Prevalence of human *Schistosoma mansoni* infection in endemic regions (2010–2024): a systematic review and meta-analysis

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Summary

Background *Schistosoma mansoni* infection poses a substantial public health challenge globally, and the World Health Organization (WHO) aims for the elimination of schistosomiasis by 2030. This study aimed to assess the current prevalence of human *S. mansoni* infection in endemic regions worldwide between 2010 and 2024.

Methods We conducted a comprehensive search in PubMed/Medline and Scopus databases as well as other public sources from 1 January 2010 to 15 July 2024. Population-based studies reporting the prevalence of *S. mansoni* infection were eligible. We undertook a random-effects meta-analysis to estimate pooled prevalences with 95% confidence intervals (CIs) in WHO-defined regions and assessed potential risk factors associated with *S. mansoni* infection. The protocol for this study was registered on PROSPERO (CRD42023438455).

Findings We identified a total of 542 eligible studies involving 1,163,866 individuals who had been tested for *S. mansoni* infection in 38 countries. The overall, pooled global prevalence of *S. mansoni* infection in endemic region was 14.8% (95% CI, 13.5%–16.1%). The pooled prevalences (95% CI) in specific regions were: 15.3% (13.9–16.8%) in sub-Saharan Africa, 12.4% (8.9–16.4%) in South America and 9.5% (5.4–14.6%) in the Eastern Mediterranean region. There was a 52.6% decrease in prevalence of *S. mansoni* infection and a 37% decrease in high-intensity infection for studies conducted between 2010 and 2014 compared to those conducted between 2020 and 2023. The present analysis revealed that factors including male gender, bathing or swimming in natural water bodies, crossing rivers or lakes, and engaging in water irrigation activities such as fishing, working in rice paddies or maintaining irrigation canals were significantly associated with *S. mansoni* infection.

Interpretation The findings of this investigation revealed that, despite a decline in prevalence and high-intensity infection, 7–12% of people in endemic regions, notably in sub-Saharan Africa, remained affected by schistosomiasis mansoni between 2020 and 2024. This study provides data of relevance to policymakers to support efforts to eliminate this disease.

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Research in context

Evidence before this study

The World Health Organization (WHO) has established a 2021–2030 Road Map for neglected tropical diseases (NTDs), aiming to eliminate schistosomiasis as a public health problem (EPHP) in all endemic countries. This roadmap sets ambitious targets, including reducing high-intensity infection prevalence to ≤5% in sentinel locations by 2020 and achieving a ≤1% prevalence of high-intensity infection by 2025. However, prior to this study, limited data were available to assess progress towards these targets, particularly at a global level. Existing studies often focused on specific regions or age groups, lacked recent data, and did not provide a comprehensive understanding of the global prevalence of *S. mansoni* infection in endemic regions or its temporal trends. To support WHO's focus, we undertook a systematic review and meta-analysis to estimate the recent global and regional prevalence of *S. mansoni* in endemic regions.

Added value of this study

We analysed data for 542 eligible studies (581 datasets) comprising 1,207,958 individuals who had been tested for *S. mansoni* infection in 38 countries. We estimated that pooled global prevalence of *S. mansoni* infection in endemic region was 14.8% (95% CI, 13.5%–16.1%). The pooled prevalences (95% CI) in specific regions were: 15.3% (13.9–16.8%) in sub-Saharan Africa, 12.4% (8.9–16.4%) in South America and 9.5% (5.4–14.6%) in the Eastern Mediterranean region. Our findings indicated a significant decline in prevalence and high-intensity infection between 2010 and 2023, indicating progress towards WHO targets. We also investigated the influence of socio-economic factors, including income levels and human development index, on prevalence, providing valuable insights for targeted interventions. Furthermore, we assessed risk factors associated with *S. mansoni* infection in endemic regions, such as exposure to contaminated water bodies and specific occupational activities, highlighting areas for public health intervention.

Implications of all the available evidence

The findings of this study, coupled with previous researches, underscore the continued need for robust control strategies against *S. mansoni* infection. Despite a decline in prevalence and high-intensity infection, the disease remains a significant threat, particularly in sub-Saharan Africa, where a substantial proportion of the population remains at risk. The identified risk factors, including exposure to contaminated water bodies and specific occupational activities, highlight the importance of public health interventions focused on improving sanitation, promoting safe water practices, and implementing targeted preventive chemotherapy programs. The study's findings provide valuable data for policymakers and health organizations to inform and strengthen efforts towards achieving the World Health Organization's goal of eliminating schistosomiasis as a public health problem by 2030. Further research is needed to investigate the impact of specific interventions and to develop innovative strategies for disease control and elimination.

Introduction

Schistosomiasis is one of the most prevalent neglected tropical diseases (NTDs), caused by parasitic trematodes of the genus *Schistosoma*. In 2021, the global burden of schistosomiasis was estimated at 2.19 million disability-adjusted life-years.[1] *Schistosoma mansoni*, *S. japonicum* and *S. haematobium* are three dominant species infecting humans, with *S. guineensis*, *S. intercalatum* and *S. mekongi* being less prevalent.[2] Globally, schistosomiasis is recognised as endemic in 78 low and middle income countries (LMIC) in tropical and subtropical areas, estimated to affect >251 million people worldwide.[3] *Schistosoma mansoni* is responsible for hepato-intestinal schistosomiasis, posing a significant threat to ∼ 780 million people in regions spanning sub-Saharan Africa (SSA), the Middle East, the Caribbean, Brazil, Venezuela and Suriname.[3]

Morbidity caused by *S. mansoni* infection is influenced by factors such as infection intensity, tissue location, the number of eggs entrapped in tissues and the immune/inflammatory response to these eggs. The disease, schistosomiasis mansoni, can be classified as acute or chronic. Acute disease can present as abdominal pain and/or diarrhoea, whereas chronic disease usually relates to a complex immune-mediated disease linked to the presence of parasite eggs in the liver, intestine and surrounding tissues, leading to fibrosis and, in advanced cases, organ failure.[4–6] In some endemic regions, such as Tanzania, periportal fibrosis is a major complication of chronic disease in 22–42% of patients, being associated with relatively high mortality.[7–9]

The diagnosis of *S. mansoni* infection usually involves examining stool samples for the presence of schistosome eggs, ideally collected on multiple days to increase diagnostic sensitivity.[10] Serological testing can detect antibodies against *S. mansoni* in blood, which can be useful for the diagnosis of infection in immigrants or travellers from endemic areas. However, such testing may not be reliable for the differentiation of current from past infection, or the monitoring of sero-reversion

in infected people following anthelmintic treatment, because antibodies can persist for 6–18 months after treatment.[10–13] Another immunological method is the reagent strip assay for the detection of circulating cathodic antigen (CCA) of *S. mansoni* in urine,[14,15] but there is some concerns regarding the reliability of this assay for the specific daignosis of *S. mansoni* infection.[16]

The World Health Organization (WHO) recommends praziquantel chemotherapy to combat schistosomiasis, primarily targeting school-aged children (5–15 years) due to their high susceptibility.[17,18] This treatment aims to prevent and control disease, supported by access to clean water and sanitation, education campaigns, snail control and large-scale preventive chemotherapy of at-risk populations.[3] The WHO 2021–2030 Road Map for NTDs aims to eliminate schistosomiasis as a public health problem (EPHP) in all endemic countries.[19,20] The goal has been to reduce morbidity by reducing high-intensity infection by to ≤5% prevalence in sentinel locations by 2020, substantially decreasing transmission, aiming to attain a ≤1% prevalence of high-intensity infection by 2025.[21–23] In 2022, with strong support from philanthropic and pharmaceutical industry partners, including Merck KGaA., the WHO enabled >89 million people to be treated with praziquantel in 33 countries, and requested that epidemiological data be collected and knowledge gaps identified to inform and support intervention programs in specific geographical regions.[24] Two studies[25,26] have estimated schistosomiasis prevalence and treatment needs in children in SSA, and adjusted estimates to the total population in this area by using spatiotemporal models. Here, to support WHO's focus, we report up-to-date estimates of the prevalence of *S. mansoni* infection in humans of various age groups in endemic countries of the world. We undertake a systematic review of the literature and a meta-analysis of published data sets.

Methods

The protocol for this systematic review and meta-analysis was registered on PROSPERO at http://www.crd.york.ac.uk as CRD42023438455. We adhered to the Cochrane Handbook of Systematic Reviews and PRISMA guidelines.[27,28] This study focused on estimating the global and regional prevalence of *S. mansoni* infection in humans. Five investigators (A.T., S.A., P.E., F.A. and M.J.T) initiated a systematic search in July 2023 using MEDLINE/PubMed, Scopus, and African Journal Online (AJOL) databases, targeting studies published between 1 January 2010 and 1 July 2023. An updated search was performed on 31 January 2024. The second update was performed on July 15, 2024. Additionally, Google Scholar (20 first pages sorted according to relevance) and SciELO.org were searched for grey literature. The search strategy and MeSH terms/keywords used are presented in Figure S1. We set no restriction on geographical area, study design or language, and non-English papers were translated using "Google Translate" (https://translate.google.com/). Investigators further examined reference lists of eligible studies and related reviews to enhance the search overall. Endnote software ×9 (Thompson and Reuters, Philadelphia, USA) was used to manage references and remove duplicates. Subsequently, four investigators (S.M., N.R., N.K. and K.B.) independently reviewed titles, abstracts and full texts of articles to identify eligible studies.

Selection criteria

Eligible studies included peer-reviewed (2010–2024), observational (i.e. cross-sectional cohort) studies—each reporting *S. mansoni* infection prevalence in ≥50 people (i.e. randomly-selected and of different ages and socio-economic statuses, without occupations or specific diseases that might have increased the probability of acquiring schistosomiasis) and utilizing conventional parasitological (faecal concentration and microscopy) methods for the detection of schistosome eggs, or techniques for the detection of *S. mansoni* DNA or egg antigens in faecal samples. If both parasitological, or molecular results were presented in a study, the overall prevalence reported by these methods was extracted. Clinical trials were included if their baseline data were derived from cross-sectional studies and we extracted only data collected at the beginning of these trials (prior to any treatment or intervention). Only studies from January 2010 onward were included to ensure that prevalence data were recent. Excluded were (1) studies comparing different diagnostic assays without prevalence data; (2) serological surveys; (3) interventional investigations, clinical trials or case–control studies in which participants received anthelmintic drugs; (4) investigations that used the same datasets multiple times; (5) studies that reported prevalence immediately (<3 months) after mass drug administration (MDA); (6) investigations of people from non-endemic populations such as travellers, expatriates or individuals displaced from regions such as in Europe and North America; (7) reports of species other than *S. mansoni*; (8) studies of people who were not representative of the general population, such as specific groups of patients (e.g., those with diabetes, endocarditis, immunocompromised status and alcoholic addiction, or those co-infected with HIV, COVID-19, *Plasmodium* spp. and/or *Mycobacteria tuberculosis*), and clearly defined population groups (e.g., pregnant women) or people involved in activities (e.g., fishing) that increased the risk of *Schistosoma* infection; and (9) case reports or series, letters, commentaries and reviews without original data sets.

Extraction and quality evaluation of data

The data collection form, designed using Microsoft Excel (Microsoft Corporation, Redmond, USA), facilitated data extraction by the investigators (A.T.P., P.E.,

N.R. and S.M.). Discrepancies were resolved through discussions and consultation with the principal investigator (A.R.). The data/informaion recorded were: (i) study characteristics—author's last name, publication year, sampling dates, diagnostic methods, country, city and WHO-region[29]; (ii) participant characteristics—age categories (children, adults and age), number of participants, number of individuals with *S. mansoni* infection, specific age, sex, residence and data on risk factors (if available); (iii) socioeconomic variables—World Bank-income category,[30] gross national income (GNI) per capita[30] and human development index (HDI).[31] The intensity of *S. mansoni* infection was classified according to WHO guidelines: light (1–99 eggs per gram of faeces [EPG]), moderate (100–399 EPG) or heavy (≥400 EPG).[21] To evaluate risk of bias, we used the Joanna Briggs Institute (JBI) Critical Appraisal Tool for observational epidemiological studies reporting prevalence data.[32] Each individual study was evaluated using nine criteria: the appropriateness of the sample frame for the target population, the sampling method of participants, the adequacy of the sample size, detailed descriptions of study subjects and settings, comprehensive data analysis coverage, use of valid identification methods, reliable and standardized condition measurement, appropriate statistical analysis, and sufficient response rate with proper management of any low response rate. Studies meeting 7–9 criteria were ranked as "low risk," those meeting 4–6 criteria as "moderate risk," and those meeting 1–3 criteria as "high risk." All supplementary figures and tables related to this study are presented in Appendix A.

Meta-analysis

Initially, individual prevalences of *S. mansoni* infection were calculated by dividing the number of test-positive cases by the study population number. To estimate pooled prevalence, we utilized the DerSimonian and Laird random-effects model (REM),[33] which integrate proportions across extremes to yield conservative estimates and 95% confidence intervals (CIs). Since prevalence is a proportion, estimates were pooled using the Freeman-Tukey double arcsine transformation to stabilize the variance of raw prevalence. Pooled estimates were computed employing Stata software (v.17 Stata Corp., College Station, TX, USA) using the 'metaprop' command. Country-specific, pooled prevalence was derived by synthesizing the prevalences obtained from all studies conducted within each respective country. Then, we calculated the pooled prevalence for WHO-defined regions by synthesizing the *S. mansoni* prevalence data across individual countries within each WHO-defined region. Heterogeneity was evaluated using Cochran's Q statistic and quantified by the I^2 statistic, identifying heterogeneity as substantial if I^2 was >75%.[34] Subgroup, univariable and multivariable meta-regression analyses explored potential sources of heterogeneity and the impact of socio-economic, demographic and study characteristics on the prevalence of *S. mansoni* infection using the 'Metareg' command in Stata. Statistical significance was set at $P < 0.1$.

Ethics

The protocols for this study were approved by the Scientific and Ethics Committee of Babol University of Medical Science (code: IR. MUBABOL.724135218).

Role of funding source

There was no funder for this study. The corresponding author (A.R.) as well as all other authors had full access to all study data and final responsibility for the decision to submit for publication.

Results

Study characteristics

Of the 11,990 publications identified, 1095 were potentially eligible after removing duplicates and screening titles/abstracts. Following the evaluation of full-texts, 542 studies (581 datasets) were deemed eligible for meta-analysis (Fig. 1). The primary characteristics of studies included here are given in Table S1. These studies involved 1,207,958 individuals from 38 countries in regions known to be endemic for *S. mansoni*. Approximately 87% of the datasets (507 datasets) originated from sub-Saharan Africa, 52 datasets were from the South American region, 22 datasets hailed from two countries in the Eastern Mediterranean region (Egypt and Yemen). Of the 542 studies included, 185 provided data on the intensity of *S. mansoni* infection (Table S2).

Global and regional prevalence estimates for *S. mansoni* infection

Table 1 provides the global as well as stratified regional and national prevalence estimates for *S. mansoni* infection. The overall, pooled prevalence of *S. mansoni* infection in endemic region was 14.8% (95% CI, 13.5%–16.2%), with substantial heterogeneity among studies (I^2 = 99.7%, $P < 0.001$). Considering WHO regions, pooled prevalences (95% CI) were: 15.3% (13.9–16.8%) in sub-Saharan Africa, 12.4% (8.9–16.4%) in South America, and 9.5% (5.4–14.6%) in the Eastern Mediterranean region (Table 1). For countries for which there were three or more eligible studies, Madagascar (51.3%), DR Congo (39.0%), Tanzania (35.2%), Uganda (35.5%) and Kenya (22.4%) exhibited some of the highest prevalences (Table 1). Moderate prevalence was estimated for countries including Côte d'Ivoire (16.7%), Ethiopia (14.0%), Cameroon (13.9%), Brazil (12.7%), Senegal (10.8%), and Zimbabwe (10.0%). A pooled prevalence of 9.5% was estimated for both Egypt and Yemen. Additional details are presented in Table 1. The funnel plot used to assess "small-study effects" did not provide evidence of publication bias (Figure S2).

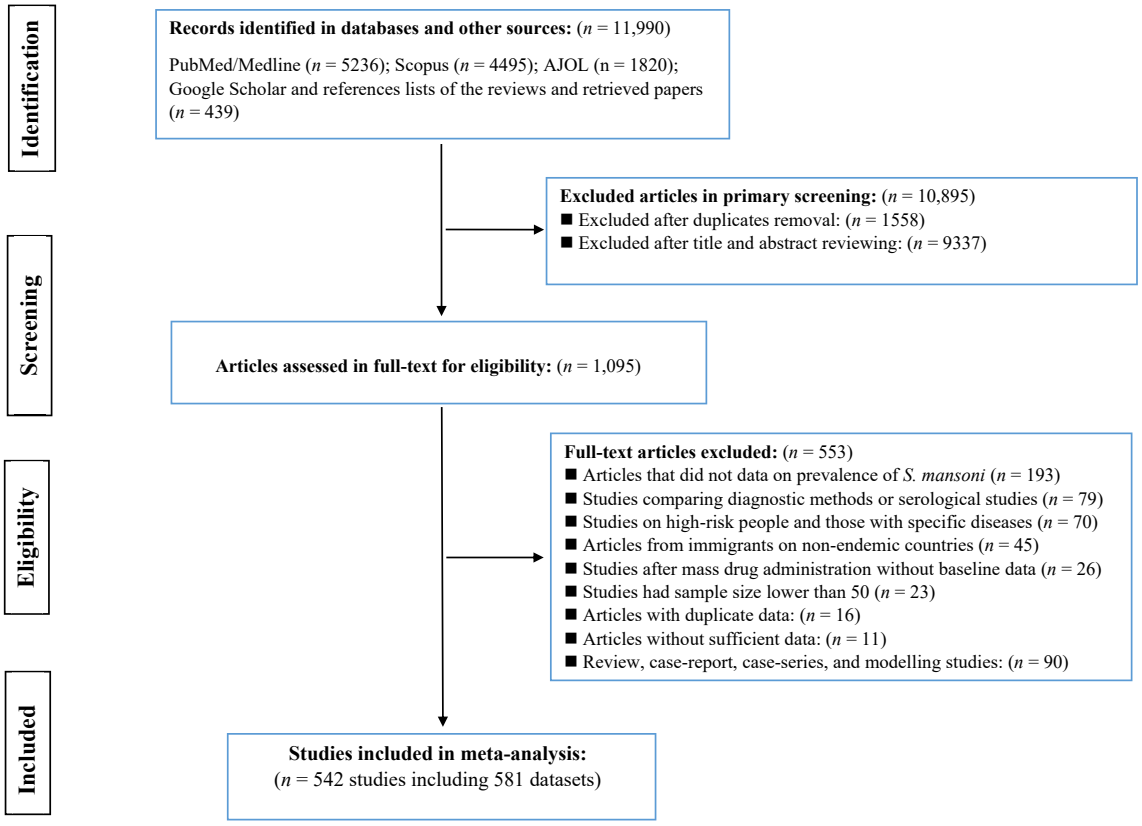

Fig. 1: Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart—indicating the literature search strategy and the numbers of included and excluded studies.

Intensity of *S. mansoni* infection

Of 542 studies, 185 yielded data/information on *S. mansoni* infection intensity (Table S2). Adhering to WHO guidelines,[21] we extracted intensity data and estimated prevalences for low, moderate and high infection intensities globally and regionally. Our analyses showed that, globally, 11.5% (10.0–13.0%), 6.2% (5.2–7.2%) and 3.2% (2.6–3.8%) of tested individuals had low, moderate and high intensities of *S. mansoni* infection, respectively. Notably, people living in sub-Saharan Africa exhibited the highest prevalence (i.e. 3.5%; 2.8–4.2%) of high-intensity infection. We observed a decline in high-intensity infection prevalence from 4.2% (2.7–6.0%) in studies published between 2010 and 2014, to 2.3% (1.7–3.0%) in studies from 2020 to 2024, indicating a 45.2% reduction of high-intensity *S. mansoni* infection between 2010 and 2024. With regard to implementation years, we indicated a decline in high-intensity infection prevalence from 3.8% (2.7–5.5%) in studies conducted between 2010 and 2014, to 2.4% (1.5–3.4%) in studies from 2020 to 2024, indicating a ~37% reduction of high-intensity *S. mansoni* infection between 2010 and 2024. Further details on infection intensities are given in Table 2.

Temporal differences in the prevalence of *S. mansoni* infection, and risk of bias

A subgroup analysis investigated the temporal prevalence of *S. mansoni* infection, categorizing publications into three groups by time periods. Pooled prevalences of 24.3% (20.1–28.8%), 14.6% (12.3–17.1%) and 11.5% (10.2–12.8%) were recorded in articles published during 2010–2014, 2015–2019 and 2020–2024, respectively (Table S3), indicating a 52.6% reduction. Additionally, according to start and end sampling dates of studies included, prevalence was 18.8% and 19.1% in 2010–2014 versus 9.8% and 8.9% in 2020–2023, indicating ~48.0% and 53.4% reduction rates, respectively (Table S3). Random-effects meta-regression analyses in relation to publication year (C = –0.073; P < 0.001; Fig. 2), start date of sampling (C = –0.069; P < 0.001; Figure S3A) and end date of sampling (C = –0.070; P < 0.001; Figure S3B) demonstrated significant decreasing trends in prevalence of *S. mansoni* infection over time; however, the wide scatter of data points indicates that the strength of the associations is relatively modest.

An assessment, using JBI tools (Table S4), revealed that 433 datasets presented a low risk of bias (scoring

WHO regions, Country (number of datasets available for a particular country)	Number of people screened (total)	Number of test positive people	Pooled prevalence % (95% CI)	I^2
Global (581)	1,207,958	141,125	14.8 (13.5–16.2)	99.75
Sub-Saharan Africa (507)	1,139,979	134,347	15.3 (13.9–16.8)	99.77
Angola (4)	22,926	800	2.0 (0.17–5.8)	99.10
Benin (3)	20,780	500	2.3 (2.0–2.6)	–
Botswana (1)	1404	7	0.5 (0.2–1.0)	–
Burkina Faso (2)	3899	44	1.1 (0.7–1.4)	–
Burundi (1)	8482	129	1.5 (1.3–1.8)	–
Cameroon (17)	27,429	2489	13.9 (8.6–20.2)	99.36
Central African Republic (1)	950	2	0.2 (0.03–0.8)	–
Chad (4)	3009	237	3.7 (0.2–10.9)	98.17
Côte d'Ivoire (41)	79,696	12,590	16.7 (12.1–21.9)	99.70
DR Congo (15)	10,787	3856	39.0 (24.6–54.5)	99.61
Ethiopia (165)	403,904	26,645	14.0 (12.3–15.9)	99.54
Gabon (1)	2245	1	0.04 (0.00–0.2)	–
Gambia (4)	4949	48	1.0 (0.01–3.1)	95.77
Ghana (14)	12,870	409	5.5 (1.9–10.6)	98.84
Guinea (1)	420	278	66.2 (61.4–70.7)	–
Kenya (51)	222,237	34,493	22.4 (16.6–28.8)	99.91
Liberia (2)	1843	314	8.0 (6.8–9.2)	–
Madagascar (5)	3015	859	51.3 (11.0–90.6)	99.77
Malawi (3)	6740	155	5.2 (0.9–12.7)	–
Mali (2)	940	107	11.3 (9.3–13.4)	–
Mozambique (3)	1077	23	1.8 (0.3–4.6)	–
Namibia (1)	3659	22	0.6 (0.4–0.9)	–
Niger (1)	86	0	0.01 (0.0–4.2)	–
Nigeria (39)	57,805	1894	4.1 (3.0–5.3)	97.22
Rwanda (2)	9673	302	2.6 (2.3–3.0)	–
Senegal (7)	6610	1174	10.8 (3.4–21.6)	99.32
Sierra Leone (5)	5037	452	5.6 (1.0–13.6)	98.95
South Africa (2)	1378	11	0.8 (0.4–1.3)	–
Sudan (19)	45,232	3845	4.2 (1.51–8.1)	99.61
Tanzania (43)	104,179	31,503	35.2 (27.7–43.0)	99.83
Togo (4)	8114	203	2.1 (1.1–3.4)	70.11
Uganda (31)	26,135	8848	35.5 (27.7–43.8)	99.45
Zambia (8)	5598	487	6.8 (1.1–16.4)	99.07
Zimbabwe (5)	26,871	1620	10.0 (7.1–13.3)	97.43
South America (52)	**43,910**	**5396**	**12.4 (8.9–16.4)**	**99.29**
Brazil (50)	43,552	5374	12.7 (9.0–16.8)	99.31
Venezuela (2)	358	22	3.1 (1.5–5.8)	–
Eastern Mediterranean (22)	**24,069**	**1382**	**9.5 (5.4–14.6)**	**98.95**
Egypt (12)	19,534	975	9.5 (3.4–18.3)	99.29
Yemen (10)	4535	407	9.5 (5.0–15.2)	97.09

Abbreviations: CI, confidence interval; DR Congo, Democratic Republic of the Congo.

Table 1: **Global, regional and national prevalence of *Schistosoma mansoni* infection (2010–2023), (results from 581 datasets performed in 38 countries).**

between 7 and 9/9), 107 datasets had a moderate risk (scoring between 4 and 6/9) and 41 studies exhibited a high risk of bias (scoring ≤3/9). Subgroup analysis revealed that pooled prevalences for studies with low, moderate and high risks of bias were 14.3% (10.5–18.6%), 15.0% (13.5–16.5%) and 14.2% (8.3–21.3%), respectively (Table S3).

Prevalence of *S. mansoni* infection in relation to socio-economic variables

Among the 581 eligible datasets, 263, 261 and 57 of them represented countries classified with low, lower-middle and upper-middle income levels, respectively. Subgroup analysis based on income level revealed the highest prevalences of *S. mansoni* infection in lower-middle income countries (16.4%, 14.2–18.7%), whereas the lowest prevalence was observed in upper-middle income countries (10.7%, 7.5–14.4%). Moreover, 114, 377 and 62 datasets represented countries categorized with low, medium, high and very high HDI levels. Subgroup analysis indicated that countries with medium HDI levels exhibited the highest prevalences (17.0%, 13.8–20.4%) and those with high HDI levels had the lowest prevalences (11.1%, 8.2–14.5%). Further details are given in Table S3. Random-effects meta-regression analyses based on GNI per capita ($C = -0.007$; $P = 0.935$; Figure S5A) and HDI ($C = 0.359$; $P = 0.607$; Figure S5B) revealed non-significant decreasing trends in prevalence in countries with high income and HDI levels, respectively (Table S5).

Prevalence of *S. mansoni* infection according to age and diagnostic method used

To assess age-specific *S. mansoni* infection prevalence, we conducted two types subgroup analyses—based on age: (a) estimating pooled prevalence categorized by overall participant age groups—children only (380 datasets), adults only (42 datasets) and all age groups (159 datasets); and based on (b) extracting prevalence data (if available) from specific age groups within individual studies. In the analysis, studies of children and adults exhibited pooled prevalences of *S. mansoni* infection of 15.5% (13.9–17.1%) and 11.3% (6.5–17.0%), respectively, and those involving all age groups had a prevalence of 14.3% (11.5–17.2%) (Table S3). For specific age-groups, individuals of ≥51 of years (21.1%, 14.7–28.1%) and 12–19 years (20.7%, 18.0–23.5%) had the highest prevalences, whereas children of ≤5 years had the lowest prevalence at 9.8% (6.1–14.1%) (Table S3).

In relation to diagnostic method used, 434 of the 581 datasets were obtained using Kato-Katz, 138 used formalin-ether or other routine sedimentation/concentration methods, and nine used molecular methods (PCR). The pooled prevalences were 18.8% (17.2–20.6%) for Kato-Katz, 4.9% (3.9–6.0%) for formalin-ether or other routine methods (e.g., direct wet mount), and 16.4% (3.6–36.0%) for PCR (Table S3).

Risk factors

Regarding risk factors, the findings indicated that males (odds ratio [OR], 1.3; 95% CI, 1.2–1.4) and individuals

Region (Number of datasets)	Number of people screened	Number of test positive people	Intensity of infection		
			Low % (95% CI)	Moderate % (95% CI)	High % (95% CI)
Global (185)	354,540	54,251	11.5 (10.0–13.0)	6.2 (5.3–7.2)	3.2 (2.6–3.9)
Sub-Saharan Africa (166)	347,681	53,023	11.5 (10.0–13.1)	6.7 (5.7–7.8)	3.5 (2.9–4.2)
South America (11)	3309	814	13.8 (7.1–22.3)	2.9 (0.8–6.1)	1.8 (0.2–4.6)
East-Mediterranean (8)	3550	414	7.6 (5.0–10.7)	2.5 (1.6–3.6)	0.6 (0.1–1.5)
Year of publish					
2010–2014 (39)	56,827	9581	13.6 (10.1–17.5)	9.5 (6.7–12.7)	4.2 (2.7–6.0)
2015–2019 (54)	108,513	25,516	13.0 (9.9–16.3)	7.2 (5.3–9.2)	4.3 (2.9–6.0)
2020–2024 (92)	189,200	19,154	9.8 (8.2–11.5)	4.5 (3.6–5.6)	2.3 (1.7–3.0)
Implementation year					
2010–2014 (78)	168,170	32,095	12.6 (10.1–15.3)	7.1 (5.5–8.8)	3.8 (2.7–5.0)
2015–2019 (79)	122,955	16,209	11.5 (9.3–13.9)	5.8 (4.4–7.4)	3.1 (2.2–4.1)
2020–2023 (28)	63,415	5947	8.4 (6.2–10.9)	4.9 (3.4–6.7)	2.4 (1.5–3.4)

Abbreviation: CI, confidence interval.

Table 2: **Intensity of *Schistosoma mansoni* infection based upon numbers of people screened with cut-offs for light, moderate or heavy intensity infection.**

engaging in activities, such as bathing (OR, 3.6; 95% CI, 2.2–5.8), swimming (OR, 3.0; 95% CI, 2.1–4.4) and/or Crossing water streams or lakes barefoot (OR, 1.2; 95% CI, 2.1–4.0) were at a significantly higher risk of contracting *S. mansoni* infection. Additionally, people engaged in irrigation activities (OR, 2.3; 95% CI, 1.5–3.4) were also found to be at a significant risk. Further details are provided in Table 3.

Univariable and multivariable meta-regression analyses to identify source(s) of heterogeneity

Table S5 displays the findings from both univariate and multivariate meta-regression analyses of study characteristics, aiming to explore the origins of heterogeneity in the prevalence estimates of *S. mansoni* infection.

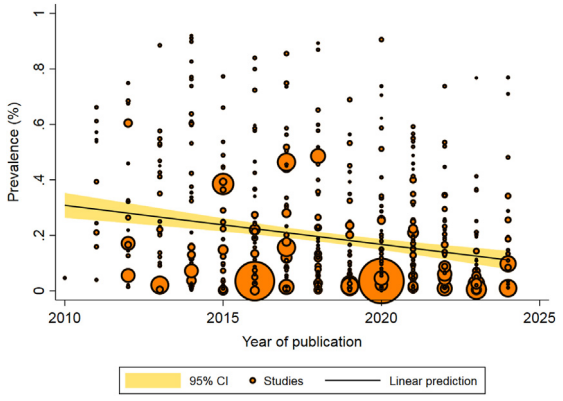

Fig. 2: Random-effects meta-regression analyses of the prevalence data for *Schistosoma mansoni* infection in endemic regions—according to publication year, showing a statistically significant downward trend in prevalence over time.

Figures S3A and B and S4A and B visually illustrate the regression trends and the variation around the regression lines. The substantial scatter of data points reflects the limited explanatory power of the covariates, as captured by the low R^2 values. As shown in Table S5, the multivariable meta-analysis indicated non-significant associations between the heterogeneity of *S. mansoni* infection prevalence and publication year (β, –0.050; $P = 0.133$), beginning (β, –0.010; $P = 0.877$) and end (β, –0.016; $P = 0.812$) dates of study sampling, GNI per capita (β, –0.186; $P = 0.331$) and HDI level (β, 1.425; 95% $P = 0.312$). This model explained 5.86% of the total heterogeneity ($I^2 = 99.75\%$).

Discussion

In WHO's road map for neglected tropical diseases 2021–2030, the elimination of schistosomiasis as a public health problem (EPHP) requires reliable and regular monitoring and estimations of infection/disease prevalence.[35] This approach is essential to accurately measure progress and to verify that the prevalence of schistosomiasis reduces in the geographical areas in which a treatment/control campaign is implemented.

Here, we conducted a systematic review and meta-analysis, aimed at estimating the prevalence of *S. mansoni* infection in endemic regions and identifying potential risk factors associated with the infection in such areas. Our findings indicate that ~15% of individuals in endemic regions are affected by *S. mansoni* infection. It is important to emphasize that our estimates relate to endemic regions within particular countries or regions, and apply specifically to areas where the transmission of schistosomiasis (from snail to human) is known to occur. Schistosomiasis is a focal disease, and both prevalence and intensity can vary

Variable: (Number of datasets) subgroup	Number of people screened (total)	Number of test positive people	Pooled prevalence % (95% CI)	Odds ratio (95% CI)
Gender: (205)				
Male	215,569	31,571	22.0 (19.2–25.0)	1.3 (1.2–1.4)
Female	212,364	26,213	18.4 (16.0–21.0)	Ref
Residence (28)				
Rural	26,081	3836	19.2 (12.9–26.4)	1.2 (0.8–1.9)
Urban	12,398	1599	17.0 (10.2–25.1)	Ref
Bathing in river or lake (20)				
Yes	4287	1582	34.1 (23.9–45.0)	3.6 (2.2–5.8)
No	3999	754	16.0 (8.2–26.0)	Ref
Swimming in river or lake (31)				
Yes	6636	2122	30.5 (23.1–38.4)	3.0 (2.1–4.4)
No	6819	1117	14.3 (8.0–22.0)	Ref
Crossing river or lake bare foot (15)				
Yes	2635	868	31.9 (20.4–44.6)	2.2 (1.2–4.0)
No	3249	832	20.3 (8.7–35.1)	Ref
Pipe water as a source of drinking (16)				
Yes	3510	550	14.6 (6.9–24.5)	Ref
No	4093	839	22.1 (13.1–32.7)	1.8 (1.0–3.0)
Washing clothes in the lake/river (26)				
Yes	7008	2053	31.5 (21.0–42.9)	1.7 (1.0–2.8)
No	4542	1102	23.2 (14.0–33.8)	Ref
Irrigational activities (12)				
Yes	1978	576	33.6 (23.7–44.3)	2.3 (1.5–3.4)
No	3953	946	20.8 (10.8–32.9)	Ref

Abbreviation: CI, confidence interval.

Table 3: **Prevalence estimates and risk factors associated with *Schistosoma mansoni* infection in humans.**

markedly over short geographical distances. Therefore, our estimates should not be generalised or considered as representative of all populations in particular countries or regions. According to our findings, the highest prevalence of *S. mansoni* infection of 15.5% (2010–2024) was recorded in endemic regions in sub-Saharan Africa (SSA). Prevalences of ~9.5%–13.1% were recorded in endemic regions of Brazil, Egypt and Yemen. Previous spatiotemporal modelling studies explored schistosomiasis distribution and treatment needs within SSA and revealed population-adjusted prevalence estimates of 7.1% (6.5–7.6) and 3.7% (3.4–4.0) in 2010 and 2019, respectively.[25,26] Discrepancies in the estimates between these studies[25,26] and the present investigation might relate to several factors, including: (1) demographics—previous studies studied only children, whereas the present study encompassed a range of age groups; and (2) methodological differences—the earlier studies adjusted estimates to the total population in SSA using spatiotemporal models, whereas our prevalence estimates are specific to the endemic areas within a country or region, making it challenging to extrapolate estimates to an entire population of a country or region.

In accordance with Kokaliaris et al.,[26] our findings revealed significant variation in *S. mansoni* infection prevalence among countries. The highest prevalences in endemic regions were recorded in several countries of SSA, including Madagascar, Guinea, the Democratic Republic of Congo, Côte d'Ivoire, Tanzania, Uganda, Kenya, Cameroon, Ethiopia, Mali and Zimbabwe, followed by Brazil, Egypt and Yemen (9.5–13.2%), indicating a need for tailored control programs to reduce or eliminate the schistosomiasis problem in these areas. Our findings also indicate a higher infection prevalence in nations with lower income levels and HDI, particularly within SSA. This disparity might be linked to impoverished communities, with limited access to clean water, inadequate sanitation, insufficient control programs and a lack of healthcare and health education.[36]

Importantly, our findings indicate a significant decline in the prevalence of *S. mansoni* infection over time. Comparing studies from 2010 to 2014, we estimated a reduction in *S. mansoni* prevalence by ~30–40% for the period 2015–2019 and ~48–53% for 2020–2024. This trend aligns with the study by Kokaliaris et al.[26] who reported prevalence reductions of 19.5% and 53.6% in the periods from 2010 to 2014 and from 2015 to 2019,

respectively, compared with findings for 2000 to 2010. Other investigations conducted in diverse geographical areas have also showed a decreasing trend of *S. mansoni* infection prevalence.[37–41] Factors likely to contribute to this decline appear to include: (1) expanded access to MDA programs and preventive chemotherapy, leading to reduced prevalence and infection intensity, seen, for example, in East and West Africa[42–44]; (2) improvement in water, sanitation and hygiene (WASH),[45] leading to decreased transmission; (3) enhanced health education to raise awareness and prevent transmission; and (4) targeted control campaigns in high-prevalence areas to reduce disease. Consistent with previous findings,[26] we estimated relatively low prevalences (0.01–3.0%) of *S. mansoni* infection in countries such as Burkina Faso, Burundi, Gambia, Niger and Togo, which appeared to have national treatment coverage rates of >75% (2015–2019). This evidence indicates that countries with regular and multiple rounds of preventive chemotherapy could achieve marked reductions in schistosomiasis mansoni.[26]

Another key aspect of this study was estimating the prevalences of low-, moderate- and high-intensity *S. mansoni* infections. High-intensity infection is associated with severe health issues, such as hepatosplenic enlargement and hepato-intestinal damage, leading to conditions such as portal hypertension and ascites.[46,47] We found that only a limited portion (one-third) of available datasets reported infection intensities, posing challenges for assessing the impact of MDA within control programs, particularly considering the WHO criterion of <1% prevalence of high-intensity infections, to attempt to reach or work toward elimination.[35,48] Our findings indicate that 11.5%, 6.3% and 3.2% of individuals tested had low, moderate and high-intensities of *S. mansoni* infection, respectively. There was a reduction of 45% in high-intensity infections and 53% in moderate-intensity infections from 2020 to 2024 with respect to 2010–2014. This is significant and reflects the efforts of control strategies and programs, and aligns with success achieved in MDA initiatives in both East and West Africa.[42–44] However, despite this decline, the prevalence of 7% for moderate to high-intensity infections in 2024 is still higher than the target (i.e. <1%) set by WHO for all endemic regions in 2025.[21]

Our analysis revealed that, apart from children of less than five years of age (65 studies) with a relatively low prevalences of *S. mansoni* infection (9.8%), similar prevalences were recorded in other age groups. The higher prevalences in people of 6–11 years and 12–30 years of age (~18% and ~21%, respectively) might relate to limited disease awareness, age-related occupations and/or behaviours—e.g., swimming, fishing and/or agricultural work, which expose them to infested water, enabling transmission.[49] Notably, according to WHO guidelines,[3] people over two years of age are targeted for treatment. The high prevalence of *S. mansoni* infection in older people (31–50%, ≥51) may be indicative of an ongoing risk of infection in all age groups, from adolescence to adulthood. Similar to some previous studies,[50–54] the present findings also revealed an increased risk of infection linked to activities in natural water bodies, such bathing, swimming, laundering and irrigation activities, and to the limited access to piped drinking water.

Our findings also highlighted that the infection risk and prevalence of infection in males was significantly higher than in females, likely due to an increased contact with schistosome-infested water associated with occupational and recreational activities, such as fishing, farming and irrigation.[55,56] Moreover, some studies[57–59] have suggested that a lower engagement rate of males in MDA programs may render them significant reservoirs of infection and transmission in some settings (e.g., in SSA). Although females also engage in water-related tasks, such as dish-washing and laundering in contaminated water, their infection risk does not seem to be significantly lower than for males in the same communities.[58] The lower prevalence in females could be due to the use of soap in their water-related activities, which may have some cercaricidal activity, potentially reducing the risk of cercarial invasion in water.[60–62] Our findings also indicate that, while people in rural areas had a higher prevalence than in urban settings, the statistical significance of this difference was inconclusive due to limited available data and small sample sizes. Given the constraints in some studies that focused on specific rural or urban locales,[63–65] conducting more comprehensive studies in both of these settings will be important in assessing the proposed link between rural residency and heightened infection prevalence.

Although the present systematic review and meta-analysis have provided significant insights into global and regional prevalence and intensity of schistosomiasis mansoni, it might have some limitations: (i) Given the specific transmission pattern of *S. mansoni* is linked to *Biomphalaria* snails, our estimates only represent endemic areas within countries and not countries in their entirety. (ii) We did not have access to continuous institutional or governmental data for most countries. Consequently, our estimates are primarily based on data from peer-reviewed articles in publicly accessible scientific databases; therefore, mapping the temporal, age-, and gender-standardised prevalence and intensity was not feasible in our study; (iii) Despite our thorough search and efforts to include grey literature, there is a possibility that some findings published in local or non-indexed journals may have been missed. (iv) Finally, the wide variety in study designs/features, methodologies and diagnostic tests used among investigations led to significant heterogeneity in prevalences, thereby presenting a limitation. Furthermore, the relatively modest regression slopes, combined with the significant data dispersion around the regression lines in our meta-

regression analyses, imply that other unmeasured factors could be influencing the observed heterogeneity. Moreover, the low R^2 values or similar statistics indicate that the covariates integrated into the model explain only a small portion of the variance in prevalence estimates. This highlights the intricate nature of the factors impacting the prevalence of *S. mansoni* infection and implies that forthcoming research should investigate additional variables that might also play a role in the observed heterogeneity. For these reasons, caution is advised when interpreting our estimates.

In conclusion, the present study offers new insights into the prevalence and intensity of *S. mansoni* infection, providing guidance for health workers and policymakers, tasked with developing and bolstering intervention and control programs against schistosomiasis mansoni. Our results highlight that, despite a notable reduction in the prevalence and intensity of *S. mansoni* infection from 2010 to 2024, a considerable proportion of the population (6–12%) in endemic regions harboured *S. mansoni* infection between 2020 and 2024, with ~7% having moderate-to high-intensity infections, suggesting that there is a gap between the WHO's goal and proposed disease elimination. Our findings serve as an initial but significant step to assessing the prevalence of *S. mansoni* infection in people in endemic regions—a topic of major importance.

Contributors

A.T.P., R.B.G. and A.R. conceived the study. A.T.P., S.A., P.E., M.Z.K., S.M. and M.J.T. searched the databases and applied inclusion and exclusion criteria. A.T.P., F.A., N.R., S.M., N.K., M.Z.K., S.M., M.S.N. and K.B. extracted and verified the information. M.S., M.H.A., M.B., K.B. and A.R. analysed the data sets, interpreted the results, and prepared the tables and figures. A.T.P., R.B.G., D.R. and A.R. drafted the manuscript. R.B.G. and A.R. reviewed and edited the final draft of manuscript. All authors commented on, or edited, drafts and approved the final version of the manuscript.

Data sharing statement

The majority of data are available in main manuscript and supplementary files; additional data can be requested from the A.R. (corresponding author) upon request.

Declaration of interests

The authors declare no competing interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.eclinm.2024.102855.

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