Toxoplasma gondii seroprevalence studies on humans and animals in Africa

Hammond-Aryee K, MSc, Student, Division of Molecular Biology and Human Genetics, Stellenbosch University
Esser M, MMed Paed(Rheum)
Head, NHLS Immunology Unit, Tygerberg; Division of Medical Microbiology, Department of Pathology, Stellenbosch University
Coordianator, Pediatrics Clinical Immunology and Rheumatology Clinics, Department of Pediatrics and Child Health, Tygerberg Hospital
Principal Investigator, Primary Immunodeficiency Register of South Africa
Van Helden PD, Professor and Head, Division of Molecular Biology and Human Genetics, Stellenbosch University
Correspondence to: Kenneth Hammond-Aryee, e-mail: kenhammond@sun.ac.za
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Abstract

Background: Toxoplasmosis is a disease caused by *Toxoplasma gondii,* which can infect nearly all mammalian and avian species. Approximately 25% of the global human population is thought to be infected. Interest in toxoplasmosis has surged since it was discovered that with the onset of acquired immune deficiency syndrome, acute toxoplasmosis could induce cranial calcification. The ensuing encephalitis can be fatal. The African human immunodeficiency virus (HIV) epidemic, increasing levels of other immunosuppressive infections (such as tuberculosis), poor sanitation practices and lack of monitoring of at-risk populations point to a predicament that may be underrated.

Objective: The objective was to review the available body of research on the seroepidemiology of *T. gondii* in Africa, in order to establish existing prevalence trends and to draw attention to available information on the pathogen in Africa.

Method: The National Center for Biotechnology Information, Google Scholar and ToxoDB databases were searched for peer-reviewed articles that focus specifically on seroprevalence studies of *T. gondii* in Africa up until the 2012 year end.

Results: Seroprevalence rates on the continent are high in humans and animals. There is a geographical trend of decreasing seroprevalence from the northern to the southern, and from the western to the eastern, regions of the continent. Most seroprevalence studies on humans were reported between 1981 and 2000.

Conclusion: There is a need for further and more consolidated information on the prevalence of *T. gondii* in Africa, in order to address morbidity and mortality from opportunistic but treatable diseases, such as toxoplasmosis in the ongoing HIV pandemic, and to improve the lives of the African population.

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Introduction

Over the years, there have been scattered, sporadic (and usually small) studies on *Toxoplasma gondii* seroprevalence in the African continent, and this is unfortunate. The current human immunodeficiency virus (HIV) epidemic on the continent, increasing levels of other immunosuppressive infections (such as tuberculosis), poor sanitation and hygiene practices, inadequate veterinary services, and high levels of poverty, coupled with lack of proactive monitoring of at-risk populations and reporting of these investigations, is part of the challenge. The absence of public health schemes to manage the spread of this pathogen places African populations at risk of ongoing and possibly increasing incidence and prevalence, as well as a corresponding increase in mortality and morbidity due to toxoplasmosis. This may be the case in particular for toxoplasma encephalitis, which is currently a leading cause of mortality and morbidity in HIV patients who have progressed to full blown acquired immune deficiency syndrome, (AIDS) who and are not on highly active antiretroviral therapy in Africa.[1]

There have been few studies on seroprevalence rates of *T. gondii* in animal species on the African continent. Given the large numbers of domestic and wild animals in Africa, as well as the lack of sophisticated animal husbandry, there is a high likelihood of transmission and hence mobility of the pathogen from animal hosts to human hosts, together with an increased risk of morbidity and mortality.

Method

A literature search of the National Centre for Biotechnology Information, Pubmed, Google Scholar and ToxoDB databases was performed, with the keywords *"Toxoplasma gondii* seroprevalence studies in Africa". This was then followed by another search using the keywords "toxoplasmosis in Africa". A further search was carried out on the references of the selected publications, as well

Table I: *Toxoplasma gondii* seroprevalence studies in immunocompetent individuals in Africa (human)

References	Country (region)	Sample size (absolute numbers)	Seroprevalence % (95% CI)	Year
Mason, Jacobs and Fripp[2]	South Africa (Transvaal)	806	37	1974
Jacobs and Mason[3]	South Africa (nationwide)	3 379	20	1978
Zardi, Adorisio, Harare and Nuti[4]	Somalia	356	43	1980
Griffin and Williams[5]	Kenya	322	42	1983
Zumla et al[6]	Zambia	189	11	1991
Zumla et al[6]	Uganda	93	27	1991
Abdel-Hameed[7]	Sudan (Gazira)	368	41.7	1991
Giebre-Xabier et al[8]	Ethiopia (nationwide)	1 016	74.4	1993
Julvez et al[9]	Niger (Niamey)	371	18	1996
Bouratbine et al[10]	Tunisia	564	58.4	2001
Maïga, Kiemtoré and Tounkara[11]	Mali (Bamako)		21	2001
Hussein et al[12]	Egypt (Qualyobia)	152	57.9	2001
Uneke, Duhlinska, Njoku and Ngwu[13]	Nigeria	144	20.8	2005
Fan et al[14]	Sao Tome and Principe (nationwide)	161	74.5	2007
Elsheikha et al[15]	Egypt	260	59.6	2009
Swai and Schoonman[16]	Tanzania (Tanga)	199	45.7	2009
Sellami et al[17]	Tunisia (Sfax)	1 691	13.7	2010
Kistiah et al[18]	South Africa (Gauteng)	497	6.4	2011
Ouologuem et al[19]	Mali (Kolle)	760	27	2012

CI: confidence interval

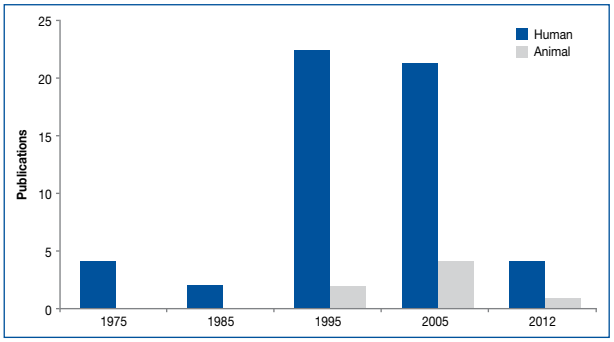

Figure 1: Number of seroprevalence studies per decade [1971-1980, 1981-1990, 1991-2000, 2001-2010 and 2011- 2012 (incomplete decade)]

as on infectious diseases congress reports and abstract compilations. Publications were selected using the year end 2012 as a cut-off.

Confidence intervals pertaining to seroprevalence rates for each reported study were derived from the corresponding publication, where available.

Results

Monitoring and reporting on *T. gondii* seroprevalence in Africa has been less than adequate since the first report was published in 1971. Figure 1 depicts the number of *T. gondii* seroprevalence studies conducted in both human and animal cohorts in Africa up until 2012. The first reported study was in 1971. The highest number of studies reported in the literature was between 1991 and 2000, and 2001 and 2011, for both human and animal cohorts.

The seroprevalence surveys that were conducted did not focus on comparable cohorts over time. Therefore, caution needs to be exercised when interpreting the data. The data presented in Tables I, II and III (and Table IV for animals), classify the investigations according to the locations in which they were conducted, the sample size of the study, the year in which the study was conducted in chronological order, the level of seroprevalence as a percentage, as well as the type of population investigated.

Discussion

Toxoplasmosis in immunocompetent individuals

Studies on *T. gondii* in asymptomatic individuals in Africa are limited in number, and none of the countries follow a systematic planned pattern of reporting (Table I). Seroprevalence rates range from 6.4-74.5%, with a median of 37%. The first reported study was from South Africa, by Mason, Jacobs and Fripp[2] in 1974, whereby a seroprevalence of 20% was found in a cohort comprising black, white, Indian and coloured immunocompetent individuals. Since then, other studies, the most recent being Kistiah et al,[18] have reported a 6.4% seroprevalence in a generalised cohort, but it was biased towards pregnant women. Swai and Schoonman[16] reported seroprevalence of 45.7% in a Tanzanian cohort predominantly comprising immunocompetent individuals who were exposed to livestock via their occupation (abattoir workers, livestock keepers and animal health workers). Zumla et al[6] reported seroprevalence of 27% in Uganda, while Griffin and Williams[5] reported seroprevalence of 42% in Kenya. Further north,

Table II: *Toxoplasma gondii* seroprevalence studies in women of reproductive age in Africa (human)

References	Country (region)	Sample size (absolute numbers)	Seroprevalence % (95% CI)	Year
Brink, de Wet and van Rensburg[20]	South Africa (Bloemfontein)	600	3	1975
Dumas et al[21]	Ivory Coast	> 2 000	37.2-70	1989
Ndumbe et al[22]	Cameroon (Yaounde)	192	77.1	1992
Schneider, Schutte and Bommer[23]	South Africa (KwaZulu-Natal)		31.3	1992
Faye et al[24]	Senegal (Dakar)	353	40.2	1993
Diallo et al[25]	Senegal (Dakar)	720	40.3	1993
Rodier et al[26]	Benin (Coutonou)	211	53.6	1995
Lelong et al[27]	Madagascar (Antanavario)	599	83.5	1995
Doehring et al[28]	Tanzania (Dar es Salaam)	849	35	1995
Onadeko, Joynson, Payne and Francis[29]	Nigeria		75.4	1996
Nabias et al[30]	Gabon (Franceville)	767	71.2	1998
Hussein et al[12]	Egypt (Qualyobia)	31	58.1	2001
Hussein et al[12]	Egypt (Qualyobia)	38	44.7	2001
Elnahas et al[31]	Sudan (Khartoum and Omdurman)	487	34.1	2003
Adou-Bryn et al[32]	Ivory Coast (Yopougon)	1 025	60	2004
Simpore et al[33]	Burkina Faso (Ougadougou)	336	25.3	2006
El Mansouri et al[34]	Morroco (Rabat)	2 456	50.6	2007
Hung et al[35]	Sao Tome and Principe (nationwide)	499	75.2	2007
Ghoneim et al[36]	Egypt (El Fayoum)	68	20.45	2009
Ghoneim et al[36]	Egypt (El Fayoum)	20	17.9	2009
Sellami et al[17]	Tunisia (Sfax)	40 566	39.3	2012
Kistiah et al[18]	South Africa (Gauteng)	376	12.8	2011

CI: confidence interval

Abdel-Hameed[7] reported a seroprevalence rate of 41.7% in Sudan, while Elsheikha et al[15] and Bouratbine et al[10] reported seroprevalence of 59.6% and 58.4%, in Egypt and Tunisia, respectively. The highest seroprevalence reported in the west of Africa was 74.5% by Fan et al[14] in Sao Tome and Principe, and the lowest of 20.8% by Uneke, Duhlinska, Njoku and Ngwu[13] in Nigeria. Prevalence rates in northern Africa followed a decreasing trend over time from 58.4% in 2001 to 13.7% in 2010. There was also a decreasing trend from 37% in 1974 to 6.4% in 2011 in southern Africa, and an increasing trend from 21% in 2001 to 27% in 2012 in western Africa. There was also an increasing trend in Eastern Africa from 43% in 1980 to 45.7% in 2009.

Women of reproductive age and pregnant women

A number of studies have been conducted on the risk group of women of reproductive age and pregnant women. Most of the studies were carried out in the west and north of Africa. The south and the east are under-represented in studies (Table II). Seroprevalence rates range from 12.8% to 83.5%, with a median of 42.5%. High rates of seroprevalence have been reported in the west of Africa, where Ndumbe et al[22] reported prevalence of 77.1% in Cameroon, and Hung et al[35] 75.2% prevalence in Sao Tome and Principe. The highest rate on the continent was recorded in the southern part of Madagascar by Lelong et al,[27] where seroprevalence of 83.5% was reported. The lowest seroprevalence was reported in South Africa, when Kistiah et al[18] reported prevalence of 12.8%. Seroprevalence rates in North Africa have generally been high, with the highest being 58.1% in Egypt, reported by Hussein et al.[12]

Seroprevalence rates in northern Africa showed a decreasing trend over time from 58.1% in 2001 to 39.3% in 2012. There was an increasing trend in southern Africa from 3% in 1975 to 12.8% in 2011, while there was an increasing trend in seroprevalence from 70% in 1989 to 75% in 2007 in western Africa. Seroprevalence rates are generally high in women of reproductive age. It is interesting to note that such high levels are comparable to those reported in similar South American cohorts.[58]

Human immunodeficiency virus- and acquired immune deficiency syndrome-related toxoplasmosis

With the advent of the HIV-AIDS era, the significance of toxoplasmosis was realised, resulting in an increase in the number of seroprevalence investigations, particularly in HIV-positive, compared to HIV-negative, populations (Table III). Seroprevalence rates range from 4-80%, with a median of 36.35%. The highest seroprevalence of *T. gondii*

Table III: *Toxoplasma gondii* seroprevalence studies in individuals with human immunodeficiency virus and acquired immune deficiency syndrome in Africa (human)

References	Country (region)	Sample size (absolute numbers)	Seroprevalence % (95% CI)	Year
Zumla et al[6]	Zambia	187	4	1991
Zumla et al[6]	Uganda	186	34	1991
Brindle, Holliman, Gilks and Waiyaki[37]	Kenya (Nairobi)	94	54	1991
Lucas et al[38]	Ivory Coast	294	21	1993
Ledru et al[39]	Burkina Faso	45	55.5	1995
Ledru et al[39]	Burkina Faso	50	52	1995
Ledru et al[39]	Burkina Faso	40	62.5	1995
Arenas et al[40]	South Africa (Western Cape)	327	43	1995
Arenas et al[40]	South Africa (Western Cape)	91	26	1995
Arenas et al[40]	South Africa (Western Cape)	61	15	1995
Woldemichael et al[41]	Ethiopia (Addis Ababa)	170	80	1998
Sonnenberg, Silber and Jentsch[42]	South Africa (KwaZulu-Natal)		24.6	1998
Millogo et al[43]	Burkina Faso (Bobo-Dioulasso)	1 828	25.4	2000
Maïga, Kiemtoré and Tounkara[11]	Mali (Bamako)		60	2001
Uneke, Duhlinska, Njoku and Ngwu[13]	Nigeria	219	38.8	2005
Lindström et al[1]	Uganda (Malago)	130	54	2006
Hari, Modi, Mochan and Modi[44]	South Africa (Gauteng)	307	8	2007
Sitoe et al[45]	Mozambique	150	18.7	2010
Sellami et al[17]	Tunisia (Sfax)	78	11.7	2010
Akanmu, Osunkalu, Ofomah and Olowoselu[46]	Nigeria (Lagos)	380	54	2010
Besong and Mathomu[47]	South Africa (north eastern)	160	18.1	2010
Kistiah et al[18]	South Africa (Gauteng)	376	9.8	2011
Addebbous et al[48]	Morroco (Marrakesh)	95	62.1	2012
Ogina, Onyemelukwe, Musa and Obiako[49]	Nigeria (northern)	219	38.7	2013

CI: confidence interval

Table IV: *Toxoplasma gondii* seroprevalence studies in Africa (animals)

References	Country (region)	Sample size (absolute numbers)	Seroprevalence % (95% CI)	Year
Cheadle, Spencer and Byron[50]	South Africa (various)	68	74	1999
Van der Puije et al[51]	Ghana (nationwide)	732	33.2	2000
Van der Puije et al[51]	Ghana (nationwide)	526	26.8	2000
Penzhorn et al[52]	Botwana (Chobe)	53	92	2002
Penzhorn et al[52]	Namibia (Windhoek)	21	100	2002
Penzhorn et al[52]	South Africa (Kruger Park)	12	100	2002
Penzhorn et al[52]	South Africa (Hluhluwe-imfolozi Park)	30	100	2002
Penzhorn et al[52]	Botwana (Chobe)	1	100	2002
Penzhorn et al[52]	South Africa (Kruger Park)	7	86	2002
Hove, Lind and Mukaratirwa[53]	Zimbabwe (nationwide)	335	67.9	2005
Samra, McCrindle, Penzhorn and Cenci-Goga[54]	South Africa (nationwide)	600	4.3	2007
Dubey et al[55]	Ghana (Kumasi)	64	64.1	2008
Ghoneim et al[36]	Egypt (El Fayoum)	62	98.4	2009
Ghoneim et al[36]	Egypt (El Fayoum)	24	41.7	2009
Boughattas et al[56]	Tunisia (nationwide)	158	17.7	2011

CI: confidence interval

in HIV patients was reported in Ethiopia by Woldemichael et al,[41] with 80% seroprevalence in 170 patients tested. The average seroprevalence figure was 52% in west Africa, ranging from 62.5% in Burkina Faso, to 21% in Ivory Coast, by Ledru et al[39] and Lucas et al,[38] respectively. The lowest rate on the continent, 4%, was recorded in Zambia by Zumla et al.[6] Lindström et al[1] and Brindle, Holliman, Gilks and Waiyaki[37] reported seroprevalence rates of 54% in Uganda and Kenya, respectively. Only one study was reported from the north of Africa. It was by Addebbous et al[48] in Morocco, where a seroprevalence rate of 62.5% was provided. Seroprevalence studies in the southern part of Africa have mostly derived from South Africa. Sonnenberg, Silber and Jentsch[42] reported the highest seroprevalence rate of 24.6% in KwaZulu-Natal province. The lowest rate of 8% was reported in Gauteng province by Hari, Modi, Mochan and Modi.[44]Seroprevalence rates follow an increasing trend in northern Africa from 11.7% in 2010 to 62.1% in 2012. There was also an increasing trend in southern Africa from 4% in 1991 to 9.8% in 2011, in western Africa of 21% in 1993 to 38.2% in 2013, and in eastern Africa from 34% in 1991 to 54% in 2006.

Toxoplasmosis in animal species

Most of the studies reported to date have been carried out in the southern part of Africa (Table IV) where Samra, McCrindle, Penzhorn and Cenci-Goga[54] demonstrated seroprevalence of 4.5% in a 600 sheep cohort in South Africa. In Zimbabwe, Hove, Lind and Mukaratirwa[53] reported seroprevalence of 67.9% in 335 investigated sheep and goats. Cheadle, Spencer and Byron[50] reported seroprevalence of 74% in wild felids in South Africa, and Penzhorn et al[52] seroprevalence of 100% in lions from the Kruger National Park and Hluhluwe-imfolozi Park in South Africa, and 92% in lions from Botswana (Chobe National Park). *T. gondii* antibodies have also been detected in felids in the wild, and in chinchillas, ferrets, cheetah, a dog and leopards in southern Africa. In Ghana, Dubey et al[55] reported seroprevalence of 64.1% in free-range chickens, while seroprevalence of 38.2% in sheep, and 26.8% in goats, respectively, was reported by Van der Puije et al.[51] There have been no documented reports on seroprevalence in animals from the eastern part of Africa, but in Egypt, Ghoneim et al[36] reported seroprevalence of 98.4% in sheep. Reported seroprevalence rates range from 4.3% to 100%, with a median of 74%. Seroprevalence rates show a decreasing trend over time in northern Africa from 98.4% in 2009 to 17.7% in 2011. There was also a decreasing trend from 74% in 1999 to 43% in 2007 in southern Africa, and an increasing trend in western Africa from 33.2% in 2000 to 64.1% in 2008.

Conclusion

Overall, seroprevalence rates on the continent are very high in both human and animal populations. The data suggest a geographical trend, with decreasing seroprevalence from the northern to the southern, and from the western to the eastern, regions of the continent. Most seroprevalence studies on humans were reported between 1981 and 2000. The majority of the serosurveys were carried out on immunocompetent individuals, followed by women of reproductive age, and then on HIV/AID patients. Only a limited number of these studies took into consideration risk factors that are most important for infection with the pathogen. Thus, very few surveys have been performed with regard to animals in order to understand zoonotic risk. If risk factors from studies in other parts of the world are taken into account, it is possible to infer that large numbers of people on the African continent, such as pregnant women and HIV-positive individuals, are at risk of a primary infection or reactivation of a chronic infection. Seroprevalence rates generally demonstrated decreasing trends over time in northern, southern and eastern Africa in all the groups studied. A noteworthy exception was western Africa, where seroprevalence rates showed an increasing trend over time in all the groups, and in HIV-AIDS patient cohorts where prevalence rates showed an increasing trend over time in all the regions. These data suggest that overall seroprevalence rates follow an increasing gradient from relatively low prevalence in the southern part of the continent, to moderate to high in the west and east, and highest in the northern part of Africa. These findings must be taken seriously, and further structured investigations carried out to ascertain the causative factors and action required to mitigate their effects.

This information is important because even if only 5% of individuals are infected and present with clinical manifestations, the implications for the burden of disease in Africa, with a population approaching one billion, are staggering. Given that toxoplasmosis is associated with clinical manifestation in HIV-positive individuals, and given that reactivation of a latent infection can be life-threatening[58] owing to a number of factors, including increased immunosuppression and encephalitis,[49] it is possible that this disease may be a neglected driver for clinical diseases such as tuberculosis, or other chronic or infectious illnesses that might otherwise not manifest themselves. In this case, the burden of disease and disability-adjusted life year cost to Africa from toxoplasmosis is considerable and deserves attention.

Conflict of interest

The authors declare no conflict of interest.

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