Parasites and Parasitism: A Global Synthesis of Burden Across all Major Parasite Group, and Data Gaps, 2015-2025

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ABSTRACT

Background:

Human parasitic infections remain a leading cause of morbidity and mortality globally, disproportionately affecting low- and middle-income countries. Despite global control efforts, comprehensive updates on the status of all major parasite groups are lacking.

Objective:

To synthesize current global epidemiological data on parasitic burden (Protozoa, Helminths, Ectoparasites) from 2015 - 2025, quantifying trends in disability-adjusted life years (DALYs), mortality, and prevalence.

Methodology:

A systematic synthesis using publicly available secondary data, Global Burden of Disease (GBD) 2021, estimates and WHO NTD reports and systematic reviews published between 2015 and 2025. WHO surveillance reports were conducted using PRISMA 2020 guidelines. Five databases were searched from January 2015 to December 2025 with predefined eligibility criteria. Data for 2015-2021 were derived from observed surveillance and GBD 2021 modelled estimates; data for 2022-2025 were generated using Bayesian age-period-cohort (BAPC) projection models, explicitly labelled as projected throughout. Data were stratified by parasite group, geographic region (WHO regions), age, and sex to identify key disparities.

Key Results:

Total parasitic DALYs declined from 74.2 million to 64 million (13.2% reduction). Malaria alone accounted for over 75% of protozoan DALYs, collectively representing the majority of parasitic mortality. Soil-transmitted helminthiases showed sustained declines. Conversely, food-borne trematodes, and cysticercosis/echinococcosis increased 105.7% and 128.6%, respectively. Sub-Saharan Africa accounts for >80% of protozoan mortality, with children under 5 years and adult males disproportionately affected.

Conclusion:

Global control programmes achieved measurable progress over the decade, yet the burden remains unacceptably high and geographically skewed. Resurgent groups and zoonotic threats demand integrated One Health frameworks, strengthened surveillance, and climate-adaptive interventions to sustain and accelerate gains.

Keywords: Parasites, Parasitism, Global burden, Secondary data, Neglected tropical diseases.

INTRODUCTION

Parasitic diseases represent one of the most persistent and geographically widespread challenges to global public health (Martins-Duarte, 2025). The disease mostly affects humans, livestock, and both domestic and

wild animals, the parasites include protozoa, (*Plasmodium, Leishmaniasis*), helminths (*Ascariasis, Trichuriasis*), and ectoparasites (fleas, ticks, and mites) impose a multifaceted burden that transcends clinical illness to entrench poverty and health inequity (King, 2010).

Intestinal parasitic infections alone are estimated to affect a quarter of the world's population, with 450 million suffering illness as a result, and the majority being children. In some high-income countries like the U.S, the major parasitic infections include cyclosporiasis, giardiasis, toxoplasmosis, toxocariasis, trichomoniasis, Chagas disease, cryptosporidiosis, and cysticercosis, and five of these equally serves as the "neglected tropical diseases" (NTDs) declared by the WHO (Hotez, 2014).

Vector-borne parasitic diseases (VBPDs), which include malaria, schistosomiasis, leishmaniasis, Chagas disease, and lymphatic filariasis, account for a substantial portion of this burden (Hotez, 2014). The period from 2015 to 2025 is particularly significant for assessing global progress. Following the launch of the WHO's 2021-2030 road map for neglected tropical diseases (NTDs), many of which are parasitic, concerted efforts by global partners have contributed to measurable declines.

Between 2015 and 2021, the disease burden from NTDs dropped from 17.2 million to 14.1 million disability-adjusted life years (DALYs), with deaths decreasing from 139,000 to 119,000 (WHO, 2026). However, this aggregate progress masks critical disparities and emerging threats. While diseases like lymphatic filariasis and onchocerciasis have shown significant declines, others, including leishmaniasis, food-borne trematodes, and cysticercosis increased. Sub-Saharan Africa continues to bear the highest burden, with malaria alone comprising over three-quarters of all parasitic DALYs (WHO, 2025).

Despite these trends, a comprehensive synthesis covering all major parasite groups for 2015 – 2025 window remains limited. This paper aims to fill that gap by providing a global synthesis of the burden of parasites and parasitism across protozoan, helminth, and ectoparasite groups. The study analyzes epidemiological data from the Global Burden of Disease (GBD) study, published systematic reviews, and WHO reports, examining trends in prevalence, mortality, and DALYs, while highlighting regional, demographic, and emerging challenges such as climate change and drug resistance (Short et al., 2017).

METHODOLOGY

Study Design and Data Sources:

This study is a systematic synthesis of global epidemiological data on parasitic diseases, conducted in accordance with PRISMA 2020 guidelines for systematic reviews (Page et al., 2021). The protocol was not prospectively registered, as this is a synthesis of publicly available aggregated burden estimates rather than a systematic review of primary individual-level studies. The study design comprises four sequential stages: (1) systematic database search, (2) eligibility screening, (3) data extraction and quality assessment, and (4) narrative and quantitative synthesis.

Search Strategy

Five electronic databases and data repositories for the period January 1, 2015 to December 31, 2025 were searched, including: GBD 2021 results tool, WHO Global Health Observatory, PubMed/MEDLINE, Scopus, and WHO NTD Road Map Reports, resulting in retrieving a total of 1,847 records. The following search string was adapted for each database:

("parasite" OR "parasitic disease" OR "parasite climate change" OR "protozoa" OR "protozoan" OR "helminth" OR "helminthiasis" OR "ectoparasite" OR "neglected tropical disease" OR "NTD")

AND

("burden" OR "prevalence" OR "incidence" OR "mortality" OR "DALY" OR "disability-adjusted life year" OR "YLL" OR "YLD")

AND

("global" OR "regional" OR "Sub-Saharan Africa" OR "Asia" OR "Latin America" OR "Worldwide")

AND

("2015" OR "2016" OR "2017" OR "2018" OR "2019" OR "2020" OR "2021" OR "2022" OR "2023" OR "2024" OR "2025")

Eligibility Criteria

Inclusion criteria:

Studies and data points were included if they reported quantifiable burden estimates for any major parasitic disease group (protozoa, helminths, ectoparasites) within 2015-2025 timeframe. If outcome of incidence, YLL, YLD, DALY, prevalence or mortality were reported in English language with defined population denominator. Data were primarily retrieved from the global Burden of Disease, Injuries, and Risk Factors Study (GBD 2021), which provides comprehensive estimates for 371 diseases and injuries across 204 countries and territories (GHDx, 2021). A narrative synthesis approach was adopted, given the heterogeneity in data sources and diseases-specific modeling strategies across parasite groups. Additional data were sourced from World Health Organization (WHO) surveillance reports and the WHO NTD Road Map 2021-2030 monitoring and evaluation framework.

Exclusion criteria:

Excluded studies include non-human-only studies, non-parasitic diseases, reported qualitative outcomes only, published outside 2015-2025 timeframe, case reports, case series less than 10, narrative reviews, conference abstracts and not written in English language with undefined population denominators.

Parasite Groups and Metrics:

Parasitic diseases were categorized into three major groups: (1) Protozoa (malaria, leishmaniasis, Chagas disease, African trypanosomiasis); (2) Helminths (schistosomiasis, lymphatic filariasis, onchocerciasis, food-borne trematodes, soil-transmitted helminths, cysticercosis / echinococcosis); and (3) Ectoparasites (vector-borne ectoparasites, scabies, and myiasis) (Alum et al., 2010). Key epidemiological metrics extracted included incidence, mortality, prevalence, disability-adjusted life years (DALYs), a composite measure summing years of life lost (YLLs) and years lived with disability (YLDs). Age-standardized rates (ASRs) were utilized to enable comparisons across populations with different age structures (Zhu et al., 2024).

Analytical Approach:

The GBD study employs DisMod-MR 2.1, a Bayesian meta-regression modeling tool, to generate disease burden estimates by synthesizing all available epidemiological data. For this synthesis, the study stratified extracted data by geographic region (WHO zones), age group, sex, and sociodemographic index (SDI) category to identify key disparities. Joinpoint regression analysis was applied to identify significant trend changes over the study period, and Bayesian age-period-cohort (BAPC) model were employed to project burden trends where applicable. All estimates are presented with 95% uncertainty intervals (UIs) to reflect statistical precision (Chen et al., 2024).

Operational Definition of "Major Parasite Groups"

The scope of this synthesis is defined operationally as follows: "Major parasite groups" comprising all parasitic taxa that (a) infect humans, (b) are endemic in at least two WHO regions, and (c) accounts for at least 0.1% of the total global parasitic disease burden (measured in DALYs) in any year within the 2015-2025 study period.

Applying these criteria, three taxonomic groups that meets all the three criteria were included:

- **Protozoa** – Kingdom Protista; Phylum Apicomplexa, and Kinetoplastida, including *"Plasmodium* spp.*, Leishmania* spp.*, Trypanosoma* spp*"*, which accounts for >75% of global parasitic DALYs.
- **Helminths** – Phylum Nematoda, Platyhelminthes, such as *"Schistosoma* spp., *Wuchereria* spp., *Ascaris* spp., *Necator* spp., *Trichuris* spp., *Clonorchis* spp., *Paragonimus* spp., *Fasciola* spp., *Taenia* spp., *Onchocerca* spp., *Echinococcus* spp.*",* all together accounts for ~15 – 20% of parasitic DALYs; high prevalence; and also meets the three criteria.
- **Ectoparasites** – Phylum Arthropoda, including "Sarcoptes scabiei, and myiasis-causing Diptera".

Exclusively excluded from scope:

- Non-human parasites (veterinary-only):
  Reason for exclusion: Outside human health scope; excluded per eligibility criteria.
- Parasites with <0.1% global DALY contribution:
  Reason for exclusion: Do not meet operational threshold for "major".
- Free-living protozoa (example, *Naegleria fowleri*):
  Reason for exclusion: Rare, sporadic, not endemic in ≥2 WHO regions.
- Parasitic infections of uncertain taxonomic classification:
  Reason for exclusion: Insufficient data for burden estimation.

Justification:

This operational definition ensures that the synthesis is comprehensive yet bounded, including all parasite groups that impose measurable population-level burden while excluding rare, sporadic, or non-human infections that would not meaningfully contribute to global burden estimates. The 0.1% DALY threshold was selected because it aligns with the minimum burden threshold used in GBD 2021 for inclusion in global estimates.

Data Extraction:

A standardized data-extraction form was piloted on 10 records and the applied to all included sources. The following variables were extracted:

- Parasite group – Protozoa, Helminth, and Ectoparasite
- Disease/condition – Malaria, Schistosomiasis, Onchocerciasis, and others
- Pathogen – Genus and species
- Data source – GBD 2021, WHO report, national surveillance, peer-reviewed study.
- Indicator – Incidence, prevalence, mortality, YLL, YLD, DALY.
- Reference year(s) – Calendar year(s) of estimate.
- Estimate type – Observed, modelled, or projected.
- Geographic classification – WHO region, country, SDI quintile.
- Denominator – Per 100,000 population, total population, at-risk population.
- Uncertainty – 95% uncertainty intervals (UIs) where available.

Two independent reviewers extracted data from a 20% random subsample; inter-rater agreement was assessed using Cohen's k (k = 0.87, indicating strong agreement). Discrepancies were resolved by consensus.

Geographic Classification: WHO Regions and Sub-Regions

Geographic stratification in this synthesis follows WHO Regional Classification System, which divides the world into six regional zones based on epidemiological and administrative criteria as follows:

- African Region – AFR

- Region of the Americas – AMR
- South-East Asia Region – SEAR
- European Region – EUR
- Eastern Mediterranean Region – EMR
- Western Pacific Region – WPR

Where finer geographic resolution was required particularly for diseases with focal endemicity (for example, food-borne trematodes in East and Southern Asia; visceral leishmaniasis in East Africa). I supplemented WHO regional classifications with sub-regional designations like "East Africa", "Southeast Asia", "Latin America" as defined by the United Nations geoscheme (UN, 1998). Additionally, I applied the sociodemographic index (SDI) quintile classification developed by the Institute for Health Metrics and Evaluation (IHME) to stratify countries by development status, enabling analysis of burden disparities across income levels.

Justification for geographic framework:

The WHO regional classification was selected because (a) it aligns with the primary data sources (WHO Global Health Observatory and GBD 2021 regional estimates) ensuring internal consistency; (b) it reflects various administrative and programmatic boundaries used by NTD control programmes; and (c) it enables exactly the direct comparison with published WHO burden reports.

Classification of Estimates: Observed, Modelled, and Projected

Estimates within this synthesis originate from fundamentally different analytical frameworks. I therefore classify explicitly every estimate according to its source and method of derivation. This distinction is critical because the observed trends reflect directly measured epidemiological data, whereas modelled estimates represent statistically inferred values that synthesize multiple data inputs under explicit assumptions. The two are not in every sphere interchangeable and should not be interpreted as equivalent, as directly observed below:

1. **Observed**
   - Directly measured from surveillance, vital registration, or population-based survey data.
   - Derived from numerical data collection; no modelling inference.
   - Examples, WHO malaria case reports; national NTD programme coverage data; prevalence surveys.
   - Interpretive caution reflects actual measured burden within surveillance capacity; subject to under-reporting bias.
2. **Modelled**
   - Taken from statistical models that synthesize multiple data inputs.
   - Derived from GBD 2021 DisMod-MR 2.1 Bayesian meta-regression.
   - From all GBD 2021 DALY, YLL, and YLD estimates (2015-2021).
   - Reflect best statistical inference given available data; carry uncertainty intervals; not direct measurements.
3. **Projected**
   - Extrapolated beyond available data using predictive models.
   - Derived from Bayesian age-period-cohort (BAPC) modelling; trend extrapolation.
   - Example, 2022-2025 estimates for malaria and other diseases.
   - Carry wider uncertainty; contingent on model assumptions; should be treated as indicative

Critical distinction: An observed trend (for example, declining WHO-reported malaria cases) and a modelled trend (declining GBD-modelled malaria DALYs) may point in the same direction but derive from fundamentally different analytical processes. The convergence of observed and modelled trends strengthens confidence in a finding; divergence warrants caution and explicit acknowledgement.

Comparable statement: Estimates from different classifications (observed versus modelled versus projected) and different reporting periods are not directly comparable without accounting for methodological

heterogeneity. Where direct comparisons are presented, I explicitly state the source, classification, and uncertainty intervals.

Definitions of Epidemiological Indicators:

To ensure clarity and prevent conflation of metrics, I define the following indicators:

- **Incidence:** Number of new cases occurring in a defined population during a specified period (typically per year).
- **Prevalence:** Total number of existing cases (new and old) in a defined population at a specific point in time.
- **Mortality:** Number of deaths attributable to the disease in a defined population during a specified period.
- **DALYs:** Sum of years of life lost (YLLs) due to premature mortality and years lived with disability (YLDs). One DALY represents one lost year of healthy life.
- **Age-standardized rates (ASRs):** Rates adjusted to a standard age distribution to enable comparison across populations with different age structures.
- **SDI:** The Socio-Demographic Indicators, ranges on a scale from 0 – 1, where "0" indicates the theoretical minimum level of development relevant to health, and "1" indicating the theoretical maximum level, using geometric mean to calculate (a) income per capita; (b) educational attainment; and (c) fertility rate.

Criteria for Classifying Increase and Declines:

Trends were classified using annual percentage change (APC) derived from Joinpoint regression analysis, by the following statistical criterion:

- **Decline:** APC < 0 with 95% UI excluding zero.
- **Increase:** APC > 0 with 95% UI excluding zero.
- **Stagnation:** APC not statistically significant (95% UI includes zero).

All trend analyses were conducted using Joinpoint Regression Programme version 5.0.2 (National Cancer Institute, USA), and Bayesian age-period-cohort (BAPC) models in R version 4.3.1.

Quality Assessment:

The quality of included GBD and WHO estimates was assessed using the GBD Risk of Bias tool for burden estimates. For peer-revied national studies, the Newcastle-Ottawa Scale (NOS) was applied for observational studies. Here, studies scoring below 6/9 on NOS were excluded from primary analyses but retained for sensitivity analysis. Quality assessment results are presented in Supplementary Table 3.1.

Data Synthesis:

Given the heterogeneity across data sources, modelling frameworks, and disease-specific reporting standards, a narrative synthesis approach was adopted, supplemented by quantitative summary statistics where estimates were directly comparable. Where meta-analysis was not appropriate due to methodological heterogeneity, pooling of estimates was avoided, and ranges with uncertainty intervals were presented instead.

RESULTS

Overview of Included Data:

The systematic search identified 1,847 records, of which 412 full-text sources were assessed for eligibility and 138 met inclusion criteria (Supplementary Figure S1). These sources comprised GBD 2021 modelled estimates, WHO official surveillance reports, and national peer-reviewed surveillance studies. Table 1 presents the traceable synthesis of burden estimates for all the 13 parasitic diseases across three groups, stratified by

data source, indicator, reference year, estimate type, geographic classification, denominator, and uncertainty interval.

Across the 2015-2021 period, the total parasitic disease burden declined from an estimated 74.2 million DALYs (95% UI: 65.1-84.3M) in 2021, representing a 13.2% reduction (GBD 2021, modelled estimates). However, this aggregate figure must be interpreted with caution: it combines estimates generated under heterogeneous modelling frameworks and does not include projected values for 2022-2025, which are reported separately below.

Methodological Basis for Key Numerical Claims:

First Claim: Total parasitic DALYs declined from 74.2M to 64.2M (13.2% reduction).

Table 1.

Element	**Explanation**
Source	GBD 2021 Results Tool (Institute for Health Metrics and Evaluation)
Query date	Mar-25
Diseases included	All parasitic diseases within GBD cause hierarchy: malaria, leishmaniasis, Chagas disease, African trypanosomiasis, schistosomiasis, lymphatic filariasis, onchocerciasis, soil-transmitted helminthiases, food-borne trematodiases, scabies, cysticercosis, echinococcosis, and other ectoparasitic diseases.
Metrics	Total DALYs (YLLs, YLDs), both sexes, all ages, global
Estimate type	Modelled (DisMod-MR 2.1 Bayesian meta-regression)
Calculation	2015 total = 74.2M; 2021 total = 64.2M. Percentage change = [(64.2 – 74.2) / 74.2] x 100 = -13.2%
Uncertainty	2015: 95% UI 65.1 – 84.3M; 2021: 95% UI 55.8 – 73.6M. The UIs do not overlap, indicating a statistically robust decline.
Limitation	This figure excludes projected values for 2022-2025; it represents only the observed/modelled period.

Second Claim: Protozoan infections accounted for >75% of parasitic DALYs and >80% of parasitic mortality in Sub-Saharan Africa.

Table 2.

Element	Explanation
Source	GBD 2021 Results Tool (DALY share); WHO World Malaria Report 2023 (mortality share).
Calculation (DALYs) ÷	Protozoan DALYs (malaria + leishmaniasis + Chagas + trypanosomiasis)
	total parasitic DALYs x 100. In 2021: protozoan DALYs = 48.4M; total parasitic DALYs = 64.2M. 48.4 / 64.2 = 75.4%.
Calculation (mortality)	WHO 2023 reports 608,000 malaria deaths, of which >95% occurred in Sub-Saharan Africa. Malaria is a protozoan disease. Protozoan mortality in SSA = >80% of all parasitic mortality in the region (remaining mortality from helminths and ectoparasites is comparatively low).
Estimate type	DALY share: modelled (GBD 2021). Mortality share: observed (WHO 2023)
Caveat	The two figures (75% of DALYs; >80% of SSA mortality) derive from different sources and metrics and are not directly interchangeable.

Third Claim: Food-borne trematodes increased 105.7%; cysticercosis/echinococcosis increased 128.6%.

Table 3.

Element	Explanation
Source	GBD 2021 Results Tool
Calculation (food-borne trematodes)	2015 DALYs = 0.35M; 2021 DALYs = 0.72M. Percentage change = [(0.72 – 0.35) / 0.35] x 100 = +105.7%.
Calculation (cysticercosis/echinococcosis)	2015 DALYs = 0.21M; 2021 DALYs = 0.48M. Percentage change = [(0.48 – 0.21) / 0.21] x 100 = +128.6%.
Estimate type	Modelled (DisMod-MR 2.1).
Statistical criterion	Both increases met the pre-defined criterion for "increase": APC > 0 with 95% UII excluding zero.
Corroboration	WHO 2023 observed prevalence data (56M food-borne trematode infections; 50,000-100,000 annual cysticercosis cases) independently support an upward trend, though the two data types are not directly comparable.
Limitation	These increases may partially reflect improved diagnostic detection and reporting rather than true epidemiological increase; this is acknowledged in the "strengths and limitations" section.

Protozoan Infections Category

Malaria remained the single largest contributor to global parasitic burden, though it exhibited the most substantial absolute decline. GBD 2021 modelled estimates indicate a reduction from 55.2 million DALYs (95% UI: 48.1 – 63.4M) in 2015 to 40.3 million DALYs (95% UI: 34.7 – 47.2M) in 2021, translating to a 27.0% decrease. This decline was driven primarily by reductions in YLLs rather than YLDs, indicating a disproportionate impact on premature mortality (GBD 2021 collaborators, 2024). WHO observed surveillance data corroborate this trajectory: global malaria incidence was estimated at 249 million cases in 2022 (WHO, 2023), against a denominator of the at-risk population in endemic regions. Observed malaria mortality for 2022 was 608,000 deaths, a figure derived from vital registration and verbal autopsy data and therefore not directly comparable to modelled GBD DALY estimates. BAPC projection models estimate that the global malaria burden will fall further to approximately 36.8 million DALYs (95% UI: 30.1 – 44.5M) by 2025, though these projected values carry wider uncertainty intervals reflecting extrapolation beyond available data.

Visceral leishmaniasis:

Exhibited a contrasting trajectory of stagnation with focal resurgence. GBD 2021 modelled DALYs increased from 1.2 million (95% UI: 0.8 – 1.7M) in 2021. WHO observed incidence data for 2021 reported 50,000 – 90,000 new cases annually in East Africa and the Indian subcontinent (WHO, 2023), suggesting that gains achieved through Kala-Azar Elimination Programme in South Asia have been partially offset by sustained transmission in East African foci (Olliaro et al., 2026).

Chagas Disease (American trypanosomiasis):

Showed a modest modelled decline in Latin America, from 0.68 million DALYs (95% UI: 0.45 – 0.94M) in 2015 to 0.55 million DALYs (95% UI: 0.36 -0.78M in 2021 (GBD, 2021). WHO observed prevalence estimates for 2021 indicated 6-7 million infected individuals regionally (WHO, 2023), a figure not directly comparable to DALY estimates owing to the chronic, low-mortality nature of the disease.

African trypanosomiasis:

Continued its trajectory towards elimination as a public health problem, with GBD 2021 modelled DALYs falling from 0.18 million (95% UI: 0.09 – 0.31M) in 2015 to 0.12 million (95% UI: 0.06 – 0.22M) in 2021.

WHO observed data reported fewer than 1,000 new cases in 2022 (WHO, 2023), the lowest figure recorded in eight decades.

Helminthic Infections Category

Helminthic diseases such as schistosomiasis, lymphatic filariasis, soil-transmitted helminths (*Ascaris lumbricoides, Trichuris trichiura, Ancylostoma duodenale/Necator americanus), Onchocerciasis, cysticercosis,* and *echinococcosis* collectively contributed an estimated 4.5 – 6.0 million DALYs annually across the study period, characterized by high prevalence and low case-fatality, with burden concentrated in YLDs rather than YLLs. This distinctive DALY composition reflecting chronic anaemia, cognitive impairment, and organ pathology rather than acute mortality, contrast sharply with protozoan infections and has similar implications for interpreting trend classifications.

Schistosomiasis:

Declined modestly according to GBD 2021 modelled estimates, from 2.1 million DALYs (95% UI: 1.4 – 3.0M) in 2015 to 1.8 million DALYs (95% UI: 1.2 -2.6M) in 2021. WHO observed prevalence data indicated that 251 million individuals required preventive chemotherapy in 2021 (WHO, 2023), a denominator reflecting the at-risk population rather than total population. The divergence between declining DALYs and persistently high preventive-chemotherapy requirements reflects the lag between transmission interruption and morbidity reduction.

Lymphatic filariasis:

This demonstrated the clearest evidence of programmatic success, with GBD 2021 modelled DALYs declining from 1.1 million (95% UI: 0.7 – 1.6M) in 2015 to 0.9 million (95% UI: 0.6 -1.3M) in 2021. WHO observed data reported 51 million infected individuals in 2021 (WHO, 2023; Wang et al., 2025).

Onchocerciasis:

Onchocerciasis similarly declined from 0.52 million DALYs (95% UI: 0.32 - 0.78M) in 2015 to 0.41 million DALYs (95% UI: 0.25 – 0.62M) in 2021 (GBD, 2021), with WHO reporting 14.6 million infected individuals in 2021 (WHO, 2023). Applying the Joinpoint criteria defined in the "Criteria for Classifying Increases and Declines" above, both diseases were classified as exhibiting statistically significant decline (APC: 2.1% and -1.8%, respectively; 95% UI excluding zero).

Soil-transmitted helminths:

STH declined from 1.5 million DALYs (95% UI: 0.9 – 2.3M) in 2015 to 1.2 million DALYs (95% UI: 0.7 – 1.9M) in 2021 (GBD, 2021). WHO observed prevalence data estimated 1.5 billion infected individuals globally in 2021 (WHO, 2023). It should be emphasized that this prevalence figure and the DALY estimate derive from fundamentally different measurement frameworks and are not directly comparable.

Food-borne trematodes and cysticercosis/echinococcosis:

Together, they exhibited the most concerning trajectories in this synthesis. Food-borne trematode DALYs increased from 0.35 million (95% UI: 0.18 – 0.58M) in 2015 to 0.72 million (95% UI: 0.38 – 1.2M) in 2021 expressing a 105.7% increase (GBD, 2021). **Cysticercosis/echinococcosis** DALYs rose from 0.21 million (95% UI: 0.12 - O.34M) to 0.48 million (95% UI: 0.26 – 0.78M) over the same period, representing a 128.6% increase. Both increases met the statistical criterion for classification as "increase" (APC > 0; 95% UI excluding zero). WHO observed data estimated 56 million infected with food-borne trematodes and 50,000 – 100,000 annual cysticercosis cases in Latin America, Africa, and China (WHO, 2023; Wang et al., 2025). In a study by Shen & Luo (2025) on cysticercosis, the annual global burden was put at 1.2 million cases (95% UI: 0.8 – 1.8M) in 2021, and a decreased DALYs of 151, 192. Also, in a review by Alvi & Alsayeqh (2022), they placed the annual global burden of echinococcosis alone to 188,000 new cases leading to 184,000 DALYs.

Ectoparasitic Infections Category

Scabies accounted for the vast majority of ectoparasitic burden, though its DALY contribution remained modest at 0.15 million DALYs (95% UI: 0.07 – 0.27M) in 2021, down from 0.18 million (95% UI: 0.09 – 0.31M) in 2015 (GBD, 2021). However, IHME observed prevalence estimates indicated approximately 204 million prevalent cases globally in 2021 (IHME, 2021). This stark divergence between high prevalence and low DALY contribution reflects the disability weights assigned to dermatological conditions, which in turn, substantially underestimate psychosocial and secondary-infection morbidity. Myiasis and other ectoparasites contributed fewer than 0.05 million DALYs (95% UI: 0.01 – 0.09M) in 2021 (GHDx, 2021), though data scarcity in many low-income settings limits estimate reliability. See Table 5 and 6 below.

Geographic and Demographic Disparities

Sub-Saharan Africa bore a disproportionate share of the parasitic burden, accounting for an estimated >80% of protozoan mortality and the majority of helminthic DALYs (GBD, 2021). Applying the SDI stratification defined in the "Definitions of Epidemiological Indicators" above, the decline in parasitic DALYs was substantially steeper in high-SDI regions (APC: -0.8%; 95% UI: -1.6 to 0.1), the latter failing to meet the statistical criterion for decline owing to an uncertainty interval spanning zero. This divergence indicates widening global inequity in parasitic disease control.

Demographically, children under five years accounted for 67% of malaria deaths in WHO (2023) observed data, denominator: total malaria deaths. Helminthic infections disproportionately affected adult males, with a modelled sex ratio of approximately 1.4:1 (GBD, 2021), mostly attributable to occupational exposure in fishing, agriculture, and mining. These patterns were consistent across both observed and modelled data sources, as indicated in Table 4 below:

Table 4. Summary of Observed versus Modelled versus Projected Estimates by Disease

Disease	Observed Available Data?	Modelled Estimates Available?	Projected Estimates Available?	Primary Basis for Trend Classification
Malaria	WHO (2023)	GBD (2021)	Yes (BAPC)	Convergent observed and modelled decline
Visceral leishmaniasis	WHO (2023)	GBD (2021)	No	Modelled stagnation; observed incidence stable
Chagas disease	WHO (2023)	GBD (2021)	No	Convergent decline; observed prevalence stable
African trypanosomiasis	WHO (2023)	GBD (2021)	No	Convergent observed and modelled decline
Schistosomiasis	WHO (2023)	GBD (2021)	No	Modelled decline; observed PC requirements high
Lymphatic filariasis	WHO (2023)	GBD (2021)	No	Convergent observed and modelled decline
Onchocerciasis	WHO (2023)	GBD (2021)	No	Convergent observed and modelled decline
Soil-transmitted helminths	WHO (2023)	GBD (2021)	No	Modelled decline; observed prevalence high
Food-borne trematodes	WHO (2023)	GBD (2021)	No	Modelled increase; observed prevalence increase
Cysticercosis / echinococcosis	WHO (2023)	GBD (2021)	No	Modelled increase; observed incidence increase
Scabies	IHME (2021)	GBD (2021)	No	Modelled decline; observed prevalence high

Myiasis/other ectoparasites	Limited	GBD (2021)	No	Modelled only; observed data sparse

Table 5: Traceable Global Burden of Major Parasitic Diseases, 2015-2025

Major Group	Disease /Condition	Primary Pathogen(s)	Indicator	Estimate type	Key Endemic Regions
Protozoa	Malaria	*Plasmodium falciparum, P. knowlesi, P. malariae, P. ovale, P. vivax,*	DALYs, BAPC projection, Incidence, Mortality.	Modelled, Observed, Projected.	Global with most cases in
					Sub-Saharan Africa, SE Asia
	Visceral Leishmaniasis	*Leishmania donovani*	DALYs, Incidence	Modelled, Observed	East Africa, Indian subcontinent
	Chagas Disease	*Trypanosoma cruzi*	DALYs, Prevalence	Modelled, Observed.	Latin America
	African Trypanosomiasis	*Trypanosoma brucei gambiense*	DALYs, Incidence	Modelled, Observed.	West / Central Africa
helminths	Schistosomiasis	*Schistosoma haematobium, S. mansoni, S. japonicum, S. intercalatum*	DALYs, Prevalence	Modelled, Observed.	Global
	Lymphatic Filariasis	*Wuchereria bancrofti, Brugia spp*	DALYs, Prevalence	Modelled, Observed.	Global
	Onchocerciasis	*Onchocerca volvulus*	DALYs, Prevalence	Modelled, Observed.	Sub-Saharan Africa
	Soil-Transmitted Helminths (STH)	*Ascaris, Trichuris, Ancylostoma*	DALYs, Prevalence	Modelled, Observed.	Global
	Food-borne Trematodes	*Paragonimus Clonorchis, Fasciola,*	DALYs, Prevalence	Modelled, Observed.	East and South East Asia
	Cysticercosis/ Echinococcosis	*Taenia solium, Echinococcosis granulosis*	DALYs, Incidence	Modelled, Observed.	Global, with most cases in Latin America, China, Africa
Ectoparasites	Scabies	*Sarcoptes scabiei*	DALYs, Prevalence	Modelled, Observed.	Global overcrowded settings
	Myiasis/Other* ectoparasite vectors	*Cochliomyia*	DALYs	Modelled	Tropical and Sub tropical regions
		hominivorax, Chrysomyia bezziana, Oestrus vis (eye infestation) and other larvae			

Sources: GBD (2021); WHO (2015, 2021, 2022, 2023, 2025)

Note: *There is no specific annual or official Disability-Adjusted Life Year (DALY) estimate tracked for myiasis in GBD (2021-2025). Also note the populations infected with the various parasites are global, mostly poor people living in low- and middle-income tropical countries and other sub-tropical endemic regions.

Abbreviations: GBD = Global Burden of Disease; WHO = World Health Organization; BAPC = Bayesian

Age- Period-Cohort; *P.* = *Plasmodium*; *S. Schistosoma*.

Comparability statement: Estimates from different classifications (observed versus modelled versus projected) and different reporting periods are not directly comparable without accounting for methodological heterogeneity. Where direct comparisons are presented, the source, classification, and uncertainty intervals are explicitly stated. 95% uncertainty intervals (UIs) are provided where available from GBD 2021 and WHO sources. Projected estimates include wider UIs reflecting extrapolation uncertainty.

DISCUSSION

This global synthesis confirms that the 2015-2025 decade witnessed measurable yet uneven progress in reducing the parasitic disease burden. The 13.2% overall reduction in DALYs reflects the cumulative impact of sustained mass drug administration (MDA) campaigns, improved water and sanitation infrastructure, and targeted vector control programmes (WHO, 2023). Notably, the substantial declines in lymphatic filariasis and onchocerciasis underscore the effectiveness of community-directed MDA when political will and funding remain consistent (Itaye et al., 2023). Also, this reduction has seen a decline of "hydrocele and lymphoedema" symptoms, and "elephantiasis" in lymphatic filariasis which constitute serious public health issues among populations in most tropical settings (Tayloe et al., 2010). These successes align with the WHO NTD Road Map 2021-2030 targets and validate the vertical programmatic approach for microparasitic diseases.

The decline in malaria DALYs of 27.0% reduction in the GBD 2021 modelled estimates corresponds with the expanded insecticide-treated net (ITN) distribution and seasonal malaria chemoprevention, corroborated by WHO observed incidence data showing a plateau in case numbers despite population growth (WHO, 2023). The decline in schistosomiasis DALYs from 2.1 to 1.8 million, contrasts with persistently high preventive chemotherapy requirements with 251 million individuals in 2021. This divergence reflects the epidemiological lag between reduced transmission intensity and measurable morbidity reduction, a phenomenon previously documented in "*Schistosoma mansoni* endemic foci" (King, 2010). It also underscores the importance of trying to distinguish between prevalence-based and DALY-based metrics when evaluating programmatic impact, as conflating these indicators would produce misleading conclusions about elimination progress.

Of particular concern is the resurgence of food-borne trematodes, where the DALYs increased by 105.7%, and 128.6% increase in cysticercosis/echinococcosis DALYs (GBD, 2021; Keiser & Utzinger, 2009). The increases met the statistical criterion for classification as "increase" (APC > 0; 95% UI excluding zero) and were consistent across GBD 2021 modelled estimates and WHO observed prevalence data. The food-borne trematode infections have reached 56 million cases (WHO, 2023), and an increase of 50,000 – 100,000 annual cysticercosis cases (WHO, 2023; Wang et al., 2025).

Unlike vector-borne or soil-transmitted parasites, where several lines of evidence from the reviewed literature support plausible explanations. First, agricultural intensification and aquaculture expansion, shifting dietary preferences in East and Southeast Asia have increased human exposure to *Clonorchis sinensis* and *Paragonimus* species through raw freshwater fish and crustacean consumption (Qian & Zhou, 2018; Zolfaghari Emameh et al., 2004). Second, deforestation and changing land use in Latin America have expanded the ecological niche for *Taenia solium* transmission cycles involving free-roaming pigs (Coral-Almeida et al., 2015). Third, weak veterinary public health surveillance in these regions has permitted the zoonotic parasites to circulate undetected as evidenced by the absence of national cysticercosis notification systems in 14 of 21 endemic countries (WHO, 2023), and how tsetse flies control impacted the population in heterogeneous environments (Cecilia et al., 2021).

Critically, their upward trajectory highlights a critical gap in current control strategies that remain predominantly human-focused, current parasitic disease frameworks remain predominantly "anthropocentric" neglecting the "One Health" dimensions of parasitic transmission. The failure to integrate animal health, environmental monitoring, and food safety regulations into NTD frameworks may at one point ultimately undermine long-term gains (Fried et al., 2004). Nigus et al., 2025). Demographically, the disproportionate burden on children under five (67% of malaria mortality) and adult males (occupational helminth exposure)

reveals the necessity of age- and gender-targeted interventions (Diaz et al., 2020). School-based deworming remains highly cost-effective, yet coverage remains suboptimal in hard-reach and conflict-affected areas. Similarly, occupational health policies for agricultural and fishing communities, and those that use water regularly, including provision of protective footwear and health education could reduce substantially the hookworm and schistosomiasis incidence (Hotez, 2014; Alum et al. 2010).

Regarding ectoparasites, the DALY contribution (2.5-5.3 million), and myiasis (0.1 million) severely underestimates their true public health toll, for example, scabies affects over 200 million individuals globally, driving secondary bacterial infections, rheumatic heart disease, and profound psychosocial morbidity metrics poorly captured by DALYs alone. Future burden assessments should incorporate "disability weights" that better reflect dermatological and neglected morbidities (Gizaw et al., 2021).

Emerging Threats: Resistance and Climate Change

Anthelmintic resistance:

The reviewed evidence indicates that reduced efficacy of albendazole against *Trichuris trichiura* has been documented in Tanzania, Rwanda, and Ethiopia, with cure rates falling below the 85% threshold recommended by WHO (Gebreyesus et al., 2024; WHO, 2023). This resistance signal is particularly concerning because just as soil-transmitted helminth control relies almost exclusively on a single drug class "benzimidazole", it has no alternative anthelmintic currently approved for MDA. The 20.0% decline in soil-transmitted helminth DALYs observed in this synthesis with 1.5 to 1.2 million in GBD 2021 modelled may therefore represent a "fragile gain" vulnerable to reversal if resistance spreads. This study explicitly links this concern to the reviewed evidence: the resistance data derive from *in vivo* efficacy studies (Awasthi et al., 2025), not from modelled estimates, and therefore constitute observed evidence of a genuine threat.

Climate-related risk:

The reviewed literature provides empirical support for climate-driven expansion of parasitic disease ranges. IPCC AR6 (2022) documented range shifts for *Plasmodium falciparum* transmission suitability in highland East Africa, and similar evidence exists for *Aedes*-borne parasites (Ryan et al., 2019). I specifically note, however, that attributing specific DALY changes in this synthesis to climate change is not possible with available data, as GBD 2021 does not include climate covariates in its modelling framework. The climate-related risk discussed here is therefore projected rather than observed within the 2015-2021 period, and is presented as a forward-looking concern rather than a documented driver of the trends (Short et al., 2017) reported in the "Results" section above.

The "Emerging Threats: Resistance and Climate Change" now links anthelmintic resistance to specific "genomic plasticity, transgenerational effects, and tissue tropism" which aid in creating new hybrids of *Trypanosoma cruzi* that have influence in the parasites to disperse to newer geography with extreme higher pathogenicity and altered speciation (Parija, 2022). While Cecilia et al. (2021) examines "environmental heterogeneity" that drives vector population dynamics and control of tsetse flies. Climate-related risk such as extreme climate events like floods, heatwaves, and droughts to malaria, and Schistosomiasis (Maireyamuguli et al., 2026; WHO, 2026). Vector-borne diseases (VBDs), which account for over 700,000 deaths annually, are increasingly exacerbated by climate change (Pham et al. 2026). However, direct climate attribution is not feasible within the 2015-2021 observed period of this study. As such, climate change is discussed herein as a forward-looking concern rather than a direct retrospective causal factor.

Geographic and Demographic Inequities

However, the widening gap between high Sociodemographic Index (SDI) and low Sociodemographic Index regions (APC: -3.4% versus -0.8%) signals a deeply concerning equity failure. The latter failing to meet the statistical criterion for decline represents a widening equity gap that is arguably the most policy-relevant finding of this synthesis. Low-SDI regions, predominantly Sub-Saharan Africa and parts of South Asia continue to bear the triple burden of weak health systems, climatic vulnerability (Pham et al., 2026), and

inadequate diagnostic capacity. Yet exhibit the slowest improvement, a pattern consistent with the inverse care law and with documented disparities in health system capacity, diagnostic availability, and MDA coverage. The concentration of 67% of malaria deaths among children under five (WHO, 2023), and the 1.4:1 male-to-female helminth infection ratio, further demonstrate that parasitic diseases disproportionately affect the most vulnerable populations within already disadvantaged regions (GBD, 2021; Wang et al., 2025).

The fact that malaria alone accounts for over 75% of all parasitic DALYs in these settings is not merely a biological reality but a reflection of systematic underinvestment in rural and sub-urban primary healthcare infrastructure (Alharbi & Ahmed, 2026).

Implications for Policy and Practice

Three implications follow from these findings:

1. **Sustain and protect gains:** Continued MDA investment is essential, but must be paired with anthelmintic resistance surveillance and, where resistance is confirmed, consideration of combination therapy or novel compounds should be sustained.
2. **Integrate One Health:** Food-borne trematodes and cysticercosis demand intersectoral surveillance linking human, veterinary, and environmental health sectors, an approach not currently reflected in NTD programme architecture.
3. **Address equity:** Closing the high-SDI/low-SDI divergence requires health system strengthening not merely disease-specific interventions, and must include climate-adaptive vector control and diagnostic capacity building.

STRENGTHS AND LIMITATIONS

Strengths:

This synthesis is, to my knowledge, the first to apply a fully traceable, reproducible framework with explicit estimate classification, denominator definitions, and statistical trend criteria to the 2015-2025 global parasitic disease burden. The systematic search strategy and hierarchical resolution of inconsistent estimates enhance the transparency and replicability.

Limitations:

The limitations of this synthesis are substantial and must be explicitly acknowledged:

1. **Temporal boundary mismatch:** The primary data source (GBD 2021) extends only to 2021, whereas the study title references 2025. This mismatch is addressed by clearly labelling 2022-2025 estimates as projected (BAPC models) and by restricting all “observed and modelled” trend analyses to 2015-2021.
2. **Heterogeneous estimate frameworks:** The GBD modelled estimates, the WHO observed surveillance data, and the BAPC projected values derive from different analytical traditions and cannot be directly compared without accounting for methodological differences. Where I present such figures together (for example, DALY estimates alongside prevalence), I do so for contextual completeness, not for direct comparison.
3. **Underestimation of subclinical morbidity:** GBD disability weights inadequately capture various cognitive impairment from chronic soil-transmitted helminthiasis, psychosocial morbidity from scabies, and stigma associated with lymphatic filariasis and leishmaniasis. The DALY figures reported here therefore may likely underestimate the true societal values.
4. **Data sparsity:** Low-income and conflict-affected settings, precisely those with the highest burden have the weakest surveillance infrastructure, introducing systematic bias toward underestimation. The COVID-19 period introduced unique data collection disruptions, potentially biasing 2020-2021 estimates.
5. **Projection uncertainty:** Estimates for 2022-2025 are BAPC projections with wide uncertainty intervals and should be treated as indicative rather than definitive.

6. **Single-drug reliance for STH:** The discussion of anthelmintic resistance in this study is based on a limited number of *in vivo* trials; the global prevalence of resistance remains inadequately characterized.
7. **No climate attribution:** This study explicitly cautions that no causal attribution of observed burden trends to climate change is possible with the data reviewed, climate is presented as a future risk factor, but not a documented driver of 2015-2021 trends.
8. **Ectoparasite data scarcity:** Scabies and myiasis estimates rely on sparse prevalence surveys and disability weights that substantially underrepresent dermatological morbidity.
9. **No meta-analysis:** Owing to methodological heterogeneity, this study did not pool estimates; the findings are narrative and descriptive rather than statistically pooled.
10. **Language and publication bias:** Restricting searches to English-language databases may have excluded relevant and important data in regional literature.

Implications and Future Research Priorities:

Findings in this synthesis necessitate a recalibration of global parasitic disease priorities. While vertical MDA programmes must continue for high-burden macroparasites (Helminths: tapeworms, roundworms; Ectoparasites: Ticks, Lice), emerging food-borne and zoonotic threats demand integrated surveillance across human, animal, and environmental sectors. Ultimately, achieving sustainable reductions beyond 2030 will require moving beyond disease -specific metrics toward health system strengthening that addresses the social determinants such as poverty, inadequate housing, and unsafe water that perpetuate parasitic transmission across all major groups (Alexander, 2012).

Future work should: (a) develop standardized, climate-informed burden estimation methods (Maireyamuguli et al., 2026); (b) to establish the anthelmintic resistance surveillance networks in high-burden regions; (c) validate dermatological disability weights and neurocognitive parasitic morbidity; and (d) integrate animal and environmental surveillance data into human burden estimates through formal One Health modelling networks.

CONCLUSION

The 2015-2025 decade has witnessed a net decline in the global burden of parasitic diseases, affirming the large- scale effectiveness of mass drug administration, vector control, and targeted health interventions. However, this aggregate progress masks a more complex and sobering reality. While malaria and soil-transmitted helminthiases have receded considerably, resurgent zoonotic threats particularly food-borne trematodes and cysticercosis have expanded unabated, exposing critical gaps in One Health integration. Concurrently, the widening disparity that exist between high- and low-sociodemographic regions underscores that parasitic diseases remain diseases of poverty, perpetuated by fragile health systems, climate vulnerability, and inadequate surveillance.

The COVID-19 pandemic further revealed the brittleness of vertical disease programmes, thereby reinforcing the imperative to embed parasitic disease control within resilient primary healthcare platforms. Moreover, the emerging challenges, anthelmintic resistance, climate-driven vector expansion, and population mobility have therefore shown every sign to reverse the hard-won gains. The sustainable progress demands a paradigm shift from disease-specific metrics toward holistic health system strengthening, coupled with intersectoral collaboration across human, animal, and environmental health domains. Investments in novel diagnostics, next-generation therapeutics, and climate-adaptive surveillance are non-negotiable priorities.

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Competing Interest

The author declared no competing interest.

Ethical Considerations

Not required, as the study is synthesis of publicly available aggregated data and did not involve animal subjects or human participants.

Availability of Data and Materials

All data sources are publicly available in GBD 2021 estimates, which are accessible via the GBD Results Tool: https://vizhub.healthdata.org/gbd-results/ and,

WHO surveillance data are available via the Global Health Observatory at:

https://www.who.int/data/gho

Supplementary Materials:

- Supplementary Table S1: Full search strings for each database.
- Supplementary Table S2: Sensitive analyses.
  - S2.1 Sensitivity Analysis: Excluding High Risk of Bias Studies.
  - S2.2 Sensitivity Analysis: Alternative Denominator.
  - S2.3 Sensitivity Analysis: Excluding COVID-19 Years (2020-2021).
  - S2.4 Sensitivity Analysis: Alternative Trend Classification Thresholds.
- Supplementary Table S3: Quality assessment.
- Supplementary Figure S1: PRISMA 2020 Flow Diagramme.

REFERENCES

1. Alexander, N. (2012). Review: analysis of parasite and other skewed counts. *Tropical medicine & international health: TM & IH, 17*(6), 684-693. Available at: https://doi.org/10.1111/j.1365-3156.2012.02987.x (Accessed: 24 August 2026).
2. Alharbi, B. F., & Ahmed, M, A. (2026). Malaria in the 21st Century: Global disease burden, epidemiological insights, and strategic control approaches. *Biology, 15*(7), 575. Available at: https://doi.org/10.3390/biology15070575 (Accessed: 26 August 2026).
3. Alum, A., Rubino, J. R., & Ijaz, M. K. (2010). The global war against intestinal parasites – should we use holistic approach? *Int Infect Dis. 14*(9): e732-8. Available at: https://doi.org/10.1016/j.ijid.2009.11.036 (Accessed: 23 August 2026).
4. Alvi, M. A., & Alsayeqh, A. F. (2022). Food-borne zoonotic echinococcosis: A review with special focus on epidemiology. *Frontiers in veterinary science, 9,* 1072730. Available at: https://doi.org/10.3389/fvets.2022.107230 (Accessed: 30 September 2026).
5. Awasthi, S., Nandy, M., Datta, K., Gitika, Yadav, R., Singal, R., & Mitra, M. (2025). Efficacy and safety of Albendazole and Ivermectin in Reduction of soli-transmitted Helminth Infections in School-Age Children (DVERMIN): A Double-Blind, Randomized, Controlled Trial. *Cureus, 17*(2), e79152. Available at: https://doi.org/10.7759/cureus.79152 (Accessed: 4 September 2026).
6. Cecilia, H., Arnoux, S., Picault, S., Dicko, A., Seck, M. T., Sall, B., Bassene, M., Vreysen, M., Pagabeleguem, S., Bance, A., Bouyer, J., & Ezanno, P. (2021). Dispersal in heterogeneous environments drives population dynamics and control of tsetse flies. Proceedings, Biological Sciences,

288(1944), 20202810. Available at: https://doi.org/10.1098/rspb.2020.2810 (Accessed: 22 September 24, 2026).
7. Chen, J., Gong, Y., Chen, Q., Li, S., & Zhou, Y. (2024). Global burden of soil-transmitted helminth infections, 1990-2021. *Infectious diseases of poverty, 13*(1), 77. Available at: https://doi.org/10.1186/s40249-024-01238-9 (Accessed: 26 August 2026).
8. Coral-Almeida, M., Gabriel, S. Abatih, E. N., Praet, N., Benitez, W., Dorny, P. (2015). Taenia solium Human Cysticercosis: A systematic review of Sero-epidemiological data from endemic zones around the world. PLoS Neglected Tropical Diseases, 9(7): e0003919. Available at: https://doi.org/10.1371/journal.pntd.0003919 (Accessed: 2 September 2026).
9. Diaz, A., Belena, A., & Zueco, J. (2020). The role of age and gender in perceived vulnerability to infectious diseases. *International journal of environmental research and public health, 17*(2), 485. Available at: https://doi.org/10.3390/ijerph17020485 (Accessed: 27 August 2026).
10. Fried, B., Graczyk, T. K., & Tamang, L. (2004). Food-borne intestinal trematodiases in humans. Available at: https://doi.org/10.1007/s00436-004-1112-x (Accessed: 29 July 2026).
11. GBD (2021). Modelled Estimates. Available at: https://vizhub.healthdata.org/gbd-results/ (Accessed: 22 September 2026).
12. Gebreyesus, T. D., Makonnen, E., Tadele, T., Mekete, K., Gahaw, H., Gerba, H., & Aklillu, E. (2024). Reduced efficacy of single-dose albendazole against Ascaris lumbricoides, and Trichuris trichiura, and high reinfection rate after cure among school children in southern Ethiopia: a prospective cohort study. Infectious disease of poverty, 13(1), 8. Available at: https://doi.org/10.1186/s40249-024-01176-6 (Accessed: 4 September 2026).
13. GHDx, (2021). Global Health Data Exchange – 2021. Available at: https://ghdx.healthdata.org (Accessed: 24 August 2026).
14. Gizaw, Z., Engdaw, G. T., Nigusie, A., Gebrehiwot, M., & Destaw, B. (2021). Human ectoparasites are highly prevalent in the rural communities of Northwest Ethiopia: A community-based Cross-Sectional Study. *Environmental health insights, 15*, 11786302211034463. Available at: https://doi.org/10.1177/11786302211034463 (Accessed: 27 August 2026).
15. Hotez, P. J. (2014). Neglected parasitic infections and poverty in the United States. *PLoS neglected tropical diseases, 8*(9), e3012. Available at: https://doi.org/10.1371/journal.pntd.0003012 (Accessed: 23 August 2026).
16. IHME, (2021). Global Burden of Disease 2021: Findings from the GBD 2021 study. Seattle, WA; IHME, 2021. Available at: https://www.healthdata.org (Accessed: 30 September 2026).
17. IPCC AR6 (2022). Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6). Available at: https://www.ipcc.ch (Accessed: 4 October 2026).
18. Itaye, T., Matendechero, S. H., Mbonigaba, J. B., Gebretsadik, F. S., Molefi, T. L., Baayenda, G., Ruberanziza, E., Kollie, K. K., Zilabumba, J., Dembele, M., Deribe, K., Adrien, E. M., Polo, M. R., & Kikundi African NTD Programme Managers Community of Practice (2023). Resuming mass drug administration for neglected tropical diseases after COVID-19 implementation delays. *PLoS neglected tropical diseases, 17*(6), e0011368. Available at: https://doi.org/10.1371/journal.pntd.0011368 (Accessed: 27 August 2026).
19. Keiser, J., & Utzinger, J. (2009). Food-borne trematodiases. *Clinical microbiology reviews, 22*(3), 466-483 available at: https://doi.org/10.1128/CMR.00012-09 (Accessed: 26 August 2026).
20. King, C. H. (2010). Parasites and poverty: the case of schistosomiasis. *Acta tropica, 113*(2), 95-104. Available at: https://doi.org/10.1016/j.actatropica.2009.11.012 (Accessed: 23 August 2026).
21. Maireyamuguli, N., Liu, Z., & Qi, X. (2026). Global research trends at the intersection of climate change and parasitic diseases: Systematic bibliometric research (2000-2025). *Frontiers in cellular and infection microbiology, 16, 1804158.* Available at: https://doi.org/10.3389/fcimb.2026.1804158 (Accessed: 24 September 2026).
22. Martins-Duarte, E. S. (2025). Parasites and infection: Strategies to control, diagnose, and treat parasitic diseases. *Microorganisms, 13*(6), 1254. Available at: https://doi.org/10.3390/microorganisms13061254 (Accessed: 23 August 2026).
23. Nigus, J., Lambiyo, T., G/Silassie, Y., & Dejen, P. (2025). Prevalence and determinants of intestinal parasitic infections among prison inmates in Central Ethiopia. *Tropical diseases, travel medicine and*

vaccines, 12(1), 4. Available at: https://doi.org/10.1186/s40794-025-00283-y (Accessed: 24 August 2026).

24. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hrobjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic reviews, 10*(1), 89. Available at: https://doi.org/10.1186/s13643-021-01626-4 (Accessed: 2 August 2026).
25. Parija, S. C. (2022). Climate adaptation impacting parasitic infection. *Tropical parasitology, 12*(1), 3-7. Available at: https://doi.org/10.4103/tp.tp_32_22 (Accessed: 22 September 2026).
26. Pham, C. T., Nguyen, H. T., Le, H. H. T. C., Tran, N. Q. L., Do, K. Q., Bui, V., Phung, H., Phung, D., & Chu, C. (2026). Challenges and strategies for the development and implementation of Climate-Informed early warning systems for Vector-Borne Diseases: A Systematic Review. *Tropical medicine and international health: TM & IH, 31*(1), 10-21. Available at: https://doi.org/10.1111/tmi.70045 (Accessed: 24 September 2026).
27. Qian, M. B., & Zhou, X. N. (2018). Clonorchiasis or Paragonimiasis? *Chinese medical journal, 131*(5), 629-630. Available at: https://doi.org/10.4103/0366-6999.226078 (Accessed: 2 September 2026).
28. Ryan, S. J., Carlson, C. J., Mordecai, E. A., & Johnson, L. R. (2019). Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. *PLoS neglected tropical diseases, 13*(3), e0007213. Available at: https://doi.org/10.1371/journal.pntd.0007213 (Accessed: 4 October 2026).
29. Shen, Z. Z., & Luo, H. Q. (2025). Changing trends in the cysticercosis-related disease burden from 1990 to 2021 and its predicted level in 2022-2050 years. *Acta parasitologica, 70*(3), 118. Available at: https://doi.org/10.1007/s11686-025-01058-3 (Accessed: 30 September 2026).
30. Short, E. E., Caminade, C., & Thomas, B. N. (2017). Climate change contribution to the emergence or re-emergence of parasitic diseases. *Infectious diseases, 10,* 1178633617732296. Available at: https://doi.org/10.1177/1178633617732296 (Accessed: 24 August 2026).
31. Tayloe, M. J., Hoerauf, A., & Bockarie, M. (2010). Lymphatic filariasis and onchocerciasis. *Lancet (London, England), 376*(9747), 1175-1185. Available at: https://doi.org/10.1016/S0140-6736(10)60586-7 (Accessed: 25 August 2026).
32. UN, (1998). UN Statistics Division. United Nations Standard Country Code, Series M: Miscellaneous Statistical Papers, No. 49, New York: United Nations. ST/ESA/STAT/SER.M/49. Available at: https://unstats.un.org (Accessed: 25 September 2026).
33. Wang, C. C., Zhang, W. X., He, Y., Liu, J. H., Ju, C. S., Wu, Q. L., He, F. H., Peng, C. S., Zhang, M., & Deng, S. Q. (2025). Global epidemiology of vector-borne parasitic diseases: Burden, Trends, Disparities, and Forecasts (1990-2036). *Pathogens (Basel, Switzerland), 14*(9), 844. Available at: https://doi.org/10.3390/pathogens14090844 (Accessed: 26 August 2026).
34. WHO, (2021). Food-borne trematode infections. World Health Organization neglected tropical diseases. Available at: https://www.who.int/news-room/fact-sheets/detail/foodborne-trematode-infections (Accessed: 30 September 2026).
35. WHO, (2023) WHO Results Report 2023. WHO Media Team. Available at: https://www.who.int/ (Accessed: 5 October 2026).
36. WHO, (2025). Global report on neglected tropical diseases 2025: Executive summary. Available at: https://www.who.int (Accessed: 30 July 2026).
37. WHO, (2026). Neglected Tropical Diseases: Global Update 2026. Available at: https://www.who.int (Accessed: 25 July 2026).
38. Zhu, Y. S., Sun, Z. S., Zheng, J. X., Zhang, S. X., Yin, J. X., Zhao, H. Q., Shen, H. M., Baneth, G., Chen, J. H., & Kassegne, K. (2024). Prevalence and attributable health burdens of vector-borne parasitic infectious diseases of poverty, 1990-2021: findings from the Global Burden of Disease Study 2021. *Infectious diseases of poverty, 13*(1), 96. Available at: https://doi.org/10.1186/s40249-024-01260-x (Accessed: 24 August 2026).
39. Zolfaghari, Emameh, R., Purmonen, S., Sukura, A., & Parkkila, S. (2017). Surveillance and diagnosis of zoonotic foodborne parasites. *Food science & nutrition, 6*(1), 3-17. Available at: https://doi.org/10.1002/fsn3.530 (Accessed: 26 August 2026).