



Prevalence of *Enterobius vermicularis* among Children in Iran: A Systematic Review and Meta-analysis

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Objectives: *Enterobius vermicularis* is a parasitic disease that is common in crowded areas such as schools and kindergartens. Primary investigations of electronic evidence have reported different prevalences of *E. vermicularis* in Iran. Therefore, we aimed to estimate the total prevalence of this infection among Iranian children using a meta-analysis.

Methods: Relevant studies were identified in national and international databases. We selected eligible papers for meta-analysis after investigating titles, abstracts, and full texts; assessing study quality; and applying inclusion/exclusion criteria. Data were extracted by two independent researchers. The results were combined using a random effects model in Stata v. 11 software.

Results: Among 19 eligible articles including 11,676 participants, the prevalences of *E. vermicularis* among all children, boys, and girls were 1.2%–66.1%, 2.3%–65.5%, and 1.7%–65.5%, respectively. Pooled prevalences (95% confidence interval) of *E. vermicularis* among all children, boys, and girls were 17.2% (12.6%–21.8%), 17.2% (12.6%–21.8%), and 16.9% (9.03%–24.8%), respectively.

Conclusion: This meta-analysis showed that a great majority of Iranian children are infected with *E. vermicularis*, possibly due to poor public health.

Key Words: *Enterobius vermicularis*, *oxyuris*, prevalence, children

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Received March 16, 2016.

Revised April 17, 2016.

Accepted March 17, 2017.

INTRODUCTION

Enterobius vermicularis is one of the most common human parasitic infections worldwide, especially in temperate climates [1], and one of the most common factors leading to malnutrition and growth retardation among children [2]. The prevalence of this infection is mainly related to public health and personal hygiene [3]. Infection transmission occurs through direct contact, and this infection is especially common among children in kindergartens and primary schools [4].

Enterobiasis re-infection occurs easily [5]. Some infected persons are asymptomatic, while others have clinical manifestations such as malaise, insomnia, peri-anal itching, and irritability. Following re-infection and chronic infection, this parasite can affect children's cognitive development [3]. In rare cases, this infection has involved the kidneys and fallopian tubes, leading to severe outcomes and even death [6,7].



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Enterobiasis is one of the most common parasitic infections in many countries, even developed ones [8]. The prevalence of the pinworm infection among children is reportedly 18% in Norway [9] and 18.5% in Korea [4]. In Iran, *E. vermicularis* infected 7.1%, 2.1%, and 24.1% of school and kindergarten children in Mazandaran province [10], Shahrood [11], and Khash [12], respectively. Investigating oxyuriasis infections can help us evaluate personal, familial, and social health statuses. The identification of determinant factors of parasitic transmission and prevention of parasitic diseases among children can lead to infection control in the community and children health promotion.

Considering the various studies that have been published regarding the prevalence of enterobiasis infection among Iranian school children, we aimed to estimate the pooled prevalence of oxyuriasis infection among Iranian kindergarten and primary school children using meta-analysis, a reliable statistical method for combining the results and determining a total estimate within the study population [13,14].

MATERIALS AND METHODS

1. Search strategy

To identify relevant studies performed between 1990 and July 2015, we searched Scientific Information Database, Magiran, and Irandoc (national databases) and PubMed, Google Scholar, Scopus, and Science Direct (international databases) using the following keywords and their Farsi equivalents: *Enterobius vermicularis*, *Oxyuris*, Intestinal infection, Intestinal parasites, Bowel parasite, Prevalence, Children, Primary schools, Preschool center, Kindergarten, Iran.

The search was conducted by two independent researchers from May 26 to July 6, 2015. We also investigated the references to enhance the search sensitivity.

2. Study selection

All duplicates and irrelevant papers were excluded after screening of titles, abstracts, and full texts. We also investigated the study results to minimize republication bias.

3. Quality assessment

Studies identified during the above steps were quality assessed using a previously applied checklist [15]. This checklist was designed based on the contents of the STROBE checklist [16] and included 12 questions addressing various methodological aspects such as study type and design, appropriate sample size estimation and selection, data collection methods and tools, study population, variable definition and assessment, study objectives, statis-

tical tests, and illustration and presentation of the results. Each question was assigned one score. Studies that achieved at least 12 quality scores [12] were considered eligible for the meta-analysis.

4. Inclusion criteria

All studies written in Persian or English estimating the prevalence of oxyuriasis among girls, boys, or both after quality assessment and achieving sufficient quality scores were entered into the final meta-analysis.

5. Exclusion criteria

Studies that did not estimate the prevalence of oxyuriasis, articles without definite sample size or full text, those that did not achieve the minimum necessary quality scores, case reports, case series, case control, and experimental studies were excluded from the meta-analysis.

6. Data extraction

We extracted the required information, including title; first author's name; study date and site; study subgroups (kindergarten or primary school children); sampling methods; diagnostic methods; prevalence of oxyuriasis among boys, girls, and all children; and the *p*-value of the association of prevalence with factors such as sex, age, residence area, educational level, and clinical manifestations. Two independent researchers entered these data into an Excel spreadsheet (Microsoft, Redmond, WA, USA).

7. Statistical analysis

All data analyses were performed using Stata v. 11 software (Stata Co., College Station, TX, USA). The standard error of prevalence in each study was calculated based on a binomial distribution. Because of significant heterogeneity detected between the results of the studies using Cochrane (Q) test and I^2 index, we applied a random effects model to combine the primary results. In addition, to reduce random variations among the point prevalences, all results were adjusted using Bayesian analysis. Moreover, we performed a sensitivity analysis to identify the studies that were more influenced by the above-mentioned heterogeneity. Point prevalences of oxyuriasis are illustrated in forest plots. In such diagrams, the study weights are determined by the box sizes, while the crossed lines indicate the 95% confidence interval (95% CI) of the prevalences.

RESULTS

During our primary search of the available databases, 1,221 studies were identified. After restricting the search strategy and

excluding duplicates, 266 articles remained. Of them, 98 papers were removed after a title and abstract review. After full-text review, 123 irrelevant articles were omitted. In the backwards citation tracking process, three relevant papers were added. In the final step, inclusion/exclusion criteria were applied and the rest of the papers were quality assessed; after that point, 19 studies [10–12,17–32] were entered into the final meta-analysis (Figure 1).

Study type was specified in 15 articles, all of which were cross-sectional. Diagnostic methods included the Scotch tape technique in 17 papers [10–12,17–24,26,28–32] and Formalin ether in two papers [25,27]. Of these studies, 15 were performed among preschoolers or kindergarteners [10–12,17–24,28–31], while four studies [25–27,32] investigated the infection prevalence among primary school children.

A total of 11,676 children (4,402 boys and 4,058 girls) were entered into the current meta-analysis (some of the studies did not specify the sex-specific prevalence). The prevalences of oxyuriasis varied from 1.2% in the studies conducted by Bahadoran et al [27] and Rostami et al [25] among 992 and 800 children, respectively, to 66.1% in the study of 700 children performed by Shahabi [32]. After adjustment by Bayesian analysis, these prevalences were changed to 1.2% and 64.4%, respectively. Among boys, infection prevalence varied between 2.3% in the Rahimi study of 395 children to 65.5% in the Shahabi study of 427 chil-

dren. Among girls, the infection prevalence varied between 1.7% in the study of Abedi et al [17] of 119 children to 65.5% in the Shahabi study of 273 children (Table 1).

Based on the random effects model ($Q = 2663$, $p < 0.001$; I^2 , 99.3%), the total prevalence of oxyuriasis among Iranian children was estimated at 17.2% (95% CI, 12.6–21.8) (Figure 2). The prevalences of infection among boys and girls were 17.2% (95% CI, 7.7–26.7; $Q = 820.9$; $p < 0.001$; I^2 , 98.9%) and 16.9% (95% CI, 9.03–24.8; $Q = 648.1$; $p < 0.001$; I^2 , 98.6%) respectively. Overlapping CIs indicated no significant inter-sex differences in infection prevalences.

Sensitivity analysis showed that the studies of Bahadoran et al [27] and Rostami et al [25] were the most influential studies on heterogeneity. However, excluding these two studies, there were no changes in the total prevalence of *E. vermicularis* (19.2%; 95% CI, 13.03–25.4; $Q = 2,270.3$, $p < 0.001$; I^2 , 99.3%). Therefore, we used all 19 selected papers in the final meta-analysis to avoid an effective sample size reduction.

Publication date and study sub-populations (kindergarten or primary school) were assessed as suspected factors for heterogeneity using univariate and multivariate meta-regression models. None of these factors significantly affected the heterogeneity (Table 2). Each year increase in publication year reduced the prevalence of *E. vermicularis* by 1.2% ($p = 0.07$). In addition, *E.*

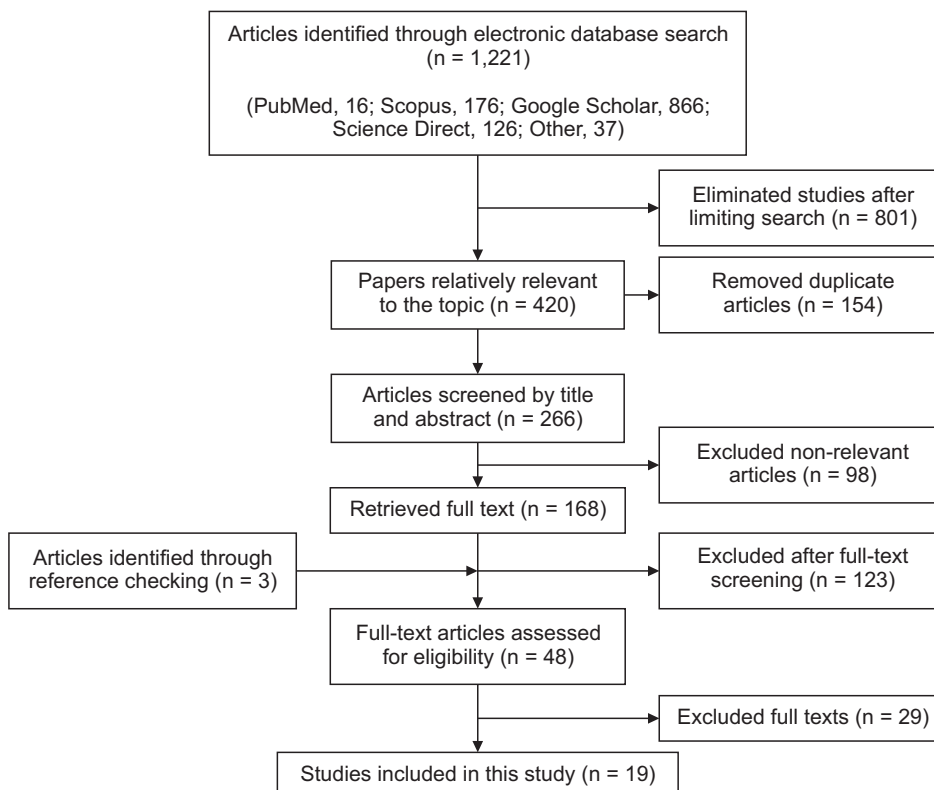


Figure 1. Literature search and review flowchart for selection of primary studies.

Table 1. Baseline characteristics of included studies in meta-analysis of prevalence of *Enterobius vermicularis* among children in Iran

No.	First author	Publication year	Sample size (n)			Prevalence (%)			Related factors with prevalence of <i>E. vermicularis</i> (p-value)							
			Total	Male	Female	Total	Male	Female	Sex	Age	Area residence	Bruxism	Insomnia	Family education		
1	Abedi [17]	2004	252	133	119	2.4	3	1.7	-	-	-	-	-	-	-	-
2	Afrakhteh [10]	2015	462	223	239	7.1	6.3	7.9	NS	NS	0.03	NS	NS	NS	-	-
3	Atashnafas [18]	2007	688	333	355	12.5	13.6	11.6	-	-	0.210	NS	0.009	0.017	-	-
4	Daryani [19]	2004	400	244	156	18.3	16.4	21.2	NS	NS	-	-	-	0.05	-	-
5	Davoudi [20]	2004	853	-	-	9.9	-	-	-	-	-	-	-	-	-	-
6	Ebrahimzade [12]	2014	907	447	460	24.1	19.5	28.7	0.042	-	0.022	-	-	-	-	-
7	Haji Aliami [29]	2014	904	460	444	2.3	-	-	-	-	-	-	-	-	-	-
8	Hazratitappeh [30]	2002	830	-	-	35.4	-	-	<0.05	-	<0.001	-	-	-	-	<0.05
9	Hazratitape [21]	2006	393	189	204	4.6	6.7	5	NS	-	-	-	-	-	-	-
10	Heidari [22]	2003	461	-	-	33.8	-	-	-	-	-	-	-	-	-	<0.005
11	Moqimi [31]	2002	300	-	-	9	-	-	NS	-	-	-	-	-	-	NS
12	Moosaviani [28]	2007	351	192	159	26.4	30.2	22	-	-	-	-	-	-	-	-
13	Motevalli [23]	2013	800	387	413	7.3	8.52	6.29	NS	NS	-	-	-	-	-	<0.05
14	Rahimi [11]	2015	811	395	416	2.1	2.3	1.9	-	-	-	-	-	-	-	-
15	Sharif [24]	2000	217	0	217	29.5	-	-	-	-	<0.05	-	-	-	-	-
16	Bahadoran [27]	1993	992	490	502	1.2	-	-	-	-	-	-	-	-	-	-
17	Rostami [25]	2012	800	482	318	1.2	-	-	-	-	-	-	-	-	-	-
18	Shahabi [32]	1996	700	427	273	66.14	66.51	65.57	-	-	-	-	-	-	-	-
19	Soheili Azad [26]	2004	555	-	-	37.8	-	-	<0.049	-	-	-	-	-	-	-

-, not available; NS, not significant.

vermicularis among primary school children was only 1.005% higher than that of kindergarten children ($p = 0.9$).

Among the eight studies investigated the relationship between *E. vermicularis* and sex [10,12,19,21,23,26,30,31], three studies [12,26,30] reported significant relationships. According to the results of two studies [26,30], infection was more common among boys, while the third study [12] reported a higher prevalence of infection among girls.

The association between *E. vermicularis* and age was estimated in four studies [10,19,23,24]. Only one of them [24] reported that 3–5-year-old children in kindergartens were significantly more infected than those in the other age groups.

Of the six studies that assessed the relationship between *E. vermicularis* and parent education level [18,19,22,23,30,31], five

studies [18,19,22,23,30] found statistically significant relationships, particularly in four studies, in which illiterate or low educated mothers more commonly had infected children.

Only four studies [10,12,18,30] compared pinworm infections among different residential areas, three of which [10,12,30] observed higher rates among rural residents.

Between two studies that investigated the association between *E. vermicularis* and insomnia [10,18], one reported a significant correlation [18]. Moreover, two studies assessed the association between infection and bruxism [10,18], while another study reported the association of *E. vermicularis* with family size, anal itching, nail biting, familial history of *E. vermicularis*, and personal history of other parasitic infections were not significant.

DISCUSSION

According to this meta-analysis, approximately 17% of kindergarten and primary school children are infected with *E. vermicularis*, and the area of residence (urban/rural) and mother's educational level are determinant factors of *E. vermicularis* among Iranian children.

The prevalences of *E. vermicularis* among Taiwan [33], Thai-

Table 2. Factors related with heterogeneity among primary studies on univariate and multivariate meta-regression

Variable	Univariate		Multivariate	
	B	p	B	p
Publication year	-1.2	0.05	-1.2	0.07
Population studies	4.4	0.5	1.0005	0.9

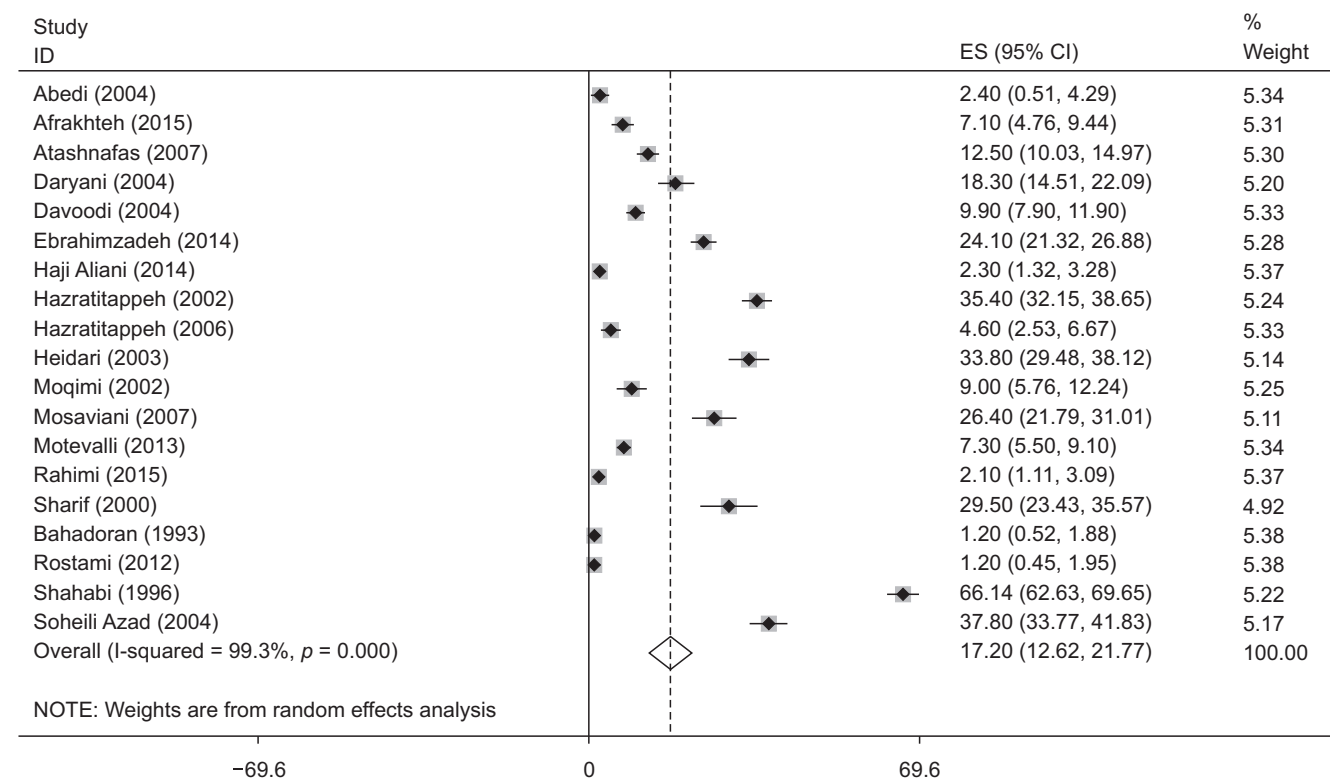


Figure 2. Prevalence of *Enterobius vermicularis* among preschoolers and kindergarteners in Iran by included studies and pooled estimate.

land [34], Malaysia [35], Sri Lanka [8], Venezuela [36], Korea [4], and Chinese [37] children are reportedly 0.6%, 38.8%, 40.4%, 38%, 19.4%, 18.5%, and 10.2%, respectively (Table 3). In Turkey [38], oxyuriasis was observed among 10.4% of children and was significantly associated with residential structure, number of rooms in the house, parents' educational level, and students' social status. In a study conducted in Norway, 18% of children developed *E. vermicularis* infection, most of whom were age 6 to 11 years [9]. There was wide variability in the results of the studies performed in other countries, possibly due to different methodologies, study environments, and situations.

Only three of eight studies in the current meta-analysis reported a significant correlation between sex and infection. Park et al [4] showed that the prevalence in boys was considerably higher than that in girls. Ebrahimzadeh et al [12] found that the infection rates among boys and girls were 19.5% and 28.7%, respectively, and the difference was statistically significant. Results of a study conducted by Hazratitappeh et al [30] showed that 14.08% more boys were infected than girls. Similar relationships between sex and oxyuriasis were observed in Venezuela by Requena et al [39] in 2007. Higher infection rates among boys could be partially attributed to higher activity, greater contact with other children and the environment, and poor personal hygiene and nutrition in boys compared to girls [26].

Requena et al [39] in Venezuela and Li et al [3] in China reported significant associations between oxyuriasis and age. A lower frequency of infection in younger children indicates the fact that younger children do not have enough knowledge about preventing infection. However, they will be able to better care themselves at older ages. There are different risk factors in different age groups. In younger children, putting toys into the mouth is a major risk factor. Risk factors among older children include independent play, exposure to a contaminated environment, and a lack of hand washing before eating. Obvious behaviors among children that are easily ignored can increase the risk of infection.

In Korea, Kim et al [40] showed that *E. vermicularis* infection was associated with parents' education level. Li et al [3] reported that parents' educational level had a major role in reducing infection. They found that one-fourth of children infected with *E. vermicularis* had more highly educated mothers and were cared by their grandparents or other persons [3]. Motevalli Haghi et al [23] reported that the rate of infection among children whose parents had a graduate degree was higher than that of children with an undergraduate degree. This finding means that highly educated parents do not have enough time to care for their children. Thus, they had to register their children in kindergartens that are susceptible to infection transmission through contaminated hands and equipment as well as poor hygiene.

In most countries, the prevalence of *E. vermicularis* infection has decreased due to screening programs. In Turkey, the infection rate in 1985 to 2000 was 45.9%, while that in 2000 to 2008 was 16% [41]. Similar reductions were observed in Greece (from 22.1% to 5.2%) and Korea (from 17.1% to 7.9%) [42–44].

Re-infection is one of the main factors of infection development because *E. vermicularis* has a very simple transmission cycle. It takes only 2–4 weeks for eggs to mature to adult worms. *E. vermicularis* can easily contaminate doorknobs, tables and chairs, toys, school equipment, and even dust. Susceptible children will be infected through close contact with the environment and contaminated children. Although some drugs can prevent re-infection, hygiene can be useful along with drug administration [3]. Health promotion as well as increasing child and family awareness will reduce the infection rate. Targeted interventions are needed to control oxyuriasis. Because of the high prevalence of re-infection in crowded areas such as kindergartens and primary schools, health education programs should be implemented among children, teachers, and parents. These programs and activities should be specifically performed for different age groups. Infected children have physical and mental problems. Control and prevention programs should be considered by educational

Table 3. Prevalence of *Enterobius vermicularis* by country

First author	Publication year	Country	Population group	Sample size (n)	Prevalence (%)
Park [4]	2005	Korea	Kindergartens and primary schools	1,661	18.5
Kuang [37]	2015	Chinese	Preschool children in kindergartens	489	10.2
Yazgan [38]	2015	Turkey	Primary school	438	10.4
Chang [33]	2009	Taiwan	Preschool children	4,349	0.6
Gunawardena [8]	2013	Sri Lanka	Primary school	260	38.0
Nithikathkul [34]	2001	Thailand	Primary school	783	38.8
Norhayati [35]	1994	Malaysia	Children aged 1–8 years	178	40.4
Maniscalchi [36]	2010	Venezuela	Children aged <12 years	2,423	19.4

authorities.

Heterogeneity among the results of different articles entered in the current meta-analysis was the first limitation of our study. Therefore, we applied a random effects model to estimate the pooled prevalence of oxyuriasis. We also performed a sensitivity analysis to identify factors involved in this heterogeneity. Another limitation was a lack of reported determinant factors in most of the selected studies.

This study provides evidence for policymakers in the Ministry of Health, Treatment and Medical Training as well as the Ministry of Education in Iran for health and prevention policy-making.

The above estimates showed that prevalence of oxyuriasis in Iran is relatively high and a great majority of Iranian children in primary schools and kindergartens are infected with *E. vermicularis*. Such results can be attributed to poor public sanitation in the community.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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