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Epidemiology and Epizootiology of Toxocariasis in the Russian Federation

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ABSTRACT

The article provides information on the incidence of toxocariasis in humans and dogs in various regions of the Russian Federation considering their age and gender. The ways of infection of potential hosts and the degree of contamination by sick animals with Toxocara eggs of cities and rural settlements are considered. The clinical symptoms of the disease manifestation and hematological parameters in people with toxocariasis are analyzed. Toxocariasis is widespread in many countries of the world. It is found in Russia, Europe, Africa, Southeast Asia, and the USA. The invasion is registered mainly among stray dogs and cats, which secrete helminth eggs in large quantities in feces in residential areas. The average infection rate among dogs and cats is about 16%, but in some cases, it can reach 90%. In 2020, the share of helminthiasis in the general structure of parasitic diseases amounted to 87.5%. In 2020, 871 cases of human disease were registered (0.59 per 100 thousand population), compared to 2019, the incidence decreased 2.25 times, and since 2011 – 3.9 times. 353 cases of toxocariasis were detected among children under 17 y.o. (1.17 per 100 thousand of this age), which is 1.9 times less than in 2019, and compared to 2011, the incidence decreased by 4.9 times.

Keywords: Spread, Dog, Human, Morbidity, Seropositivity, Soil.

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INTRODUCTION

Toxocariasis is one of the dominant parasitic diseases of humans and animals caused by the nematodes *Toxocara canis* and *T. mystax (T. cati),* parasitic mainly in canine and feline animals, as well as in humans. Since the beginning of the official recording of the invasion (1991), there has been a significant increase in the incidence of toxocariasis in the population of the Russian Federation – from 0.03 (1991) to 2.19 per 100 thousand population (2014). From 1991 to 2015, the incidence of toxocariasis among the population increased significantly – from 0.03 to 1.72 per 100 thousand population. At the same time, urban residents suffer from this disease more often than people living in rural areas (57% and 43% of reported cases, respectively) [1]. Of the total number of patients with toxocariasis, about 40% are children under 14 years of age. The highest levels of morbidity were observed in the Ural and Siberian Federal Districts (FD). Thus, in the Ural Federal District, the average annual incidence rate was 6.3 per 100 thousand population with fluctuations from 3.4 (2005) to 9.0 (2012). In the Siberian Federal District, this indicator was in the range of 1.3 (2005) – 3.4 (2014), averaging 2.9 per 100 thousand population [1].

A serious problem, especially in large cities, is the incidence of toxocariasis in the population [2]. The total number of people infected with Toxocara is only an assumption because this invasion belongs to the larval helminthiasis group and is not always recorded [3, 4].

Of the diseases of invasive etiology,

helminthiases occupy 87.5%. In comparison with the indicators of 2011, the etiological structure of the incidence of parasites has changed – the proportion of helminthiasis has increased by 10.3%. A serious problem in recent years is the incidence of toxocariasis in the population, especially in large cities. In 2020, 871 cases of human disease were registered (0.59 per 100 thousand population), compared to 2019, the incidence decreased 2.25 times, and since 2011 – 3.9 times. 353 cases of toxocariasis were detected among children under 17 y.o. (1.17 per 100 thousand of this age), which is 1.9 times less than in 2019, and compared to 2011, the incidence decreased by 4.9 times. In 2020, parasitosis pathogens were detected in the soil of livestock complexes – 0.8% (in 2019 – 1.71%, in 2011 – 4.5%), crop farms – 1.9% (in 2019 – 0.77%, in 2011 – 2.0%), in the residential area – 0.81% (in 2019 – 0.88%, in 2011 – 1.5%), including in the territories of children's organizations and playgrounds – 0.52% (in 2019 – 0.57%, in 2011 – 1.1%), in the sanitary protection zone of water supply sources – 1.3% (in 2019 – 1.04%, in 2011 – 1.4%). The high number of dogs in urban settlements provided non-compliance with the rules of their maintenance, the absence of measures for the disinfection of excrement lead to a wide circulation of the causative agent of toxocariasis in the environment (soil) and an increase in the risk of infection of the population [5, 6].

The purpose of the study is to assess the prevalence of toxocariasis among people with a breakdown by sex and age groups and dogs in the Russian Federation. The selection of scientific papers was carried out depending on their scientific value relative to the research topic **(Figure 1)**. 175 publications were analyzed, and 50 of them contained data about the spread of human and animal toxocariasis. Preference was given to publications from the E-Library database since the review is focused on research in the Russian Federation. State Reports of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare "On the state of sanitary and epidemiological welfare of the population in the Russian Federation" were also used.

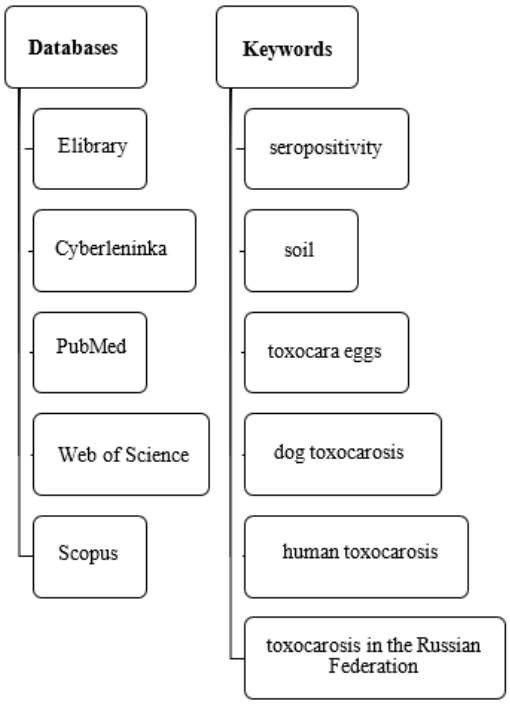

Figure 1. A systematic review of published data on the prevalence of toxocariasis in the Russian Federation

Incidence of animals and humans with toxocariasis

Toxocariasis in dogs

The incidence of dogs with toxocariasis in different cities averages 40%, whereas in rural areas it is twice as much, and in some cases reaches 100%, especially in puppies in the first months of life [7].

Dogs can get infected with helminths intrauterine as a result of the migration of larvae through the placenta from the mother to the fetus; by direct infection with parasite eggs through water, feed, soil, and paratenic hosts [8]. The incidence of toxocariasis is very high due to the large number of dogs and their high infection rate. Up to 15 thousand Toxocara eggs can be contained in 1 g of dog feces, thus a huge number of helminth eggs get into the soil [9, 10]. The average prevalence of dogs on different continents ranges from 15 to 93% [11, 12].

From 2011 to 2017, 1600 fecal samples from domestic dogs and 1119 from domestic cats were examined in Moscow. The intensity of Toxocara invasion in domestic dogs was 2.43%. Infection in different years of the study varies from 1.62% to 4.16% in adult animals, and from 2.4 to 10.8% in puppies. In general, the infection rate of puppies is 2 times higher than that of adult dogs and is 5.39%. The intensity of infestation in adult

cats is 3.95%, in 2012 the minimum detection of infection was 0.66%, and the maximum infection rate was recorded in 2017 and amounted to 13.43%. Kittens, as well as puppies, are more intensely infected with Toxocara, namely 10.03%. In general, the infection rate of cats with Toxocara is 5.63%. Studies show that the infection rate of cats is 2 times higher than that of dogs, both in the group of adult animals and in the group of kittens. Stable infestation of domestic animals with this type of helminths makes them a constant source of contamination of the urban environment with Toxocara eggs and imposes a risk for humans [13, 14].

In Krasnodar, during 2018-2019, fecal samples of 107 domestic dogs were examined (a positive sample was found in 64 individuals or 68.4%), aged from birth to 9 years. The greatest number of diseases were registered in summer (82.9%) and spring (58.6%), less in autumn (45.2%) and winter (18.2%). The most susceptible to invasion are young individuals aged 0 to 2 months – 62.6%, from 2 to 6 months – 25%, and from 6 to 12 months – 9.4%. Infested (infected) dogs aged from 1 to 6 years made up only 3%, and individuals from 6 years and older were free of Toxocara [15].

On the territory of the Yamalo-Nenets Autonomous Okrug, fur-bearing animals often have toxocariasis [16]. The invasiveness of fur-bearing animals with *T. canis* was 24.3±3.2% with an abundance index equal to 14.4±1.10 individuals (according to the results of pathoanatomic studies) or 304.5±20.5 eggs in 1 g of feces (coprological method). The maximum incidence was registered in silver-black foxes – 28.9%, and the minimum – 12.6% in arctic foxes. In the population of wild Arctic foxes, *T. sapis* was found in 32.4% with an EI of 14.2 individuals. To the greatest extent, dogs are invaded by *T. canis* (17.6%) [17].

In dogs in Tyumen, the extent of invasion varies from 12.3 to 44.8%. In summer, the invasion reaches a maximum of 44.8±3.2%, and in autumn it decreases to 26.7±1.3%. By winter, it stabilizes at a minimum value of 12.3±1.4%, and in spring there is a new rise to 32.8±2.3%. The increase in the incidence of dogs with toxocariasis in summer is mainly associated with an increase in the number of young animals, which are the main carrier of sexually mature parasites [18, 19].

In the conditions of the Altai Territory, the highest rates of invasion intensity among all the dogs studied were recorded with toxocariasis – more than 40% and Toxascaridosis – more than 39% [20, 21].

Toxocariasis in humans

For *T. canis*, a human being is a paratenic host. Human infection with Toxocara occurs mainly when ingesting eggs in case of contact with a sick animal or with soil contaminated with Toxocara eggs. Children are especially susceptible to this helminthiasis because of playing in the sand and with dogs. The probability of human contact with *T. canis*-seeded soil is approximately 15% (for adults). However, it increases sharply in children with geophagia and in adults who traditionally often come into contact with soil seeded with Toxocara eggs [9, 10].

Human gets infected with Toxocara when invasive Toxocara eggs enter the gastrointestinal tract when eating unwashed vegetables and berries. The possibility of human infection is not excluded when eating raw or insufficiently heat-treated meat of paratenic hosts – chickens, pigeons, lambs, and pigs. Transplacental and transmammary transmission of toxocariasis by a pregnant or lactating woman has not been proven [22].

The relevance of the problem and prevention of toxocariasis is because currently, following economic and political crises in different countries of the world, people's living standards are declining, living conditions are deteriorating, and sanitary and hygienic standards are not observed. In addition, the spread of the disease is associated with waves of migration, with refugees. Toxocariasis is widespread in several regions and countries in Africa, Southeast Asia, Russia, the USA, and Europe [14, 19, 23-26].

All the symptoms of the invasion form a very contradictory clinical picture, which sometimes raises doubts even among experienced practicing physicians. This is due to the lack of awareness of doctors, primarily therapists, and pediatricians, in the field of parasitology. That is why, instead of toxocariasis, the following diagnoses are most often made: allergic disease, chronic pneumonia, dermatitis, and others, which complicates the treatment of patients [20, 21, 27-29].

The spectrum of clinical manifestations of invasion depends on the infecting dose, the ingestion of larvae into certain organs or tissues, as well as the severity of the host's immune

response. Toxocariasis is characterized by a long recurrent course (from several months to several years), which is associated with the periodic resumption of migration of Toxocara larvae. Target organs for toxocariasis can be the liver, lungs, eyes, skeletal muscles, myocardium, and central nervous system. Infection with this helminthiasis is possible at any age, but it is most typical for children 1-6 years old. The migration of the Toxocara larva is accompanied by a powerful immune response, manifested by local inflammation, and eosinophilia. Most often visceral and ocular forms are distinguished in the classification of toxocariasis. The incubation period is difficult to be determined since a single contact with the source of the invasion can provoke the infection. In rare cases, when it is possible to assume the timing of infection, clinical symptoms get manifested 2-3 weeks after possible contact with the pathogen. In typical cases, the visceral form of invasion in the acute stage is manifested by general clinical symptoms characteristic of acute infectious and allergic diseases and organ lesions of varying severity. The main symptoms of visceral toxocariasis are recurrent fever, pulmonary syndrome, enlarged liver, lymphadenopathy, eosinophilia, and hypergammaglobulinemia. When the lungs are affected, patients suffer a dry, unproductive night cough. During auscultation, dry whistling rales are heard – single or over the entire surface of the lungs, sometimes there are foci of wet rales. X-ray examination of patients reveals multiple or single eosinophilic infiltrates, an increase in the pulmonary pattern, and a pattern of bronchopulmonary infiltration [7].

Soil is the leading risk factor for human infection. Thus, in the study of 481 samples of depersonalized dog feces in various territories of southern Russia, the proportion of positive samples averaged 29.31%. The proportion of samples with *T. canis* eggs ranged from 6.0% in the Krasnodar Territory to 16.7% in the Republic of Adygea. This fact is due to the effective pre-sale deworming of puppies of domestic dogs and planned deworming of adult animals 3-4 times a year. In the feces of dogs, Toxocara eggs prevailed over the rest and accounted for 42.2%, being a powerful factor in soil pollution. Thus, dogs should be regarded as one of the main sources of contamination of the soil with Toxocara eggs, which does not exclude their role in the fecal-oral mechanism of human infection. The leading role as a source of toxocariasis belongs to stray animals. The results of an immunological examination for the presence of specific antibodies to *T. canis* in the conditionally healthy population of southern Russia evidence the significant proportion of seropositive individuals [30-32]. The level of seropositivity of the examined persons was in the range of 19.5–40.9% in the Rostov region, 17.0–25.0% – in the Astrakhan region, 21.78–37.11% – in the Krasnodar Territory, 22.5–47.0% – in the Republic of Adygea, 34.0–42.27% – in the Karachay-Cherkess Republic, 13.8% – in the Chechen Republic and 19.9% – in the Republic of Crimea. Thus, the evidence of a high degree of contact of the population with the causative agent of this helminthiasis is the seroprevalence index when taking into account long-term cumulative indicators of the detection of specific antibodies to the causative agent of toxocariasis, which on average ranges from 13.8% in the Chechen Republic to 37.2% in the Republic of Adygea [33].

As a result of studies conducted in Khabarovsk in 2010-2019, immunoglobulins of class G to *T. canis* antigens were detected in 1414 (18.7%; 95% DI:17.83-19.59%) examined residents of the Amur region. Seropositive individuals were found in all territories covered by this study. The largest number of seropositive persons was revealed during the survey of the population of the Jewish Autonomous Region (37.3–95%). At the same time, 44.0% of the surveyed residents were seropositive in the Birobidzhan district. In the Khabarovsk Territory, the highest rates of seropositivity of the population were observed in residents of the Bikinsky (53.0–95%), Khabarovsk (28.1–95%), and Lazo districts (24.9–95%). The results obtained indicate a high frequency of detection of antibodies to Toxocara antigens among the rural population of the region. This is probably due to a large number of dogs (on a leash and hunting) on the territory of villages and frequent contact with people with the soil when working on garden plots. In the Amur region, the vast majority of the surveyed persons were residents of Blagoveshchensk, which may have influenced the results obtained. It is generally believed that there are more favorable conditions for the maturation of geohelminth eggs in the southern territories of

the country than in the territory of the Amur region. This is probably due to a longer period of climatic winter and lowers monthly average temperatures characteristic of the Far East region. At the same time, despite the more severe climatic conditions, statistically significant differences in the seropositivity indicators of the population of certain territories of southern Russia and the Amur region were not revealed [30].

In the Astrakhan region from 2013 to 2017, 17419 cases of parasitic invasion were registered, including 87.5% of helminthiasis. Human toxocariasis accounted for 34 (0.22%) cases. The maximum number of cases of toxocariasis was registered in 2013 and 2017 – 29.4 and 32.4%, respectively. In other years, cases of toxocariasis among humans were also recorded, but with a lower frequency of cases: in 2014 and 2015 – 14.7% each, and 2016 – 8.8%. The highest frequency (64.7%) of toxocariasis was registered in women. Both adults and children were affected by toxocariasis. Thus, the share of the adult population was 82.4%, including persons employed in production (working population) – 67.6%, pensioners – 11.8%, and unemployed – 2.9%. The share of children in the overall structure of the incidence of toxocariasis was 17.6%; 11.8% of them attended preschool institutions and 2.9% attended secondary school. In one (2.9%) case, the child was at home with their parents [34].

Studies conducted in the Irkutsk region from 2008-2018 showed that the average incidence of toxocariasis was 0.39 ± 0.07 per 100 thousand population. However, the highest rates were registered in 2018 – 0.78 per 100 thousand. In addition, there were three peaks: in 2011, 2014, and 2016. In other words, these are two periods, the duration of which is from 2 to 3 years. Most often suffer children under 14 years (0.54± 0.15 per 100 thousand). The maximum average annual morbidity rate of the population living in rural areas was 0.57± 0.09 per 100 thousand population and it exceeds the average regional level by 1.5 times. The morbidity of the population during the study period increased almost 4 times (from 0.2 ± 0.03 to 0.78 ± 0.06 per 100 thousand population), with an average annual growth rate of 14.5%. Rural residents are most susceptible to the infection. From 2008-2018, 103 cases of toxocariasis were registered in the Irkutsk region. Of these, adults made up 68.0%, and children under 17 years of age – had 32.0%. When analyzing sick children by age, cases of toxocariasis were revealed among all age groups, except for children under the age of 1 year. Children aged 7-14 years (44.0%) and 3-6 years (38.0%) accounted for most of the infected, 12% of patients were among children aged 1-2 years, and 6.0% in the age group 15-17 y.o. [5, 6].

Similar studies were carried out in Krasnodar. The study involved 34 children (17 boys and 17 girls aged 1 to 17 years) who were being examined and treated at the children's diagnostic center in Krasnodar from 2013-2016, suspected of visceral toxocariasis. Among the observed children from 1 to 7 years made up 29.4%; older than 7 years – 70.8%, with a uniform distribution by gender. The duration of toxocarous invasion up to a year was detected in 17 (50%) children; up to 2 years – in 2 (5.8%); up to 3 years – in 14 (41%); five years – in 1 (3.2%) patients. Epidemiological anamnesis showed that 14 (41.1%) of sick children had dogs in the house, 10 (29.5%) had cats, and 6 (17.5%) went to suburban land plots in summer. Other children probably got infected through food (when eating insufficiently washed vegetables, herbs, and berries), water (when bathing), or household contact [35].

Soil pollution with toksocar eggs

A comparison of data on the incidence of toxocariasis with the results of seroepidemiological studies suggests that the true level of morbidity of the population with this helminthiasis in the territories of southern Russia is significantly higher than officially reported. The results of the seroepidemiological survey of the population of the territories of the south of Russia correlate with the data of sanitary and parasitological studies of the soil (the correlation coefficient between the seropositivity of the population and parasitic soil contamination is 0.85). The contamination of the soil with helminth eggs ranged from 0 to 58.0% in the studied territories with a contamination intensity from 0 to 85 eggs per 1 kg of soil. At the same time, in the period from 2011 to 2018, the proportion of viable helminth eggs averaged 21.3% in the Rostov Region; 39.6% in the Republic of Adygea; 27.5% in the Karachay–Cherkess Republic; 8.3% in the Astrakhan Region. In the Krasnodar Territory, viable

Toxocara eggs were not found among those identified during the entire period of research, however, the proportion of positive samples with toxocariasis pathogens averaged 9.6%, which indicates the need for caution in assessing the epidemiological situation and taking into account indicators of soil contamination with toxocariasis pathogens during zoning of territories. Toxocara eggs took the main share among the eggs of geohelminths in the soil of the territories of the south of Russia – 73.4% with an average proportion of viable ones – 3.8%. By territories, the average viability index of identified Toxocara eggs was: in the Rostov region – 5.6%; in the Republic of Adygea – 0.5%; in the Karachay-Cherkesskaya Republic – 5.0%; in the Astrakhan region – 8.0%. These data also indicate the continuing potential for the risk of toxocariasis infection in the population of the territories of southern Russia. The maximum contamination of the soil with eggs of the causative agent of this helminthiasis was recorded in the Astrakhan region – 30.0%, the minimum – in the Republic of Adygea – 6.7%. The intensity of soil contamination ranged from 3.5 eggs/kg in the Krasnodar Territory to 26.8 eggs/kg in the Rostov region [36].

In the Kursk region, Toxocara eggs were found in 45.3% of the examined soil samples. It was found that the largest percentage of samples (90.9%) containing helminth eggs were found in places where animals congregate (near garbage cans and heat stations). When examining samples taken from walking areas (from parks and squares, as well as playgrounds), helminth eggs were found in 59.8 and 28.0% of samples, respectively. Studies of 117 snow samples showed the presence of helminth eggs in 47.9 samples. The highest percentage of positive snow samples was recorded in places where stray animals congregate – 83.3% [8].

In Krasnogorsk, the areas of building blocks' adjacent territories, namely areas with grass, turned out to be the most seeded; since such territories are the most suitable for walking pets, as well as homeless animals more often defecate in areas with grass. A large degree of contamination of building blocks' adjacent territories, compared with the territories of parks, is a consequence of the accessibility and proximity of these places to the place of residence of citizens, which is why these areas are often used to walk dogs [37].

The soil and water bodies of 63 villages and 9 cities of Kabardino-Balkaria are not safe concerning contamination with eggs of *T. canis* pathogen and pose a significant danger to humans and animals. Contamination of soil and water by *T. canis* eggs in the North Caucasus region goes through the chain "dog – feces – water – soil – farm animals and humans", which causes the activity of the epidemic process of invasions with 80-100% contamination by eggs. The rate of contamination with *T. canis* eggs in the soil in territories of well–maintained households amounted to 33%, poor-maintained equaled 92%, and soil in places where dogs are kept and in vegetable gardens - 100%. In the soil from the territories of schools and parks, *T. canis* eggs were found in 70-96% of samples. Extensive indicators of contamination of soil samples of agricultural objects with *T. canis* eggs were: scrapings from feeders – 58%, scrapings from the floor – 93%, soil of courtyards – 100%; water from puddles and holes – 100%, soil of livestock farms 80-100%. There is a high level of contamination with *T. canis* eggs in summer residence places. Toxocara eggs were found in 80% of soil samples; 65% of dill samples; 74% of samples of parsley; 66% of cilantro; 70% of lettuce; 63% of sorrel; in 37% of green peas; 44% of samples of tomatoes; in 62% of cabbage; in 56% samples of cucumbers on open ground. On average, *T. canis* eggs were found in 61.7% of samples with the presence of 16.24 ± 1.56 eggs per 100 g of sample [38].

In the city of Kirov, the average infection rate of dogs with Toxocara was 18.7%. When comparing the contamination of soil and dog excrement with *T. canis* eggs, a directly proportional relationship is traced – the contamination of the soil with Toxocara eggs directly depends on the contamination of the soil with canine excrement. The average rate of soil contamination with *T. canis* eggs at three sites in the city of Kirov was 36%. The highest percentage of soil contamination with Toxocara eggs was detected in the park and park area – 48%. The infection rate of dogs with Toxocara was 18.7%. There is a direct dependence of biological soil pollution on the infestation of dogs with *T. canis* coming to these territories [39].

The seropositivity of the population to toxocariasis and the contamination of the soil

with Toxocara eggs in the territories of southern Russia are high and do not correlate with the incidence of toxocariasis in the surveyed territories. This suggests that the true level of morbidity of the population with helminthiasis under study in the territories of southern Russia is significantly higher than officially recorded [9, 10].

CONCLUSION

Dogs are one of the main sources of contamination of the soil with Toxocara eggs, which causes a high risk of infection in people and especially children with toxocariasis. The results of the seroepidemiological survey of the population correlate with the data from sanitary and parasitological studies of the soil. At the same time, stray animals play a leading role as a source of the disease. Toxocariasis is one of the main socially significant problems, to solve which it is necessary to combine the efforts of medical and veterinary specialists with the support of local governments.

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ETHICS STATEMENT: The study was conducted in accordance with international ethical standards.

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