Tehran University of Medical Sciences Publication
http://tums.ac.ir

Iran J Parasitol

Open access Journal at
http://ijpa.tums.ac.ir

Iranian Society of Parasitology
http://isp.tums.ac.ir

Review Article

Enterobius vermicularis Infection in Thailand (2013–2024): A Comprehensive Epidemiological Analysis: A Narrative Review

***Panita Khampoosa [1], Surat Haruay [2]**

1. *Department of Public Health, Faculty of Physical Education, Sports and Health, Srinakharinwirot University, Nakhon Nayok 26210, Thailand*
2. *Community Health Program, Faculty of Public Health, Ubon Ratchathani Rajabhat University, Ubon Ratchathani 34000, Thailand*

Received 20 Apr 2025
Accepted 09 Jul 2025

Keywords:
E. vermicularis;
Epidemiology;
Hygiene;
Public health;
Thailand

***Correspondence**
Email:
panita@g.swu.ac.th

Abstract

This study provides a comprehensive epidemiological analysis of *Enterobius vermicularis* prevalence in Thailand from 2013 to 2024, revealing significant regional disparities and key demographic risk factors. We provided a consolidated analysis of *E. vermicularis* prevalence in Thailand, encompassing data from 2013 to 2024 by reviewing findings from international databases (PubMed, Google Scholar), and local Thai publications. The studies reported a striking average prevalence of 11.39% in the Northern region, with alarmingly high rates reaching 46.55% in Sukhothai's Satchanalai District, where children aged 1-4 years accounted for 83.33% of cases. In contrast, the Southern region showed a much lower average prevalence of 1.82%, influenced by hygiene practices, parental education, and sibling presence. The Central region's average prevalence of 4.74% was associated with age, gender assigned at birth, and parental education. Housing conditions, including inadequate sanitation and overcrowding, consistently exacerbated transmission across all regions. These findings underscore the urgent need for targeted public health interventions, including routine screenings for young children, enhanced hygiene education, and improved sanitation infrastructure, to combat *E. vermicularis* infections throughout Thailand effectively. Reporting this epidemiological evidence is crucial for informing and guiding effective public health policies and interventions, ultimately contributing to the reduction of *E. vermicularis* burden and improved population health.

Introduction

Enterobius vermicularis, a globally distributed nematode, primarily infects humans. Adult pinworms reside in the cecum, with females measuring 8-13 mm and males 2-5 mm. Gravid females migrate to the perianal area at night to lay eggs, driving transmission through the fecal-oral route via ingesting eggs from contaminated surfaces, food, or water. Self-infection through inadequate handwashing or nail-biting is also common, and less frequent routes include inhala-

tion of airborne eggs or direct inoculation (1-3).

E. vermicularis infections can cause significant morbidity. The most common symptom is perianal pruritus, especially at night, which can result in excoriations and secondary infections. Children may also experience insomnia, abdominal pain, and irritability. In rare cases, complications such as eosinophilic ileocolitis or acute appendicitis can occur (4,5).

Diagnosis is typically confirmed using the transparent tape method, which captures eggs from the perianal area for microscopic examination. Anal swabs and stool samples are alternative diagnostic methods, although stool samples are less frequently positive (6,7).

As a globally prevalent nematode, *E. vermicularis* infects humans primarily through fecal-oral transmission. Co-infections with other soil-transmitted helminths (STHs), such as *Ascaris lumbricoides* and *Trichuris trichiura*, are common, particularly in communities with inadequate sanitation. These infections result primarily from ingesting eggs from contaminated soil due to poor sanitation (8). STHs affect an estimated 1.5 billion people worldwide, highlighting their significant public health burden (9). Understanding *E. vermicularis* epidemiology in Thailand is crucial for developing effective control measures and mitigating its public health impact.

Understanding its epidemiology in Thailand is crucial. Although numerous studies have documented the presence of this parasite, a comprehensive, nationwide analysis of its prevalence and associated factors, particularly regional disparities, is lacking. This review aimed to bridge this gap by providing a comprehensive analysis of *E. vermicularis* prevalence and associated factors in Thailand. By synthesizing existing research and highlighting regional variations, we wanted to provide data that will inform the development of targeted public health interventions, ultimately contributing to the mitigation of this parasite's public health impact and improving the well-being of vulnerable populations across the country.

Methods

Study Design and Data Sources

This study employed a narrative review to investigate the prevalence of *E. vermicularis* infections across Thailand from 2013 to 2024. A comprehensive literature search was conducted in prominent databases, including PubMed, Google Scholar, and local Thai journals, to identify relevant research studies. The search strategy aimed to capture a broad representation of the infection landscape, focusing on studies reporting prevalence rates, demographic factors (age, gender assigned at birth, socio-economic status), and associated risk factors (hygiene practices, living conditions).

Study Selection and Data Extraction

Studies were included if they reported original data on the prevalence of *E. vermicularis* in Thai populations between 2013 and 2024. Data were extracted systematically, including prevalence rates, sample sizes, demographic details, and findings related to risk factors. Information was categorized based on Thailand's geographical regions: Northern, Northeastern, Eastern, Central, and Southern.

Data Analysis and Limitations

This study utilized a cross-sectional design, analyzing existing data to assess the prevalence of pinworm infections in different population groups and geographical contexts. The analysis aimed to identify significant trends and variations in infection prevalence across regions. However, it is important to acknowledge several limitations. The reviewed studies exhibited variations in sample sizes, which may influence the comparability of results and the generalizability of findings. Subsequently, the cross-sectional nature of the original studies limits the ability to establish causal relationships between risk factors and infection prevalence. Additionally, the potential for publica-

tion bias, inherent in any systematic review, cannot be entirely excluded. Future research should consider longitudinal studies and standardized methodologies to provide a more robust understanding of *E. vermicularis* epidemiology in Thailand.

Prevalence of E. vermicularis

E. vermicularis infections exhibit significant regional variations across Thailand, highlighting the influence of diverse socio-economic and environmental factors (Fig. 1).

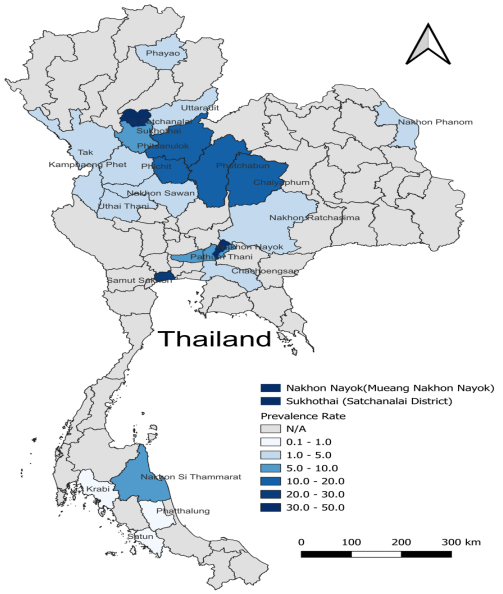

Fig. 1: The prevalence of *E. vermicularis* infections across Thailand's provinces

Northern Thailand

The Northern region presents notably high prevalence rates. In Phitsanulok, a 2022 study reported an 11.50% prevalence, with genetic analysis confirming a predominance of Type A *E. vermicularis* (10). Within Phitsanulok, district-level prevalence ranged from 12.0% to 19.3%, with Wat Soa Hin recording the highest rate at 19.3% (10,11). Sukhothai Province had an overall rate of 7.40%; however, the Satchanalai District exhibited an alarming 46.55% prevalence, predominantly affecting children aged 1-4 years (10,12). Other Northern provinces showed varying rates: Phichit (10.80%), Uttaradit (4.80%), and Uthai Thani (3.10%) (13). The average prevalence for the Northern region is estimated at 11.39%.

Northeastern Thailand

E. vermicularis prevalence in the Northeast is generally lower than in the North. Recent data from Nakhon Ratchasima reported a 1.72% prevalence (14). Chaiyaphum, however, showed a notable 11.30% rate, particularly affecting children aged 7-9 years, underscoring the need for enhanced hygiene education (15,16). The average prevalence for the Northeastern region is approximately 4.74%.

Central Thailand

The Central region exhibits higher prevalence rates compared to the Northeast. Samut Sakhon reported a significant 25.20% prevalence (12). In Nakhon Nayok, certain areas, such as Mueang Nakhon Nayok, showed alarming rates of 43.60% (17). The average prevalence for the Central region is 15.23% (12,18-22).

Southern Thailand

Conversely, the Southern region demonstrates the lowest *E. vermicularis* prevalence,

mirroring trends in the Northeast. Nakhon Si Thammarat reported a 5.79% prevalence, influenced by multiple risk factors (23). Other Southern provinces, including Patthalung, Satun, and Krabi, recorded notably low rates of 0.50% (24-26). The average prevalence for the Southern region is significantly low at 1.82%.

In summary, the prevalence of enterobiasis varies considerably across Thailand's regions: Northern (11.39%), Northeastern (4.74%), Central (15.23%), and Southern (1.82%), reflecting the impact of diverse socio-economic and environmental factors (Figs. 1,2, Table 1).

Age and gender assigned at birth

Age is a critical determinant of *E. vermicularis* prevalence in Thailand. Studies consistently identify children aged 3 to 9 years as being at the highest risk, with prevalence rates peaking around age 8 (15,27). This heightened vulnerability is attributed to age-specific behaviors, including increased hand-to-mouth activity, close peer interactions, and the presence of younger or older siblings, all of which enhance transmission risks (23). Furthermore, children in this age group frequently engage in outdoor activities, increasing their exposure to contaminated environments (14).

While *E. vermicularis* infections are typically associated with children, they also occur in adults (28-31). For instance, 6 out of 33 adult patients with intestinal parasitic infections were positive for *E. vermicularis* using Katz's modified Kato thick-smear technique (29). However, the prevalence in adults may be underestimated, particularly when using the formalin-ether concentration technique (6,7). The issue of *E. vermicularis* infections in adolescents and adults has often been overlooked in research, and many infected individuals in these age groups may be asymptomatic or unconcerned about their health, posing a significant transmission risk.

The influence of gender assigned at birth on *E. vermicularis* prevalence is less clear, with conflicting findings across studies. Some research suggests boys are more likely to be infected, attributing this to behavioral factors such as playing in dirt and less attention to personal hygiene (23). Conversely, other studies report no significant gender differences, indicating that hygiene practices and local sanitation conditions may be more influential (17,19,20). This highlights the need for further research to clarify the role of gender assigned at birth and to focus on broader environmental and behavioral determinants of infection.

Socioeconomic status and cultural practices

Socioeconomic status significantly impacts *E. vermicularis* prevalence. Children from lower socioeconomic backgrounds are at higher risk due to inadequate sanitation, limited access to clean water, and lower health literacy (32). For example, Thunyaporn et al. (14) demonstrated that families in rural Thailand with lower income and education had higher pinworm infection rates in their children. Addressing these socioeconomic disparities is crucial for effective prevalence reduction. Overcrowded living conditions, with children in larger households, also increase transmission via close contact (33).

Household practices and parental education are critical factors in childhood enterobiasis (34,35). Increased hygiene awareness significantly reduces prevalence, highlighting the need for community hygiene education initiatives (36,37). Community engagement in health education effectively lowers enterobiasis rates, particularly in high-risk groups (38,39). Notably, higher parental education is associated with lower *E. vermicularis* prevalence, as educated parents understand hygiene importance (37,40). Consequently, children of more educated parents have lower infection rates (14, 41-43).

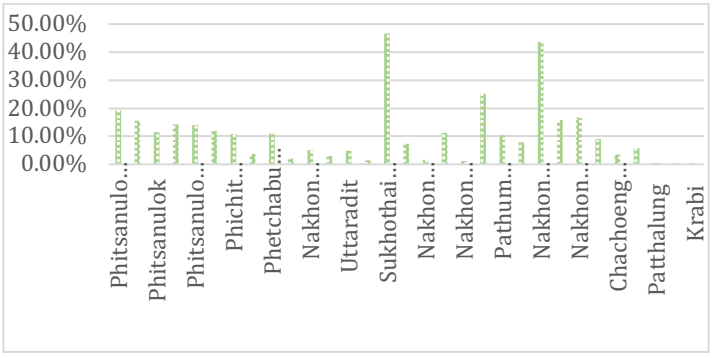

Fig. 2: Geographic distribution of *E. vermicularis* infection prevalence rates across Thailand, illustrating regional variations

Table 1: Prevalence and key findings of *E. vermicularis* studies in Thailand (2013-2023)

Region	Province/ District	Prevalence	Year	Research Author	Significant findings
North	Phitsanulok	11.50%	2022	Janthu et al., 2022 (10)	• A relatively low prevalence rate of 7.4% was reported. • Genetic analysis identified two types of pinworms: Type A and Type B. Type A was found to be the more common variety.
	Phitsanulok (Mueang District)	14.1%	2015	Polseela and Vitta, 2015 (11)	
	Phitsanulok (Wat Krab Phuang)	15.6%		Polseela and Vitta, 2015 (11)	
	Phitsanulok (Wat Kung Waree)	13.9%		Polseela and Vitta, 2015 (11)	
	Phitsanulok (Wat Sakat Namman)	12.0%		Polseela and Vitta, 2015 (11)	
	Phitsanulok (Wat Soa Hin)	19.3%		Polseela and Vitta, 2015 (11)	
	Sukhothai	7.40%	2022	Janthu et al., 2022 (10)	
	Phitchit	10.80%	2022	Janthu et al., 2022 (10)	
	Khamphaeng Phet	3.70%	2022	Janthu et al., 2022 (10)	
	Phetchabun	11.10%	2022	Janthu et al., 2022 (10)	
	Tak	2.10%	2022	Janthu et al., 2022 (10)	
	Nakhon Sawan	5.00%	2022	Janthu et al., 2022 (10)	
	Uthai Thani	3.10%	2022	Janthu et al., 2022 (10)	
	Uttaradit	4.80%	2022	Janthu et al., 2022 (10)	
	Phayao	1.4%	2017	Baiubol et al., 2017 (13)	
	Sukhothai (Satcha-nalai District)	46.55%	2013	Fukraksa et al., 2013 (12)	• The highest rate of pinworm infections was observed in the 1-4 age group. • This age group was 83.33% of total cases
Average		**11.39%**			
NorthEast	Nakhon Ratchasima	1.72%	2023	Thunyaharn et al., 2023 (14)	
	Chaiyaphum	11.30%	2018	Laoraksawong et al., 2018 (15)	• Children aged 7-9 years had the highest rate of pinworm infections. • Younger children were found to be more likely to be infected compared to older children. • The study recommends that children be screened for pinworms 1-2 times a year. • It emphasizes the importance of educat-ing everyone about personal hygiene to prevent infections.

	Nakon Phanom	1.2%	2023	Chuangchaiya et al., 2023 (16)	
Average		**4.74%**			
CentraL	Samut Prakarn	5.17%	2019	Changsap et al., 2019 (20)	Three significant risk factors • Nail biting in children. • Insufficient parental income. • Lower parental education levels ($p < 0.05$).
	Samut Sakorn	25.2%	2013	Fakraksa et al., 2013 (12)	• A contributing factor to the high prevalence of intestinal parasites among immigrant children in Thailand is transmission from parents.
	Phatum Thani (Rungsit)	7.80%	2018	Taylor et al., 2018 (19)	• Factors associated with pinworm infection include age, gender, parents'education, income, living situation, and symptoms. • Older children and families with higher education levels were linked to lower prevalence rates. • Control strategies for pinworm infections should focus on children in orphanages.
	Phatum Thani (Muaeng)	10.4%	2014	Kitvatanachai et al., 2017 (25)	• A association was found between pinworm infection and thumb-sucking behavior. • Parental occupation and income were also identified as factors
	Nakhon Nayok (Ongkharak)	15.77	2018	Buppan et al., 2018 (18)	• Boys were more likely to be infected than girls. • The highest prevalence rate was observed among 8-year-olds.
	Nakhon Nayok (Mueang Nakhon Nayok)	43.6%	2017	Khampoosa, 2017 (17)	• The highest prevalence rate of *E. vermicularis* was observed in 5-year-old, 29.6%. • *E. vermicularis* eggs attached to their fingernails. • Two children had *Ascaris* eggs attached to their fingernails
	Nakhon Nayok (Ban Na)	16.7%	2017	Khampoosa, 2017 (17)	
	Nakhon Nayok (Ongkharak)	9.0%	2017	Khampoosa, 2017 (17)	
	Chachoengsao	3.40%		Changsap et al., 2021 (21)	• Boys were more likely to be infected than girls. • There was no clear link between pinworm infections and factors such as symptoms, parental background, or prevention behaviors. • Despite the low prevalence rate, the study indicates an ongoing outbreak in the area.
Average		**15.23%**			
South	Nahon Si Thammarat	5.79%	2020	Laoraksawong et al., 2020 (23)	Factors associated with a higher likelihood of infection included: • Boys • Children aged 3-6 years • Children whose mothers only completed primary school • Children with siblings • Children who sometimes wash their hands after using the toilet • Children with long fingernails • Children who suck their fingers.
	Patthalung	0.50%	2021	Sanprasert et al., 2016 (24)	
	Satun	0.50%	2022	Roongruanchai et al., 2017 (26)	
	Krabi	0.50%	2017	Kitvatanachai et al., 2017 (25)	
Average		1.82%			

Housing Conditions Affecting E. vermicularis Prevalence

Housing conditions significantly influence the prevalence of enterobiasis, particularly in areas with limited sanitation and hygiene resources. Inadequate sanitation facilities, such as the absence of flush toilets or latrines, increase infection risk due to practices like open defecation, leading to environmental contamination (44,45). Effective hygiene practices are equally critical; poor access to clean water hinders proper handwashing, a key preventative measure against fecal-oral transmission of pinworm eggs (46). Overcrowded living conditions further exacerbate the issue by facilitating close contact among children, enhancing the spread of infection (47,48).

Environmental cleanliness plays a direct role in prevalence rates. Regular cleaning of contaminated surfaces and linens can effectively reduce the presence of pinworm eggs (39). Poor ventilation in homes can also contribute to airborne transmission, as contaminated dust accumulates in poorly ventilated spaces. Importantly, education on hygiene practices can mitigate the impact of adverse housing conditions. Targeted interventions have proven effective in lowering enterobiasis prevalence, even in challenging living situations (19,39). Addressing these housing-related factors is essential for developing comprehensive public health strategies aimed at reducing enterobiasis transmission in vulnerable populations.

Conclusion

Enterobius vermicularis in Thailand revealed significant regional differences influenced by socioeconomic, environmental, and behavioral factors. Children aged 3 to 9 are most affected, with the highest prevalence around age 8, largely due to behaviors like hand-to-mouth activity and close contact with peers. The research also found that socioeconomic status is a key factor, as children from lower-income families often have higher infection rates due to poor sanitation and limited access to clean water.

The findings highlight the importance of parental education, with higher education levels correlating with lower infection rates. Furthermore, housing conditions like inadequate sanitation and overcrowding contribute significantly to transmission. Given these findings, the study concludes with a call for urgent public health interventions. Recommended actions include implementing routine screenings in schools, deploying enhanced hygiene education programs, addressing socioeconomic disparities, adopting a household-focused approach to education, and improving living environments.

Acknowledgements

The authors gratefully acknowledge the following individuals and organizations for their invaluable contributions to this study Faculty of Physical Education, Sport and Health, Srinakharinwirot University for their financial support of the study and the Faculty of Public Health, Ubon Ratchathani Rajabhat University for their support with study software.

Conflict of Interest

We, the authors, declare that no competing interests exist in relation to the work reported in this manuscript.

References

1. Kaniyur V, Chandra Prasad KH, Devan PP, et al. *Enterobius vermicularis* in the nose: A rare entity. Indian J Otolaryngol Head Neck Surg. 2005; 57:148-150.
2. Babady NE, Awender E, Geller R, Miller T, Scheetz G, Arguello H, Weisenberg SA, Pritt B. *Enterobius vermicularis* in a 14-year-old girl's eye. J Clin Microbiol. 2011;49:4369-4370.

3. Mallick SK, Sengupta R, Banerjee AK. Unusual presentation of *Enterobius vermicularis* in conjunctival sac. Trop Doct. 2015; 45:247-249.
4. Patmano M, Gümüş T, İlhan Türkel F. A Rare Cause of Acute Appendicitis: *Enterobius vermicularis*. Turkiye Parazitol Derg. 2021;45(3):220-222.
5. Arredondo Montero J, Bronte Anaut M. Acute appendicitis and *Enterobius Vermicularis*: A rare association? Ann Pathol. 2022;42(6):497-498.
6. Wong JY, Becker SN. *Enterobius vermicularis* ova in routine cervicovaginal smears. Light and scanning electron microscopic observations. Acta Cytol. 1982; 26:484-487.
7. Martinez-Giron R, Torre-Bayon C, Tamargo-Pelaez ML, et al. *Enterobius vermicularis* ova in a Pap smear: typical and uncommon morphology. Acta Cytol. 2007;51:668-670.
8. Fan CK, Chuang TW, Huang YC, et al. *Enterobius vermicularis* infection: prevalence and risk factors among preschool children in kindergarten in the capital area, Republic of the Marshall Islands. BMC Infect Dis. 2019;19(1):536.
9. Chen J, Gong Y, Chen Q, et al. Global burden of soil-transmitted helminth infections, 1990-2021. Infect Dis Poverty. 2024;13(1):77.
10. Janthu P, Dumidae A, Subkrasae C, et al. Prevalence and genetic analysis of *Enterobius vermicularis* in schoolchildren in lower northern Thailand. Parasitol Res. 2022;121(10):2955-2965.
11. Polseela R, Vitta A. Prevalence of intestinal parasitic infections among schoolchildren in Phitsanulok Province, Northern Thailand. Asian Pac J Trop Dis. 2015;5:539-542.
12. Fukraksa C, Limmongkhol A, Watchsuputr T, et al. *Enterobius vermicularis* Strongyloides stercoralis Minute intestinal fluke (MIF) Taenia Sukhothai Province. Science and Technology J Mahasarakham University. 2013; 32(6):794-800.
13. Baiubol P, Wiriyawattana C, Tayanram S, et al. The prevalent of intestinal parasite infestation among primary school students in a district. Naresuan Phayao J. 2017; 10(1):12-14.
14. Thunyaharn S, Yingsiwaphat V, Saichanma S, et al. Prevalence and Related Factors of Pinworm Infection in Preschool Children of Ban Mai Municipal Child Development Center, Nakhon Ratchasima Province, Thailand. Prog Appl Sci Tech. 2023;13(2):1-8.
15. Laoraksawong P, Pansuwan P, Krongchon S, et al. Prevalence of *Enterobius vermicularis* infection among Students from Elementary Schools, Chaiyaphum Province, Thailand. Journal of Science & Technology MSU. 2018;37(4).
16. Chuangchaiya S, Srithai C, Ponrachom C. Prevalence and risk factors for Opisthorchiasis in Nakhamin Sub-District, Phonsawan District, Nakhon Phanom Province, Thailand. Journal of Health Science of Thailand, 33(4), 587–596.
17. Khampoosa P. *Enterobius vermicularis* infection in 3 to 6 year-old school children living in Nakhon Nayok Province. J Fac Physic Edu. 2017;20(1):181-190.
18. Buppan P, Kosuwin R, Srimee P. Prevalence rate of *Enterobius vermicularis* in Elementary school Students 1 - 3, Ongkharak District, Nakhonnayok Province. Thammsat University Medical Journal. 2018;18(2)
19. Taylor A, Saichua P, Rhongbutsri P, et al. A preliminary epidemiological study of pinworm infection in Thaklong Municipal Early Childhood Development Center and Rangsit Babies' Home, Pathum Thani, Thailand. BMC Res Notes. 2018;11(1): 603.
20. Changsap B, Wannapinyosheep S, Tantravanich S, et al. Prevalence of Pinworm (*Enterobius vermicularis*) Infection among Preschool and Lower Primary School Children in Bangbo District, Samut Prakarn Province, Thailand. Thai Journal of Public Health. 2019; 49(2).
21. Changsap B, Piapinthong A, Puttanantadet B, et al. Survey on prevalence of *Enterobius vermicularis* among children in Bang Nam Priao district, Chachoengsao province, Thailand. Dis Control J. 2021;47(Suppl 1):839-47.
22. Kitvatanachai S, Kritsiriwutthinan K, Taylor A, Rhongbutsri P. Modified Nonnutrient Agar Plate Culture for the Diagnosis of

Strongyloides stercoralis and Hookworm Infections in La-Ngu District, Satun Province, Southern Thailand. J Parasitol Res. 2022; 2022:1117400.
23. Laoraksawong P, Pansuwan P, Krongchon S, et al. Prevalence of *Enterobius vermicularis* infections and associated risk factors among schoolchildren in Nakhon Si Thammarat, Thailand. Trop Med Health. 2020;48:83.
24. Sanprasert V, Charuchaibovorn S, Bunkasem U, et al. Comparison between direct smear, formalin-ethyl acetate concentration, and Mini Parasep Solvent-Free Concentrator for screening of intestinal parasitic infections among school-age children. Chula Med J. 2016;60(3):255-269.
25. Kitvatanachai S, Taylor A, Rhonghutsri P, Pongstaporn W. Determine the prevalence of intestinal and soil-transmitted helminths using different copromicroscopic techniques in Krabi Province, Thailand. Asian Pac J Trop Dis. 2017;7(12):719-723.
26. Roongruanchai K, Sermsart B, Nuntiya M, et al. Prevalence and health effects of intestinal parasitic infection in school children in Satun Province, Thailand: A Cross-Sectional Study. Siriraj Medica Journal. 2017.
27. Saksirisampant W, Prownebon J, Kulkumthorn M, et al. Prevalence of intestinal parasitic infections among school children in the central region of Thailand. J Med Assoc Thai. 2006;89(11):1928-33.
28. Oothuman P, Noor Hayati MI, Mastura MH, et al. Prevalence of *Enterobius vermicularis* amongst adults living in hostels by six successive day examination. Southeast Asian J Trop Med Public Health. 1992;23(1):82-6.
29. Sato M, Sanguankiat S, Pubampen S, Kusolsuk T. Enterobiasis: a neglected infection in adults. Southeast Asian J Trop Med Public Health. 2008;39(2):213-6.
30. Vose L. Pinworm in pregnancy. J Midwifery Womens Health. 2012;57(2):184-7.
31. Kanya R, Gopinathan A, Arumugam SL, et al. Atypical Manifestation of *Enterobius vermicularis* Infestation in Adults: A Report of a Rare Case. Cureus. 2024;16(10):e72074.
32. Pethleart A, Saichua P, Rhongbutsri P, et al. Prevalence and risk factors for pinworm infection in the kindergarten of Thammasat University, Thailand. Southeast Asian J Trop Med Public Health. 2010;41(2):306-10.
33. Nithikathkul C, Changsap B, Wannapinyosheep S, et al. The prevalence of enterobiasis in children attending mobile health clinic of Huachiew Chalermprakiet University. Southeast Asian J Trop Med Public Health. 2001;32 Suppl 2:138-42.
34. Kim DH, Son HM, Kim JY, et al. Parents' knowledge about enterobiasis might be one of the most important risk factors for enterobiasis in children. Korean J Parasitol. 2010;48(2):121-6.
35. Kassaw MW, Abebe AM, Abate BB, et al. Knowledge, Attitude and Practice of Mothers on Prevention and Control of Intestinal Parasitic Infestations in Sekota Town, Waghimra Zone, Ethiopia. Pediatric Health Med Ther. 2020; 11:161-169.
36. Wang LC, Hwang KP, Chen ER. *Enterobius vermicularis* infection in schoolchildren: a large-scale survey 6 years after a population-based control. Epidemiol Infect. 2010;138(1):28-36.
37. Kim DH, Yu HS. Effect of a one-off educational session about enterobiasis on knowledge, preventative practices, and prevalence rates among schoolchildren in South Korea. PLoS One. 2014;9(11):e112149.
38. Kang IS, Kim DH, An HG, et al. Impact of health education on the prevalence of enterobiasis in Korean preschool students. Acta Trop. 2012;122(1):59-63.
39. Kim DH, Cho MK, Park MK, et al. Environmental factors related to enterobiasis in a southeast region of Korea. Korean J Parasitol. 2013;51(1):139-42.
40. Özdil K, Karataş N, Zincir H. Low socioeconomic level and *Enterobius vermicularis*: A interventional study to children and their mothers in home. Zoonoses Public Health. 2020;67(8):882-891.
41. Chen KY, Yen CM, Hwang KP, Wang LC. *Enterobius vermicularis* infection and its risk factors among pre-school children in Taipei,

Taiwan. J Microbiol Immunol Infect. 2018;51(4):559-564.
42. Balaj M, York HW, Sripada K, et al. Parental education and inequalities in child mortality: a global systematic review and meta-analysis. Lancet. 2021; 398(10300):608-620.
43. Nithikathkul C, Akarachantachote N, Wannapinyosheep S, et al. Impact of health educational programmes on the prevalence of enterobiasis in schoolchildren in Thailand. J Helminthol. 2005;79(1):61-5.
44. González-Ramírez LC, Robalino-Flores X, De la Torre E, et al. Influence of Environmental Pollution and Living Conditions on Parasite Transmission among Indigenous Ecuadorians. Int J Environ Res Public Health. 2022;19(11):6901.
45. River MR, De Angelo C, Feliziani C, et al. Enterobiasis and its risk factors in urban, rural and indigenous children of subtropical Argentina. Parasitology. 2022;149(3): 396–406.
46. Mahmud MA, Spigt M, Bezabih AM, et al. Efficacy of Handwashing with Soap and Nail Clipping on Intestinal Parasitic Infections in School-Aged Children: A Factorial Cluster Randomized Controlled Trial. PLoS Med. 2015;12(6):e1001837.
47. González-Moreno O, Domingo L, Teixidor J, Gracenea M. Prevalence and associated factors of intestinal parasitisation: a cross-sectional study among outpatients with gastrointestinal symptoms in Catalonia, Spain. Parasitol Res. 2011;108(1):87-93.
48. Matthys B, Bobieva M, Karimova G, et al. Prevalence and risk factors of helminths and intestinal protozoa infections among children from primary schools in western Tajikistan. Parasit Vectors. 2011; 4:195.