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Prevalence of *Toxocara* eggs in Latin American parks: a systematic review and meta-analysis

D. Katterine Bonilla-Aldana[1], Laura Valentina Morales-Garcia[2], Juan R. Ulloque Badaracco[3], Melany D. Mosquera-Rojas[3], Esteban A. Alarcón-Braga[3], Enrique A. Hernandez-Bustamante[4], Ali Al-kassab-Córdova[5], Vicente A. Benites-Zapata[6], Alfonso J. Rodriguez-Morales[7,8], Olinda Delgado[9]

[1]Research Unit, Universidad Continental, Huancayo, Peru;
[2]Faculty of Veterinary Medicine, Fundación Universitaria Autónoma de las Américas-Institución Universitaria Visión de las Américas, Pereira, Risaralda, Colombia;
[3]Escuela de Medicina, Universidad Peruana de Ciencias Aplicadas, Lima, Peru;
[4]Sociedad Científica de Estudiantes de Medicina de la Universidad Nacional de Trujillo, Trujillo, Peru;
[5]Centro de Excelencia en Estudios Económicos y Sociales en Salud, Universidad San Ignacio de Loyola, Lima, Peru;
[6]Unidad de Investigación para la Generación y Síntesis de Evidencias en Salud, Vicerrectorado de Investigación, Universidad San Ignacio de Loyola, Lima 15012, Peru;
[7]Master in Clinical Epidemiology and Biostatistics, Universidad Científica del Sur, Lima, Peru;
[8]Gilbert and Rose-Marie Chagoury School of Medicine, Lebanese American University, Beirut, Lebanon;
[9]Immunoparasitology Section, Tropical Medicine Institute, Universidad Central de Venezuela, Caracas, Venezuela

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SUMMARY

Introduction: Toxocariasis is an infection caused in canines, felines, humans, and other vertebrates by species of the genus *Toxocara*, such as *T. canis* and *T. cati*. The embryonated eggs of these parasites are the main form of acquisition of the infection both for definitive hosts, such as the dog and the cat, respectively and for paratenic hosts, such as humans and other vertebrates. Toxocariasis infection in humans causes visceral larva migrans syndrome. When deposited on park soils, environmental contamination becomes a risk for environmental, human, and animal health.
Objective: To systemically estimate the prevalence of *Toxocara* spp. eggs in park soils in Latin America.
Methods: A systematic review and meta-analysis were performed to evaluate the prevalence of *Toxocara* eggs in park soils in Latin America, defined by copro-parasitological, molecular and immunological techniques. We searched PubMed, Scopus, Web of Sciences, Embase, LILACS and SciELO for studies published from 1900 through 28 January 2023. A meta-analysis was performed using a random-effects model to calculate the pooled prevalence and 95% confidence intervals (95% CI). Heterogeneity was measured through I^2 statistics.
Results: Forty-nine studies (2,508 parks and 12,833 samples) were included, of whom 44 had a low risk of bias. The pooled prevalence of *Toxocara* eggs in parks in Latin America was 50.0% (95% CI: 40.0%-60.0%). Argentina had the highest prevalence of *Toxocara* eggs in parks (100%), followed by Brazil (66%) and Venezuela (63%). The pooled prevalence of *Toxocara* eggs in soil samples was 20.0% (95% CI: 14.0%-26.0%); in faecal samples, it was 13.0% (95% CI: 6.0%-23.0%).
Conclusion: The presence of *Toxocara canis* eggs in public parks in Latin America is a zoonotic and public health threat for the people who go to these places, especially if children play on the ground with dirt or contaminated objects; since many pet owners and general public are not adequately informed about the mode of transmission of this parasite.

Keywords: Toxocara, prevalence, park, Latin America, systematic review, meta-analysis.

Corresponding author
D. Katterine Bonilla-Aldana
E-mail: dbonilla@continental.edu.pe

INTRODUCTION

Zoonotic diseases still represent a significant disease burden globally, especially in low and middle-income countries. Despite that, their prevention and control have decreased due to the increase in globalization, population, migration, internal and external displacement of animals and humans, and the recent COVID-19 pandemic [1]. It is estimated that 20% of zoonoses worldwide are of parasitic origin, with companion animals and humans being the most vulnerable [2]. Parasites associated with zoonoses include helminths such as *Toxocara canis* and *Toxocara cati*, which are globally distributed, infect dogs, cats and accidentally other hosts, including humans [3]. Indeed, the usual localization of *Toxocara canis* is in the small intestine. However, migrating larvae can be found in the intestinal cavity and numerous organs (lungs, eyes, heart, and liver, among others) [4].

Toxocara canis parasites in pregnant canines can grow up to 10 centimetres and invade puppies before birth. Dog puppies not dewormed at around two weeks old excrete *Toxocara* spp. eggs, equivalent to 10,000 per gram of faeces [5, 6]. These eggs can survive for about three years in soil, which increases the chances of infesting humans [7]. In its biological cycle, this nematode is also a large soil reservoir. Consequently, contaminated soils in open public parks are a health risk for people, especially children, due to their playing habits, which involve handling the soil and putting their hands in their mouths, leading to geophagy [7, 8].

In Latin America, there are very few studies on the prevalence of *Toxocara* eggs in soils in public areas [2]. A study conducted on a university campus in Venezuela evaluated soil samples, finding that 43.8% had eggs and larvae of helminths, highlighting *Toxocara* spp. as the most frequent. In another study carried out in public parks in La Plata, Argentina, a prevalence of 70% of nematode eggs was detected, of which 33% corresponded to *Toxocara* spp. In Colombia, there are few studies, one of them in public parks in Tunja, where it was found that 60.7% of the parks were positive for nematodes in samples of canine faecal matter and 100% on land [9]. The nematodes found were eggs and larvae of *Toxocara* spp, *Ancylostoma* spp, *Trichuris vulpis,* and *Strongyloides* spp. In Bogotá, they established the presence of gastrointestinal nematodes in the soils of public parks, finding *Toxocara* spp. eggs 5.4%, *Strongyloides* spp. 3.3%, among others [9]. Another study in three public parks in Duitama, Boyacá, found larval eggs of *Toxocara canis* in 25 samples, representing 34.7% of the total analyzed [10]. Although the prevalence of these parasites differs, their presence is substantial and merits further assessment. All in all, the cases of *Toxocara* in humans represent a threat to public health. Although they are not subjected to epidemiological surveillance, in 2018, a study was carried out in which the mobility of *Toxocara* eggs mediated as a risk factor was identified by walking dogs in contaminated parks from there to the home [11, 12]. In another study conducted in a low-income community from Bogotá, positive titers were found in 47.5% of inhabitants, and 46.3% of the puppies were positive for *Toxocara* [13]. Over time, different studies have identified contaminated parks as a source of *Toxocara* infection, recognising that human disease can be fatal [10, 14, 15]. Therefore, the present meta-analysis aimed to estimate the prevalence of *Toxocara* in park soils in Latin America.

METHODS

Registration and reporting

All procedures used in this study were consistent with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [16]. A short protocol version was uploaded to the International Prospective Register of Systematic Reviews (PROSPERO) with code CRD42023404643 (https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=404643).

Data sources and searches

The search strategy followed the Peer Review of Electronic Search Strategies (PRESS) checklist [17]. It was built using MeSH, Emtree, and free terms for '*Toxocara* park', '*Toxocara* egg', and '*Toxocara* soil', searching by the countries of Latin America. In addition, the following databases were searched without language restriction from 1900 through 28 January 2023: PubMed, Scopus, Web of Sciences, Embase, LILACS and SciELO. The complete search strategy is in Table 1.

Study selection and data extraction

Peer-reviewed published articles reporting contamination by *Toxocara* spp. eggs in parks, with

Table 1 - Search strategies.

Source	*PubMed*
Search	*Formula*
#1	Ascaridae [MH] OR Toxocara [MH] OR "Toxocar*" [TIAB] OR ("park" [TIAB] AND "soil*" [TIAB]) OR "garden*" [TIAB]
Source	*Scopus*
Search	*Formula*
#1	TITLE-ABS-KEY ("Toxocar*" OR ("park" W/3 "soil*") OR "soils*")
Source	Web of Science
Search	Formula
#1	TI=("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks") OR AB=("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks") OR AK=("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks") OR KP=("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks") OR TS=("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks")
Source	*Embase*
Search	*Formula*
#1	'Rickettsia'/exp OR ("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks"):ti OR ("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks"):ab OR ("Toxocar*" OR ("park" NEAR/3 "soils") OR "parks"):kw
Source	LILACS
Search	Formula
#1	(Toxocar* OR (park adj3 soils) OR parks).ti. OR (Toxocar* OR (park adj3 soils) OR parks).ab. OR (Toxocar* OR (park adj3 soils) OR parks).kw.
Source	*Scielo*
Search	*Formula*
#1	(Toxocara) AND (parks) OR (soil)

either parasitological or molecular confirmation, were included. We considered egg detection for parasitological tests and PCR for tests based on molecular biology. On the other hand, case reports, case series, editorials, commentaries, and review articles were excluded.

The references retrieved from the search strategy were independently screened by titles and abstracts by four researchers (JR U-B, MD M-R, EA H-B and EA A-B). Then, the remaining full-text references were screened by the same researchers. As mentioned above, observational studies that reported the contamination of parks with parasitological or molecular confirmation of *Toxocara* spp. were included for quantitative synthesis (meta-analysis). Two researchers (LV M-G and OD) independently completed the data extraction form for each included study. The extracted information was: publication type, country, publication date, type of samples (soil or faecal samples) obtained in the parks, total parks evaluated and the number of infected parks or samples evaluated by serological or molecular tests. A third researcher (A A-C) checked the list of articles and data extractions to ensure that duplicate reports or information from the same study would not be included. Discrepancies in the study selection or data extraction processes were resolved through discussion or by a third party (AJ R-M).

Risk of bias assessment

Two researchers (JR U-B and MD M-R) independently assessed the risk of bias through the Newcastle Ottawa Scale adapted for cross-sectional studies (NOS-CS) [18]. A survey with seven or more stars was deemed low risk of bias. Contrarily, a study with less than seven stars was considered a high risk of bias.

The assessment of publication bias is not recommended for proportional meta-analysis due to the following reasons:

1) conventional funnel plots and Egger's test are inaccurate for these analyses,
2) there is no evidence that proportions adjust correctly to funnel plots or Egger's tests.

Therefore, we did not perform a publication bias assessment due to the above [19, 20].

Data analyses

The statistical analysis was performed in Stata 17.0© (Stata Corporation, College Station, TX, USA). A random-effects model (DerSimonian and Laird method) was performed to estimate pooled prevalences with their corresponding 95% Confidence Intervals (95% CI). We approached heterogeneity by Cochran's Q statistic and I^2 index. Values equal to or greater than 60% were defined as high heterogeneity for the I^2 statistic, and p-values <0.05 were considered indicators of heterogeneity in Cochran's Q test. In addition, we performed subgroup analyses by methods and countries. Also, a sensitivity analysis included only those studies at low risk of bias.

RESULTS

Selection of studies

Our search strategy yielded 820 articles. After removing duplicates and screening for titles and abstracts, 84 articles underwent full-text review. Finally, 49 articles were included in the systemic review and meta-analysis [21-69]. The PRISMA flow chart is shown in Figure 1.

Characteristics of included studies

The characteristics of the included articles are summarized in Table 2. A total of 49 articles were included, in which 2,508 parks were evaluated, with 12,833 samples obtained from the parks (2,487 faecal samples and 10,346 soil samples). The studies ranged from 1989 to 2021, but 2019 there were 7 (14%) (Table 2). The studies were distributed as follows: Peru (11 studies), Mexico (9 studies), Brazil (7 studies), Colombia (4 studies), Venezuela (4 studies), Argentina (3 studies), Chile (3 studies), Bolivia (1 study), Costa Rica (1 study), Cuba (1 study), Ecuador (1 study), Paraguay (1 study) and Uruguay (1 study). All faecal samples were evaluated by centrifugation-flotation, searching for *Toxocara* eggs. The presence of *Toxocara* eggs in soil samples was assessed by the following methods: Double W, centrifugation-flotation, and sedimentation.

Risk of bias assessment

In the risk of bias assessment, five studies were at high risk, while the remaining 44 were at low risk of bias (Table 3).

Prevalence of Toxocara in parks

The pooled prevalence of *Toxocara* eggs in parks in Latin America was 50.0% (95.0% CI: 40.0%-

Figure 1
PRISMA Flow Diagram.

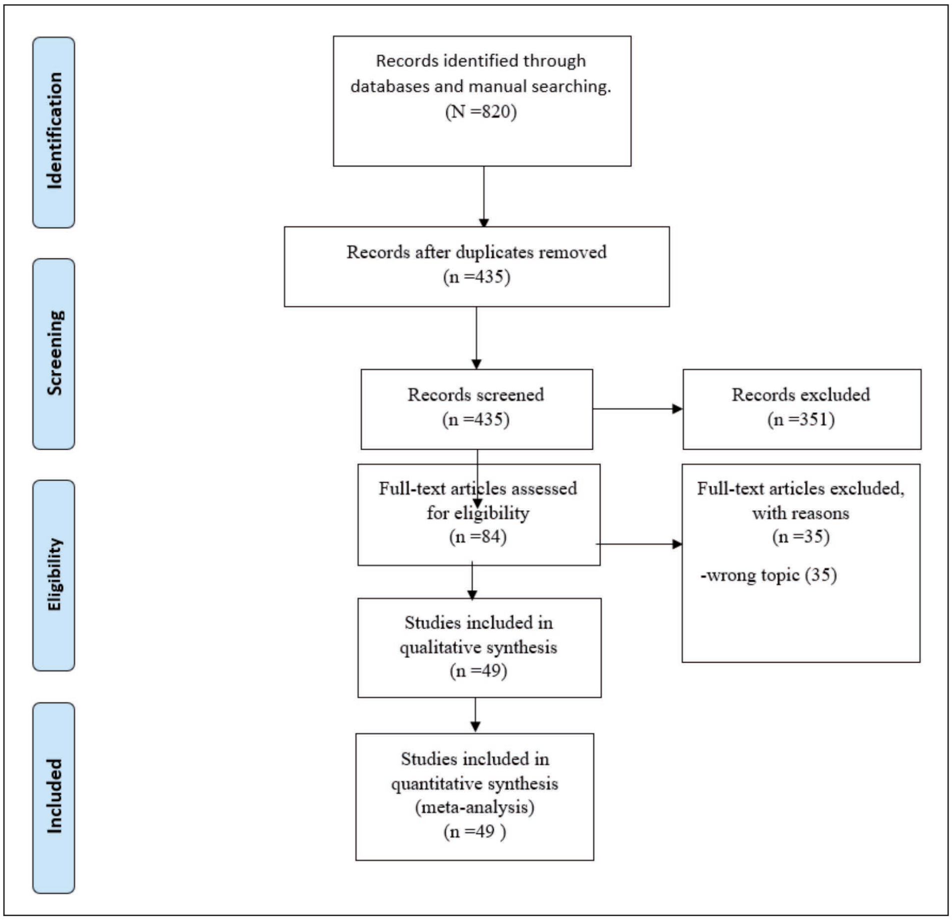

Table 2 - Characteristics of the included studies.

Author	*Year-Publication*	*Year of sample collection*	*Country*	*Total number of evaluated parks*	*Total number of parks contaminated with Toxocara*	*Sample obtained from the parks*	*Methods used to assess soil samples*	*Methods used to evaluate fecal samples*	*Total number of samples evaluated*	*Total number of samples contaminated with Toxocara*	*References*
Chavez A et al.	2002	1998-1999	Peru	558	235	Soil	Double "W"	NR	NR	NR	[32]
Vargas-Nava A et al.	2020	2013	Mexico	236	18	Soil	Centrifugation-flotation	NR	1180	115	[65]
Lettieri-Texeira M et al.	2008	2007	Brazil	NR	NR	Soil	Sedimentation	NR	25	7	[45]
Paquet-Durand I et al.	2007	2005-2006	Costa Rica	NR	NR	Soil	Sedimentation	NR	44	6	[55]
						Fecal	NR	Centrifugation-flotation	69	5	
Farfan-Pajuelo D et al.	2019	2018	Peru	10	7	Soil	Double "W"	NR	NR	NR	[54]
Devera R et al. (A)	2008	2004	Venezuela	20	11	Soil	Sedimentation	NR	80	23	[33]
Devera R et al. (B)	2020	2019	Venezuela	10	8	Soil	Sedimentation	NR	40	13	[24]
Santarem V et al.	1998	1995-1996	Brazil	10	6	Soil	Centrifugation-flotation	NR	120	21	[63]
Guzmán-Quinche F et al.	2019	2014	Ecuador	35	16	Fecal	NR	Centrifugation-flotation	245	31	[58]
Cáceres-Pinto C et al.	2016	2012	Peru	21	14	Soil	Double "W"	NR	276	74	[27]
Malca C et al.	2019	2014-2016	Peru	131	1	Soil	Double "W"	NR	NR	NR	[47]
Lopez F et al.	2005	1999	Peru	123	78	Soil	Double "W"	NR	NR	NR	[46]
Polo-Teran et al.	2007	2005-2006	Colombia	52	49	Soil	Sedimentation	NR	1560	84	[56]

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Author	*Year-Publication*	*Year of sample collection*	*Country*	*Total number of evaluated parks*	*Total number of parks contaminated with Toxocara*	*Sample obtained from the parks*	*Methods used to assess soil samples*	*Methods used to evaluate fecal samples*	*Total number of samples evaluated*	*Total number of samples contaminated with Toxocara*	*References*
La Rosa V et al.	2001	1999	Peru	108	37	Soil	Double "W"	NR	NR	NR	[68]
Marques JP et al.	2012	2010	Brazil	120	82	Soil	Centrifugation-flotation	NR	NR	NR	[48]
Eisen A et al.	2019	2018	Brazil	NR	NR	Soil	Centrifugation-flotation	NR	162	1	[35]
							Sedimentation	NR	216	0	
Martínez-Barbabosa I et al.	1998	1996	Mexico	82	7	Soil	Centrifugation-flotation	NR	NR	NR	[49]
Cazorla-Perfetti D et al.	2007	2004	Venezuela	38	24	Soil	Centrifugation-flotation	NR	NR	NR	[31]
Romero-Núñez C et al.	2009	2005	Mexico	NR	NR	Soil	Centrifugation-flotation	NR	310	186	[60]
						Faecal	NR	Centrifugation-flotation	200	135	
Benavides-Melo C et al.	2020	2019	Colombia	31	17	Soil	Centrifugation-flotation	NR	155	19	[26]
Menocal-Heredia L et al.	2018	2013-2014	Cuba	23	3	Faecal	Centrifugation-flotation	Centrifugation-flotation	28	1	[44]
Armstrong W et al.	2011	2003	Chile	87	6	Soil	Centrifugation-flotation	NR	193	70	[25]
Díaz-Anaya A et al.	2015	2013	Colombia	28	28	Soil	Centrifugation-flotation	NR	124	53	[34]
						Faecal	NR	Centrifugation-flotation	124	5	
Medina-Pinto R et al.	2018	2015	Mexico	20	1	Faecal	NR	Centrifugation-flotation	100	1	[50]

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Author	*Year-Publication*	*Year of sample collection*	*Country*	*Total number of evaluated parks*	*Total number of parks contaminated with Toxocara*	*Sample obtained from the parks*	*Methods used to assess soil samples*	*Methods used to evaluate fecal samples*	*Total number of samples evaluated*	*Total number of samples contaminated with Toxocara*	*References*
Lee D et al.	2021	2018-2020	Brazil	20	11	Soil	Centrifugation-flotation	NR	83	13	[43]
Ramírez-Rubio L et al.	2019	2016-2017	Mexico	56	26	Soil	Centrifugation-flotation	NR	560	66	[59]
Alonso J et al. (A)	2001	1998	Argentina	5	1	Soil	Centrifugation-flotation	NR	475	6	[22]
Alonso J et al. (B)	2006	2003-2004	Argentina	44	10	Soil	Centrifugation-flotation	NR	612	26	[23]
Melín-Coloma M et al.	2016	2014	Chile	43	0	Soil	Double "W"	NR	NR	NR	[51]
Alcantara N et al.	1989	NR	Brazil	96	31	Soil	Centrifugation-flotation	NR	298	74	[21]
						Faecal	NR	Centrifugation-flotation	277	51	
Vidal M et al.	2019	NR	Brazil	NR	NR	Faecal	NR	Centrifugation-flotation	92	23	[67]
Garcia-Blasquez D et al.	2017	2016	Peru	10	9	Soil	Double "W"	NR	NR	NR	[38]
Gallardo J et al.	2015	NR	Venezuela	32	20	Soil	Double "W"	NR	NR	NR	[37]
Montalvo-Sabino E et al.	2014	2014	Peru	11	10	Soil	Double "W"	NR	NR	NR	[53]
Iannacone J et al.	2012	2007-2008	Peru	NR	NR	Soil	Centrifugation-flotation	NR	117	81	[41]
Young-Candia C et al.	2011	2010	Peru	25	12	Soil	Double "W"	NR	200	14	[69]

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Author	*Year-Publication*	*Year of sample collection*	*Country*	*Total number of evaluated parks*	*Total number of parks contaminated with Toxocara*	*Sample obtained from the parks*	*Methods used to assess soil samples*	*Methods used to evaluate fecal samples*	*Total number of samples evaluated*	*Total number of samples contaminated with Toxocara*	*References*
Guarín-Patarroyo C et al.	2016	NR	Colombia	3	3	Soil	Centrifugation-flotation	NR	72	25	[39]
Castillo Y et al.	2001	1998-1999	Peru	17	12	Soil	Double "W"	NR	NR	NR	[30]
Canese A et al.	2003	NR	Paraguay	51	27	Soil	Centrifugation-flotation	NR	NR	NR	[28]
Lara-Reyes E et al.	2019	NR	Mexico	27	22	Soil	Centrifugation-flotation	NR	NR	NR	[42]
Poma R et al.	2018	2016	Bolivia	10	8	Faecal	NR	Centrifugation-flotation	300	19	[57]
Mendoza-Meza D et al.	2015	2013	Colombia	NR	NR	Soil	Centrifugation-flotation	NR	13	5	[52]
Fonrouge R et al.	2000	NR	Argentina	22	15	Soil	Centrifugation-flotation	NR	242	32	[36]
Tsuji O et al.	1996	1995	Mexico	156	17	Soil	Centrifugation-flotation	NR	281	36	[66]
Romero-Núñez C et al. (C)	2013	NR	Mexico	7	7	Soil	Centrifugation-flotation	NR	2374	587	[61]
Salinas P et al.	2001	1996-1998	Chile	110	25	Soil	Centrifugation-flotation	NR	159	29	[62]
Castillo D et al.	2000	1999	Chile	96	36	Faecal	NR	Centrifugation-flotation	288	39	[29]
Tiyo R et al.	2008	2003-2004	Brazil	17	17	Soil	Centrifugation-flotation	NR	375	195	[64]
Hernandez S et al.	2003	2000	Uruguay	70	37	Faecal	NR	Centrifugation-flotation	764	99	[40]

NR: Not reported.

Table 3 - Quality assessment of included studies.

Study	*Newcastle - Ottawa quality assessment scale for cross-sectional studies*								
	Selection				*Comparability*	*Outcome*			
	Representativeness of the sample	*Sample size*	*Non-respondents*	*Ascertainment of the exposure (risk factor)*	*The subjects in different outcome groups are comparable based on the study design or analysis. Confounding factors are controlled. Maximum: ☆☆*	*Assessment of outcome*	*Statistical test*	*SCORE*	*Evidence quality (bias)*
Chavez A et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Vargas-Nava A et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Lettieri-Texeira M et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Paquet-Durand I et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Farfan-Pajuelo D et al.	☆	☆		☆	☆	☆	☆	6	High risk
Devera R et al. (A)	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Devera R et al. (B)	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Santarem V et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Guzmán-Quinche F et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Cáceres-Pinto C et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Malca C et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Lopez F et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Polo-Teran et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
La Rosa V et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Marques JP et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Eisen A et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Martínez-Barbabosa I et al.	☆	☆		☆	☆	☆	☆	6	High risk
Cazorla-Perfetti D et al.	☆	☆		☆	☆	☆	☆	6	High risk
Romero-Núñez C et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Benavides-Melo C et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Menocal-Heredia L et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Armstrong W et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Díaz-Anaya A et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk

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Study	*Newcastle - Ottawa quality assessment scale for cross-sectional studies*								
	Selection				*Comparability*	*Outcome*			
	Representa-tiveness of the sample	*Sample size*	*Non-respondents*	*Ascertainment of the exposure (risk factor)*	*The subjects in different outcome groups are comparable based on the study design or analysis. Confounding factors are controlled. Maximum: ☆☆*	*Assessment of outcome*	*Statistical test*	*SCORE*	*Evidence quality (bias)*
Medina-Pinto R et al.	☆	☆		☆	☆	☆	☆	6	High risk
Lee D et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Ramírez-Rubio L et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Alonso J et al. (A)	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Alonso J et al. (B)	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Melín-Coloma M et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Alcantara N et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Vidal M et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Garcia-Blasquez D et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Gallardo J et al.	☆	☆		☆	☆	☆	☆	6	High risk
Montalvo-Sabino E et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Iannacone J et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Young-Candia C et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Guarín-Patarroyo C et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Castillo Y et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Canese A et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Lara-Reyes E et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Poma R et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Mendoza-Meza D et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Fonrouge R et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Tsuji O et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Romero-Núñez C et al. (C)	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Salinas P et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk
Castillo D et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Tiyo R et al.	☆	☆	☆	☆	☆☆	☆	☆	8	Low risk
Hernandez S et al.	☆	☆	☆	☆	☆	☆	☆	7	Low risk

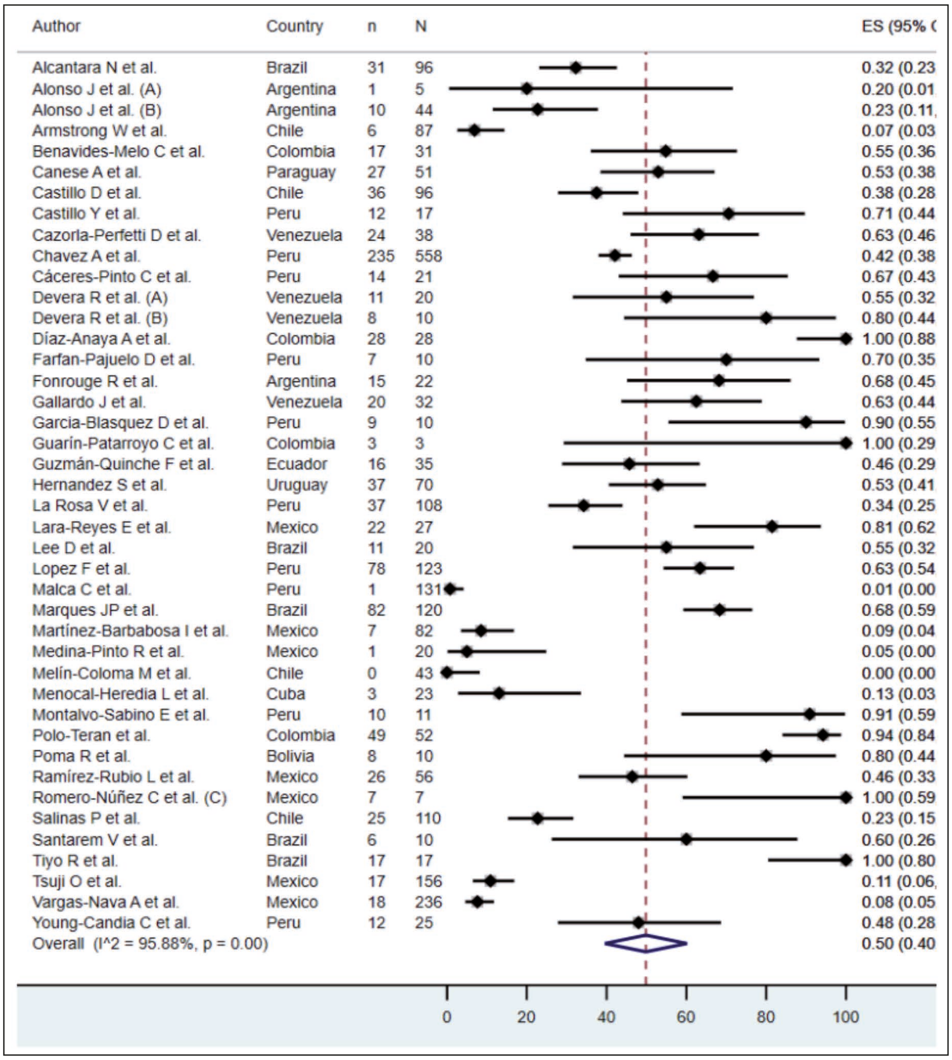


Figure 2
Toxocara eggs prevalence in parks.

60.0%) with high heterogeneity (I^2=95.88%) (Figure 2). In the subgroup analysis according to country (Figure 3), Colombia had the highest prevalence of *Toxocara* eggs in parks (92%; 95% CI 64.0%-100.0%), followed by Brazil (66.0%; 95% CI 40.0%-88.0%), and Venezuela (63.0%; 95% CI 53.0%-73.0%). In the sensitivity analysis, after removing the articles at high risk of bias, heterogeneity was decreased (I^2=96.09%) (Figure 4).

Prevalence of Toxocara in parks according to sample source

The pooled overall prevalence of *Toxocara* eggs in soil samples collected from parks was 20.0% (95% CI: 14.0%–26.0%) (Figure 5). However, in the subgroup analysis according to methods (Figure 6), the prevalence of *Toxocara* eggs in soil was 22.0% (95% CI: 15.0%–30.0%) for Centrifugal-flotation, 14.0% (95% CI: 4.0%–27.0%) for sedimentation, and 17.0% (95% CI: 14.0%–21.0%) for Double W method. On the other hand, the pooled prevalence of *Toxocara* in faecal samples collected from parks was 13.0% (95% CI: 6.0%–23.0%) (Figure 7). No studies reported molecular findings, then were omitted.

DISCUSSION

Toxocariasis is a highly prevalent parasitic disease, especially in Latin America [70]. Although

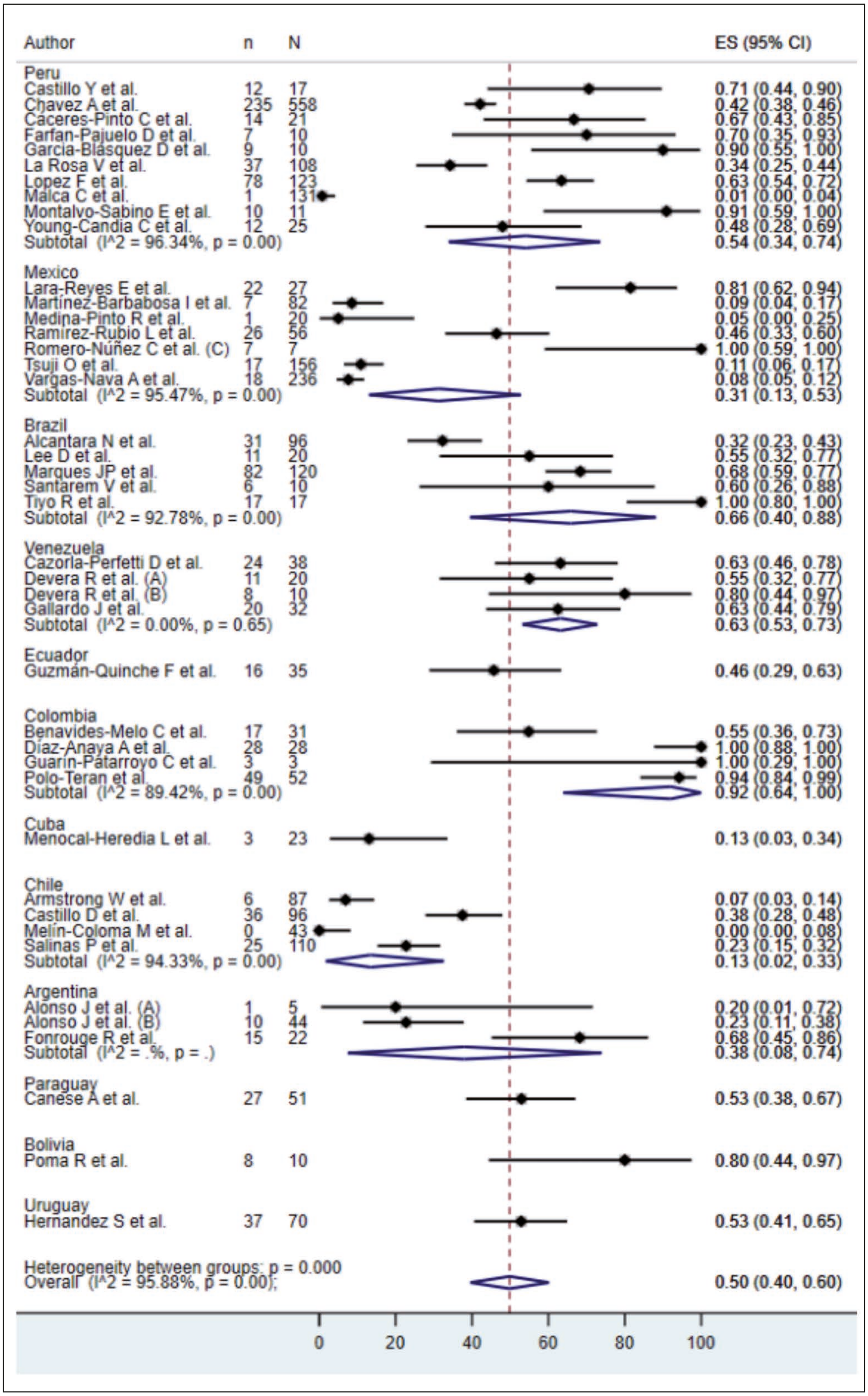


Figure 3
Subgroup analysis by country when evaluating the prevalence of parks with *Toxocara* eggs.

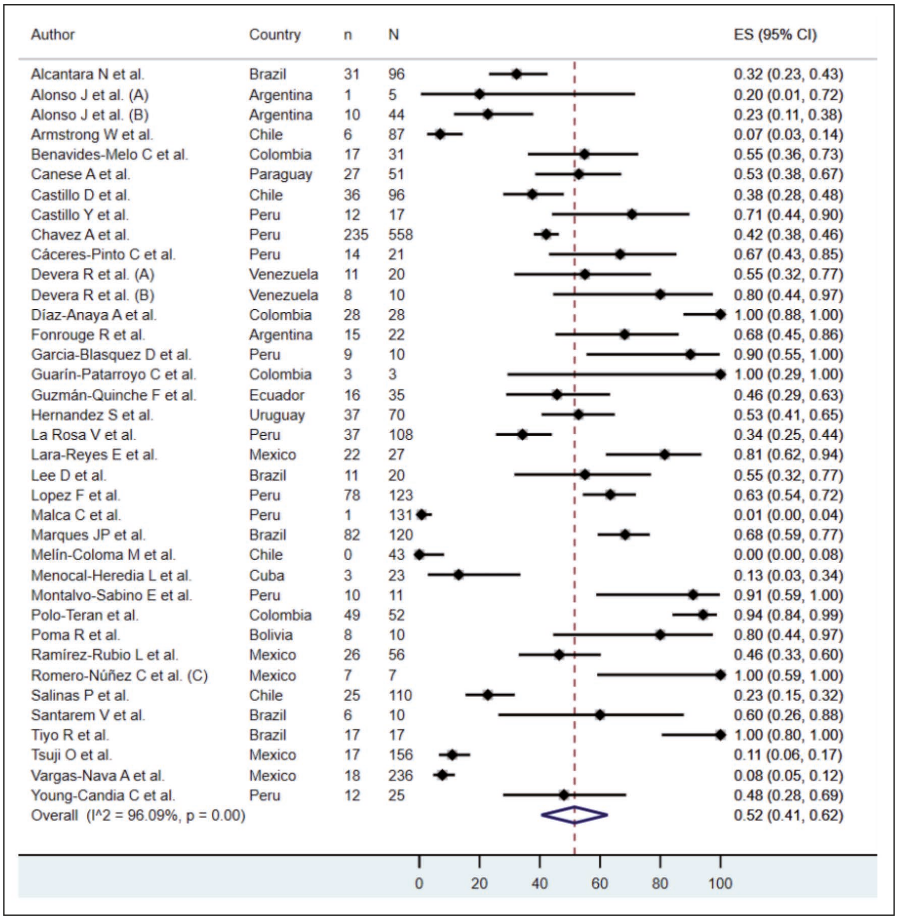


Figure 4
Sensitivity analysis according to the risk of bias when evaluating the prevalence of parks with *Toxocara* eggs.

its clinical importance, which may lead even to fatal cases, is not a condition under surveillance in most countries of the region [71-73].

Based on the search of six databases, this systematic review and meta-analysis estimated the pooled prevalence of *Toxocara* eggs in parks from Latin America. As different reports have suggested, there is significant variability in the prevalence of this parasite among countries [74]. The global prevalence in Latin American parks land in the present study, using the search for studies published in databases of studies in different Latin American countries between 1989 and 2023, allowed the development of a meta-analysis. Additional studies have reported the existence of *Toxocara* eggs in soil samples in parks in public areas in Latin America, in Colombia 2.5%, Puerto Rico 6.5%, Costa Rica 7%, Ecuador 8.5%, Mexico 12.5%, Uruguay 16.1%, Cuba 17.9%, Bolivia 27%, Peru 27.7%, Brazil 29.7, Argentina 35.1%, Paraguay 53%, Venezuela 63.16%, and Chile 66.7%. That shows that soils are critical for *Toxocara* transmission and need intervention to prevent and control disease in animals and humans [75-78]. Additionally and consistently, studies in Italy have shown similar results. In a survey in the Central region of the country, evaluating *Toxocara* prevalence in the soil of 22 public playgrounds of Ancona, it found that parasites were detected in the soil samples of 95.5% of playgrounds and that the most prevalent helminth found was *Toxocara canis*, in the soil samples from 54.5% of playgrounds [79].

The parasitological methods used in the studies mainly were Double w, with a prevalence of 44.1%, centrifugation at 10%, sedimentation at 13.7%, and flotation at 23.9%. Currently, the serological diagnosis of toxocariasis is carried out using the ELISA immune-enzymatic technique in

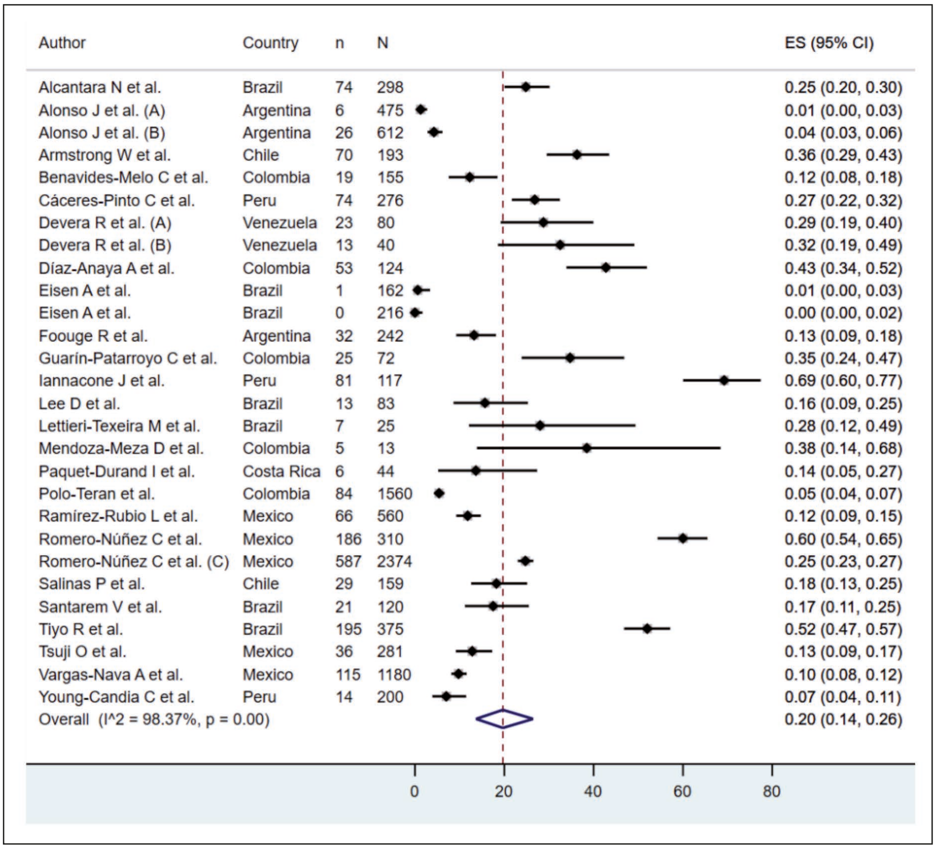


Figure 5 Prevalence of *Toxocara* eggs in samples from park soils.

some places to detect the presence of antigens secreted by the *Toxocara* larvae, allowing the diagnosis of the different clinical presentations of the disease [80-82]. Nevertheless, there is a lack of studies using molecular tools, as standardized PCR for *Toxocara* in the region's laboratories is primarily unavailable.

Variations according to multiple factors, as expected, were observed. The variation per year can be due to the socioeconomic level, age, pollution, culture, and the varied climate of the region where the study was carried out influencing factors. Other factors may be the presence of garbage deposits, not picking up the excrement by pet owners and the community's commitment to cleanliness improvement and implementation of public parks [76]. Additionally, a certain margin of inaccuracy remains due to bias that cannot be undone when conducting analyses involving the sampling of the soil and the faeces of animals. Nevertheless, the results obtained in this study indicate that the soils of public parks in Latin America are sites of risk of infection with *Toxocara*, considerably [83].

It is very striking that in Latin American countries such as Costa Rica, Colombia, and Venezuela, there are very few studies carried out on *Toxocara* prevalence in park soils, especially Venezuela, according to other studies carried out, and with the present study, it is one of the most countries with the highest prevalence in Latin America [2, 6, 55, 74].

We can observe that this zoonosis is widely distributed worldwide in low-, middle- and high-income countries due to the habit of having companion dogs that are frequently infected or acquire the parasite from the environment. Becoming a great source of infection for human beings. For *Toxocara*, the soil is a great reservoir where the eggs evolve to the larvae stage (L2), which allows them to remain stable for one to three years; this raises the possibility of a human being becoming infected, which can not only become infected, but can end up having severe clinical consequences, and even death when associated with the development of visceral larva migrans syndrome [80, 84, 85].

Toxocara is an intestinal nematode that parasitises dogs (*T. canis*) and cats (*T. cati*), mainly those that have a wandering habit and are not subject to health plans, which are disseminators of this parasite, playing an essential role in the *Toxocara* cycle and its transmission to humans [76]. Dogs and cats are the definitive hosts of *T. canis* and *T. catis*, which lodges in the intestinal lumen of these animals and is excreted in the form of eggs, larvae, and adults in the faeces [78]. These faeces are deposited in public spaces such as parks and other green areas, representing a potential risk to public health [78]. Exposing the human population to the risk of infection, especially children interacting with pets and the soil in these spaces [4]. That is associated with geophagy habits.

Toxocariasis is a zoonotic disease of great importance in terms of morbidity and, in some cases, mortality that it can cause in humans because of how complex its control can be for public health. Regarding its association with other pathologies,

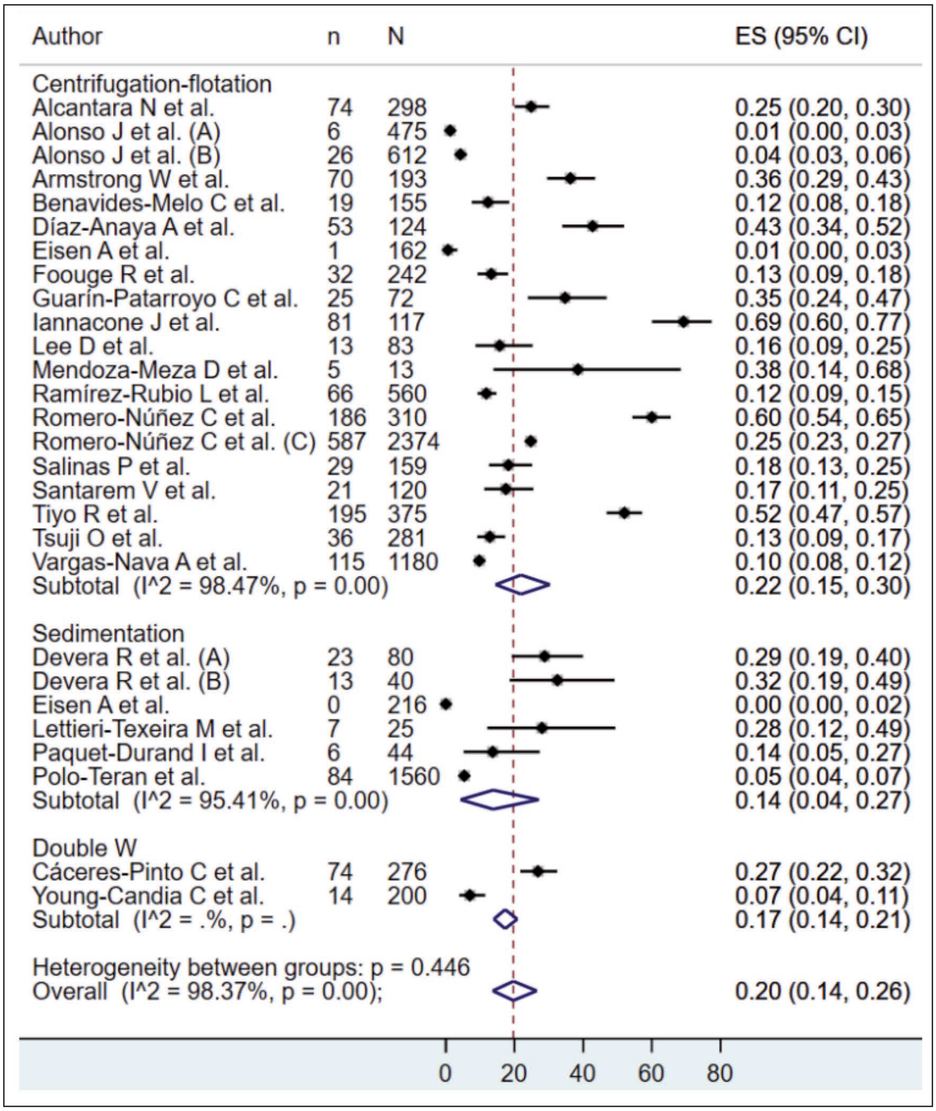
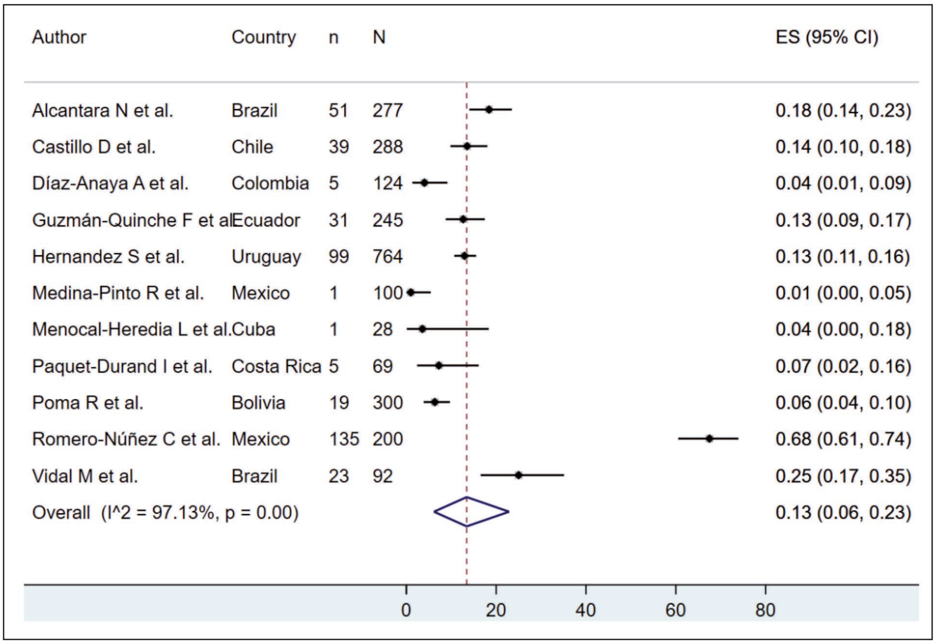


Figure 6
Subgroup analysis by the method of the prevalence of *Toxocara* eggs in soil parks sampling.

Figure 7
Prevalence of *Toxocara* in faecal samples obtained in parks.



this *Toxocara* infection can be considered forgotten and neglected due to the scarcity of solutions and national and Latino studies [86]. Toxocariasis is a pathology that is not regularly reported in Latin America. Its diagnosis is infrequent because it is not even considered clinical suspicion and also due to the lack of reagents since the diagnosis is made by serology [87-89].

There are no clearly defined risk groups since the infection does not respect age, sex, occupation, or social condition. However, it is recognized that children under ten may be at the most significant risk for contracting the infection due to the habits of playful activity and lack of care in hygiene, which facilitate the transmission of the disease [90, 91].

These results make us see that the population of stray animals increases considerably every day, and many, due to poor pet ownership, are abandoned on the streets. Consequently, they present unfavorable health conditions, bringing them diseases, including toxocariasis [4]. Furthermore, the number of dogs without an owner and a leash is higher compared to the number of dogs with an owner and on a leash and of dogs with an owner and without a leash, which shows that good breeding of dogs and population control of stray dogs is not carried out. However, the results suggest no correlation between the average number of dogs and the number of *Toxocara* eggs [80, 86, 92].

Unlike studies in Latin America, in countries such as France, Switzerland, South Korea, and Spain, a low prevalence of the disease is observed because they control infections in domestic and stray dogs, reducing the percentage of contamination towards the human being. However, it does not eradicate the risk since the parasite is found naturally in the soil and the environment [93, 94].

Mass deworming measures should be implemented for dogs without owners, diagnosis and deworming in dogs with owners, immediate elimination of dog faeces, since at that moment the eggs are not yet infective, application of ovicidal substances on surfaces and elements that may be contaminated with faecal matter from canines and educational campaigns directed at the community on the risks of acquiring toxocariasis [90, 95, 96].

The dog has always been and will be one more component of the human family; in the rural environment, to take care of the house, and in the urban environment, mainly as a companion animal, we have an increasing canine population, and good management is not carried out mainly of excreta [97]. Prevention of infections in humans depends on the treatment and prevention of *Toxo-*

cara spp. diseases in animals [98]. Contamination can be reduced in public areas by establishing restrictions on stray animals, collecting faeces by pet owners, and preventing animal access in areas such as children's playgrounds [90].

In order to reduce human exposure, dogs and cats should be dewormed. Pups from 3 weeks to 3 months of age shed large numbers of *Toxocara canis* eggs. Cats excrete *Toxocara cati*, especially between 2 and 6 months of life [99].

Good hygiene can help prevent infection or severe illness. Hands and raw food should be washed thoroughly before eating. Children should be taught not to eat dirt and to wash their hands after playing with pets or participating in outdoor activities. Children should not play in areas where animal faeces have been found [99].

Adequate control of this parasitic zoonosis would substantially reduce public health risks, mainly in the risk of infection in children under ten, who are more susceptible to contagion and more susceptible to acquiring more pathogenic forms of toxocariasis [96]. Therefore, it is necessary to promote collaboration between researchers related to toxocariasis to achieve superior research worldwide, especially in developing countries where it is more critical due to its high incidence, as well as the epidemiological, clinical, ecological, molecular, and treatment associated with toxocariasis [100].

CONCLUSIONS

The presence of *Toxocara canis* eggs in public parks in Latin America is a risk of zoonosis and public health for the people who go to these places, especially if children play on the ground, with the earth, or with contaminated objects, since many of them pet owners and the general public are not adequately informed about the mode of transmission of this parasitosis.

Awareness should be created in the population about implementing adequate health plans, such as deworming, vaccination, hygiene practices, and prevention in children. Furthermore, the findings show us the role of stray dogs with a high prevalence of *Toxocara canis* in the transmission of this zoonotic infectious disease; those that, due to defecation habits, in the streets and public squares, eventually lead to environmental contamination, which is why, at the government level, programs to control the ownerless canine population should be strengthened, promoting the responsibility of pets, trade, and sanitation of public parks and recreation areas.

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Declaration of competing interest
The authors declare no conflicts of interest.

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