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Worldwide prevalence of protozoans and helminths among disabled people: a systematic review and meta-analysis

Ahmed Galip Halidi^{1*} and Kemal Yaran^{1,2}

Abstract

Background Parasitic diseases represent a substantial public health concern on a global scale, particularly affecting communities characterized by low socioeconomic status and insufficient sanitation practices. Within these communities, individuals with disabilities are disproportionately impacted. According to the existing literature, it is posited that the prevalence of parasitic infections among disabled individuals is notably high, a factor often neglected when examining the intestinal parasites present in these individuals, alongside the diverse geographical and socioeconomic variations worldwide. This study posits that the prevalence of parasitic infections in individuals with disabilities is indeed elevated, and that there are significant socioeconomic and geographic disparities in species-specific prevalence. This study aimed to ascertain the global pooled prevalence of helminth and protozoan infections in individuals with disabilities, identify the prevalent parasite species, and compare the prevalence across various geographic regions worldwide.

Methods A systematic review and meta-analysis were conducted using the Reporting System for Systematic Reviews and Meta-Analyses. PubMed, Web of Science, Scopus, and the TR index were searched in August 2024 using the predetermined keywords. No time restrictions were imposed. The methodological quality of the studies was evaluated using the Joanna Briggs Institute's Critical Appraisal Checklist for randomized controlled, experimental, and cross-sectional studies. A meta-analysis method was used to pooled the data.

Results A total of 12608 samples from 50 articles were included in the analysis. The pooled helminth and protozoan parasite prevalence was 40%, with high heterogeneity ($I^2 = 98.48\%$, $P < 0.001$). Subgroup analysis revealed that the most common country for helminths and protozoans in disabled people was Canada, at a rate of 73% ($I^2 = 95.23\%$, $P < 0.001$). Subgroup analysis of parasite species revealed that *Toxoplasma* sp. (40%; prevalence with 95% CI: 40%, $I^2 = 98.83$) was the most frequently detected parasite among disabled people, followed by *Entamoeba histolytica/dispar* and *Toxocara* spp. *Entamoeba coli*, *Entamoeba hartmanni*, *Ascaris lumbricoides* and *Blastocystis* spp. In the subgroup analysis performed with the data obtained in the classification according to the differences in diagnostic methods, 42% ($I^2 = 98.03$, $P < 0.001$) in molecular techniques, 36% ($I^2 = 98.52$, $P < 0.001$) in serological methods, 41% ($I^2 = 98.4$, $P < 0.001$) in gaita microscopic examinations.

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Conclusion The global prevalence of protozoa and helminths among individuals with disabilities is significantly high, with notable occurrences in Canada, Philippines, and Ethiopia. The primary determinants of this situation include socioeconomic conditions, educational level, and geographical factors. It is imperative to educate disabled individuals and their families about transmission pathways and preventive measures for protozoa and helminths. Furthermore, local governments and public authorities should endeavor to improve the living conditions of individuals with disabilities, particularly those facing self-care challenges.

Keywords Protozoan, Helmint, Disabled People, Meta-Analysis

Background

Parasitic infections (PIs) remain a persistent and widespread global public health concern, particularly in developing countries where sanitation infrastructure and access to health education are limited. These infections, affecting an estimated 3.5 billion individuals worldwide and ranging from protozoa to multicellular helminths, contribute significantly to gastrointestinal morbidity, malnutrition, and impaired development, particularly in vulnerable populations [1, 2].

The control of parasitic infections depends heavily on interrupting the complex life cycles of these organisms, which often involve both definitive and intermediate hosts [3, 4]. Inadequate hygiene practices, poor living conditions, and limited access to healthcare increase the risk of parasitic transmission in low-resource settings [5, 6].

Among high-risk groups, individuals with disabilities are particularly susceptible to parasitic infections because of physical or cognitive limitations that impair personal hygiene and self-care. Institutionalized living conditions, such as rehabilitation or long-term care centers, further exacerbate this vulnerability by increasing exposure to unsanitary environments [7, 8]. Several studies have highlighted the alarmingly high prevalence rates of intestinal parasites among people with intellectual disabilities, with rates reaching 41% in Iran and up to 56.7% in Ethiopia, significantly higher than those in non-disabled populations [9, 10].

Despite this burden, parasitic infections in individuals with disabilities remain under-recognized in public health policies and research. Understanding the prevalence and associated risk factors is critical for developing targeted prevention strategies, including hygiene education, routine screening, and environmental interventions. This study aimed to synthesize current epidemiological evidence on the prevalence of intestinal parasitic infections among individuals with disabilities, with a particular focus on social determinants and care conditions that influence susceptibility.

Objectives

This study aimed to determine the global prevalence of helminth and protozoan infections among individuals with disabilities, identify the most common parasitic

species, and compare their prevalence across different geographical regions worldwide.

Methods

This analysis is a systematic review and meta-analysis of published articles to estimate the global prevalence of helminth and protozoan parasites among individuals with disabilities. The literature search, selection of publications, and reporting of results were performed in accordance with the PRISMA guidelines (S1 Checklist) [11, 12]. The protocol for this systematic review and meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database. The registration number is CRD42024593439.

Search strategy

On November 20, 2024, an extensive literature search was conducted using all identified keywords across four electronic databases (PubMed, Web of Science, TR index, and Scopus) to identify studies that detailed the prevalence of helminths and protozoa among disabled individuals globally. There were no language restrictions. Furthermore, a manual search was conducted by examining the references of the retrieved articles to discover any additional relevant studies that might have been missed. The comprehensive search strategy for all the databases is detailed in Table S1.

Data management and study selection

The process of initially retrieving and managing all identified articles was performed using Mendeley software. Following the removal of duplicates, two authors (AGH and KY) independently selected relevant studies. The titles and abstracts of these studies were scrutinized according to pre-established eligibility criteria. Articles that appeared potentially eligible or whose eligibility was uncertain were subjected to full-text review. Any disagreements or uncertainties were resolved through discussion, with a third reviewer (SA and AE) being consulted when necessary. Efforts were made to obtain missing data or clarify uncertainties by contacting the corresponding authors. Articles that reported identical research data or findings, even if published in different formats or under different titles by the same author, were counted only once.

Inclusion and exclusion criteria

The criteria for selecting full-text articles for this study were as follows: (1) studies that utilized a cross-sectional design; (2) research conducted on a global level that detailed the prevalence of helminths and protozoan parasites; and (3) studies meeting these specified conditions. The exclusion criteria were as follows: (1) case reports, reviews, and studies lacking original data; (2) research not employing a cross-sectional approach; (3) studies in which the overall prevalence was neither reported nor inferable from the results, or in which the analysis was unclear or ambiguous; (4) surveys conducted in hospital or healthcare environments; and (5) articles with restricted access and those whose authors did not respond to two email inquiries.

Definition of intestinal protozoan infection and outcome measures

In the context of this study, were defined as detection of one or more of the following, helminths and protozoa parasites: *Toxoplasma* sp., *E. histolytica/dispar*, *Toxocara* spp., *Entamoeba coli*, *Entamoeba hartmanni*, *Blastocystis* spp., *Ascaris lumbricoides*, *Trichurus trichura*, *Endolimax nana*, *Enterobius vermicularis*, *Strongyloides stercoralis*, *G.intestinalis/duedonalis/labmbilia*, Hookworms, *Hymenolepis nana*, *Cryptosporidium* spp., *Chilomastix mesnili*, *Dientamoeba fragilis*, *Iodamoeba butschlii*, *Taenia* spp. The main outcome of this systematic review and meta-analysis was the estimated pooled prevalence of helminth and protozoan parasites among disabled individuals worldwide. The prevalence of helminths and protozoa was defined as the ratio of positive samples to the total number of samples.

Data extraction

Two authors, AGH and KY, extracted pertinent data from each eligible article and logged them into a pre-designed Excel spreadsheet. Before the data were included in the review, SA and AE performed a double-check to ensure that the information was consistent, unbiased, and error-free. The data collected comprised the first author's name, publication year, country and region of the study, sample size, total number of cases, species identified, and number of species identified.

Quality assessment

Two independent authors (AGH and KY) evaluated the methodological quality of each study included in the analysis using the Joanna Briggs Institute (JBI) checklist for prevalence studies [13]. This checklist consists of nine items, each with four possible responses: 'yes', 'no', 'unclear', and 'not applicable' [14].

Data analysis

Pooled prevalence estimates with 95% confidence intervals (CIs) were calculated for each study. A random-effects model using the Restricted Maximum Likelihood (REML) method was employed to account for the expected heterogeneity across studies. Between-study heterogeneity was assessed using the I^2 statistic and Cochran's Q test, with I^2 values >75% interpreted as indicating substantial heterogeneity. To explore the potential sources of heterogeneity, subgroup analyses were performed based on geographic region and diagnostic methods (microscopy, serological, and molecular).

Additionally, univariate meta-regression analyses were conducted to examine the influence of publication year and sample size on prevalence estimates. Publication year was treated as a continuous moderator to assess whether temporal changes affected prevalence. The sample size was also examined to determine whether the study size significantly influenced the pooled estimates, as smaller studies may tend to report higher or lower prevalence due to random error or methodological limitations.

Sensitivity analyses were conducted to assess the robustness of the findings by excluding studies with a high risk of bias. Publication bias was evaluated both visually using funnel plots and statistically using Egger's regression test. All statistical analyses were performed using STATA version 18 (StataCorp, College Station, TX, USA).

Subgroup and sensitivity analyses

To better understand the variability in prevalence estimates, subgroup analyses were pre-specified and conducted according to (1) continent or country of study origin, (2) type of diagnostic method used (microscopic, serologic, molecular), and (3) the category of parasitic agent (helminths vs. protozoa). Sensitivity analyses were performed by excluding studies with unclear or high risk of bias and rerunning the meta-analysis to evaluate the consistency of the pooled prevalence estimates.

Results study selection

A total of 1657 articles were identified from four databases. After 913 duplicates were removed, another 661 studies were excluded from the remaining articles after title and/or abstract evaluations. A total of 33 articles were excluded during the full-text assessment (Table S2). Finally, only 50 articles (3%) met the eligibility criteria and were included in the systematic review and meta-analysis (Fig. 1).

Characteristics of included studies

The comprehensive characteristics of the included studies are listed in Table 1. The 50 eligible studies were conducted in 17 countries worldwide. The Islamic Republic

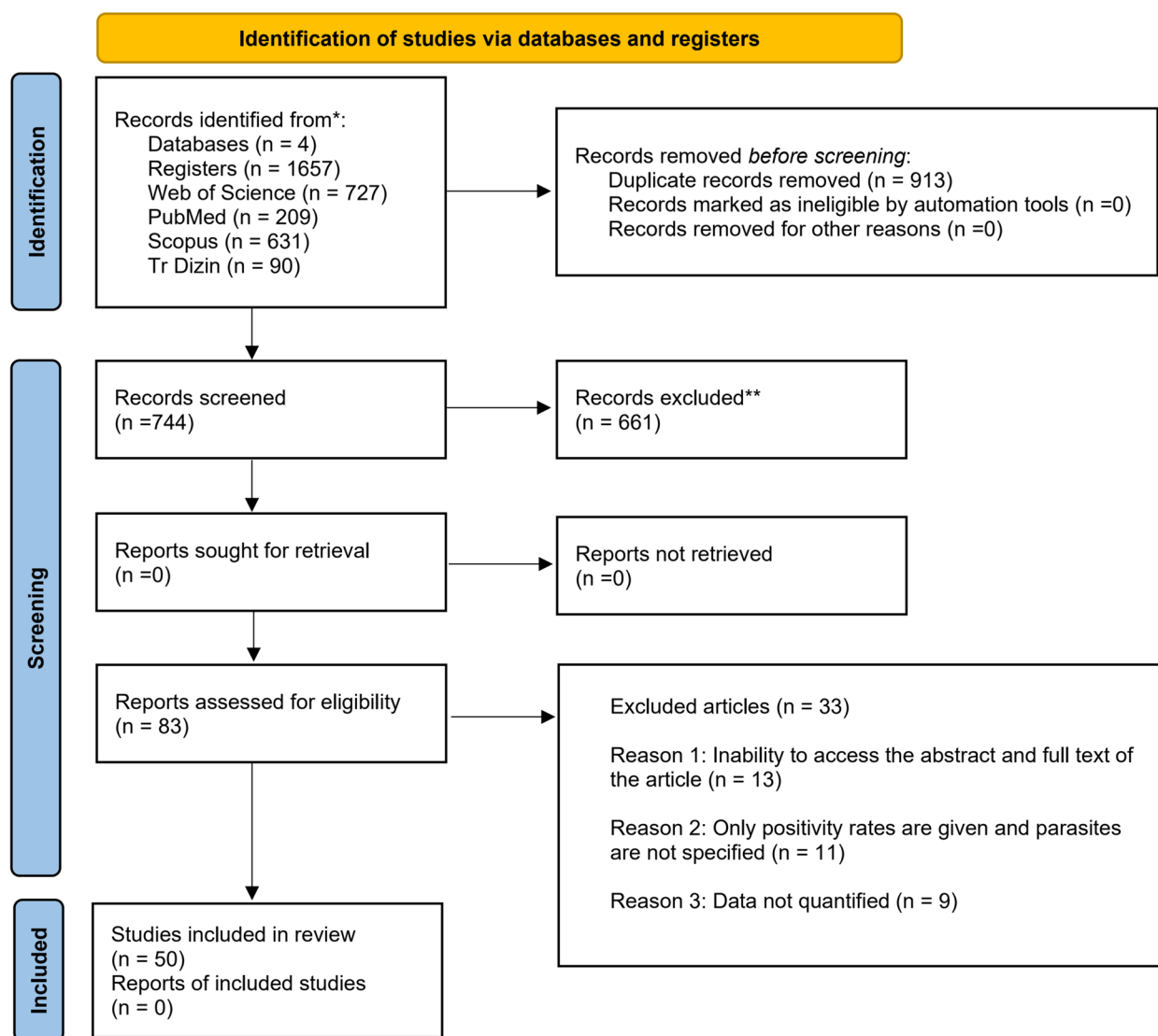


Fig. 1 PRISMA 2020 flow diagram of study selection

of Iran had the highest number of eligible studies [15], followed by the United States of America (five studies), Japan (five studies), Canada (three studies), the Arab Republic of Egypt (three studies), Italy (three studies), Turkey (three studies), Taiwan (two studies), the United Kingdom (one study), Ethiopia (one study), and D. P. R. of Korea (1 study), Norway (1 study), Philippines (1 study), Poland (1 study), Saudi Arabia (1 study), Tanzania (1 study), and Yemen (1 study) (Fig. 2).

The included studies examined a total of 12,608 disabled individuals for the presence of helminths and protozoan parasites. Most of the included studies used multiple diagnostic methods, including microscopy and serological and molecular-based methods. A map showing the geographical distribution across the continent based on the included studies is shown in Fig. 2.

Pooled prevalence of intestinal parasite

The pooled prevalence of protozoans and helminths among people with disabilities worldwide was 40% (95% CI: 34–46%) (Fig. 3). Significant heterogeneity was observed in all included studies ($I^2=98.48$, $P<0.001$). Among these countries, Canada had the highest prevalence at 73% ($I^2=99.44$, $P<0.001$). In analyses in which parasites were evaluated separately, *Toxoplasma* sp. (40%; 95% CI: 24–56%, $I^2=98.83$) was the most frequently detected parasite in disabled individuals (Fig. 4), followed by *E. histolytica/dispar*, *Toxocara* spp., *E. coli*, *E. hartmanni*, *Blastocystis* spp., *A. lumbricoides*, *Trichurus trichura*, *Endolimax nana*, *Enterobius vermicularis*, *Strongyloides stercoralis*, *G. intestinalis/duodenalis/labmbliia*, Hookworms, *Hymenolepis nana*, *Cryptosporidium* spp., *Chilomastix mesnili*, *Dientamoeba fragilis*, *Iodamoeba butschlii* and *Taenia* spp. (Table 2).

Table 1 General characteristics of the studies included in the systematic review and meta-analysis

No	Firs autor. (Year)	Ref. no	Region	Samp size	Positive	Prevalence with 95% CI	95% lower CI	95% upper CI	Weight (%)
1	Ezatpour, B., et al. (2015)	[16]	IRAN	158	48	0.304	0.232	0.376	2.01
2	Abe, N., et al. (2012)	[17]	JAPAN	68	4	0.059	0.003	0.115	2.03
3	Ahmadi, M., et al. (2015)	[15]	IRAN	341	112	0.328	0.279	0.378	2.04
4	Awadi, A., et al. (2022)	[18]	YEMEN	107	3	0.028	0.000	0.059	2.06
5	Brook, I., et al. (1981)	[19]	USA	1400	283	0.202	0.181	0.223	2.06
6	Fentahun, AA., et al. (2019)	[10]	ETYOPIA	104	59	0.567	0.472	0.663	1.96
7	Gatti, S., et al. (2000)	[20]	ITALY	550	125	0.227	0.192	0.262	2.05
8	Gatti, S., et al. (1995)	[21]	ITALY	77	26	0.338	0.232	0.443	1.94
9	Gharavi, M.J. et al. (2005)	[22]	IRAN	353	49	0.139	0.103	0.175	2.05
10	Giacometti, A., et al. (1997)	[23]	ITALY	238	128	0.538	0.474	0.601	2.02
11	Hassanein, F., et al. (2017)	[24]	EGYPT	200	17	0.085	0.046	0.124	2.05
12	Hazrati, T., et al. (2010)	[25]	IRAN	225	44	0.196	0.144	0.247	2.04
13	Huminer, D., et al. (1992)	[26]	USA	106	30	0.283	0.197	0.369	1.98
14	Jongweon, L., et al. (2000)	[27]	KOREA	112	40	0.357	0.268	0.446	1.98
15	Kaczmariski, M., et al. (1977)	[28]	POLAN	121	42	0.347	0.262	0.432	1.99
16	Kaplan, M., et al. (2004)	[29]	TÜRKİYE	96	18	0.188	0.109	0.266	2.00
17	Kawatu, D., et al. (1992)	[30]	CANADA	93	79	0.849	0.777	0.922	2.01
18	Kawatu, D., et al. (1993)	[31]	CANADA	88	74	0.841	0.764	0.917	2.00
19	Khalili, B., et al. (2014)	[32]	IRAN	108	38	0.352	0.262	0.442	1.98
20	Khedri, M., et al. (2021)	[33]	IRAN	318	135	0.425	0.370	0.479	2.03
21	Langset, M., et al. (1978)	[34]	NORWAY	510	270	0.529	0.486	0.573	2.05
22	Mohammadi-M, V., et al. (2019)	[35]	IRAN	126	69	0.548	0.461	0.635	1.98
23	Nagakura, K., et al. (1990)	[36]	JAPAN	620	164	0.265	0.230	0.299	2.05
24	Nagakura, K., et al. (1989)	[37]	JAPAN	190	72	0.379	0.310	0.448	2.01
25	Naiman, H., et al. (1980)	[38]	CANADA	73	36	0.493	0.378	0.608	1.92
26	Nishise, S., et al. (2010)	[39]	JAPAN	76	37	0.487	0.374	0.599	1.93
27	Nyundo, AA., et al. (2017)	[40]	TANZANIA	233	29	0.124	0.082	0.167	2.05
28	Omar, M.S., et al. (1992)	[41]	SAUDI ARABIA	100	14	0.140	0.072	0.208	2.01
29	Omidian, M., et al. (2021)	[42]	IRAN	117	33	0.282	0.201	0.364	1.99
30	Omidian, M., et al. (2023)	[43]	IRAN	117	35	0.299	0.216	0.382	1.99
31	Pakmehr, A., et al. 2022	[8]	IRAN	119	36	0.303	0.220	0.385	1.99
32	Rashno, M., et al. (2016)	[44]	IRAN	87	58	0.667	0.568	0.766	1.96
33	Rasti, S., et al. (2012)	[45]	IRAN	243	191	0.786	0.734	0.838	2.04
34	Rivera, W.L., et al. (2006)	[46]	PHILIPPINES	113	74	0.655	0.567	0.743	1.98
35	Saeidinia, A., et al. (2016)	[47]	IRAN	173	51	0.295	0.227	0.363	2.01
36	Sargeaunt, P.G., et al. (1982)	[48]	ENGLAND	174	44	0.253	0.188	0.317	2.02
37	Sharif, M., et al. (2010)	[49]	IRAN	362	95	0.262	0.217	0.308	2.04
38	Sharif, M., et al. (2007)	[50]	IRAN	336	265	0.789	0.745	0.832	2.05
39	Shehata, AI., et al. (2015)	[51]	EGYPT	200	87	0.435	0.366	0.504	2.01
40	Shehata, AI., et al. (2016)	[52]	EGYPT	188	94	0.500	0.429	0.571	2.01
41	Shokri A., et al. (2012)	[53]	IRAN	133	64	0.481	0.396	0.566	1.99
42	Sirivichayakul, C., et al. (2003)	[54]	TAIWAN	1086	619	0.570	0.541	0.599	2.06
43	Soosaraie, M., et al. (2013)	[55]	IRAN	196	24	0.122	0.077	0.168	2.04
44	Su, SB., et al. (2014)	[56]	TAIWAN	443	179	0.404	0.358	0.450	2.04
45	Tachibana, H., et al. (2000)	[57]	JAPAN	50	27	0.540	0.402	0.678	1.86
46	Thacker, S.B., et al. (1979)	[58]	USA	38	32	0.842	0.726	0.958	1.92
47	Thacker, S.B., et al. (1981)	[59]	USA	38	23	0.605	0.450	0.761	1.81
48	Yoeli, M., et al. (1963)	[60]	USA	1437	255	0.177	0.158	0.197	2.06
49	Atambay, M., et al. (2007)	[61]	TÜRKİYE	117	53	0.453	0.363	0.543	1.98
50	Doni Y.N., et al. (2015)	[62]	TÜRKİYE	50	29	0.580	0.443	0.717	1.87

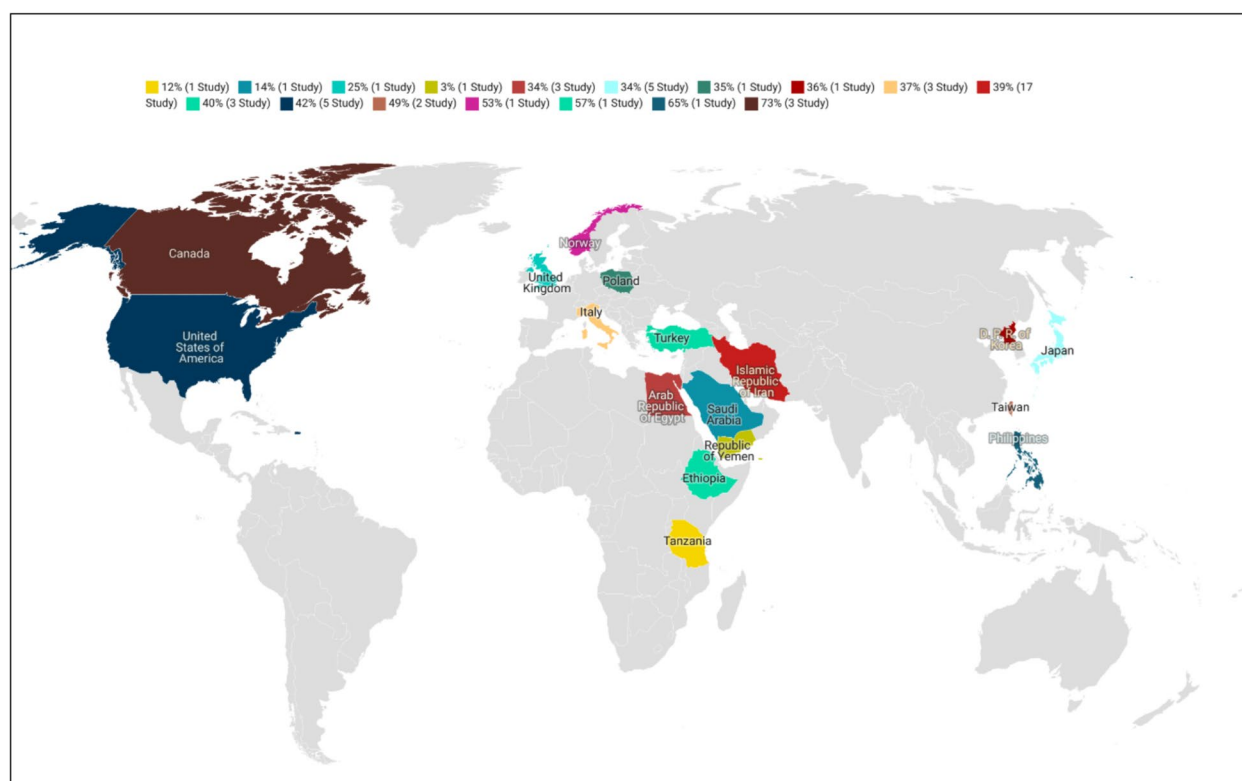


Fig. 2 Distribution of pooled prevalences and number of studies by geographical region (<https://datawrapper.dwcdn.net/6j65l/1/>)

Subgroup analysis

In the subgroup analysis according to the countries in which the studies were conducted, the prevalences were 73% in Canada ($I^2=95.23$, $P<0.001$), 49% in Taiwan ($I^2=97.21$, $P<0.001$), 42% in the USA ($I^2=99.54$, $P<0.001$), 40% in Turkey ($I^2=93.74$, $P<0.001$), 39% in Iran ($I^2=97.87$, $P<0.001$), 37% in Italy ($I^2=96.07$, $P<0.001$), 34% in Japan ($I^2=96.86$, $P<0.001$), and 34% in Egypt ($I^2=95.23$, $P<0.001$) (Fig. 2). Subgroup analysis of the data obtained from the classification according to the differences in diagnostic methods resulted in 42% ($I^2=98.03$, $P<0.001$) for molecular techniques, 36% ($I^2=98.52$, $P<0.001$) for serological methods, and 41% ($I^2=98.4$, $P<0.001$) for microscopic examination of feces (Fig. 5). The results showed a statistically significant effect of PI prevalence on individuals with disabilities.

Quality assessment and publication bias

As a result of the meta-analysis of the data of the studies included in the study using STATA 18 software, the funnel plot graph showing the publication bias showed that the publication bias was at an acceptable level (Fig. 6). In addition, in this study, with high heterogeneity ($I^2=98.48$, $P<0.001$), the Galbraith and Bubble graphs clearly showed the situation (Fig. 7). Begg's rank test and Egger's regression intercept test were used to determine whether funnel plot asymmetry was larger than expected by

chance. Using the results of the tests by Egger and Begg, there was no significant publication bias ($P>0.05$). Meta-regression analyses were performed using variables such as standard deviation (Fig. 8), study year (Fig. 9), and sample size (Fig. 10) extracted from the study data, and the corresponding graphs were subsequently generated.

Common worldwide prevalence of protozoans and helminths among disabled people

Considering the included studies and the type of parasite detected, the number and percentage of studies belonging to the parasite and the prevalence of the parasites at 95% CI according to the random-effects model, respectively. *Toxoplasma* sp. ((9/50[18%]), (40%; 95% CI: 24–56%, $I^2=98.83$)) (Fig. 11), *E. histolytica/dispar* ((24/50[28%]) (20%; 95% CI: 13–28%, $I^2=99.60$)), (Fig. 4), *Toxocara* spp. ((4/50[8%]) (19%; 95% CI: 11–26%, $I^2=88.37$)), (Fig. 12), *E. coli* ((24/50[48%]) (17%; 95% CI: 11–22%, $I^2=98.17$)), (Fig. 13), *E. hartmanni* ((6/50[12%]) (14%; 95% CI: 3–31%, $I^2=99.68$)), (Fig. 14), *Blastocystis* spp. ((16/50[32%]) (13%; 95% CI: 7–19%, $I^2=99.10$)), (Fig. 15), *A. lumbricoides* ((6/50[12%]) (13%; 95% CI: 3–23%, $I^2=99.73$)), (Fig. 16), *T. trichura* ((12/50[24%]) (9%; 95% CI: 1–17%, $I^2=99.32$)), (Fig. 17), *E. nana* ((17/50[34%]) (9%; 95% CI: 2–16%, $I^2=99.25$)), (Fig. 4), and *E. vermicularis* ((12/50[24%]) (9%; 95% CI: 1–18%, $I^2=99.56$)) (Fig. 18), and *S. stercoralis* ((12/50[24%]) (8%;

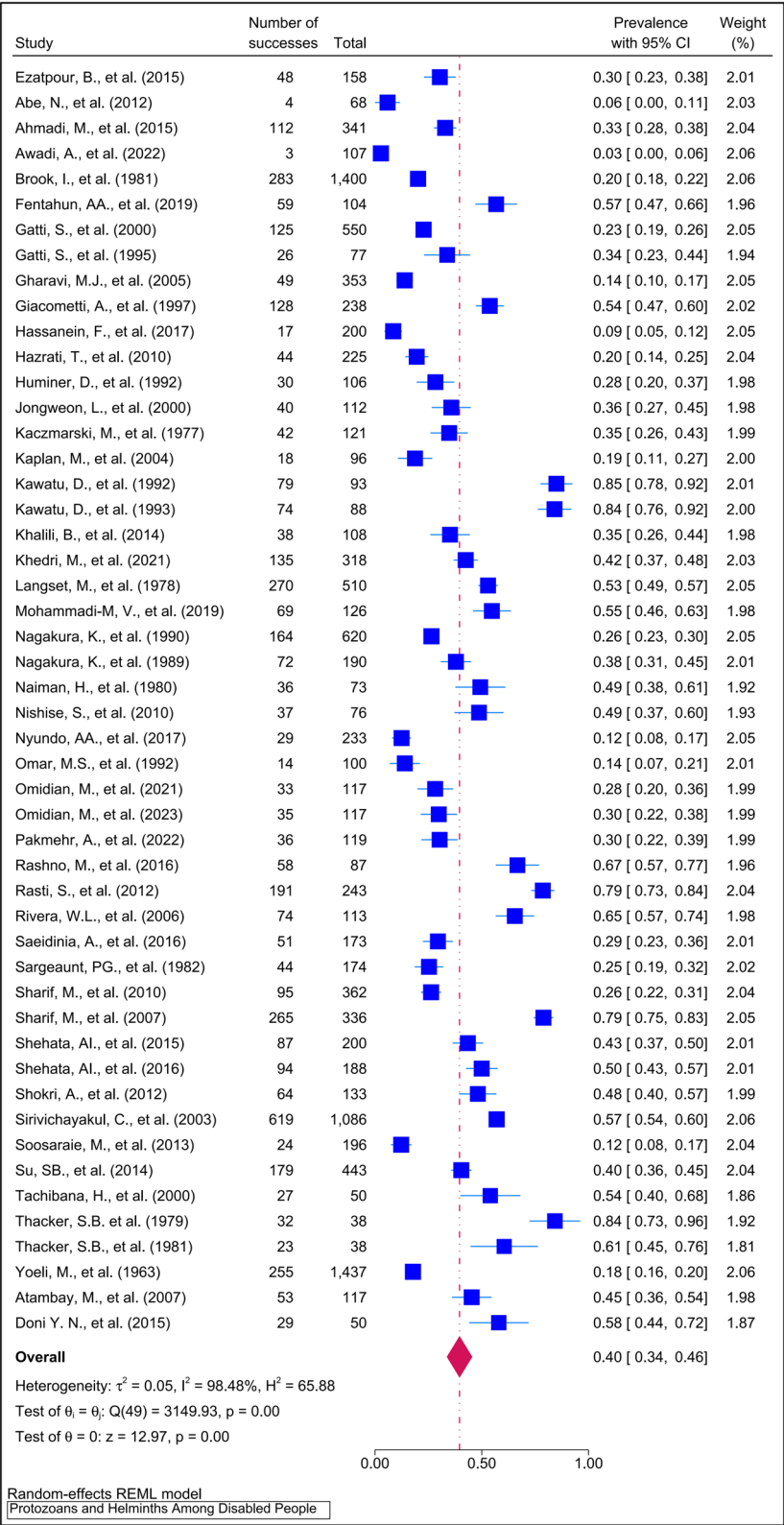
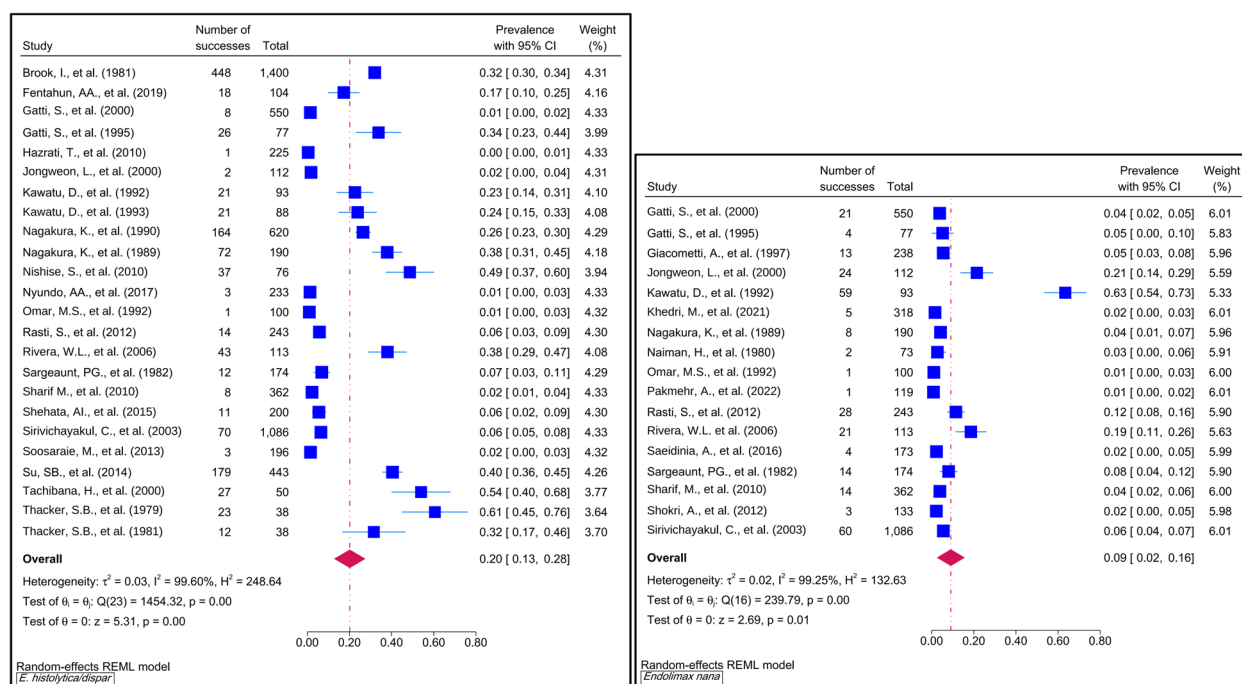


Fig. 3 Forest plot presenting the Worldwide Prevalence of Protozoans and Helminths Among Disabled People (with 95% CI and %weight)

**Fig. 4** Forest plot showing the prevalence of *E. histolytica/dispar* and *E. nana* among disabled people in world**Table 2** Worldwide prevalence of protozoans and helminths among disabled people

Parasite Type	Parasite name*	Sample size	Prevalence with 95% CI	95% lower CI	95% upper CI
Protozoan	<i>Toxoplasma</i> sp.	860	0.40	0.24	0.56
Protozoan	<i>E. histolytica/dispar</i>	1,224	0.20	0.13	0.28
Helminth	<i>Toxocara</i> spp.	340	0.19	0.11	0.26
Protozoan	<i>E. coli</i>	890	0.17	0.11	0.22
Protozoan	<i>E. hartmanni</i>	125	0.14	0.03	0.31
Protozoan	<i>Blastocystis</i> spp.	453	0.13	0.7	0.19
Helminth	<i>A. lumbricoides</i>	242	0.13	0.3	0.23
Helminth	<i>T. trichura</i>	415	0.09	0.01	0.17
Protozoan	<i>E. nana</i>	282	0.09	0.02	0.16
Helminth	<i>E. vermicularis</i>	191	0.09	0.01	0.18
Helminth	<i>S. stercoralis</i>	683	0.08	0.03	0.13
Protozoan	<i>G.intestinalis/duedonalis/labmblia</i>	379	0.08	0.05	0.10
Helminth	Hookworms	85	0.07	0.03	0.10
Helminth	<i>H. nana</i>	129	0.06	0.02	0.13
Protozoan	<i>Cryptosporidium</i> spp.	52	0.06	0.04	0.17
Protozoan	<i>C. mesnili</i>	111	0.05	0.00	0.11
Protozoan	<i>D. fragilis</i>	47	0.05	0.01	0.08
Protozoan	<i>I. butschlii</i>	97	0.03	0.02	0.05
Helminth	<i>Taenia</i> spp	7	0.01	0.00	0.01

*Parasite species with zero pooled prevalence are not included in the table

95% CI: 3–13%, $I^2 = 99.54$)) (Fig. 17), and *G. intestinalis/duedonalis/labmblia* ((26/50[52%]) (8%; 95% CI: 5–13%, $I^2 = 94.12$)) (Fig. 13), Hookworms ((4/50[8%]) (7%; 95% CI: 3–10%, $I^2 = 77.74$)), (Fig. 14), *H. nana* ((8/50[16%]) (6%; 95% CI: 2–13%, $I^2 = 99.61$)), (Fig. 11), *Cryptosporidium* spp. ((4/50[8%]) (6%; 95% CI: 4–17%, $I^2 = 99.12$)), (Fig. 12), *C. mesnili* ((10/50[20%]) (5%; 95% CI: 0–11%, $I^2 = 99.46$)), (Fig. 18), *D. fragilis* ((7/50[14%]) (5%; 95%

CI: 1–8%, $I^2 = 93.73$)), (Fig. 16), *I. butschlii* ((14/50[28%]) (3%; 95% CI: 2–5%, $I^2 = 88.12$)), (Fig. 15), *Taenia* spp. ((4/50[8%]) (1%; 95% CI: 0–1%, $I^2 = 20.13$)), (Fig. 19). In these studies, protozoa and helminths were found in the worldwide prevalence of protozoans and helminths among disabled individuals (Table 2).

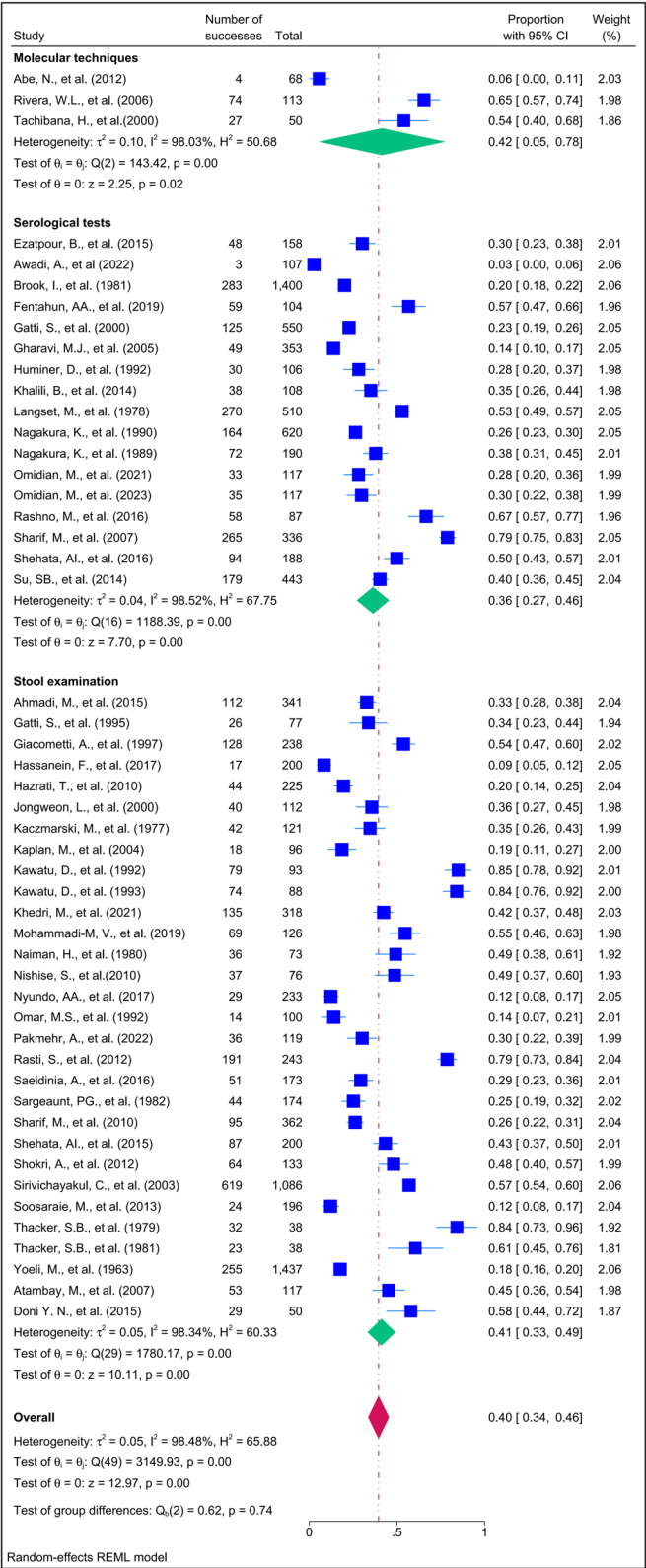


Fig. 5 Forest plot presenting the worldwide Prevalence of Protozoans and Helminths Among Disabled by diagnostic method in People (with 95% CI and %weight)

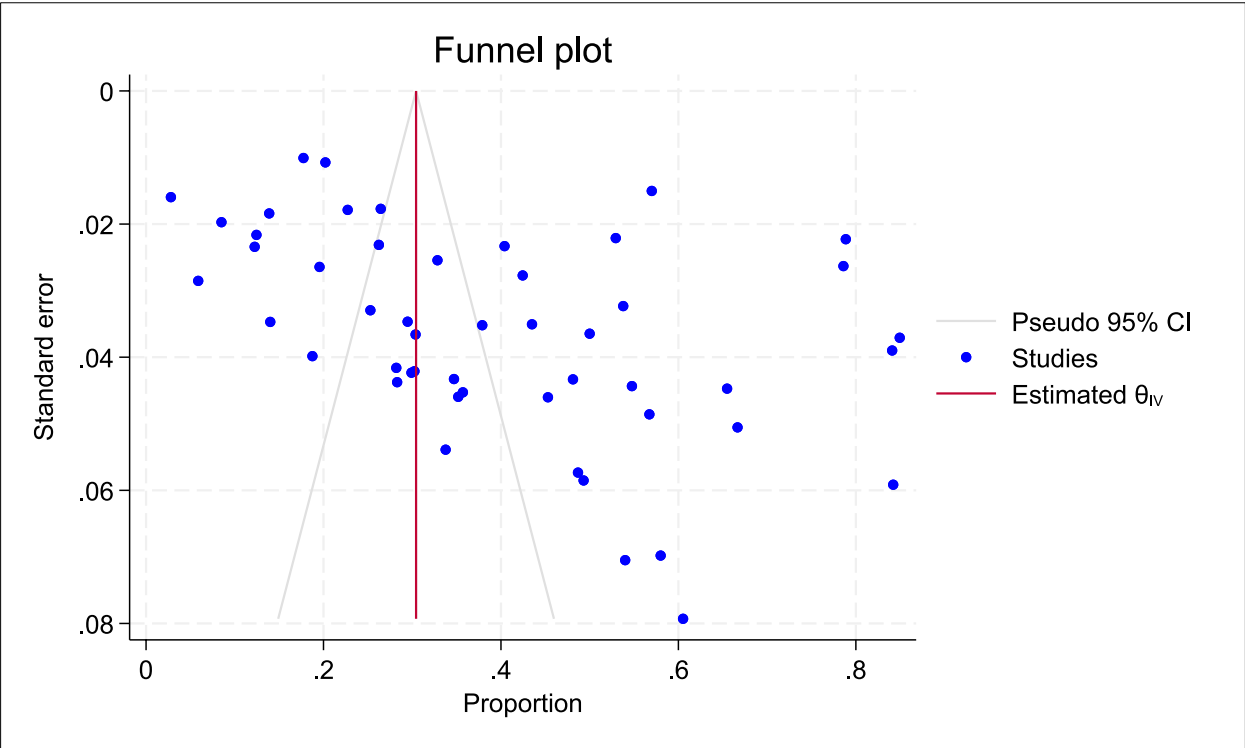


Fig. 6 Funnel plot representing evidence of Publication Bias

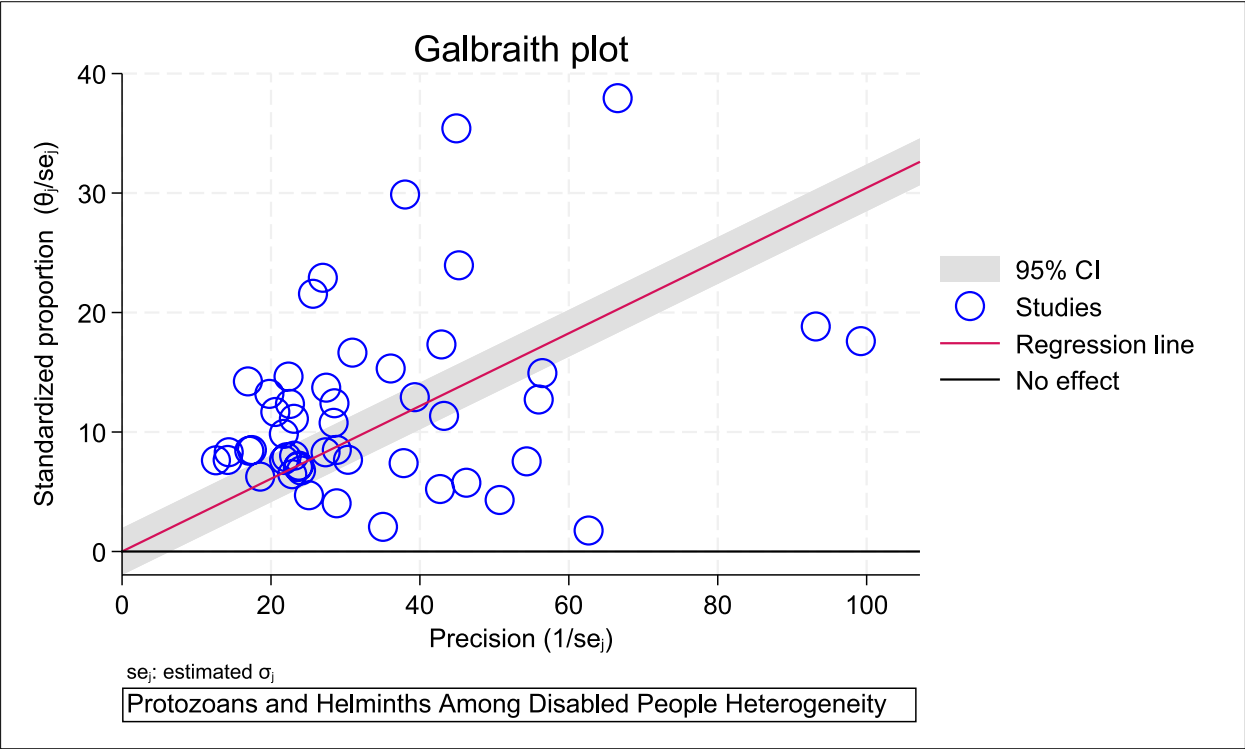


Fig. 7 Funnel plot representing evidence of Galbraith plot representing evidence of Heterogeneity

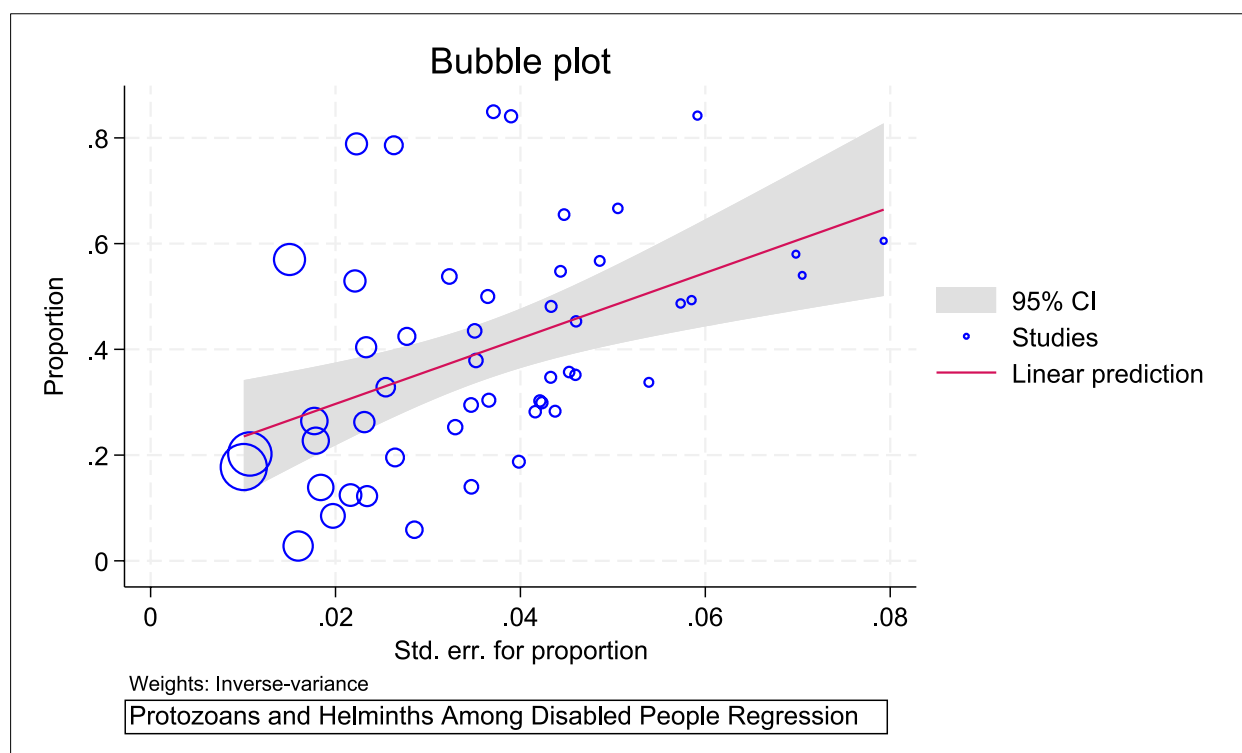


Fig. 8 Bubble plot meta-regression for protozoan and helminth prevalences in individuals with disabilities

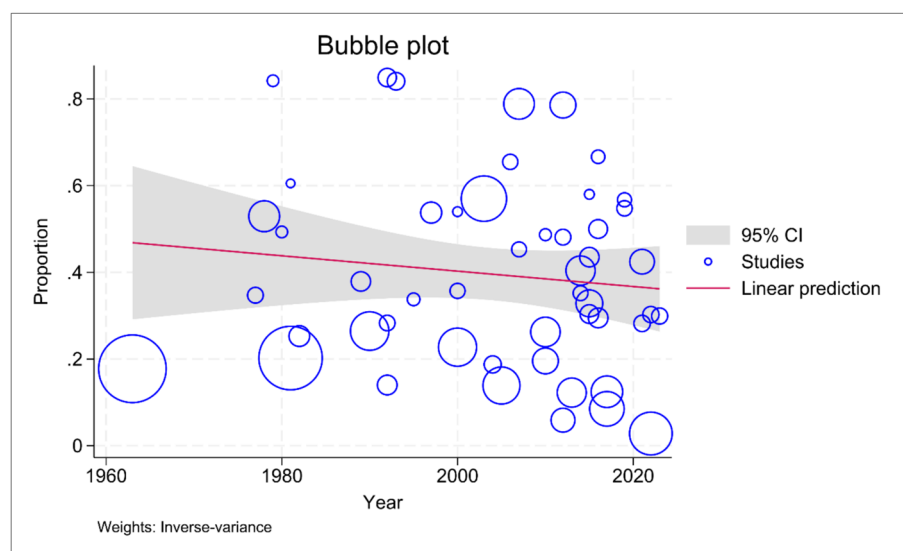


Fig. 9 Bubble plot meta-regression by year for protozoan and helminth prevalence in people with disabilities

Sensitivity analysis

Sensitivity analyses showed that the exclusion of small studies did not significantly change the pooled estimates. *Balantidium coli*, *Cyclospora* spp., *Enteromonas hominis*, *Isoospora belli*, *Microsporidia* spp., *Retortamonas intestinalis*, *Trichomonas hominis*, *S. mansoni*, *Diphyllobothrium latum*, *Opisthorchis viverrine*, *Echinostoma* sp., *Trichostrongylus* sp. were not excluded because they

had a very small effect on the results, and this effect was tolerable. The prevalence remained within the 95% confidence interval (CI) of the corresponding overall prevalence. Overall, the stability of protozoans and helminths among disabled people worldwide confirms the reliability and rationality of our analyses.

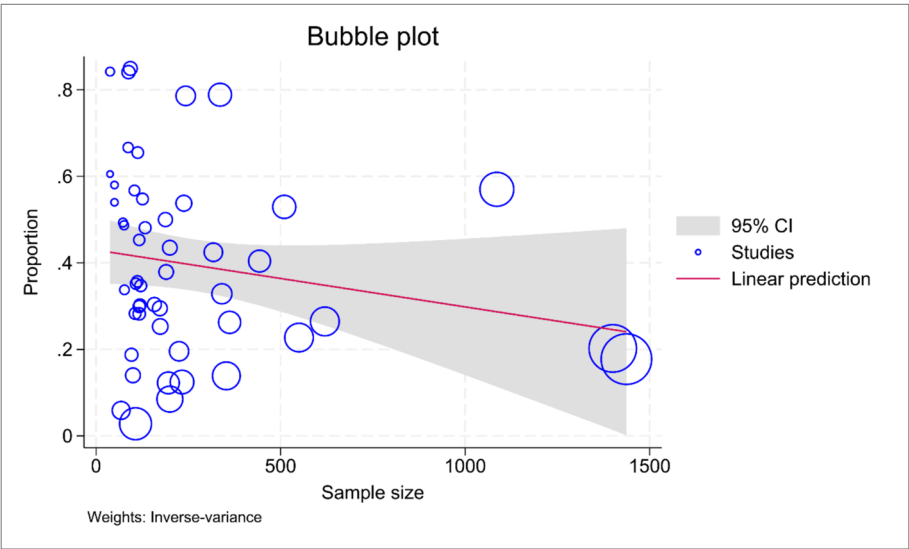


Fig. 10 Bubble plot meta-regression by sample size for protozoans and helminth prevalence in people with disabilities

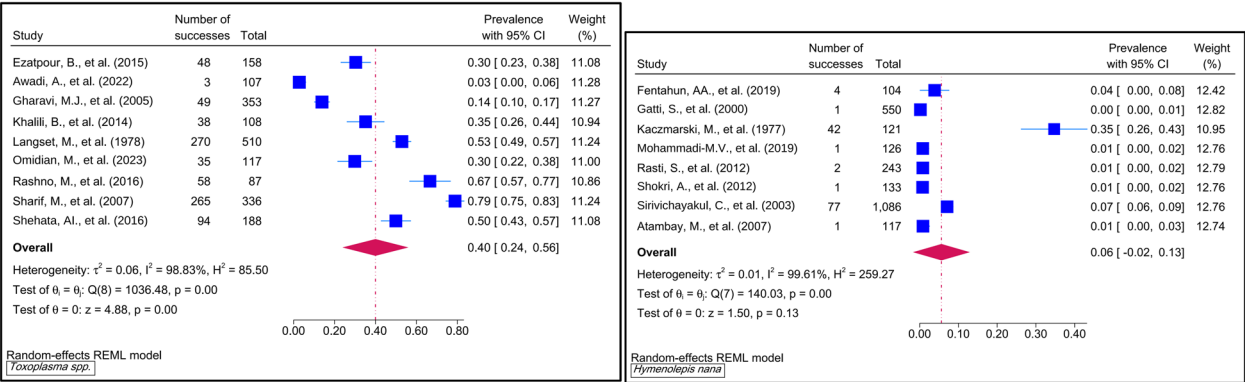


Fig. 11 Forest plot showing the prevalence of *Toxoplasma* sp. and *H. nana* among disabled people in world

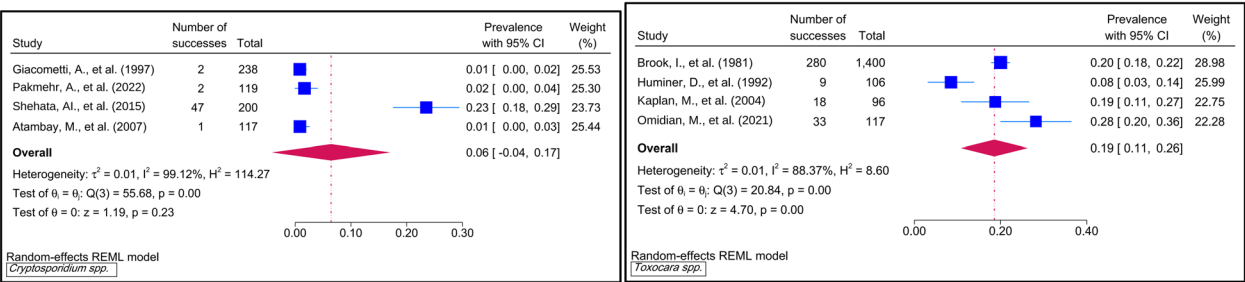


Fig. 12 Forest plot showing the prevalence of *Cryptosporidium* spp. and *Toxocara* spp. among disabled people in world

Discussion

This is the first systematic review and meta-analysis to investigate the global prevalence of protozoa and helminths in individuals with disabilities. These results are based on meta-analyses of relevant data obtained from 12,608 individuals with disabilities documented in 50 studies conducted across 17 countries. The countries from which the data were collected and the pooled

prevalence of the identified parasites varied within the scope of the study. Our findings indicate that the global prevalence of protozoa and helminths among individuals with disabilities was 40% (95% CI: %34–46).

Parasitic diseases are a serious global health problem, especially in developing regions. The combination of biological, socioeconomic, and environmental factors causes certain demographic groups to be disproportionately

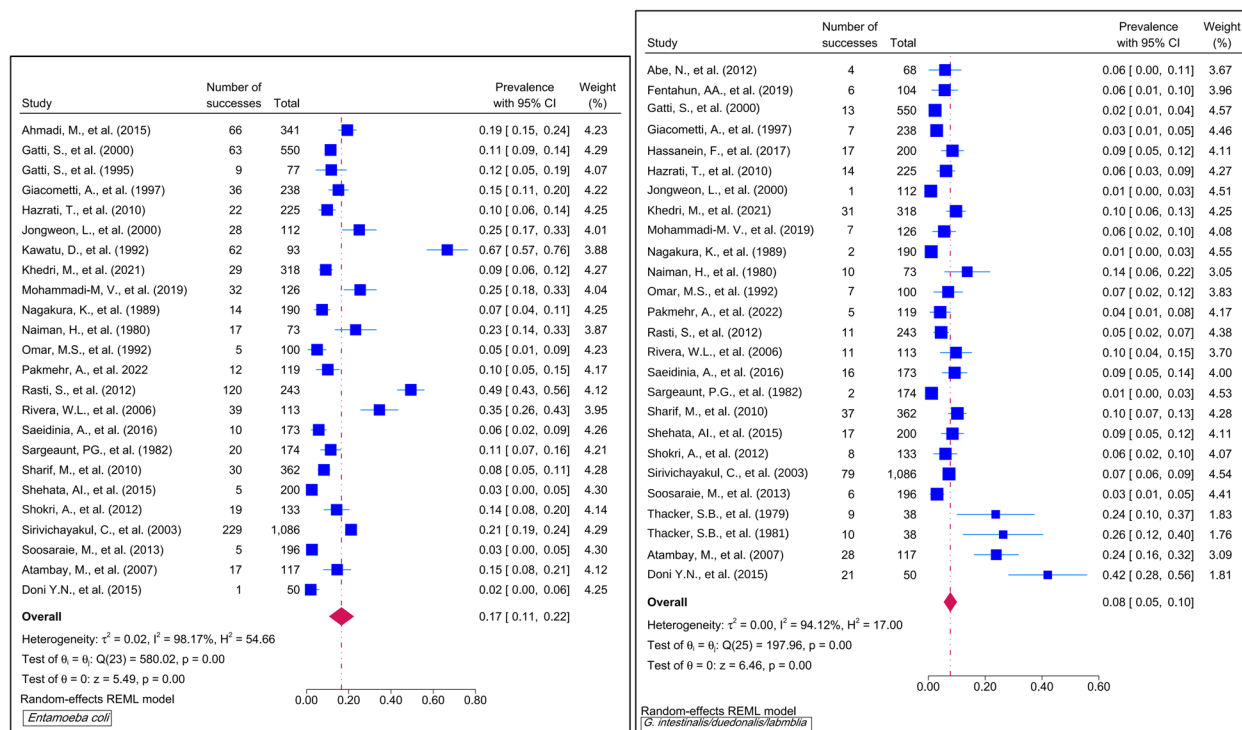


Fig. 13 Forest plot showing the prevalence of *E. coli* and *G. intestinalis/duodenalis/labmblia* among disabled people in world

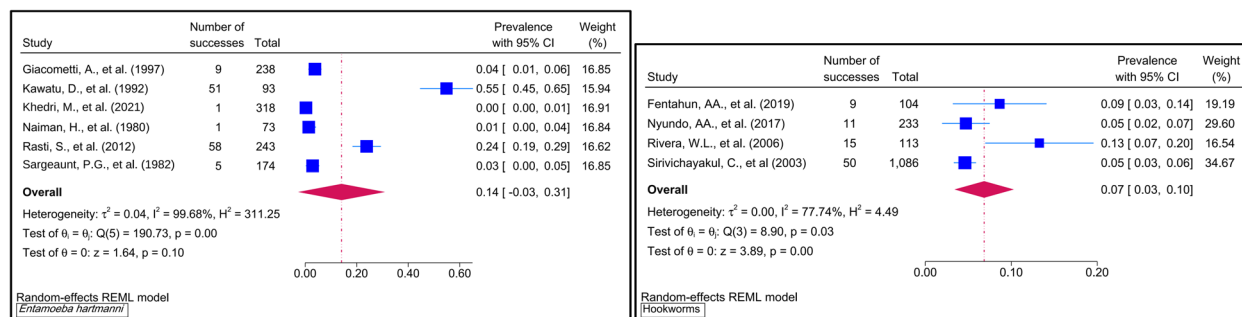


Fig. 14 Forest plot showing the prevalence of *E. hartmanni* and Hookworms among disabled people in world

affected by these diseases and to face higher risks of infection [51, 63, 64]. When these groups are examined, children, due to their developing immune systems, inadequate hygiene habits, and frequent interactions with the external environment, are susceptible to helminth and protozoan infections [4, 65]. In older adults, the weakening of the immune system and the presence of chronic diseases increase their vulnerability to infections. Opportunistic parasites can cause severe clinical conditions in this population [66–69]. During pregnancy, the physiological suppression of the mother's immune system, especially with parasitic infections such as *Toxoplasma gondii*, which can be transmitted transplacentally, increases the risk of congenital anomalies in the fetus [70–72]. Individuals with suppressed immune systems, such as those with HIV/AIDS, organ transplant

recipients, and oncology patients undergoing immunosuppressive therapy, are particularly vulnerable to opportunistic parasitic infections [73, 74]. Migrants, refugees, residents of conflict zones, individuals engaged in agriculture and livestock farming, and people traveling to tropical and subtropical regions are among the groups susceptible to parasitic infections [75–79].

Individuals with disabilities should be evaluated with special attention within these groups. Intellectual, physical, and developmental disabilities can negatively affect personal hygiene practices. In addition, dependence on caregivers and communal living conditions increase the risk of contracting parasitic infections. The prevalence of parasitic infections in the intestines and oral cavity is significantly higher among individuals with disabilities than in the general population [7–9]. A meta-analysis

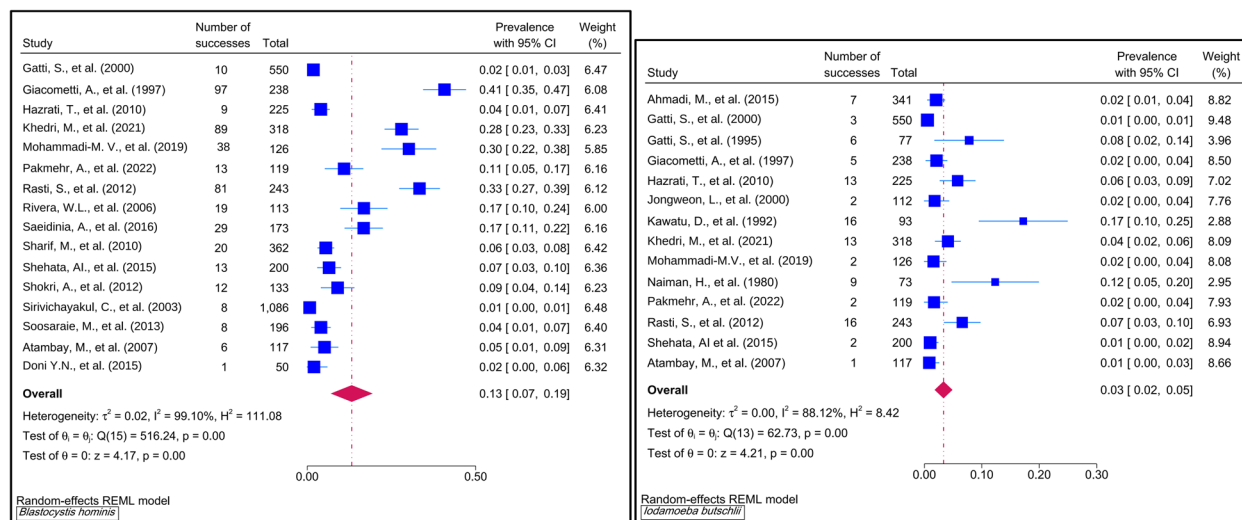


Fig. 15 Forest plot showing the prevalence of *Blastocystis* spp. and *I. butschlii* among disabled people in world

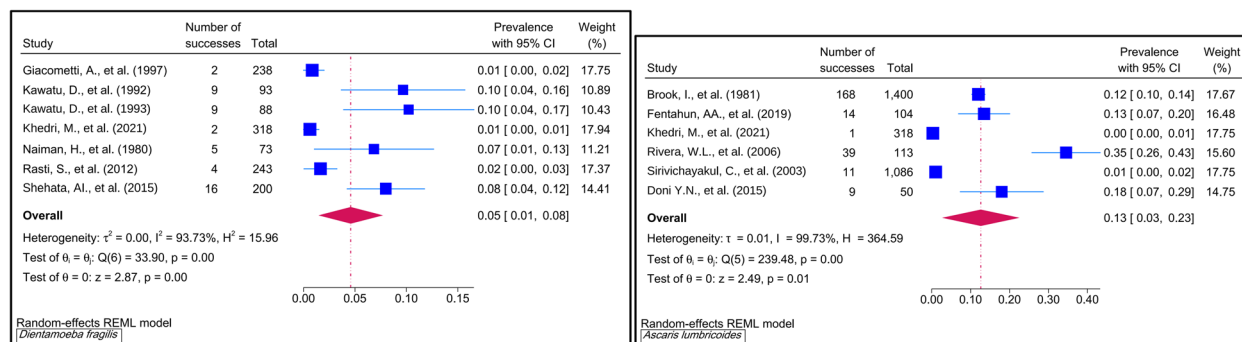


Fig. 16 Forest plot showing the prevalence of *D. fragilis* and *A. lumbricoides* among disabled people in world

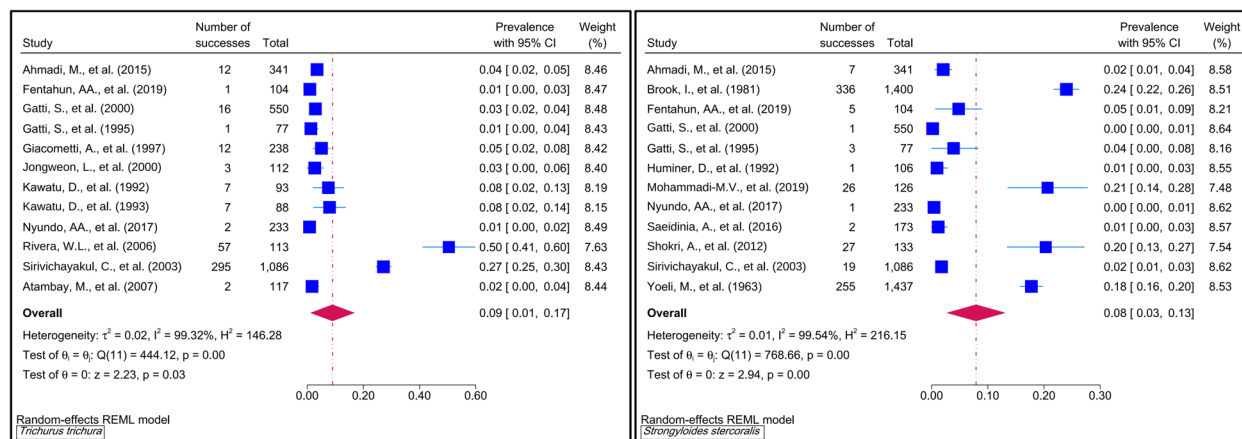


Fig. 17 Forest plot showing the prevalence of *T. trichura* and *S. stercoralis* among disabled people in world

conducted in Iran reported a pooled prevalence of 41% for intestinal parasitic infections among individuals with intellectual disabilities. The most frequently encountered species were *E. coli* (16.2%) and *Blastocystis* spp. (12.2%), and *G. duodenalis* (11.9%). Among helminths, *E. vermicularis* (11.3%) and *S. stercoralis* (10.9%) were the most

common species [9]. A study conducted in southern Iran found that 26.1% of individuals with intellectual disabilities had infections caused by intestinal parasites. The most common parasites in these cases were, respectively, *Blastocystis* spp., *E. coli*, and *G. lamblia* [8]. In northern Iran, a prevalence rate of 26.2% was recorded, with the

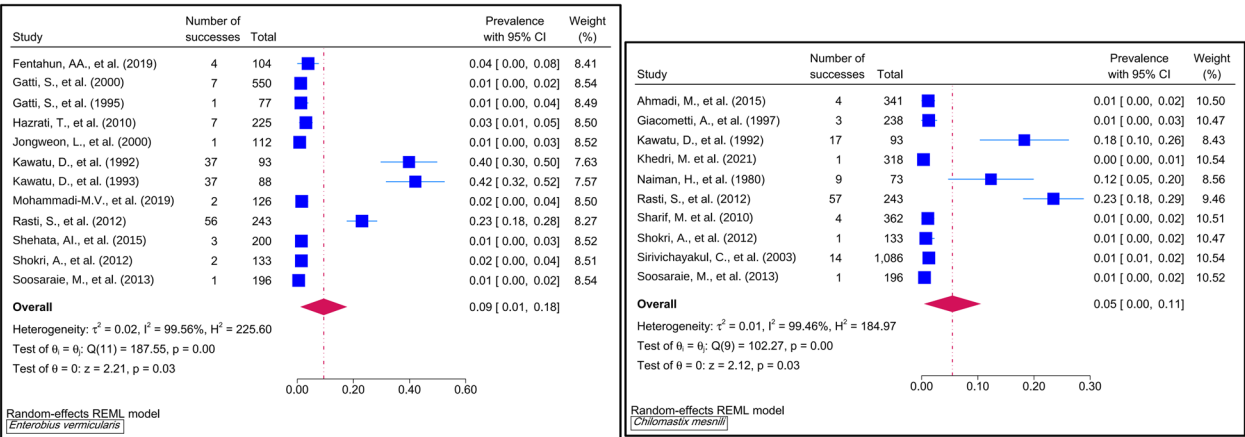


Fig. 18 Forest plot showing the prevalence of *E. vermicularis* and *C. mesnili* among disabled people in world

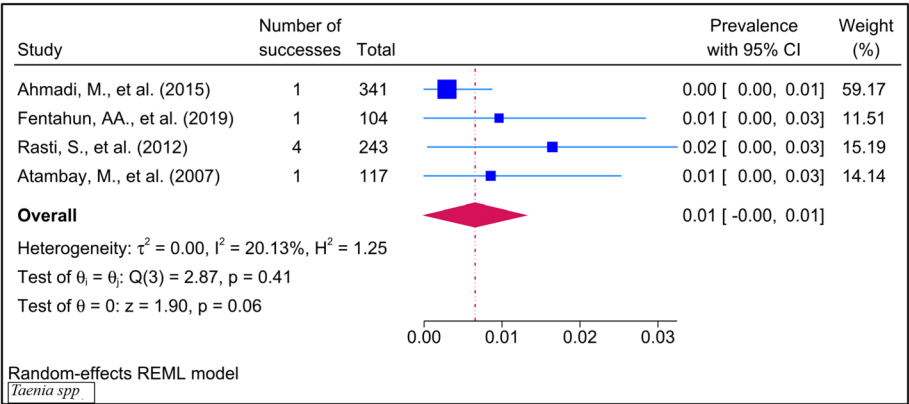


Fig. 19 Forest plot showing the prevalence of *Taenia* spp. among disabled people in world

most widespread species being *G. lamblia*, *E. coli*, and *Blastocystis* spp. [49]. In a study conducted in Lorestan, the frequency of oral cavity parasites, particularly *Entamoeba gingivalis* and *Trichomonas tenax*, ranged between 40.5% and 42.8% in children with intellectual disabilities. In contrast, this rate was found to be between 18.1% and 19.5% among children without disabilities [80]. A comparative study conducted in Ethiopia showed that intestinal parasitic infections were observed in 56.7% of students with intellectual disabilities compared to 41.1% among students without disabilities [10].

Parasitic diseases significantly reduce the quality of life of individuals and cause economic losses. To develop effective strategies for the control and prevention of these diseases, further research on the epidemiology and risk factors of parasitic diseases is necessary. These diseases, which can result from agents such as helminths, protozoa, and arthropods, are considered significant public health issues, especially among individuals with disabilities with limited self-care abilities. Although various studies have been conducted at the regional level to examine this situation, they are insufficient and fail to fully reveal the true extent of the problem. The prevalence

of parasitic diseases is influenced by complex interactions among environmental, socioeconomic, hygienic, and individual factors. To understand this situation in depth, it is important to evaluate the countries included in our study from a holistic perspective. In this context, hygiene practices, sanitation infrastructure, socioeconomic status, and differences in access to diagnostic tools in the countries where data were collected support the findings of our study. Considering the current situation in these countries and the findings of our study.

Canada has a strong sanitation infrastructure. In urban areas, households have access to safe water and sanitation. However, in Northern Canada, although the health-care system provides basic services free of charge, access to rural areas is limited. Insufficient laboratory services in remote areas can lead to delays in diagnosis, while digital health services cannot be provided in places lacking internet infrastructure [81–84]. In this comprehensive meta-analysis, the pooled prevalence of protozoan and helminth infections among individuals with disabilities in Canada was 73% ($I^2=95.23$, $P<0.001$). In Taiwan, an advanced public health and sanitation system ensures that 99% of the population has access to drinking water

and sewage systems. Although the national health insurance covers 99% of the population, delays in services occur in rural areas due to a shortage of medical professional staff [85–87]. In our study, the pooled prevalence of protozoan and helminth infections among individuals with disabilities in Taiwan was 49% ($I^2 = 97.21$, $P < 0.001$). In the United States, considered one of the most advanced countries in the world in terms of health infrastructure and technology, access to drinking water is above 99%, although aging infrastructure in rural areas can cause water pollution in some areas. The US uses advanced techniques for the diagnosis of parasitic diseases and has well-developed laboratory infrastructure [88–90]. Despite these resources, our study found that the pooled prevalence of protozoan and helminth infections among individuals with disabilities in the USA was 42% ($I^2 = 99.54$, $P < 0.001$). In Turkey, significant progress has been made through hygiene practices, public health initiatives, and educational programs. However, regional and rural–urban disparities persist. While 98% of the population can access safe drinking water, wastewater treatment facilities are primarily concentrated in western regions [91–93]. According to data obtained from studies included in this research, the pooled prevalence of protozoan and helminth infections among individuals with disabilities in Turkey was 40% ($I^2 = 93.74$, $P < 0.001$). In Iran, while sanitation services in urban centers are maintained at an adequate level, they are insufficient in rural areas. Water scarcity is a major issue, and per capita water consumption is below the global average. Although urban areas are equipped with well-developed laboratories, rural health facilities are relatively inadequate [94, 95]. In this meta-analysis, the pooled prevalence of protozoan and helminth infections among individuals with disabilities in Iran was 39% ($I^2 = 97.87$, $P < 0.001$). Italy, a high-income European Union member state, has a robust health infrastructure. The country guarantees universal access to drinking water and maintains a comprehensive sewage system. However, income levels in the southern regions are lower compared to the north, and migrants may face various challenges in accessing health services [96–98]. In our study, the pooled prevalence of protozoan and helminth infections among individuals with disabilities in Italy was 37% ($I^2 = 96.07$, $P < 0.001$). In Japan, school health screenings initiated in the 1930s have played a major role in controlling helminth infections. The country has high standards for access to comprehensive sanitation services, as well as water and waste management. Nevertheless, 8.9% of the population lives in “depopulated areas,” where access to health services is restricted [99–103]. In our study, the pooled prevalence rate of protozoan and helminth infections among individuals with disabilities in Japan was 34% ($I^2 = 96.86$, $P < 0.001$). In Egypt, infrastructure and health services are

significantly limited in rural areas of the country. While hygiene practices are widespread in cities, they are less common in rural areas. As of 2022, 75% of households had access to handwashing with soap, whereas this rate dropped below 50% in rural areas. Diagnostic opportunities are well developed in major cities, but such services remain limited in rural areas, where parasitic infections such as *Schistosoma* spp. are particularly common [104–107]. The pooled prevalence of protozoan and helminth infections among individuals with disabilities in Egypt was 34% ($I^2 = 95.23$, $P < 0.001$). In Yemen, Ethiopia, South Korea, Poland, Norway, Tanzania, Saudi Arabia, the Philippines, and the United Kingdom, only a single study was identified per country; therefore, the pooled prevalence of protozoan and helminth infections among individuals with disabilities could not be calculated for these countries.

The types and prevalence of parasites identified in our study are consistent with the literature. In this context, according to the literature, toxoplasmosis is a common zoonotic infection that affects 30–50% of the world's population and is particularly important for individuals with intellectual or neurological disabilities [108]. Individuals in this group may be at an increased risk of infection due to challenges in maintaining personal hygiene and accessing healthcare services. A study conducted in the Hormozgan region of Iran found that 29.9% of 117 individuals with intellectual disabilities tested positive for anti-*Toxoplasma gondii* IgG antibodies [43]. Individuals with intellectual and neurological disabilities are affected at similar rates as those in the general population [109]. However, the risk of infection may be higher in patients with severe intellectual disabilities. Although toxoplasmosis is thought to contribute to the disease burden, the causality of this relationship remains unknown. Enhancing access to hygiene and healthcare services is essential for preventing infections in individuals with disabilities. In our study, we found the pooled prevalence of *Toxoplasma* sp. to be 40%. *E. histolytica/dispar* is a parasitic organism that poses a major public health problem worldwide, and the disease it causes is called amebiasis. Clinical symptoms can range from mild to severe, depending on the host's immune response, metabolic factors, and the amount of the parasite ingested [110–113]. In our meta-analysis, the pooled prevalence of *E. histolytica/dispar* was 20%. Toxocariasis is a common infection in temperate and warm areas, often associated with poor hygiene, large populations of stray cats and dogs, and environmental conditions that facilitate the embryogenesis of the parasite eggs. The eggs of *Toxocara canis*, *Toxocara cati*, and other animal ascarid helminths mature in the soil and are subsequently transmitted to dogs, cats, and other animals [114–117]. In our study, we found the pooled prevalence of *Toxocara* spp. to be 19%.

E. coli and *E. hartmanni* are among the many non-pathogenic protozoa found in humans. These organisms are transmitted via the fecal–oral route, and mature cysts are frequently found in contaminated water. Considering the weakened immune status of individuals with disabilities, effective management of parasitic agents is necessary [118–122]. In our study, the pooled prevalence of *E. coli* and *E. hartmanni* was 17% and 14%, respectively. *Blastocystis* spp. are protozoan parasites that inhabit the gastrointestinal systems of various animals, including humans. This genus comprises numerous species, each capable of causing various gastrointestinal symptoms. The prevalence and distribution of *Blastocystis* spp. infection vary regionally. According to the World Health Organization (WHO) and other health organizations, *Blastocystis* infections are more common in tropical and subtropical regions than in temperate areas. The estimated prevalence ranges from 10 to 50%, showing significant differences depending on the health conditions and sanitation standards in different parts of the world [123–127]. In our study, the pooled prevalence of *Blastocystis* spp. was 13%. *A. lumbricoides* is a helminth widespread worldwide and poses significant health risks. The eggs of this parasite are expelled in feces and subsequently transmitted to healthy individuals through contaminated soil, water, food, and hand-to-mouth contact. Globally, the prevalence of this parasite ranges from 10 to 25%, but can rise to 20–80% especially in tropical and subtropical areas. This condition is more frequently observed in children and individuals with disabilities [128–131]. In our study, the pooled prevalence of the parasite was 13%. *E. vermicularis* is an intestinal parasite (helminth) that is common worldwide, particularly affects children, and is reported to be associated with developmental and learning difficulties. According to the literature, the global prevalence rate ranges from 10 to 50%. Studies have shown that *E. vermicularis* is found at a significant rate in individuals with disabilities [132–135]. In our meta-analysis, this rate was found to be 9%, which is consistent with the rates reported in the literature. The pooled prevalences of other parasites identified in our study are as follows, *T. trichiura* (9%), *E. nana* (9%), *S. stercoralis* (8%), *G. intestinalis* (8%), hookworms (7%), *H. nana* (6%), *Cryptosporidium* spp. (6%), *C. mesnili* (5%), *D. fragilis* (5%), *I. butschlii* (3%), and *Taenia* spp. (1%).

The current literature and the findings of this meta-analysis clearly demonstrate that the identified parasites with their pooled prevalence represent a serious global public health concern. These infections can be prevented and controlled through the provision of clean drinking water, implementation of proper sanitation practices, community health education, and improvement of personal hygiene. The importance of planning and education at both regional and global levels is crucial for achieving

these goals. These measures should be implemented to include the entire population, especially individuals with disabilities. Given the significance of this issue, it is important to highlight some public health policies implemented worldwide. The World Health Organization (WHO) has published a strategic roadmap for the decade covering 2021–2030, aiming for the global elimination of parasitic diseases known as Neglected Tropical Diseases (NTDs). This roadmap particularly emphasizes the importance of reaching vulnerable groups, such as individuals with disabilities. [5, 6, 136–139] Within the framework of WHO's NTD strategy, it is aimed to expand community-based health screenings, promote disability-friendly hygiene and sanitation practices, and increase the access of individuals with disabilities to Mass Drug Administration (MDA) processes [5, 137–139]. Universal Health Coverage (UHC) policies, developed under the United Nations Sustainable Development Goals (SDGs), specifically aim to increase access to health services for disadvantaged communities. Based on the principle of "Leaving no one behind," these policies aim to ensure uninterrupted access to preventive and curative services for individuals with disabilities against parasitic diseases [8–10]. Within the scope of Uganda's integrated Neglected Tropical Diseases (NTD) program, the Integrated Mass Drug Administration (MDA) Program for Persons with Disabilities has assigned mobile health teams, in cooperation with the Ugandan Ministry of Health and the World Health Organization (WHO), to ensure the active participation of individuals with physical disabilities in mass anti-parasitic drug campaigns [5, 137]. In Bangladesh, the Bangladesh Rural Advancement Committee (BRAC) has developed Braille materials and audio education modules for visually impaired individuals living in areas where intestinal parasites are common. This initiative has significantly reduced infection rates by increasing awareness of hygiene. In the fight against Chagas disease, home disinfection and vector control measures have been adapted to meet the special needs of individuals with disabilities in affected regions [140, 141].

Global health policies aimed at eliminating parasitic diseases must also consider the needs of individuals with disabilities to ensure health equity. The sustainability of these policies and the active participation of individuals with disabilities are critical. Sustainable strategies for combating parasitic infections should prioritize primary prevention, social integration, and treatment processes. The following strategies may be implemented to achieve these goals:

Accessibility-based health service design

Health service units must be equipped with disability-friendly infrastructure, such as elevators, ramps, and sign language interpreters, to meet the needs of individuals

with physical and mental disabilities. In addition, the expansion of mobile health services, the integration of routine stool analysis and parasite screening programs, and the development of disability-friendly service models in family health centers are of great importance [142, 143].

Inclusive hygiene education and health literacy

To enhance the health literacy of individuals with disabilities and their caregivers, it is essential to prepare visually supported and simplified hygiene education materials. Furthermore, it is necessary to create sustainable training modules on parasitic diseases for use in educational and rehabilitation settings. These educational sessions cover fundamental topics, such as hygiene practices, food safety, fecal–oral transmission routes, and recognizing symptoms of parasites [144–146].

Water, Sanitation, and Hygiene (WASH) investments

WASH projects should be planned in line with the principle of “disability-sensitive design” in all infrastructure investments, with the aim of providing safe access to hygiene facilities in areas where individuals with disabilities live. Adapting standard infection control measures, such as hand hygiene, water sanitation, and vector control, to meet the specific needs of individuals with disabilities, such as providing accessible washbasins and toilet infrastructure, can significantly reduce the risk of parasitic infections [147, 148].

Public health nursing practices for individuals with disabilities

Public health nurses play an important role in organizing infection control, hygiene, and sanitation-focused educational initiatives for individuals with disabilities and their caregivers. Through regular screening programs, they facilitate the early diagnosis of parasitic diseases and rapid identification of infections by conducting stool analysis, skin examinations, and symptom monitoring. Additionally, they play a key role in organizing community-based hygiene campaigns, conducting home visits and health assessments, monitoring regional parasite prevalence, analyzing risk factors, and evaluating the effectiveness of community health interventions [149–151].

Strengths and limitations

This study aims to contribute to disease control efforts by providing important epidemiological information on the global prevalence of helminths and protozoa in individuals with disabilities. Furthermore, being the first meta-analysis of the prevalence of parasitic diseases in individuals with disabilities is one of the strengths of our study. However, this study has some limitations. Due to

insufficient data, we were unable to include some studies on helminths and protozoa in individuals with disabilities. Additionally, some countries could not be included in this study because of the absence of relevant studies. Another limitation of this study is the inability to compare countries due to the insufficient number of studies from various nations. The dataset mainly consisted of studies from Iran, which limited the generalizability of the findings.

Conclusion

This meta-analysis revealed that the global prevalence of protozoa and helminths in individuals with disabilities was 40% (95% CI: 34–46%). Considering the potential for these pathogens to be transmitted via food, water, and hands contaminated with feces, poor hygiene caused by inadequate self-care skills in individuals with disabilities is a significant factor. Our findings provide quantitative evidence that the prevalence of protozoa and helminths in individuals with disabilities (40%) should be considered a serious global public-health concern. To solve this problem, local and public authorities must organize awareness-raising educational programs on protozoa and helminths for individuals with disabilities and their families and emphasize mechanisms to prevent the transmission of parasitic agents, such as public health nursing practices. Our findings show that research efforts have been concentrated in Iran, whereas studies in other countries have fallen short of the desired standards. To enhance the global relevance and applicability of these findings, future research should prioritize the inclusion of data from under-represented regions. To overcome this limitation, it is necessary to focus on studies conducted in poorly represented countries such as Brazil. In particular, collaboration with scientists and organizations in these regions could encourage research on the prevalence of parasitic diseases among individuals with disabilities.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-025-24074-4>.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Acknowledgements

Not applicable.

AI software

During the preparation of this manuscript, the authors used Paperpal software for language editing. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Authors' contributions

Conceptualization: Ahmed Galip Halidi, Kemal Yaran. Data curation: AGH, KY. Formal analysis: AHG. Investigation: AGH, KY. Methodology: AGH, KY. Software: AGH, KY. Validation: Selahattin Aydemir and Abdurrahman Ekici. Visualization: AGH, KY. Writing – original draft: AGH, KY. Writing – review & editing: AGH, KY. Writing – review & editing: Ahmed Galip Halidi, Kemal Yaran.

Funding

No payment was made for the study.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no competing interests.

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Received: 13 March 2025 / Accepted: 21 July 2025

Published online: 30 September 2025

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