A REVIEW ON TOXOPLASMOSIS IN HUMANS AND ANIMALS FROM KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

Toxoplasmosis is a zoonotic disease caused by a protozoan parasite, *Toxoplasma gondii* which infects all warm blooded animals including humans. Three forms of *T. gondii* exist i.e. tachyzoite, bradyzoite (an intermediate host) and oocyte (in cats). This study was reported to review the prevalence of toxoplasmosis in Khyber Pakhtunkhwa. For this study past 10 years data (2010-2020) was reviewed in humans and animals of Khyber Pakhtunkhwa. Data was reviewed for in humans (both male and female) of different age groups and women of different trimesters. Research papers were also reviewed for the prevalence of this disease in following animals (sheep, goats, buffaloes, cows and chickens) of KPK. The prevalence was higher in the 1st trimester as compared to 2nd and 3rd trimesters. Highest prevalence was recorded in the age of 30-55 years while low prevalence was recorded in the younger age group (15-30 years). In animals this disease was more prevalent in the sheep and goats and less prevalent in the chickens. According to sex wise prevalence, the rate of toxoplasmosis was high in female

gender of sheep, goat, buffalo, cow and caged chicken as compared to male gender of these animals. It is recommended that this review should be extended to other provinces of Pakistan to know the exact status of toxoplasmosis in Pakistan.

Introduction

A majority of rising communicable diseases in humans are zoonotic diseases (1). *Toxoplasma gondii* is the leading cause of toxoplasmosis, which is a zoonotic disease with worldwide prevalence (2). One third of human population is infected by *T.gondii* globally (3). It is believed that the parasite has ability to infect all warm blooded animals worldwide (4). Infertility in domestic ruminants is also caused by this protozoan parasite (5).

The disease is asymptomatic in case of acute infection; in immune-competent hosts 80% of primary *T. gondii* infections are asymptomatic. Following primary infection, *T. gondii* establishes suppressed infection, tachyzoite convert into the inactive bradyzoite form inside the tissue cysts. *T. gondii* primary infections are controlled by host immune system but when the cyst resides in eye region, it is activated and cause ocular toxoplasmosis, leading to vision loss. Toxoplasma encephalitis is caused in severe case which consists of multiple discrete brain lesions. Trans-placental toxoplasmosis (congenital toxoplasmosis) may also occur. In congenital toxoplasmosis mostly brain and eye becomes infected however extra-cranial pathology also occurs in up to half of neonates (6). Disease may be ocular toxoplasmosis (infection of the eye) and congenital toxoplasmosis. Toxoplasmosis acquired in the immune-competent patient is mainly asymptomatic while toxoplasmosis acquired or reactivated toxoplasmosis in the immune-deficient (immune system not fully functioning) patient is symptomatic (symptoms like

headache, fever, muscle pain and respiratory tract infection that last for more than a month appear) (7).

Tissue cysts (cysts that contain bradyzoites) sometime reside near or in the eye tissue that cause ocular toxoplasmosis. In this case patient loses vision because of damage to retinal tissues by *T. gondii*. Blurred vision or loss of vision is caused by destruction of Macula tissues in the eye. Lesions develop on the retina (8). Vertical trans-placental transmission leads to congenital toxoplasmosis (CT), in which tacyzoite form of *T. gondii*, transfer from infected mother to fetus through placenta. In case of CT severe infection occurs in newborn baby at time of birth or later in life. Abnormalities like low mental development, encephalitis, vision problem and liver disability to perform function (9).

Cat is the definitive host of this parasite. The life cycle of this parasite consist of three stages tachyzoite, bradyzoite and oocyte which consist of sporozoites. Tachyzoite is fast dividing form responsible for rapid spread of the parasite between cells and tissues and appearance of symptoms in patient. Bradyzoite is slow dividing form that exists dormant in tissue cyst unless the individual becomes severely immune compromised. Oocytes are shed in cat feces which becomes risk factor for the spread of diseases (10).

The sexual cycle occur in the gastrointestinal tract of cats, cats infected when ingest tissue cysts containing bradyzoite (11). Oocyte rupture epithelium and release, finally shed in cat feces (12).

In case of CT infants develop symptoms at birth or later in life. There is more chance of miscarriage when mother is infected with *T. gondii,* fetus with *T. gondii* may lose vision, development retardation and some other abnormalities of brain occur.

Keeping in view the importance of this parasite, the aim of this study is to find out the age wise prevalence of toxoplasmosis in humans (both male and female), trimester wise prevalence in pregnant women, and sex wise prevalence in animals of Khyber Pakhtunkhwa.

Prevalence of Toxoplasmosis in humans of Khyber Pakhtunkhwa

A study was reported by Khan et al., (13) to check the prevalence of toxoplasmosis in Kohat. A total of 180 blood samples were collected. Out of the total obtained samples 14.4% (n=26) sample were found to be seropositive for IgM while 85.5% (n=154) were found IgM seronegative for Toxoplasmosis. The prevalence was high in first trimester i.e. about 20% (n= 12/60). Another study was designed to check the prevalence of *T. gondii* in relation with age, pregnancy, abortion, its occurrence, transmission and diagnosis. A total of 420 serum samples were collected from human (females) Malakand Agency, and Khyber Pakhtunkhwa, Pakistan. Out of 420, 276 females were infected. Highest rate of infection was about 63.77%, found in the age group of 21-30 years where as low prevalence was 0.72%, found in the age group of 41-50 years and no patients were above 50 years. Out of 276 positive females, 51.44% (142) had contact with cats and 48.55% (134) females had no contact. The results showed that there was no significant difference between the females that had contact with cats and those who had no contact. It has been suggested that contacts with cats may have no importance in transmission of toxoplasmosis (14).

A research was conducted by Hussain Shah et al. (15) to find out the prevalence of toxoplasmosis in humans of Chitral. Total of 300 samples were collected, the duration of collecting data was July-December, 2013. Out of 300 tested samples, 74 were found infected

with *T. gondii* showing an overall 24.7% prevalence. Based on age, all the participants were divided into two groups one comprised of women aged up to 25 and group two above 25 years.

Infection rate was higher in women aged 25 years, infection rate was almost double (33.1%) in women from Upper Chitral, rural areas than from Lower Chitral, i.e. urban areas 18.8% and in women rearing animals in the home 27.2% compared to those having no animals in homes 13.0%. From the result it was found that the prevalence was mostly related to the place where they live and the age of women.

A study was conducted by Shah et al. (16) to check the sero prevalence of inborn Toxoplasmosis in District Swabi, KPK. Data was collected from March to June 2015. Blood samples of 100 pregnant women were taken from maternity ward at District Head Quarter Hospital Swabi and analyzed for congenital toxoplasmosis. Among 100 pregnant women 12% were reported positive for T. gondii. It was found that women at the third trimester were at greater risk to be positive for congenital toxoplasmosis. The prevalence was about 6.45% (n=2), 8.82% (n=3) and 20% (n=7) in the 1st, 2nd and 3rd trimester respectively. According to age wise distribution of toxoplasmosis, the females were divided into three age groups i.e. from 17-23 years old with prevalence about 18%, second age group was 24-30 years with prevalence of 2% and the third age group was from 31-36 years old in which 25% prevalence was recorded. Regarding age factor, women at the age of 31-36 showed high prevalence i.e. 25% for toxoplasmosis in District Swabi.

Another study was reported to determine the seroprevalence of *T. gondii* in pregnant women of District Swat, KP, and Pakistan. A total 360 blood samples collected from pregnant women of

Swat and were analyzed in which 170 out of 360 were infected. From the result it was found that the prevalence was 47.2%. In association of age with toxoplasmosis the population was divided into two groups i.e. from 18-25 years and 26-33 years. The highest seropositivity i.e. about 54.7% was observed among individual of the age group 26-33 years as compared to 38.8% amongst the age group of 18-25 years. A significant difference was observed in seroprevalence between educated 22.07% and uneducated 66.01% females. As for the trimester wise relation of this disease, at the 1st trimester prevalence was 61.7%, while at the 2nd and 3rd trimester the prevalence was 58.4% and 27.7% respectively (17).

A research was reported by Faisal et al. (18) in District Charsadda. Total of 200 samples collected from the pregnant women population in 3 tehsils of the district Charsadda. The duration of the sampling was from September, 2017 to December, 2017. Women of various age were included, the age varied from 15 to 55 years. Result show that 65.5% were negative 34.5% was detected positive for the parasite. Women with the age groups 15–25 years showed a moderate infection of about 23.63%, highly infected women were in the age of 26–40 years with a total prevalence of 54.55% of the total studied population while low prevalence of the parasite was recorded in the age group 41–55 years i.e. about 21.87%.

A study was conducted by Khan et al. (19) in order to find Sero-positivity of anti *T. gondii* IgG, IgM and IgG+IgM in relation to participants' age. Total of 600 samples were collected in which 17.5% (n=105) were infected. Highest IgG sero-prevalence 24% was observed in 36-45 years old group. Whereas the highest sero-positivity of IgM was 14% in the oldest group 61-75 years old. There was a difference in sero-positivity for IgG+IgM among the different age groups. In

different age groups occurrence of toxoplasmosis varies. Lowest sero-prevalence i.e. 10% was observed in the age below 15 years, while highest prevalence i.e. 29.41% was recorded in age of 31-45 years. Age group 61-75 years also showed nearly same higher prevalence 28.57% of human toxoplasmosis.

A study was conducted to determine the seroprevalence of *T. gondii* among male population in District Charsadda, KPK. There 300 random samples were collected from the male population, the age of the participants varied from 15 to 75 years. From the result it was clear that 21% (63 out of 300 samples) were found positive for the parasite. An important relationship was determined between the infection and age group in the population. From the results, it was concluded that the infection was more prevalent in the age group of 46-55 years with 35.41% and less prevalent in age 15-25 years with 8.33% (20)

Trimester wise prevalence of toxoplasmosis in pregnant women

The overall prevalence of toxoplasmosis at trimester wise in pregnant women was 32.5% (208 out of 640). Total prevalence in the 1 trimester was 40.8% (85), 36% (75) at the 2nd trimester and 23% (48) at the 3rd trimester. Highest prevalence i.e. 40.8% was recorded at the first trimester and low prevalence about 23% at the 3rd trimester (Table 1).

Age wise prevalence of toxoplasmosis in humans of KPK

Age wise prevalence of toxoplasmosis in humans, age groups of humans were divided into various groups in which highest prevalence was recorded in 30-55 years and low prevalence in

the younger age (15-30 years), however there were exception in case of (14, 15) who found low prevalence in the higher age group (Table 2).

Prevalence of toxoplasmosis in animals of KPK

A research was reported by Shah et al., (21) in order to find out the prevalence of *T. gondii* in animals sheep and goats of District Mardan, Pakistan. A total 640 samples were collected, out of 640 samples the number of goats and sheep were 350 and 290 respectively. From the result the overall prevalence was 43.12%. The rate of infection in goats was 42.28% while in sheep it was about 44.13%. Sex wise prevalence of toxoplasmosis in goats was about 26% in male while for female it was 54.5%. The prevalence of toxoplasmosis was higher in females as compared to male goats. Out of male sheep, 45.83% were detected seropositive for *T. gondii* antibodies while in female it was about 42.94%. The goats and sheep of age more than 2 years were more likely to be seropositive with toxoplasmosis than the younger goats and sheep.

Another study was conducted to check the sero-prevalence of *T. gondii* in chickens including caged chickens as well as domesticated chickens in Mardan District of Khyber Pakhtunkhwa province in Pakistan. A total of 536 (68 caged and 468 domesticated chickens) samples collected randomly from studied area. Out of 536 samples, 101 were found positive with overall prevalence of 18.85%. In caged chickens the prevalence was 5.90% while it was about 20.70% for domesticated chickens. Females have little high rate of prevalence 22.20% as compared to male 17.80 % in domestic chicken. The infection rate was higher in uncaged/free range 20.70% as compared to caged chickens 5.90 %. The high prevalence in free ranged chickens as compared to caged ones indicates the environmental contamination with oocyte because free

ranged chickens become mainly infected by feeding from ground or soil and the ground is contaminated with oocyte of *T. gondii* (22).

A study was conducted by Kamal et al., (23) in order to find out *T. gondii* in domestic animals. A total of 374 blood samples were collected from domestic animals (cows, goats, sheep and buffaloes) from District Charsadda, Pakistan. Blood about 5ml from each animal collected and tested. Out of these 374 blood samples, 298 were found positive with overall prevalence of 79.7%. A total of 100 blood samples were collected from cows in which 72% were found positive, in 121 goats, 81.8% were positive. Similarly, 103 samples were collected from Sheep, in which 86.4% were positive whereas out of 50 samples from buffalo 76% were found positive. A total of 260 females and 114 males were tested for *T. gondii* infection. Out of which 82.69% (215) females 78.80% (83) males were found positive. This also indicated that prevalence was high in females among these animals. Prevalence of toxoplasmosis was also detected in different sex groups. The highest prevalence of toxoplasmosis was found in females as compared to males. In male buffaloes the 76.92% while in females the prevalence was 75.67%. In male goats' prevalence was 72.41% while in females the prevalence was about 84.78%, in male sheep 84.78% were found seropositive and in female 91.42% were found infective. In male cows 69.23% were detected infective whereas in females 73.77% were found seropositive. Due to warm and humid climatic conditions of this area the prevalence rate of toxoplasmosis was high in the animals of District Charsadda. Life styles of the inhabitant's customs, traditions, weather conditions, age of the animals and husbandry practices also affect the rate of prevalence.

In another study total of 270 samples collected from different localities of District Charsadda, Pakistan and were tested for prevalence of *T. gondii*, in which 127 samples of buffalo and 143 samples of sheep were included. The result indicated that 17.32% were detected seropositive for *T. gondii* in buffalo and 40% were detected in sheep. Out of 40 male buffalo, 5 were detected seropositive while in 87 examined female buffalo, 17 were detected seropositive for *T. gondii* infection. Out of 78 examined male sheep 26 were detected seropositive for *T. gondii* antibodies while 32 out of 65 female sheep were detected seropositive for *T. gondii* antibodies. In buffaloes the prevalence recorded was greater in female buffaloes 19.54% as compared to male buffaloes 11.11%. The occurrence recorded was greater in female sheep i.e. 60% as compared to male sheep i.e. 25%. The prevalence rates of toxoplasmosis were greater at the age of above 2 years from below two years in buffaloes similar result was found in the case of sheep. Study demonstrates that toxoplasmosis was more prevalent in female and older sheep and buffaloes, therefore proper measure should be taken to control toxoplasmosis (23).

Sex wise prevalence of Toxoplasmosis in animals of KPK

The prevalence as about 51.30% (n=275), 52.4% (n=247), 33.9% (n=60), 72% (n=72), 18.84% (n=101) in sheep, goats, buffaloes, cows and chickens, respectively. The highest prevalence was recorded in sheep 51.30% and goats 52.4%, however little difference occurred in their prevalence. Gender wise, highest prevalence of about 44.9% was recorded in females as compared to male gender with prevalence of 35.4% of the respective animals (Table 1)

Methodology

This study was conducted to evaluate prevalence of toxoplasmosis in KPK to develop a complete explanation of the disease condition in KPK for future use. English database i.e. Google Scholar were searched. For this study, past 10 years data (2010-2019) was reviewed in humans and animals of Khyber Pakhtunkhwa. Data was reviewed for toxoplasmosis prevalence in humans (both male and female) of different age groups and women of different trimester. Research papers were also reviewed for the prevalence of this disease in following animals (goats, sheep, chickens and buffaloes) of KPK. Search resulted in a total of 12 reports published from 2010 to 2019 in KPK.

Study area

Khyber Pakhtunkhwa was earlier known as the North-West Frontier Province until 2010. Within Pakistan, Khyber Pakhtunkhwa shares a border with Azad Kashmir, Gilgit-Baltistan, Baluchistan and Islamabad. It has 7 division, 35 districts, population 35.53 million (2017) and 101,741 km² area (smallest province by area) with latitude and longitude coordinates are 34.9526° N, 72.3311° E.

Discussion

Among pregnant women, approximately 1.1% was infected by *T. gondii* during gestation, while in more exact criteria prevalence was about 0.6% in pregnant women (24). Worldwide

seroprevalence of *T. gondii* infection in pregnant women was 7%-53.3%. Women suffer from reproductive losses having toxoplasmosis were about 39.8% in Pakistan. Severe fetal damage occur in new born due to *T. gondii* infection, in immune-compromised individual it lead to mortality (17).

In this review, in association of trimester wise prevalence with toxoplasmosis in pregnant women the prevalence was 20%, 18.6% and 1% at first, second and third trimester respectively according to (13). Likewise (16) the occurrence was 6.45%, 8.8% and 20% at the 1st, 2nd and 3rd trimester, respectively. In the same way (17) the prevalence was found to be 61.7%, 58.4% and 27.7% at the 1st, 2nd and 3rd trimester, respectively. From the above prevalence rate at trimester wise the overall occurrence was highest at the 1st trimester followed by the 2nd and lowest at the 3rd trimester. This is due to high permeability of placenta to tachyzoite form of *T. gondii.* This finding was also in agreement with Rostami et al., (24) whose finding were 1.7%, 1.0% and 0.1% at the 1st, 2nd and 3rd trimester respectively, and also supported by Sadiqui et al., (25).

However there was exception in case of Shah et al.,(16) who found highest prevalence about 20% in the third trimester.

On relationship of age with toxoplasmosis, the prevalence was 63.77% in the age of 21-30 years and 0.72% in the age of 41-50 years according to (Khan et al., 2014). In the same way Hussain (15) the rate was high in the age of 25 years and low above in age of 25 years. According to Shah et al., (16) the prevalence was 25% and 2% in the age of 31-36 years and 24-30 years, respectively. Similarly 54.7% and 38.8% prevalence were recorded in the age of 26-33 years and

18-25 years, respectively. According to Faisal et al (18) the prevalence was 54.55% in the age of 26-40 years and 21.87% in 41-55 years. Likewise (23) the occurrence was 29.41% and 10% in the age of 31-45 and 10 years, respectively. According to Jan et al.,(20) the prevalence was 35.41% and 8.33% in the age of 46-55 years and 15-25 years, respectively.

According to above findings, highest prevalence was recorded in the age of 30-55 years and low prevalence was observed in the younger age (i.e. 15-30 years), highest prevalence, in the higher age is due to low immunity and also associated with hygienic condition. However there were exception in cases reported by Khan et al., and Shah et al., (15) who found low prevalence in middle age group. High prevalence was recorded in higher age than younger age it, may be due to low resistance in higher age to *T. gondii* infection.

In this review, sex wise prevalence of toxoplasmosis in animals, according to a study (21) out of 350 goats, 148 goats were infected in which the prevalence were 26% in male and 54.5% in female goats. While in sheep out of 290, 128 were infected, prevalence was about 45.83% and 42.94% in male and female sheep's respectively. According to (23) 89 out of 103 sheep, 98 out of 121 goats, 72 out of 100 cows and 38 out of 50 buffaloes were found infected. The prevalence was 84.78%, 72.41% 69.23% and 76.92% in male sheep's, goats, cows and buffaloes, respectively. Similarly in female sheep, goats, cows and buffaloes, the prevalence was 91.42%, 84.78%, 73.77% and 75.67% respectively. In the same way according to Kamal et al., (23) out of 143 sheep's 58 and out of 127 buffaloes 22 were found infected. The occurrences were 33.33% and 12.5% in male sheep's and buffaloes while in female sheep and buffaloes the prevalence was 49.23% and 19.54% respectively. According to Mahmood et al., (22) out of 68, 4 caged

chickens and out of 468, 97 domesticated chickens were infected. In these the prevalence was 0% and 17.80% in male, and 6.98% and 22.20% in females of caged and domesticated chickens respectively.

The Highest prevalence was recorded in sheep 51.30% and goats 52.4%, however little difference occurred in their prevalence. The ratio of high prevalence in goats and sheep is depends on their feeding habits, people takes their sheep and goats outside of the home for grazing, and there is high chance of contamination while buffaloes and chickens, feed in farms and there is little chance of contamination of food with cat feces. Gender wise, highest prevalence of about 44.9% was recorded in females as compared to male gender with 35.4% prevalence, of the respective animals.

This result was comparable to Ahmad (26) who reported 18.16% prevalence in sheep, 14.32% in goats and 15.17% in buffaloes. Prevalence was high in female of respective animals. The prevalence was 18.16% in sheep and 14.32% in goats according to a study reported from Punjab (27). In Iran, 31% prevalence was found for sheep and 27% for goats (28). However the findings of this study was against to (29) who found high prevalence in goats than sheep. Similarly there was exception in case of Shah et al., (21) who found high prevalence about 45.83% in male as compared to female sheep with prevalence of 42.94%.

CONCLUSION

The purpose of present study was to know the prevalence of toxoplasmosis in humans and animals of KPK. According to this review toxoplasmosis was more prevalent in pregnant women in the first trimester then followed by the second trimester. Low prevalence was recorded at

the third trimester. The reason is that in the first trimester the placenta is more permeable to tachyzoite form of *T. gondii.* Regarding age factor, most of cases were recorded in the age of 30-55 years and low prevalence in the younger age group (15-30 years). Highest prevalence, in higher age is due to low immunity and also associated with hygienic condition. In animals this disease was more prevalent in the sheep and goats and less prevalent in the chickens. The ratio of high prevalence in goats and sheep is depends on their feeding habits as people takes their sheep and goats outside of the home for grazing. According to sex wise prevalence, the rate of toxoplasmosis was high in gender female of sheep, goats, buffaloes, cows and caged chickens as compared to male gender of these animals.

Recommendation

Prevalence of Toxoplasmosis must be extended to other warm blooded animals, to reduce the risk factors. It is also recommended that this review should be extended to other provinces of Pakistan to know the exact status of toxoplasmosis in Pakistan. .

REFERENCES

1. Shwab EK, Saraf P, Zhu X-Q, Zhou D-H, McFerrin BM, Ajzenberg D, et al. Human impact on the diversity and virulence of the ubiquitous zoonotic parasite Toxoplasma gondii. Proceedings of the National Academy of Sciences. 2018;115(29):E6956-E63.
2. Vieira PdC, Waghabi MC, Beghini DG, Predes D, Abreu JG, Mouly V, et al. Toxoplasma gondii impairs myogenesis in vitro, with changes in Myogenic Regulatory Factors, altered host cell proliferation and secretory profile. Frontiers in cellular and infection microbiology. 2019;9:395.
3. Schlüter D, Barragan A. Advances and challenges in understanding cerebral toxoplasmosis. Frontiers in immunology. 2019;10:242.
4. Arranz-Solís D, Cordeiro C, Young LH, Dardé ML, Commodaro AG, Grigg ME, et al. Serotyping of Toxoplasma gondii infection using peptide membrane arrays. Frontiers in cellular and infection microbiology. 2019;9:408.

5. Kakooza S, Tumwebaze M, Nabatta E, Byaruhanga J, Tayebwa DS, Wampande E. Risk factors and co-existence of infectious causes of reproductive failures in selected Uganda cattle and goats: A Brucella spps-Toxoplasma gondii study. Open Access Library Journal. 2018;5(4):1-12.
6. Alday PH, Doggett JS. Drugs in development for toxoplasmosis: advances, challenges, and current status. Drug design, development and therapy. 2017;11:273.
7. Ben-Harari RR, Connolly MP. High burden and low awareness of toxoplasmosis in the United States. Postgraduate medicine. 2019;131(2):103-8.
8. Furtado JM, Smith JR, Belfort Jr R, Gattey D, Winthrop KL. Toxoplasmosis: a global threat. Journal of global infectious diseases. 2011;3(3):281.
9. Mustafa M, Fathy F, Mirghani A, Mohamed MA, Muneer MS, Ahmed AE, et al. Prevalence and risk factors profile of seropositive Toxoplasmosis gondii infection among apparently immunocompetent Sudanese women. BMC research notes. 2019;12(1):1-6.
10. Watson GF, Davis PH. Systematic review and meta-analysis of variation in Toxoplasma gondii cyst burden in the murine model. Experimental parasitology. 2019;196:55-62.
11. Hill DE, Dubey J. Toxoplasma gondii. Foodborne parasites: Springer; 2018. p. 119-38.
12. Kochanowsky JA, Koshy AA. Toxoplasma gondii. Current Biology. 2018;28(14):R770-R1.
13. Khan SN, Khan S, Ayaz S, Jan AH, Jehangir S, Attaullah S, et al. Seroprevalance and risk factors of toxoplasmosis among pregnant women in District Kohat, Khyber Pakhtunkhwa, Pakistan. World Applied Sci J. 2011;14(14):1032-6.
14. Khan MZ, Ur-Rahman S, Gul N, Khan AA. Toxoplasmosis; seroprevalence, comparative analysis of diagnostic techniques and identification of risk factors in humans in Malakand Agency, Khyber Pakhtunkhwa, Pakistan. Int J Biosci. 2014;5(4):1-6.
15. Hussain Shah MS, Naz F, Jan A, Ullah R, Khan SFA, Haseeb A, et al. Seroprevalence and Risk Factors of Toxoplasmosis among Women in District Chitral, Khyber Pakhtunkhwa, Pakistan. World Journal of Zoology. 2016;11(3):135-40.
16. Shah N, Khan A, Khisroon M, Adnan M, Jawad SM. Seroprevalence and risk factors of toxoplasmosis in pregnant women of district Swabi. Pure and Applied Biology (PAB). 2017;6(4):1306-13.
17. Aleem U, Ullah S, Qasim M, Suliman M. Seroprevalence of Toxoplasmosis in Pregnant Women in Matta, Upper Swat, Khyber Pakhtunkhwa, Pakistan. Journal of Saidu Medical College. 2018;8(2).
18. Faisal S, Jan H, Haroon M, Khan MT, Jan FU, Iqbal T, et al. Seroprevalence of human Toxoplasma gondii infection among pregnant women in Charsadda, KP, Pakistan. Journal of Parasitic Diseases. 2018;42(4):554-8.
19. Khan MB, Khan S, Rafiq K, Khan SN, Attaullah S, Ali I. Molecular identification of Toxoplasma gondii in domesticated and broiler chickens (Gallus domesticus) that possibly augment the pool of human toxoplasmosis. PloS one. 2020;15(4):e0232026.
20. Hasnain Jan MH, Faisal S, Abid Kamal MT, Khan KA, Muhammad W. Sero-epidemiology of human Toxoplasma gondii infection among male population in Charsadda, KPK, Pakistan. International Journal of Biosciences. 2018;12(4):110-6.
21. Shah M, Zahid M, Asmat P, Alam A, Sthanadar A. Seroprevalence of Toxoplasma gondii in goats and sheep of district Mardan, Pakistan. Int J Biosci. 2013;7:90-7.

22. Mahmood ZU, Zahid M, Sthanadar AA, Shah M, Hussain A. Seroprevalence of Toxoplasma gondii infection in Gallus domesticus of district Mardan, Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Zoology. 2014;46(6).
23. Kamal A, Din JU, Kamil A, Khan MT, Bibi H, Hussain A, et al. Seroprevalence of Toxoplasma gondii in sheep and buffalo of District Charsadda, Khyber Pakhtunkhwa, Pakistan. International Journal of Biosciences. 2019;14:497-502.
24. Rostami A, Riahi SM, Contopoulos-Ioannidis DG, Gamble HR, Fakhri Y, Shiadeh MN, et al. Acute Toxoplasma infection in pregnant women worldwide: a systematic review and meta-analysis. PLoS neglected tropical diseases. 2019;13(10):e0007807.
25. Sadiqui S, Shah SRH, Almugadam BS, Shakeela Q, Ahmad S. Distribution of Toxoplasma gondii IgM and IgG antibody seropositivity among age groups and gestational periods in pregnant women. F1000Research. 2018;7.
26. Ahmad N, Qayyum M. Seroprevalence and risk factors for toxoplasmosis in large ruminants in northern Punjab, Pakistan. The Journal of Infection in Developing Countries. 2014;8(08):1022-8.
27. Ahmad N, Iqbal Z, Mukhtar M, Mushtaq M, Khan KM, Qayyum M. Seroprevalence and associated risk factors of toxoplasmosis in sheep and goats in Pothwar region, Northern Punjab, Pakistan. Pak J Zool. 2015;1:161-7.
28. Atail HBM. Sero-prevalence of toxoplasmosis in sheep and goats in El-Gadarif state: Sudan University of Science & Technology; 2017.
29. Asgari Q, Sarnevesht J, Kalantari M, Sadat SJA, Motazedian MH, Sarkari B. Molecular survey of Toxoplasma infection in sheep and goat from Fars province, Southern Iran. Tropical Animal Health and Production. 2011;43(2):389-92.

Table 1 Trimester wise prevalence of Toxoplasmosis in pregnant women

District	Total sample	Infected sample	1st trimester %age (n)	2nd trimester %age (n)	3rd trimester %age (n)	Total Prevalence	References
Kohat	180	26	20% (12)	18.6% (13)	2% (1)	14.4%	(13)
Swabi	100	12	6.45% (2)	8.8% (3)	20% (7)	12%	(16)
Swat	360	170	61.7% (71)	58.4% (59)	27.7% (40)	47.2%	(17)
Total	640	208	40.8% (85)	36% (75)	23% (48)	32.5%	

Table 2 Age wise prevalence of Toxoplasmosis in humans of KPK

Total Sample	Infected Sample	District	Age Group (year)	High Prevalence (%)	Age Group (year)	Low Prevalence (%)	References
420	276	Malakand Agency	21-30	63.77%	41-50	0.72%	(14)
300	74	Chitral	25	High	Above 25	Low	(15)
100	12	Swabi	31-36	25%	24-30	2%	(16)
1`	170	Swat	26-33	54.7%	18-25	38.8%	(17)
200	69	Charsadda	26-40	54.55%	41-55	21.87%	(18)
600	105	Mardan	31-45	29.41%	Below 15	10%	(23)
300	63	Charsadda	46-55	35.41%	15-25	8.33%	(20)

Table 3 Sex wise prevalence of Toxoplasmosis in Animals of KPK

Animals	Total sample	Infected (%)	Male	Infected sample	Prevalence	Female	Infected Sample	Prevalence	Reference
Sheep	290	44.13 %	120	55	45.83%	170	73	42.94%	(21)
Sheep	103	86.40 %	33	25	84.78%	70	64	91.42%	(23)
Sheep	143	40.55 %	78	26	33.33%	65	32	49.23%	(23)
Total	536	51.30 %	231	106	45.88%	305	169	55.40%	
Goats	350	42.3%	150	39	26%	200	109	54.5%	**(21)**
Goats	121	80.9%	29	21	72.41%	92	78	84.78%	**(23)**
Total	471	52.22 %	179	60	33.51%	292	187	64.04%	
Buffaloes	50	76%	13	10	76.92%	37	28	75.67%	**(23)**
Buffaloes	127	17.32 %	40	5	12.5%	87	17	19.54%	**(23)**
Total	177	33.9%	53	15	28.30%	124	45	36.3%	
Cows	100	72%	39	27	69.23%	61	45	73.8%	**(23)**
Chickens (caged)	68	5.9%	10	0	0%	58	4	6.89%	(22)
Chickens	468	20.72	152	27	17.80%	316	70	22.20%	(22)

(dome)		%							
Total	536	18.84 %	162	27	16.7%	374	74	19.9%	