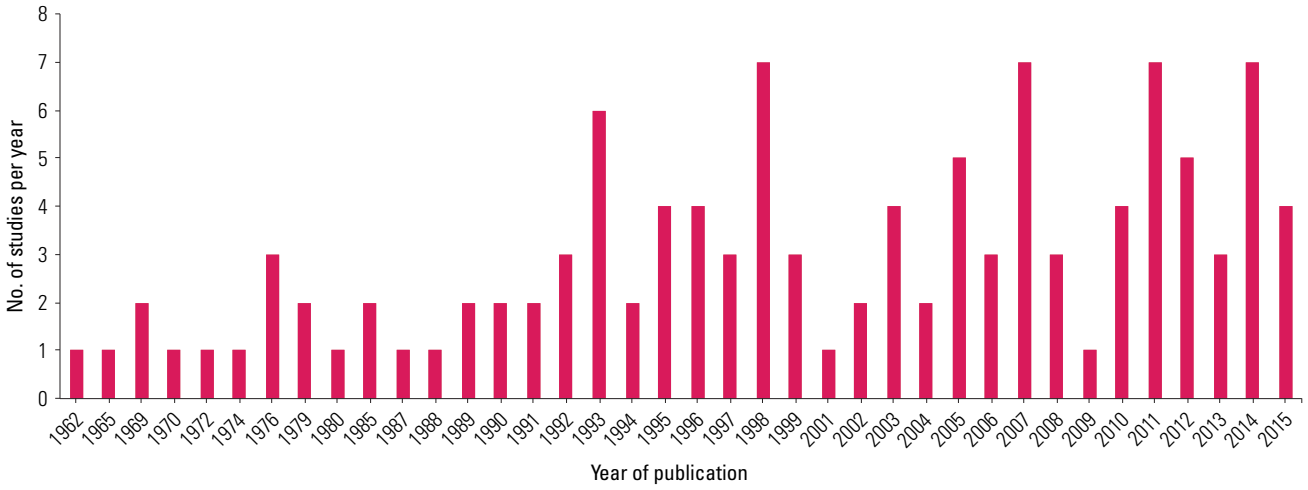

Fig. 2

Publications on the seroprevalence of *Toxoplasma gondii* in South Asian countries included in this study, by year

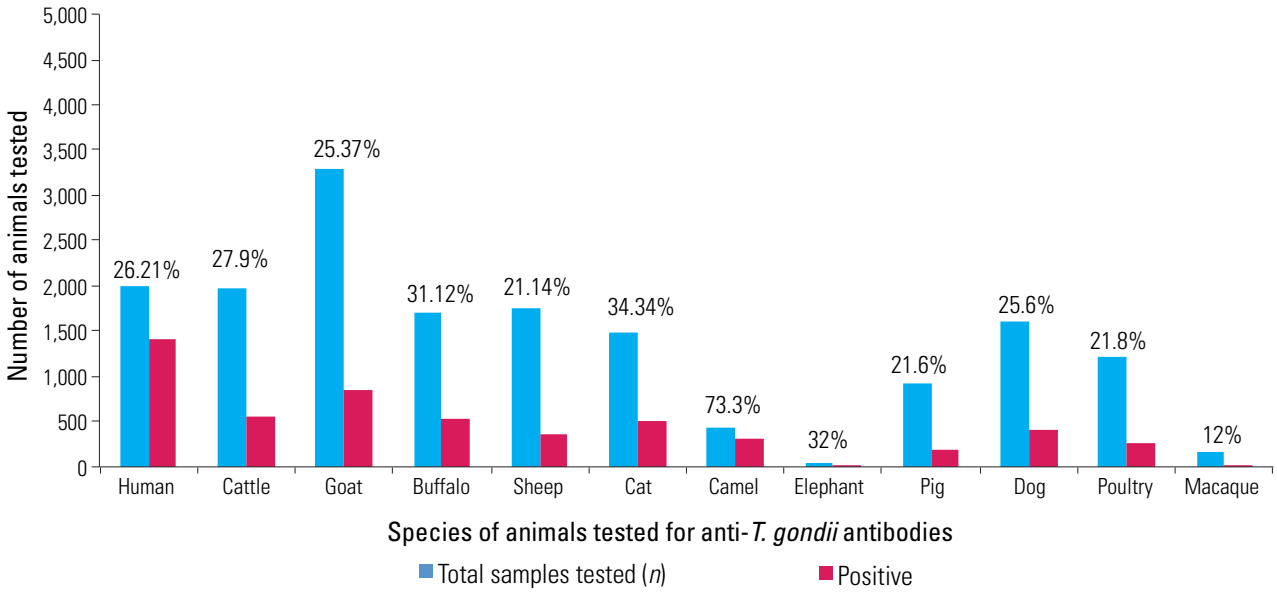

Fig. 3
Number of samples tested by species and the percentage of samples positive for anti-*Toxoplasma gondii* antibodies in South Asian countries
*Total samples tested × 25 = 2,000 × 25 = 50,000

Table I
Seroprevalence of *Toxoplasma gondii* in various species of animal and humans in Pakistan

Location	Reference	Test	No. of sera	Prevalence (%) (CI)	Host
South-West Pakistan	(17)	LAT	100	25 (0.16–0.33)	Cattle
			40	2.53 (0.02–0.07)	Sheep
			48	0	Goat
			64	0	Human
Islamabad	(18)	ELISA	47	12.73 (0.03–0.22)	Human
Lahore	(19)	LAT	210	58.57 (0.54–0.65)	Murine
			90	36.66 (0.26–0.46)	*Mus musculus*
			300	11.33 (0.07–0.14)	Human
Karachi	(20)	DAT	324	46 (0.40–0.51)	Human
Kohat	(21)	ELISA	180	26 (0.19–0.32)	Human
Rawalpindi & Islamabad	(22)	IFAT	240	17 (0.12–0.21)	Human
Rawalpindi & Islamabad	(23)	ELISA	335	5 (0.03–0.07)	Human
			65	12 (0.04–0.20)	Human
Rahim Yar Khan	(24)	LAT	200	19 (0.13–0.24)	Goat
Malakand Agency	(25)	ICT	420	13.14 (0.09–0.16)	Human
		LAT		14.1 (0.10–0.17)	
		ELISA		65.71 (0.61–0.70)	

CI: 95% confidence interval, reported as proportion
DAT: direct agglutination test
ELISA: enzyme-linked immunosorbent assay
ICT: immuno-chromatographic technique
IFAT: indirect fluorescent antibody test
LAT: latex agglutination test

of sheep and 12.09% of goats (27). A herd of 15 does with reproductive disorders were tested: four were seropositive according to a LAT titre of 1:128 and seropositivity was associated with abortion and neonatal mortality in three does (28). Later, the seroprevalence of *T. gondii* antibodies was investigated using samples from 83 sheep, 146 goats and 37 cattle from a dozen subsistence farms in Bangladesh (29). Fifty-eight of 83 sheep (69.9%), 89 of 146 goats (61.0%)

and 10 of 37 cattle (27.0%) were seropositive for the pathogen. Seroprevalence in young goats (<1-year-old) was significantly lower than that in adult goats (>1-year-old) (29). Overall, in Bangladesh, the seroprevalence of toxoplasmosis was highest in sheep (64%), followed by goats (54%), humans (50%) and cats (33.33%) (29). The other three seroprevalence studies (30, 31, 32) conducted in Bangladesh and included in this paper, are summarised in Table II.

Table II
Seroprevalence of *Toxoplasma gondii* in various species of animal and humans in Bangladesh

Location	Reference	Test	No. of sera	Prevalence (%) (CI)	Host
Mymensingh	(30)	LAT	56	64 (0.51–0.76)	Sheep
		LAT	33	54 (0.37–0.71)	Goat
Mymensingh	(31)	LAT	49	12.43 (0.03–0.21)	Human
		LAT	14	50 (0.23–0.76)	Human
		LAT	617	11.18 (0.08–0.13)	Human
		LAT	428	12.88 (0.09–0.16)	Goat
		LAT	24	33.33 (0.14-0.52)	Cat
Dhaka	(32)	LAT	16	0 (0)	Human
		IgG-ELISA	286	38.53 (0.32–0.44)	Human
		IgM-ELISA	88	1.12 (0.01–0.03)	Human

CI: 95% confidence interval, reported as proportion
ELISA: enzyme-linked immunosorbent assay
Ig: immunoglobulin
LAT: latex agglutination test

India

In adult humans, the prevalence of specific anti-*T. gondii* antibodies has varied in the reports from 5% to 80% (33). In the first nationwide serological survey in humans, a total of 23,090 serum samples were tested for the presence of IgM and IgG antibodies (34). Anti-*T. gondii* IgM antibodies, evidence of recent infection, were detected in 2% (n = 469) of the population and IgG antibodies, suggestive of longer-term infection, were detected in 24.3% (n = 5,611) of the population (34). Geographical variation in the seroprevalence was observed, with the highest rate of infection in the southern Indian terrorities and a lower rate of infection in northern regions of India (34). In another study, a total of 52 patients with congenital cataract were screened for anti-*T. gondii* antibodies. Specific anti-*T. gondii* IgM antibodies were detected in 3.8% of the patients (35).

In southern India (the Caimbatore region), out of 249 samples tested during an outbreak of ocular toxoplasmosis, 178 were seropositive (36). Similarly, congenital toxoplasmosis and toxoplasmosis in immunocompromised individuals, such as patients with acquired immunodeficiency syndrome (AIDS), has been reported in India. In domestic animals, the prevalence of *T. gondii* is higher in pigs, sheep and goats than in cattle, horses and riverine buffaloes (37, 38). Although bovids are important livestock species in India, limited data are available on the seroprevalence of *T. gondii* in cattle and buffaloes. However, seroprevalence values of 9.7–33.7% have been reported in goats, cattle, horses, pigs, sheep, buffaloes and dogs (39). In northern India, a serological survey of 3,761 animals, including rats, sheep, pigs, cattle, dogs, goats, horses, cats and buffaloes, using IHA, revealed a seroprevalence of 9.7%, 25.3%, 31.5%, 19.3%, 30.9%, 30.3%, 11.8%, 33.7% and 15.7%, respectively (38). In another study, Sharma *et al*. (2008) showed low seropositivity in the Indian Punjab in human and livestock populations (40). One possible explanation offered was that cats are not commonly kept as pets in the Indian Punjab (40). In Madras, the prevalence in poultry was recorded as 39.5% (41). In India, the seroprevalence in pigs was 31.5% (42). Overall, it has been reported that meat-producing animals such as sheep, goats and pigs are posing a threat, with a high prevalence of toxoplasmosis. The parasite is more prevalent in humid and damp areas than in dry and hot environmental conditions (43, 44). Several studies (45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98) conducted to determine the prevalence of *T. gondii* using various serological assays in India are summarised in Table III.

Nepal and other countries

Given the huge variety in the geography of Nepal, the prevalence varies by region. In the Eastern Terai community, 48.6% seroprevalence was reported by Rai *et al*. (1989) for *T. gondii* infection in humans (99). This seroprevalence was lower than in studies from western and eastern Nepal. Seroprevalence was significantly higher in Indo-Aryans than in Tibeto-Burmans (99). The Indo-Aryan community lives at lower altitudes and they are reported to consume more mutton and pork. The prevalence was significantly lower in the Tibeto-Burman community, probably because they are inhabitants of higher altitude regions and consume less mutton and pork (99, 100). Both pork and mutton play an important role in the transmission of human toxoplasmosis (101). Similarly, the prevalence in District Chitawan was significantly higher than in District Mustang, which may be due to their relatively recent human migration and changing meat-eating habits (100, 101, 102, 103). Although almost half of the population of Nepal is seropositive for *T. gondii*, only a single case of congenital toxoplasmosis has been reported (104). Rai *et al*. (2003) reported a case of ocular toxoplasmosis in Nepal, while a second case of

Table III
Seroprevalence of *Toxoplasma gondii* in various species of animal and humans in India

Location	Reference	Test	No. of sera	Prevalence (%) (CI)	Host
Varanasi	(45)	TORCH infection	380	19.43 (0.15–0.23)	Human
Nagaland	(46)	MDAT	106	42 (0.31–0.49)	Mithun (cattle)
Nagaland	(47)	MDAT	104	28 (0.19–0.36)	Mithun (cattle)
Haryana	(48)	IHA	122	6.63 (0.02–0.10)	Sheep
			79	11.52 (0.04–0.19)	Goat
Chennai	(49)	MDAT	99	100 (1.0–1.0)	Buffalo
India	(50)	IgG-ELISA	1,464	22.40 (0.20–0.24)	Human
(National study)	(51)	IFAT	2,075	7.74 (0.06–0.08)	Human
Lucknow	(52)	IgG-ELISA	493	58.83 (0.54–0.63)	Human
		IgM-ELISA		5 (0.03–0.07)	Human
Tamil Nadu	(53)	IgG-ELISA	350	13.14 (0.09–0.16)	Human
Lucknow	(54)	IgM-ELISA	60	8.32 (0.01–0.15)	Human
Chandigarh	(55)	IHA	7,222	16 (0.15–0.16)	Human
Aligarh	(56)	ELISA	48	35.44 (0.21–0.49)	Human
Indian Occupied Kashmir (Srinagar)	(57)	IgM-ELISA	285	49.47 (0.43–0.55)	Human
Andhra Pradesh	(58)	ELISA	210	49.52 (0.42–0.56)	Human
Maharashtra	(59)	IgG-ELISA	194	35.10 (0.28–0.41)	Human
			16	75 (0.53–0.96)	Human
Maharashtra	(60)	MAT	741	17.94 (0.16–0.21)	Chicken
New Delhi	(61)	ELISA	180	45 (0.37–0.52)	Human
North India	(62)	ELISA	503	41.73 (0.37–0.46)	Human
	(63)	IHA	107	19.64 (0.12–0.27)	Goat
			40	25 (0.11–0.38)	Sheep
			50	52 (0.38–0.65)	Cattle
Assam	(64)	IgG- & IgM-ELISA	180	41.63 (0.34–0.48)	Human
	(65)	IgG-ELISA	380	42.10 (0.37–0.48)	Human
		IgM-ELISA	380	10.52 (0.07–0.13)	
New Delhi	(66)	TORCH	120	11.63 (0.05–0.17)	Human
	(67)	IgM-ELISA	20	4 (0.04–0.12)	Human
		IgG-ELISA	20	55 (0.33–0.76)	
Karnataka	(68)	ELISA	1,000	20.32 (0.17–0.22)	Human
	(69)	TORCH	175	13.11 (0.08–0.18)	Human
Bombay	(70)	ELISA	165	30.92 (0.23–0.38)	Human
			89	67.83 (0.58–0.77)	Human
			25	28 (0.10–0.45)	Human
Bombay	(71)	IgG-ELISA	100	20 (0.12–0.27)	Human
		IgM-ELISA		25 (0.16–0.33)	
Bombay	(72)	ELISA	162	18.52 (0.12–0.24)	Human
			729	21.94 (0.18–0.24)	Human
Bombay	(73)	rSAG2-ELISA	60	50 (0.37–0.62)	Sheep
			63	41.26 (0.29–0.53)	Goat
			45	64.44 (0.50–0.78)	Cattle

Table III (cont.)

Location	Reference	Test	No. of sera	Prevalence (%) (CI)	Host
Bombay	(74)	MAT	61	40.98 (0.28–0.53)	Human
			118	47.46 (0.38–0.56)	Goat
			102	21.57 (0.13–0.29)	Cattle
			92	19.57 (0.11–0.27)	Buffalo
			91	53.85 (0.43–0.64)	Pig
			100	0	Chicken
Assam	(75)	ELISA	241	9.54 (0.05–0.13)	Human
Hyderabad	(76)	IgG-ELISA	867	29 (0.02–0.03)	Human
Khammam	(77)	IgG-ELISA	92	33.92 (0.26–0.32)	Human
Coimbatore	(78)	ELISA	248	48 (0.41–0.54)	Human
Pune	(79)	ELISA	251	34.26 (0.28–0.40)	Human
Chandigarh	(80)	IgG-ELISA	500	4.66 (0.02–0.06)	Human
		IgM-ELISA		5.43 (0.03–0.07)	
New Delhi	(81)	IFAT	1,036	2.99 (0.02–0.04)	Human
Chandigarh	(82)	IgG-ELISA	100	12 (0.05–0.18)	Human
		IgM-ELISA		6 (0.01–0.10)	
		IgA-ELISA		7 (0.02–0.12)	
New Delhi	(83)	HAT	258	12.42 (0.08–0.16)	Human
		SFMDT	132	23.48 (0.16–0.30)	Human
Chennai	(84)	IgG-ELISA	593	8.93 (0.06–0.11)	Human
		IgM-ELISA		1.74 (0.00–0.02)	
Chandigarh	(85)	IgG-ELISA	300	15.33 (0.11–0.19)	Human
Jodhpur	(86)	IgG-ELISA	385	17.23 (0.13–0.21)	Human
New Delhi	(87)	HAT	675	14 (0.11–0.16)	Human
Calcutta	(88)	LAT	248	23.79 (0.18–0.29)	Human
Haryana	(89)	LAT	64	28.12 (0.17–0.39)	Human
Calcutta	(90)	TST	574	17.07 (0.14–0.20)	Human
Visakhapatnam	(91)	IgG-ELISA	80	45 (0.34–0.55)	Human
		IgM-ELISA		20 (0.11–0.28)	
	(92)	IHA	94	56.3 (0.46–0.66)	Monkey
Chandigarh	(93)	IHA	243	19.3 (0.14–0.24)	Cattle
Haryana & Uttar Pradesh	(94)	HA	603	71 (0.67–0.74)	Equine
Jharnpani & Porba	(95)	ELISA	195	4.10 (0.01–0.06)	Mithun (cattle)
Calcutta	(96)	MAT	540	7.72 (0.05–0.10)	Human
Uttar Pradesh	(97)	IgG-ELISA	100	42 (0.32–0.51)	Human
		IgM-ELISA		32 (0.22–0.41)	Human
Calcutta	(98)	LAT	752	22.63 (0.19–0.25)	Human

CI: 95% confidence interval, reported as proportion
DAT: direct agglutination test
ELISA: enzyme-linked immunosorbent assay
HA: haemagglutination
IFAT: indirect fluorescent antibody test
Ig: immunoglobulin
IHA: indirect haemagglutination
LAT: latex agglutination test
MAT: modified agglutination test
MDAT: modified direct agglutination test
r SAG2–ELISA: recombinant surface antigen 2 ELISA
SFMDT: Sabin and Feldman's methylene blue dye test
TORCH: toxoplasmosis, other (syphilis, varicella-zoster, parvovirus B19), rubella, cytomegalovirus and herpes
TST: toxoplasma skin test

Table IV
Seroprevalence of *Toxoplasma gondii* in various species of animal and humans in Afghanistan, Bhutan, Nepal, Maldives and Sri Lanka

Location	Reference	Test	No.of sera	Prevalence (%) (CI)	Host
Nepal	(109)	ELISA	345	55.44 (0.50–0.60)	Human
		MLAT	191	3 (0.00–0.05)	Human
		IgM-ELISA	13	5 (0.06–0.16)	Human
Eastern Nepal	(110)	MLAT	656	42.12 (0.38–0.45)	Human
Central Nepal	(111)	IgM-ELISA & MLAT	778	48 (0.44–0.51)	Human
Western Nepal		IgM-ELISA & MLAT	459	49 (0.44–0.53)	
Achaham & Dang, Nepal	(112)	MLAT	404	65.34 (0.47–0.93)	Human
Kathmandu, Nepal	(113)	P/M	742	11.73 (0.09–0.14)	Pig
Kathmandu, Nepal	(114)	TORCH	276	13.74 (0.09–0.17)	Human
Afghanistan	(115)	M-IHA	435	73.34 (0.69–0.77)	Camel
				31.63 (0.27–0.36)	Goat
				20.42 (0.16–0.24)	Sheep
				20.43 (0.16–0.24)	Buffalo
				15.74 (0.12–0.19)	Cattle
Sri Lanka	(116)	MAT	45	32.00 (0.17–0.44)	Elephant
		MAT	8	0	Elephant
	(117)	IFAT	552	53 (0.48–0.57)	Human
Colombo, Sri Lanka	(118)	MAT	86	30.23 (0.20–0.39)	Cat
Kandy & Ambewela, Sri Lanka	(119)	MAT	139	22.32 (0.15–0.29)	Goat
Peradeniya, Sri Lanka	(120)	MAT	86	74.43 (0.65–0.83)	Dog
Peradeniya, Sri Lanka	(121)	MAT	100	39 (0.24–0.48)	Chicken
Polonnaruwa, Sri Lanka	(122)	MAT	170	12 (0.06–0.16)	Macaque
Peradeniya, Sri Lanka	(123)	IHA	16	25 (0.03–0.46)	Goat

CI: 95% confidence interval, reported as proportion
ELISA: enzyme-linked immunosorbent assay
IFAT: indirect fluorescent antibody test
Ig: immunoglobulin
IHA: indirect haemagglutination
MAT: modified agglutination test
M-IHA: micro modified indirect haemagglutination test
MLAT: micro-latex agglutination test
P/M: post-mortem
TORCH: toxoplasmosis, other (syphilis varicella-zoster, parvovirus B19, rubella, cytomegalovirus and herpes)

toxoplasmosis was associated with malignancy in a woman with a history of obstetric disease (105).

The prevalence of toxoplasmosis in livestock in Nepal has not been investigated. Similarly, in Afghanistan, Maldives and Bhutan, only one citation related to *T. gondii* infection in domestic animals was found, and no information regarding *T. gondii* infection in humans was available. Additionally, no published papers were obtained from the databases that describe *T. gondii* infection in Maldives and Bhutan but the pathogen is likely to be present because toxoplasmosis has been reported in surrounding areas in India, including Arunchal Pradesh, Assam and Nagaland, in free-ranging and captive mithuns (*Bos frontalis*). Several studies of the prevalence of toxoplasmosis in Sri Lanka (formerly Ceylon) have been published: the presence of anti-*T. gondii* antibodies was reported in rodents (106), dogs, cats (107) and humans (108). Other studies (109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123) of the seroprevalence of toxoplasmosis in various species in Afghanistan, Bhutan, Nepal, Maldives and Sri Lanka are summarised in Table IV.

Conclusions

This paper reviews seroprevalence studies based on immunodiagnostics. The studies reviewed anti-*T. gondii* antibodies detected in animals, birds and humans in South

Asian countries. The data will help researchers, physicians and veterinarians to better understand the transmission dynamics of toxoplasmosis, which may lead to improved control and prevention of the negative impact of *T. gondii* infection on human health and livestock production in South Asian countries. To the authors' knowledge, no South Asian countries monitor *T. gondii* infection. However, only a few countries in the world regularly report *T. gondii* in humans and even fewer countries monitor *T. gondii* infection in other animals. The identification of environmental risk factors for the transmission of *T. gondii* requires further study. Additionally, there is a need to compare and evaluate different diagnostic techniques to better understand the genotype of the parasite and the source of *T. gondii* infection, which may help to interrupt the transmission of *T. gondii*.

Séroprévalence de *Toxoplasma gondii* dans les pays d'Asie du Sud

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Résumé

La toxoplasmose est une maladie cosmopolite causée par *Toxoplasma gondii*, un protozoaire unicellulaire obligatoire appartenant au phylum des Apicomplexa. Du fait de sa distribution géographique, pratiquement toutes les espèces animales sont exposées, ainsi que l'homme. Les auteurs ont fait une recherche dans plusieurs bases de données, dont Google Scholar, PubMed et Science Direct, sur les articles consacrés à *T. gondii* dans les pays d'Asie du Sud, qui a permis d'extraire un total de 113 articles présentant toutes les caractéristiques d'une enquête sérologique. L'infection par *Toxoplasma gondii* chez l'homme et chez les animaux d'élevage a fait l'objet de plusieurs enquêtes recourant à divers tests sérologiques. Ces études font état d'un total de 14 431 échantillons prélevés d'animaux domestiques et de 53 899 échantillons prélevés chez l'homme, qui ont été soumis à une épreuve de détection d'anticorps dirigés contre *T. gondii* dans les pays d'Asie du Sud. Les études ont couvert les espèces suivantes : bovins (*n* = 1 981), chèvres (*n* = 3 285), buffles (*n* = 1 695), moutons (*n* = 1 747), chats (*n* = 1 480), chameaux (*n* = 435), éléphants (*n* = 45), porcs (*n* = 920), chiens (*n* = 1 604) et volailles (*n* = 1 206). Ce panorama exhaustif sera utile aux biologistes, aux intervenants en santé publique, aux médecins et aux vétérinaires et permettra de mieux appréhender la distribution de *T. gondii* dans la région. Ces connaissances contribueront à concevoir et à appliquer des mesures de prévention efficaces afin de mieux gérer cette zoonose dans les pays d'Asie du Sud.

Mots-clés

Inde – Pakistan – Prévalence sérologique – Secrétariat de l'Association sud-asiatique de coopération régionale – *Toxoplasma gondii* – Toxoplasmose.

Seroprevalencia de *Toxoplasma gondii* en los países de Asia meridional

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Resumen

La toxoplasmosis es una zoonosis cosmopolita causada por un protozoo, parásito intracelular obligado, del grupo de los apicomplejos: *Toxoplasma gondii*. Por su amplia distribución geográfica, constituye una amenaza para casi todos los animales, incluido el ser humano. Tras indagar en bases de datos de publicaciones (Google Scholar, PubMed y Science Direct) en busca de información relacionada con la presencia de *T. gondii* en los países del meridión asiático, los autores encontraron un total de 113 artículos que cumplían el criterio de dar cuenta de investigaciones sobre la seroprevalencia. Para estudiar la infección por *Toxoplasma gondii* en el ganado y el ser humano se habían empleado diversas pruebas serológicas. En el conjunto de esos estudios, que cubrían todos los países de Asia meridional, se habían analizado un total de 14.431 muestras de animales domésticos y 53.899 muestras humanas para detectar anticuerpos contra *T. gondii*. Los animales analizados eran: ganado vacuno (*n* = 1.981), cabras (*n* = 3.285), búfalos (*n* = 1.695), ovejas (*n* = 1.747), gatos (*n* = 1.480), camellos (*n* = 435), elefantes (n = 45), cerdos (*n* = 920), perros (*n* = 1.604) y aves de corral (*n* = 1.206). Este repaso general, que resultará útil a biólogos, agentes de salud pública, médicos y veterinarios, permite conocer mejor la distribución de *T. gondii* en la región, lo que además será de ayuda a la hora de determinar y aplicar medidas eficaces de prevención con objeto de controlar más eficazmente esta zoonosis en los países de Asia meridional.

Palabras clave

Asociación del Asia Meridional para la Cooperación Regional – India – Pakistán – Seroprevalencia – *Toxoplasma gondii* – Toxoplasmosis.

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