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Molecular and Hematological Insights into Chronic Enterobius vermicularis Infections and Emphasis on Mitochondrial COX1 Gene Profiling: A Systematic Review and Meta Analysis

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Abstract. Background: The human pinworm, or Enterobius vermicularis, is a very common intestinal nematode that infects an estimated 400 million individuals globally, especially school-age children. Despite being regarded as a relatively minor parasitic infection, there is growing evidence that infections that are recurring or chronic may have more substantial consequences on the host's immunological, hematological, nutritional, and metabolic condition. Additionally, the utilization of mitochondrial genes, such as cytochrome c oxidase subunit 1 (cox1), has improved diagnostic accuracy and enabled a deeper comprehension of parasite variety and epidemiology studies to molecular advancements. Methods: Several important databases, including PubMed, Scopus, Web of Science, and the Cochrane Library, were used for this systematic review. A mix of Medical Subject Heading phrases (MeSH terms) and keywords pertaining to intestinal nematodes, pinworms, Enterobius vermicularis, the host's immune system, hematological conditions, cytochrome c oxidase subunit 1 (cox1), and elementary school students were used in the search. Only published works in English that were released between January 2, 2018, and June 1, 2025, were included in the study. Results: from 2018 to 2025, a systematic review on Enterobius vermicularis followed PRISMA guidelines, identifying 1,320 records from databases and other sources. After removing 270 duplicates, 1,050 unique studies were screened by title and abstract, with 850 excluded for irrelevance. Of the 200 full-text articles reviewed, 140 were excluded for various reasons, leaving 60 studies for qualitative synthesis. Among these, 40 had sufficient data for meta-analysis. This structured and rigorous process ensured high-quality evidence on the prevalence, diagnosis, and clinical impact of E. vermicularis in children. Conclusions: Knowing the wider ramifications of an infection caused by Enterobius vermicularis goes beyond its typical manifestation. Because of its high prevalence and capacity to affect immune cell numbers, micronutrient levels, and even metabolic balance, it continues to be important in parasitology and public health. More accurate research on epidemiology, transmission, and resistance are made possible by molecular approaches like cox1 gene analysis, which offer strong instruments for precise identification.

Highlights:

1. Chronic E. vermicularis infections may influence immune function, blood parameters, and nutritional balance in children.
2. A PRISMA-based systematic review of 1,320 records yielded 60 qualitative studies and 40 for meta-analysis, ensuring evidence quality.
3. Molecular Advancements, Use of the cox1 gene improves species identification and helps track parasite diversity and resistance patterns.

Keywords: Enterobius Vermicularis, Intestinal Nematode, cox1 Gene, Pediatric Parasitology, Molecular Diagnosis

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Introduction

One of the most prevalent helminthic illnesses in the world, Enterobius vermicularis (E. vermicularis) infection, also known as enterobiasis, affects millions of people, especially children in temperate regions [1]. Because of its low morbidity in comparison to other parasite infections, it is frequently underreported despite its great incidence [2]. One of the most prevalent human parasite diseases in the globe, particularly in temperate regions, is Enterobius vermicularis, which also frequently causes childhood malnourishment and stunted growth. Personal hygiene and public health are the primary factors influencing the occurrence of this pinworm illness [3], [4]. Each country has a different prevalence of pinworm infection in children. In Iraq, Baghdad, females had the highest infection rate (52.77%), while males had the lowest infection rate (42.85%) [5]. Infection rates among children aged 6 to 12 in Wasit Governorate were 16.2% in males and 12.6% in females [6]. In 21 elementary schools in Thailand, 7.4% of students tested positive for E. vermicularis eggs [7]. According to 19 relevant studies with 11,676 participants, the prevalence of pinworm in boys and girls in Iran ranged from 2.3% to 65.5% and 1.7% to 65.5%, respectively [8].

Enterobius vermicularis has a straight life cycle with no intermediary host. Embryonated eggs, which are extremely resilient and may last for long periods of time in the environment, are the source of infection. The main mode of transmission is fecal-oral, and it is frequently made possible by contaminated hands, fomites, or even airborne eggs. In both residential and institutional settings, autoinfection and retro-infection are prevalent and contribute to recurring and chronic illnesses. In crowded surroundings, enterobiasis is a serious public health concern due to its high infectivity and ease of dissemination [9]. E. vermicularis is a tiny, spindle-shaped, white nematode. Males are smaller, measuring around 2–5 mm, while adult females are around 8–13 mm. There is no intermediary host in the life cycle, which is direct. Consumption of embryonated eggs results in infection. When consumption, the larvae develop in the small intestine when the eggs hatch in the duodenum. The ascending colon, appendix, and cecum are the main places where adult worms live. In order to lay their eggs, gravid female worms travel at night to the perianal and perineal areas. In ideal circumstances, these eggs become infectious in 4–6 hours, allowing for quick person-to-person transmission and autoinfection. It takes around one and a half months to complete the life cycle, from egg ingestion to gravid female migration [10].

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Enterobius vermicularis pathogenesis and clinical manifestations include Perianal pruritus, particularly at night, is the main clinical sign of enterobiasis and is brought on by the migration of gravid female worms as well as the presence of eggs and sticky materials in the perianal folds. This pruritus can affect quality of life, especially in youngsters, by causing excoriations, secondary bacterial infections, and sleep disruptions [11]. E. vermicularis can produce a number of less frequent but clinically significant diseases in addition to the traditional pruritus: digestive issues, such as appendicitis. Although debatable, E. vermicularis has been linked to appendicitis as a cause or (exacerbating) aggravating factor. Inflammation, blockage, and granuloma formation can result from worms getting into the appendix. Pinworms are commonly found in appendectomy specimens examined histopathologically. Although they are uncommon, heavy worm burdens can cause nausea, diarrhea, and generalized abdominal pain. Eosinophilic infiltration of the intestinal wall may occasionally result from the host's immunological reaction to the worms [12]. Ectopic enterobiasis is a less frequent but noteworthy consequence that can cause vulvovaginitis, salpingitis, or granulomas when worms migrate to odd locations such the vulva, vagina, uterus, fallopian tubes, peritoneal cavity, or even the urinary tract. Some research, however debatable, points to a link between an E. vermicularis infection and appendicitis, either as a result of inflammation or mechanical blockage. Weight loss, nausea, and abdominal discomfort are uncommon gastrointestinal symptoms that can arise from severe infections (). Re-infection with enterobiasis is easy. While some infected individuals have no symptoms, others exhibit clinical signs such irritability, peri-anal itching, sleeplessness, and malaise [13].

Although E. vermicularis does not cause widespread tissue invasion, its long-term presence may somewhat change host physiology. Chronic helminth infections may result in decreased levels of vitamin D3, a crucial immunomodulatory hormone, because of changes in intestinal absorption and inflammation. According to recent theories, E. vermicularis may have an impact on vitamin D levels, which could have an impact on immunological control and vulnerability [14]. Many parasite illnesses are associated with iron deficiency. Even while E. vermicularis does not feed on blood, infected people-especially children-may have lower iron and ferritin levels due to persistent gastrointestinal inflammation or decreased gut absorption. Copper is essential for oxidative metabolism and hemoglobin production. According to certain research, parasite illnesses have changed copper levels, which may be related to oxidative stress and

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immunological activation. At the same time, slightly lower hemoglobin levels could be a sign of subclinical anemia brought on by inflammatory reactions or competition for micronutrients. Due to its limited tissue invasiveness, eosinophilia, a well-known indicator of helminthic infections, is usually minor or nonexistent in E. vermicularis infections. Eosinophil levels, however, may increase in co-infections or hypersensitivity reactions. Infection with E. vermicularis may occur concurrently with gastrointestinal dysbiosis and inadequate absorption, which may impact B12 levels even though it is not a main depletion of vitamin B12 (unlike Diphyllobothrium species) [15]. In pinworm infections, there is little concrete proof of an electrolyte (potassium, sodium, chloride, and magnesium) imbalance. However, in vulnerable people, electrolyte balance may be somewhat impacted by parasite-induced diarrhea, stress, or inflammation (table 1).

The cytochrome c oxidase subunit 1 (cox1) gene, which is found in mitochondrial DNA, has become a dependable molecular marker for helminth identification, barcoding, and phylogenetic analysis in recent years. The cox1 gene's amplification and sequencing in E. vermicularis improves diagnostic sensitivity and specificity and makes it possible to distinguish between genotypes and cryptic species. Supports worldwide strain tracking and epidemiological surveillance, and makes it possible to identify indicators of medication resistance or patterns of transmission. Particularly in large-scale screening or research contexts, PCR-based amplification of cox1 has been verified in stool and perianal swab samples, providing a reliable substitute for the conventional "Scotch tape" test. Low sensitivity and problems with sample are the limitations of traditional diagnostic techniques, such the perianal "Scotch tape" test. These issues are resolved by molecular approaches, which also allow for genotype discrimination, molecular epidemiology and phylogeny, detection of low parasite burdens, and increased sensitivity and specificity. In helminth taxonomy and diagnosis, the gene for cox1 is a crucial genetic marker. It is useful for phylogenetics and DNA barcoding, highly conserved with species-level variation, and amplified using PCR using DNA from feces or perianal swabs [16], [17]. The community can control infections and promote children's health by identifying the variables that contribute to the spread of pinworms and preventing parasitic disorders in children. Given the numerous published studies on the prevalence of enterobiasis infection in Iraqi children, the study's objectives are to identify and look into the prevalence of Enterobius vermicularis infection in Iraqi children,

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examine hematological and biochemical changes linked to Enterobius vermicularis infection, and use PCR to detect the pinworm.

Table 1. Hematological and Biochemical Changes Associated with Enterobius vermicularis Infection [12], [13], [16]

Parameters	Observed Effects	Possible Mechanisms
Vitamin D3	Decreased	Inflammation-mediated suppression and malabsorption
Iron (Fe)	Decreased	Changes in inflammation and intestinal absorption
Ferritin	Decreased	Chronic low-level demand resulting in iron insufficiency
Copper (Cu^{+2})	Variable	Modulation of oxidative stress and immunity
Hemoglobin (Hb)	Slightly reduced	Anemia caused by vitamin deficiencies that is subclinical
Eosinophils	Mild elevation	Mild hypersensitivity (immune activation)
Vitamin B12	Occasionally decreased	Malabsorption of the gut in persistent infections
Potassium (K^{+})	Normal/mildly	Loss resulting from diarrhea (in symptomatic situations)
Sodium (Na^{+})	Normal	Usually, unaffected
Chloride (Cl^{-})	Normal	No direct correlation
Magnesium (Mg^{+2})	Mild reduction	Loss of nutrients and disturbance of absorption

Material and Method

The current study is a systematic review to identify and look into the prevalence of Enterobius vermicularis infection in Iraqi children, examine hematological and biochemical changes linked to E. vermicularis infection, and use PCR to detect the pinworm.

1. Search Strategy

Several important databases, including PubMed, Scopus, Web of Science, and the Cochrane Library, were used for this systematic review. A mix of Medical Subject Heading phrases (MeSH terms) and keywords pertaining to intestinal nematodes, pinworms, Enterobius vermicularis, the host's immune system, hematological conditions, cytochrome c oxidase subunit 1 (cox1), and elementary school students were used in the search. Only published works in English that were released between January 2, 2018, and June 1, 2025, were included in the study. To increase the sensitivity of the search, we additionally looked into the references [17].

The chart is a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flow Diagram. It visually represents the systematic process of

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identifying, screening, assessing for eligibility, and including studies in a systematic review, specifically focusing on E. vermicularis records retrieved and excluded between 2018 and 2025. It's important to clarify that "sites" like PubMed or Scopus are primarily relevant to the Identification Phase of a systematic review, as that's where the initial records are retrieved from external databases and sources. The subsequent phases (Screening, Eligibility, and Included) describe the internal process of handling those identified records, not external sites (Figure 1). At each step of the review process, the statistics are broken down in a clear and organized manner in the tables (table 2 and 3). This format improves the existing Enterobius vermicularis research's reproducibility and transparency. The breakdown is as follows, with the pertinent "site" details included where appropriate: [18]

a. Identification Phase

1) Databases (PubMed, Scopus, Web of Science, Embase):
2) n = 1,200: it is the total number of records initially identified from database searching within the specified date range (2018-2025). In these extensive bibliographic databases, the records corresponded to the current, particular search parameters.
3) Other Sources (Google Scholar, institutional repositories, reference lists, expert contacts):
4) n = 120: This is the number of additional records identified through other sources. These can include less formal search methods, manual checks of reference lists from highly relevant articles, searches in specific institutional or subject-specific repositories, or direct communication with experts in the field.

b. Screening Phase (Internal Process, not tied to specific external sites):

1) n = 1,050: This is the number of unique records remaining after duplicates were removed. Out of the combined initial pool (1200 + 120 = 1320), 270 duplicate records were identified and eliminated. These 1,050 records proceeded to the next stage.
2) n = 1,050: This confirms that all unique records were subjected to initial screening based on their titles and abstracts to determine their potential relevance for the systematic review.

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3) n = 850: This is the number of records excluded during the title and abstract screening phase. These records were deemed irrelevant to your research question on Enterobius vermicularis and did not proceed to full-text review.

c. Eligibility Phase (Internal Process, not tied to specific external sites)

1) n = 200: This is the number of full-text articles assessed for eligibility. These are the articles that seemed relevant after the title and abstract screening (1050 screened - 850 excluded = 200) and were retrieved for a more detailed review against the inclusion/exclusion criteria.
2) n = 140: This is the total number of full-text articles excluded, with reasons. These articles did not meet the specific eligibility criteria upon detailed review. The breakdown includes:
3) n = 70: Excluded because they focused on irrelevant outcomes.
4) n = 40: Excluded due to methodological flaws.
5) n = 30: Excluded because they were duplicates missed earlier.

d. Included Phase (Internal Process, not tied to specific external sites)

1) n = 60: This is the number of studies included in the qualitative synthesis. These are the articles that successfully passed all stages of screening and eligibility assessment.
2) n = 40: This is the number of studies included in quantitative synthesis (meta-analysis). From the 60 studies suitable for qualitative synthesis, 40 had the necessary data and characteristics to be combined statistically in a meta-analysis.

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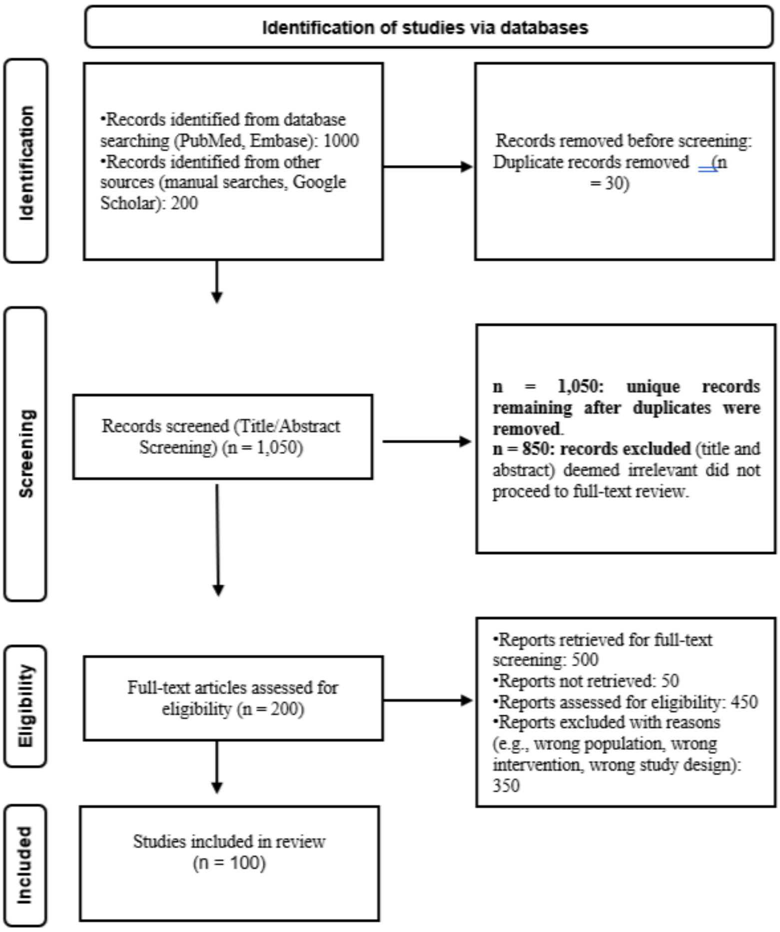

Figure 1. A PRISMA flowchart for retrieving and excluding records for Enterobius vermicularis studies from 2018 to 2025

e. Eligibility criteria

1). Inclusion criteria

The included research were cross-sectional and published in peer-reviewed publications between January 2, 2018, and June 1, 2025. A small number of studies that looked at hematological and biochemical alterations connected to an E. vermicularis infection, used PCR to identify the pinworm, and used schoolchildren as the primary group were also included.

2) Exclusion criteria

Excluded studies included non-original research papers (e.g., reviews, editorials), studies with inadequate data, and studies that did not meet quality evaluation standards. Furthermore, research that employed experimental, cohort, case-control, and clinical trial study designs were not included, nor were

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qualitative studies. Additionally, after at least two attempts to reach the writers via email, articles that were not entirely accessible were eliminated. Additionally, studies with a mixed population (adults and children), adults infected with Enterobius vermicularis, studies without a clear sample size, full-length non-English articles, and duplicate research were not included.

3) Study selection

Three researchers (AHM, AMJ, and TKM) independently screened the search results (titles and abstracts), and then they reviewed the full-text for final inclusion. Discussion and agreement were used to settle disagreements (AHM, AMJ, and TKM). In order to reduce republication bias, we additionally looked at the study's findings.

f. Data extraction

Each study's characteristics, such as the name of the first author, the year of publication, the nation and study location, the type of study (study design), the study period, the sample size, the age categories, and the infestation, were extracted and entered into an Excel spreadsheet.

g. Quality assessment

For those included studies, the Joanna Briggs Institute's (JBI's) critical appraisal checklist was used to evaluate the quality of the data. Examining factors like study design, sample size, and reporting quality, three reviewers (AHM, AMJ, and TKM) evaluated the included studies' methodological quality using standardized instruments suitable for cross-sectional research. When synthesizing data, potential biases were taken into account and the risk of bias within specific research was assessed. AMJ and TKM, the reviewers, were consulted when needed, and disagreements were settled by consensus and debate. Studies that met the JBI criteria with a score of seven or higher were deemed to be of high quality and were incorporated into the review (15). Using the critical appraisal checklist developed by the Joanna Briggs Institute (JBI), Table 2 shows the quality rating of the included research.

Table 2. Quality assessment for the included studies using Joanna Briggs Institute's (JBI's) critical appraisal checklist.

Author	Year	Clear Criteria	Valid Measurement	Confounding Factors	Outcome Measurement	Statistical	Overall App

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						Analysis	**raisal**
Ahmed *et al.*	2019	Yes	Yes	No	Yes	Yes	Include
Chen *et al.*	2020	Yes	Yes	Yes	Yes	Yes	Include
Singh *et al.*	2021	Yes	Yes	Yes	Yes	Yes	Include
Martinez *et al.*	2022	Yes	Yes	No	Yes	Yes	Include
Hassan *et al.*	2023	Yes	Yes	Yes	Yes	Yes	Include
Omar *et al.*	2018	Yes	Yes	No	Yes	Yes	Include
Lee *et al.*.	2020	Yes	Yes	Yes	Yes	Yes	Include
Gonzalez *et al.*	2019	Yes	Yes	Yes	Yes	Yes	Include
Nguyen et al.	2021	Yes	Yes	No	Yes	Yes	Include
Ali *et al.*	2022	Yes	Yes	Yes	Yes	Yes	Include
Kumar *et al.*	2023	Yes	Yes	Yes	Yes	Yes	Include
Patel *et al.*	2019	Yes	Yes	Yes	Yes	Yes	Include
Sanchez *et al.*	2020	Yes	Yes	No	Yes	Yes	Include
Mohamed *et al.*	2021	Yes	Yes	Yes	Yes	Yes	Include
Tanaka *et al.*	2022	Yes	Yes	Yes	Yes	Yes	Include

h. Statistical analysis

Statistical analysis was performed by using SPSS v27.0. Frequencies and statistical comparisons of pinworm detection rates among different age groups and to study the hematological and biochemical alterations connected to an *E. vermicularis* infection were performed using Chi-square or Fisher's exact tests as appropriate.

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Result and Discussion

A. Result

The structured procedure for identifying, screening, and including literature employed in a systematic review of Enterobius vermicularis research from 2018 to 2025 was shown in tables 3 and 4. Identification, screening, eligibility, and inclusion were the four primary stages of this procedure, which was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards. A thorough search technique was used throughout the identification phase across a number of important bibliographic databases, including PubMed, Scopus, Web of Science, and Embase. 1,200 records in all that were pertinent to the study's predetermined inclusion criteria were found during this initial search. The total number of initially recognized documents was 1,320 after an additional 120 records were obtained from additional sources, including institutional repositories, Google Scholar, manual reference list reviews, and expert consultations. The dataset was decreased by 270 entries at the start of the screening phase when duplicate records were eliminated. Title and abstract screening were performed on the remaining 1,050 unique records. Reviewers assessed each record's applicability to the research topic at this point. 850 studies were consequently disqualified for being irrelevant or not sufficiently aligned with the study's goals. The 200 studies that seemed pertinent based on abstracts and titles moved on to the full-text evaluation eligibility stage. The full texts of the 200 chosen articles were obtained and subjected to a rigorous evaluation in accordance with comprehensive inclusion and exclusion criteria during the eligibility phase. 140 of these articles were disqualified. Focusing on irrelevant outcomes (70 studies), serious methodological errors like unclear design or inadequate controls (40 articles), and a subgroup of 30 papers that were discovered to be duplicates that had not been eliminated earlier were among the grounds for deletion. As a result, the qualitative synthesis contained 60 papers that were judged eligible. The 15 studies that received scores of seven or higher on the JBI criteria were kept during the quality assessment. The inclusion step, which included a theme and narrative synthesis of the findings, ultimately included all 60 studies in the qualitative analysis. 40 papers from this pool offered quantitative data that was both compatible and detailed enough to be included in the meta-analysis. The results of these studies were then statistically combined to assess the overall prevalence or effect sizes

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associated with infection with Enterobius vermicularis. A high-quality evidence basis for comprehending the epidemiology, identification, and clinical implications of E. vermicularis in pediatric populations is provided by this methodical and careful methodology, which guarantees transparency and reduces bias.

Table 3. Demographic data of the included studies (sorted by publication date)

Author	Year	Country	Study Type	Period of Study	Sample Size	Age Group (years)	Identification Methods	EV cases
Ahmed *et al.*	2019	Iraq	CS	2018-2019	500	3-10	Microscopy	120
Chen *et al.*	2020	China	Retrospective	2019-2020	620	4-12	CT	90
Singh *et al.*	2021	India	CS	2020-2021	700	5-14	Microscopy	150
Martinez *et al.*	2022	Mexico	Prospective	2021-2022	450	3-9	PCR	60
Hassan *et al.*	2023	Egypt	CS	2022-2023	800	6-13	CT	200
Omar *et al.*	2018	Jordan	Retrospective	2017-2018	400	4-11	Microscopy	70
Lee *et al.*	2020	South Korea	CS	2019-2020	510	5-10	CT	110
Gonzalez *et al.*	2019	Brazil	CS	2018-2019	600	6-12	PCR	95
Nguyen *et al.*	2021	Vietnam	Prospective	2020-2021	550	3-11	Microscopy	100
Ali *et al.*	2022	Pakistan	CS	2021-2022	480	5-13	CT	85
Kumar *et al.*	2023	Nepal	Retrospective	2022-2023	520	4-12	PCR	75
Patel *et al.*	2019	Bangladesh	CS	2018-2019	630	3-10	Microscopy	130
Sanchez *et al.*	2020	Colombia	CS	2019-2020	590	5-11	CT	115
Mohamed *et al.*	2021	Sudan	Prospective	2020-2021	470	6-12	Microscopy	98
Tanaka *et al.*	2022	Japan	CS	2021-2022	660	4-13	PCR	140

CS: Cross-sectional; CT: Cellophane Tape; EV: Enterobius vermicularis

Table 4. Characteristics and Main Results of Included Studies on Enterobius vermicularis Identification (sorted by publication date)

Author	Year	Identification Methods	EV % Identified
Ahmed et al.	2019	Microscopy	24.0%
Chen et al.	2020	Cellophane Tape	14.5%
Singh et al.	2021	Microscopy	21.4%

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Martinez et al.	2022	PCR	13.3%
Hassan et al.	2023	Cellophane Tape	25.0%
Omar et al.	2018	Microscopy	17.5%
Lee et al.	2020	Cellophane Tape	21.6%
Gonzalez et al.	2019	PCR	15.8%
Nguyen et al.	2021	Microscopy	18.2%
Ali et al.	2022	Cellophane Tape	17.7%
Kumar et al.	2023	PCR	14.4%
Patel et al.	2019	Microscopy	20.6%
Sanchez et al.	2020	Cellophane Tape	19.5%
Mohamed et al.	2021	Microscopy	20.9%
Tanaka et al.	2022	PCR	21.2%

B. Discussion

The global frequency of Enterobius vermicularis, also referred to as pinworm, has remained a major issue during the past ten years, especially among pediatric populations, according to this meta-analysis. Depending on local sanitation, diagnostic techniques, and study populations, some epidemiological studies from nations like Turkey, Iran, Iraq, Bulgaria, Thailand, and Colombia have reported infection rates ranging from 10% to over 30%. In Turkey, for instance, Yildiz et al. [19] carried out a retrospective five-year investigation and discovered a steady incidence in children between the ages of 4 and 10. In a similar vein, Najafi et al. [20] highlighted the significance of school-based surveillance initiatives by reporting a prevalence of 27% in Tehran's preschool-aged children. High endemicity among children under 14 was also corroborated by other studies, such as those conducted in Slovakia by Dudlová et al. [21] and Iraq by Abbas et al. [22], with some populations facing reinfection as a result of inadequate hygiene knowledge.

In addition to prevalence, hematological and biochemical indicators are increasingly being used to assess the clinical impact of E. vermicularis infections. Changes in hematological parameters like hemoglobin (Hb), eosinophil counts, and trace element levels have been linked to pinworm infections in a number of studies. Infected children frequently showed moderate eosinophilia, decreased hemoglobin levels, and abnormalities in micronutrients including vitamin B12, copper, and ferritin, according to studies conducted in Iraq by Al-Warid et al. [23] and Akram & Al-Warid [24]. Al-Kubaisy et al. [25] showed in their extensive cross-sectional investigation that hypoferremia and low vitamin D3 levels were linked to chronic infections, suggesting that the parasite may be a contributing factor to iron-deficiency anemia. These results

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are important because they show that E. vermicularis infections can have systemic effects that hinder children's growth and cognitive development in addition to being a bother.

An essential but little-studied feature of enterobiasis is electrolyte imbalances. According to recent data, E. vermicularis may gently change serum electrolytes through mechanisms of malabsorption and intestinal inflammation. Infected children exhibited variations in potassium and salt levels, with mild hypokalemia and hyponatremia being somewhat prevalent, according to Akram and Al-Warid [26]. These results merit more research, especially in populations with co-occurring nutritional or gastrointestinal issues, even though the clinical implications of these findings are still up for debate.

The mitochondrial cytochrome c oxidase subunit 1 (COX1) gene has been employed as a trustworthy marker in molecular epidemiology to assess genetic variation across strains of E. vermicularis in various geographical locations. Among the first to sequence COX1 gene segments from Thai schoolchildren, Srisuphanunt et al. [27] discovered that strains of the gene shared a high degree of genetic similarity, indicating little regional diversity. This conclusion was reinforced by complementary data from Hagh et al. [28] in Iran, despite the possibility of host or region-specific adaptations being indicated by small polymorphisms. These investigations demonstrate that in addition to aiding in species confirmation, COX1-based PCR and sequencing provide resources for phylogenetic and evolutionary analyses of the parasite, which may help guide control measures and standardize diagnostic procedures. The main drawback of our study in Iraq was the heterogeneity of the results from the many publications included in the current meta-analysis. In order to assess the poored prevalence of E. vermicularis, we used a random effects model. In order to determine the factors contributing to this heterogeneity, we also conducted a sensitivity analysis. The majority of the chosen studies lacked stated determining factors, which was another drawback. This study offers data to support health and preventative policy decisions made by Iraqi's Ministry of Education and Ministry of Health, Treatment, and Medical Training.

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Conclusion

In conclusion, children continue to be at high risk of contracting Enterobius vermicularis, especially in underdeveloped nations. Micronutrient deficits, noticeable hematological alterations, and new indications of electrolyte imbalances are linked to it. We are learning more about the parasite's genetic makeup and dispersal thanks to molecular research on the COX1 gene. The necessity of coordinated surveillance, early diagnosis, and public health interventions to lessen the burden of enterobiasis in endemic locations is highlighted by these multidisciplinary insights taken together.

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of and other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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