

Systematic Review of the Relationship between Hygiene Practice and the Incidence of *Ascaris lumbricoides* Infection in Southeast Asian Children

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ARTICLE INFO	ABSTRACT
ORCHID ID Author 1: - Author 2: https://orcid.org/0000-0002-1073-2067	Soil-Transmitted Helminth (STH) infection is one of the Neglected Tropical Diseases (NTDs) that affects around 1.5 billion people worldwide, including regions like Southeast Asia. The most common species infecting humans is <i>Ascaris lumbricoides</i> . Preschool-age and school-age children are particularly vulnerable to STH infection due to their living environments in areas where STH is prevalent. Infection of STH, especially <i>Ascaris lumbricoides</i> , can hinder physical and cognitive development and, in severe cases, cause obstruction of the small intestine. Various factors, such as hygiene practices, can influence the transmission of <i>Ascaris lumbricoides</i> infection in children. This study aims to explore the association between hygiene practices and the occurrence of <i>Ascaris lumbricoides</i> infection in children. A systematic review was carried out, and articles were searched in four databases: PubMed, EMBASE, Scopus, and ProQuest. Subsequently, the articles were selected based on specific criteria. Five articles were identified during the search. These articles revealed a significant association between handwashing habits, toilet usage, and washing fruits before consumption with the occurrence of <i>Ascaris lumbricoides</i> infection. On the other hand, there was no significant association found between washing vegetables before consumption and trimming nails and the occurrence of <i>Ascaris lumbricoides</i> infection in children.
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1. Introduction

Neglected Tropical Diseases (NTDs) are a group of diseases commonly found in tropical regions and often overlooked in global health agendas. One of these NTDs is soil-transmitted helminth (STH) infections, which develop and transmit through soil (Jourdan et al., 2018; World Health Organization, 2023a). Common STH species that infect humans include *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus*, and *Strongyloides stercoralis* (World Health Organization, 2023b). It is estimated that around 24% of the world's population (1.5 billion) is infected with STH (World Health Organization, 2023b). The highest prevalence of STH infections occurs in Southeast Asia, accounting for one-third of the global cases. Factors such as tropical and sub-tropical climates, lack of access to clean water, inadequate sanitation facilities, and poor hygiene practices contribute to the high prevalence of STH in this region (Dunn et al., 2016).

According to the World Health Organization (WHO), approximately 260 million preschool-age children and 654 million school-age children are highly vulnerable to STH infections due to living in STH-endemic areas (Pan American Health Organization, 2023; World Health Organization, 2023b). Infection in children can result from their behavior, such as putting hands into the mouth after playing in soil, not washing hands with soap, and consuming unwashed fruits and vegetables (Makata et al., 2021; World Health Organization, 2023b). *Ascaris lumbricoides* is the most common STH species causing infections in humans, with global cases estimated at 807 million to 1.2 billion (Centers for Disease Control and Prevention, 2022). The same trend is observed in Southeast Asia, with approximately 227 million cases (Jex et al., 2011). In children, *Ascaris lumbricoides* infections can lead to malnutrition and have impacts on physical and cognitive development (Idowu et al., 2022). Severe infections can cause intestinal obstruction (EC & DL., 2022; Nurmantu et al., 2023). Several studies have shown a relationship between hygiene behavior and STH infections in children (Al-Murisi et al., 2022; E. Tefera et al., 2017). However, there is still a lack of systematic review specifically addressing the association between hygiene behavior and *Ascaris lumbricoides* infections among children in the Southeast Asian region.

2. Method

This study was conducted to investigate the relationship between hygiene practices and *Ascaris lumbricoides* infection among children in Southeast Asia using a systematic review method. The selection of literature for this research was carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method. The research was conducted in June 2023. The literature search was performed in three stages: identification, screening, and selection.

The identification stage involved literature searches in four databases, namely PubMed, EMBASE, Scopus, and ProQuest, using appropriate research topic keywords (Table 1) combined with Boolean operators AND and OR.

Table 1. Keywords for Database Search

Term 1. Children	<i>Child, Children</i>
Term 1.1. Preschool-Age Children	<i>Preschool-age children, PSAC, Infant</i>
Term 1.2. School-Age Children	<i>Schoolchildren, School-age children, SAC</i>
Term 2. Hygiene Practices	<i>Hygiene, Sanitary condition</i>
Term 2.1. Handwashing	<i>Hand disinfection, Hand washing, Hand-washing, Handwashing, Hand hygiene, Hand Sanitization, Hand Cleansing, Hand Sanitation</i>
Term 2.2. Toilet Usage	<i>Toilet facilities, Bathroom equipment, Toilet, Latrine, Bathroom, Water closet</i>
Term 2.3. Washing Fruits and Vegetables	<i>Vegetable, Fruit, Wash, Raw</i>
Term 2.4. Nail Trimming Habit	<i>Nail biting, Nail</i>
Term 3. <i>Ascaris lumbricoides</i>	<i>Ascaris lumbricoides, Ascariasis, Ascaris infection, Ascariases</i>
Term 4. Presence <i>Ascaris lumbricoides</i>	<i>Egg</i>

Term 4.1. On Hand and Nails	<i>Hand contamination, Nail contamination</i>
Term 4.2. On Food	<i>Food contamination, Vegetable contamination, Fruit contamination</i>
Term 4.3. On Soil	<i>Soil, Pollution</i>
Term 5 Southeast Asia	<i>Southeast Asia, ASEAN, Brunei, Myanmar, Burma, Cambodia, Timor-Leste, East Timor, Indonesia, Laos, Lao People's Democratic Republic, Lao PDR, Malaysia, Philippines, Singapore, Thailand, Vietnam</i>

The articles that have been identified in the identification phase will then be further screened in the screening phase using the web-based application Rayyan, through three stages, namely duplication, type of literature, and relevance of article titles and abstracts to the research topic. Subsequently, the literature will be selected based on inclusion criteria, which include the publication date range from January 2013 to March 2023, containing variables of *Ascaris lumbricoides* and hygiene habits, having separate analysis for *Ascaris lumbricoides* infection, being conducted in Southeast Asia, involving a study population of children aged preschool to school-age (1 – 15 years), being original research, using the English language, and published in Q1, Q2, and Q3 journals. Exclusion criteria include grey literature and reviews. The articles that pass the screening process will be designated as the ones used in this study.

The data analysis is descriptive. The first stage involves the synthesis process to identify similarities and differences among the literature, followed by a critical analysis by comparing the literature with the theories presented in the literature review section. The final stage involves drawing conclusions from the conducted analysis. The results of the data analysis will be presented in the form of tables and descriptive sentences.

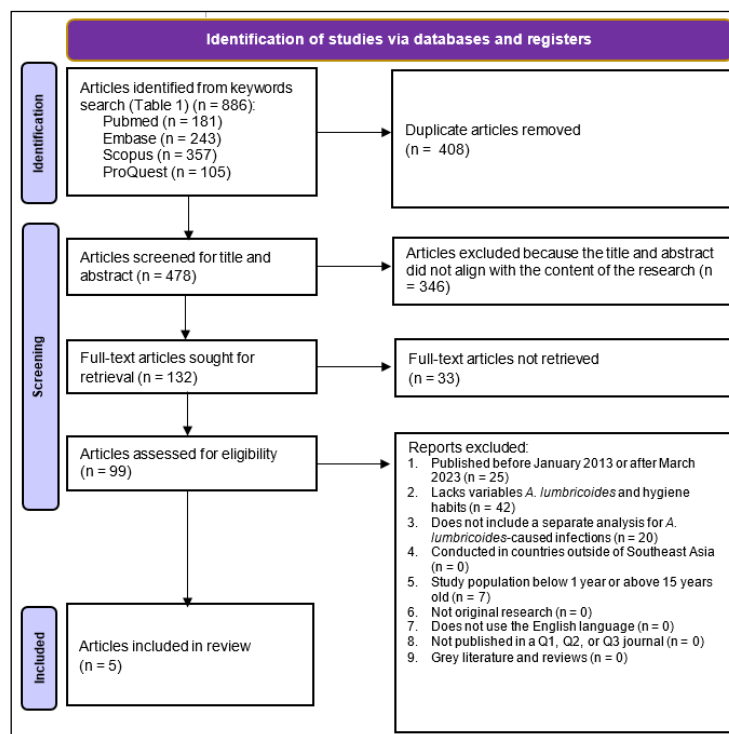


Figure 1. PRISMA Diagram

3. Result and Discussion

Based on the literature screening process following the PRISMA guidelines, a total of 5 articles were obtained and used in this study (Table 2).

Table 2. Overview of the Characteristics of Study Results Included in the Systematic Review

Code	Author, Year - Country	Article Title	Location and Population	Sample	Diagnosis Method	Data Collection and Study Design	Hygiene Practices
01	Nasr, et al. (2020) - Malaysia	A holistic approach is needed to control the perpetual burden of soil transmitted helminth infections among indigenous schoolchildren in Malaysia	6 states in Malaysia; school-age Orang Asli children	1.142	Direct smear, formalin-ether sedimentation, and Kato-Katz.	Questionnaire, cross-sectional	Washing hands before meals & after defecation, open defecation, geophagy, trimming nails, wearing footwear, and washing fruits & vegetables before consumption.
02	Pasaribu, et al. (2019)- Indonesia	Prevalence and risk factors of soil-transmitted helminthiasis among school children living in an agricultural area of North Sumatera, Indonesia	Suka Village, Karo Regency, North Sumatera, Indonesia; elementary school students	468	Kato-Katz	Questionnaire, cross-sectional	Handwashing, toilet usage, footwear usage, and playing with soil habit.
03	Aw, et al. (2021) - Timor Leste	Novel statistical approaches to identify risk factors for soil-transmitted helminth infection in Timor-Leste	6 elementary schools in Kota Aileu and Manufahi, Timor-Leste; elementary school students	464	Real-time multiplex quantitative PCR (qPCR)	Questionnaire, cross-sectional	Handwashing, defecation, and using footwear.
04	Nasr, et al. (2020) - Malaysia	Towards an effective control programme of	13 villages in Lipis District, Pahang,	484	Formalin-ether sedimentation, Kato-	Questionnaire, cross-sectional	Handwashing before meals & after defecation,

		soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 1: Prevalence and associated key factors	Malaysia; Orang Asli children ≤15 years old		Katz.dan Harada Mori		open defecation, geophagy, trimming nails, using footwear, and washing fruits and vegetables before consumption.
05	Nasr, et al. (2020) – Malaysia	Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 2: Knowledge, attitude, and practices	215 households from thirteen villages in Lipis District, Pahang, Malaysia; Orang Asli children ≤15 years old	215	Formalin-ether sedimentation, Katz.dan Harada Mori	Questionnaire, cross-sectional	Household members' habit of handwashing before meals & after defecation, using footwear, and washing fruits & vegetables before consumption.

The articles obtained from literature search have diverse characteristics, both in terms of the prevalence of *A. lumbricoides* infection in children and hygiene practices. None of the articles analyzed the presence of *A. lumbricoides* eggs on hands, nails, food, and soil (Table 3).

Table 3. Characteristics of Respondents on Selected Articles

Code	Author, Year – Country	Sample	Prevalence	Handwashing Habit	Toilet Usage	Washing Fruits & Vegetables	Nail Trimming Habit
01	Nasr, et al. (2020) – Malaysia	1.142	n = 721 (63,1%)	<p><u>Washing hands before eating:</u> No (n = 473) (67% infected with <i>A.lumbricoides</i>) Yes (n = 669) P-value = 0,022</p> <p><u>Washing hands after defecation:</u> No (n = 324)</p>	<p><u>Indiscriminate defecation:</u> No (n = 845) (63,9% infected with <i>A.lumbricoides</i>) Yes (n = 297) P-value = 0,363</p>	<p><u>Washing fruits before eating:</u> No (n = 370) (68,4% infected with <i>A.lumbricoides</i>) Yes (n = 772) P-value = 0,011</p> <p><u>Washing vegetables</u></p>	<p><u>Cutting nails periodically:</u> No (n = 576) (64,2% infected with <i>A.lumbricoides</i>) Yes (n = 566) P-value = 0,436</p>

				(64,2% infected with <i>A.lumbricoide</i> s) Yes (n = 818) P-value = 0,639	<u>before</u> <u>eating:</u> No (n = 508) (62% infected with <i>A.lumbricoid</i> es) Yes (n = 634) P-value = 0,480
02	Pasaribu, et al. (2019)- Indonesia	468	n = 188 (40,17 %)	<u>Hand washing</u> <u>habits:</u> No (n = 234) Yes (n = 234) P-value = <0,005	<u>Latrine</u> <u>usage:</u> No (n = 70) Yes (n = 398) P-value = <0,005
03	Aw, et al. (2021) - Timor Leste	464	n = 182 (39,2%)	<u>Handwashing</u> <u>with soap or</u> <u>ash:</u> No (n = 71) Yes (n = 393) P-value = 0,307 <u>Washing</u> <u>hands before</u> <u>eating and</u> <u>preparing</u> <u>food:</u> No (n = 307) Yes (n = 157) P-value = 0,330 <u>Washing</u> <u>hands after</u> <u>toileting:</u> No (n = 204) Yes (n = 260) P-value = 0,028 <u>Washing</u> <u>hands after</u> <u>contact with</u> <u>dirt:</u> No (n = 52) Yes (n = 412) P-value = 0,791	<u>Main place</u> <u>of</u> <u>defecation</u> <u>is toilet:</u> No (n = 159) Yes (n = 305) P-value = 0,717 <u>Practices</u> <u>open</u> <u>defecation:</u> No (n = 267) Yes (n = 197) P-value = 0,214

04	Nasr, et al. (2020) - Malaysia	484	n = 181 (37,4%)	<p><u>Washing hands before eating:</u> No (n = 279) (44,4% infected with <i>A.lumbricoide</i>s) Yes (n = 205) P-value = <0,001</p> <p><u>Washing hands after defecation:</u> No (n = 191) (50,8% infected with <i>A.lumbricoide</i>s) Yes (n = 293) P-value = <0,001</p>	<p><u>Indiscriminate defecation:</u> Yes (n = 323) (39,3% infected with <i>A.lumbricoide</i>s) No (n = 161) P-value = 0,216</p>	<p><u>Washing fruits before eating:</u> No (n = 268) (38,1% infected with <i>A.lumbricoide</i>s) Yes (n = 216) P-value = 0,737</p> <p><u>Washing vegetables before eating:</u> No (n = 156) (42,9% infected with <i>A.lumbricoide</i>s) Yes (n = 328) P-value = 0,082</p>	<p><u>Cutting nails periodically:</u> No (n = 235) (38,3% infected with <i>A.lumbricoide</i>s) Yes (n = 249) P-value = 0,61</p>
05	Nasr, et al. (2020) - Malaysia	484	n = 181 (37,4%)	<p><u>Washing hands before eating:</u> No (n = 22) (32,4% infected with <i>A.lumbricoide</i>s) Yes (n = 75) P-value = <0,05</p> <p><u>Washing hands after defecation:</u> No (n = 33) (47,8% infected with <i>A.lumbricoide</i>s) Yes (n = 101) P-value = <0,05</p>	-	<p><u>Washing fruits before consumption:</u> No (n = 27) (39,1% infected with <i>A.lumbricoide</i>s) Yes (n = 61) P-value = >0,05</p> <p><u>Washing vegetables before consumption:</u> No (n = 43) (62,3% infected with <i>A.lumbricoide</i>s)</p>	-

Yes (n =
105)
P-value =
>0,05

Out of the five articles obtained from the literature search, none of them analyzed the presence of *Ascaris lumbricoides* eggs on hands and nails. However, several articles discussed the relationship between hand and nail hygiene habits and the occurrence of *Ascaris lumbricoides* infection in children. Research conducted by Nasr, et al. (2020), Aw, et al. (2021) Nasr, et al. (2013) and Nasr, et al. (2013) showed a significant association between the habit of washing hands before meals and after defecation and the occurrence of *Ascaris lumbricoides* infection in children. Infective *Ascaris lumbricoides* eggs can adhere to hands and nails after contact with soil contaminated with infective *Ascaris lumbricoides* eggs or after defecation. Without washing hands, infective *Ascaris lumbricoides* eggs will remain on the hands and nails and can be ingested when someone eats (EC & DL., 2022; Hohmann et al., 2001). On the other hand, no research found a significant relationship between the habit of cutting nails and the occurrence of *Ascaris lumbricoides* infection. This may be due to other factors related to the presence of *Ascaris lumbricoides* eggs on nails, such as handwashing habits. Although not directly related, the habit of cutting nails should not be disregarded. Research conducted by Nasr, et al. (2020) and Nasr, et al. (2013) found that 64.2% and 38.3% of children who did not have a routine habit of cutting nails experienced *Ascaris lumbricoides* infection. This indicates that the habit of cutting nails is still associated with the occurrence of *Ascaris lumbricoides* infection. Moreover, children have a habit of sucking their fingers (Shrestha et al., 2012). If there are infective *Ascaris lumbricoides* eggs on the nails, these eggs can be ingested. Therefore, implementing the habit of cutting nails and washing hands in children is essential. When washing hands, it is advisable to use soap and thoroughly clean the area under the nails.

From the articles obtained from the literature search, there were no articles specifically analyzing the presence of *Ascaris lumbricoides* eggs in food. However, several articles discussed the relationship between food-related hygiene habits and the occurrence of *Ascaris lumbricoides* infection in children. Research conducted by Nasr, et al. (2020) showed a significant association between the habit of washing fruits before consumption and the occurrence of *Ascaris lumbricoides* infection in children. This happens because Orang Asli children have a habit of consuming fallen rambutan fruits from the ground by peeling the skin using their teeth without washing them first. This results in *Ascaris lumbricoides* eggs entering the children's mouths (Nasr et al., 2020). On the other hand, research conducted by Nasr, et al. (2013) and Nasr, et al. (2013) found no significant association between the habit of washing fruits and vegetables before consumption and the occurrence of *Ascaris lumbricoides* infection in children. This may be because other factors influence the presence of *Ascaris lumbricoides* eggs on fruits and vegetables, such as the habit of properly cooking vegetables before consumption^[33]. However, in the study conducted Nasr, et al. (2013), it was found that 38.1% and 42.9% of children who did not have the habit of washing fruits and vegetables before consumption suffered from *Ascaris lumbricoides* infection. The study by Nasr, et al. (2013) also found that 39.1% and 62.3% of children who did not have the habit of washing fruits and vegetables suffered from *Ascaris lumbricoides* infection. This indicates a connection between the presence of *Ascaris lumbricoides* eggs in food and the occurrence of *Ascaris lumbricoides*

infection in children. Therefore, the habit of washing fruits and vegetables needs to be applied to prevent the entry of infective *Ascaris lumbricoides* eggs into the body through food.

There were no articles that specifically analyzed the presence of *Ascaris lumbricoides* eggs in the soil. However, some articles discussed the relationship between soil-related hygiene habits and soil characteristics with the occurrence of *Ascaris lumbricoides* infection in children. Research conducted by Pasaribu et al. (2019) found that the habit of playing with soil or dust by children could increase the likelihood of *Ascaris lumbricoides* infection in children by up to 2.56 times. This is because soil is a medium for the development of *Ascaris lumbricoides* eggs (Jourdan et al., 2018). After incubating for 10-15 days in moist, warm, and protected soil, the larvae inside the *Ascaris lumbricoides* eggs will develop into third-stage larvae (L3) that are infective (EC & DL, 2022). When children play on soil contaminated with *Ascaris lumbricoides* eggs, their hands can be contaminated with *Ascaris lumbricoides* eggs, and then they put their hands with contaminated eggs into their mouths. This can cause children to be infected with *Ascaris lumbricoides* (World Health Organization, 2023b). This indicates a relationship between the presence of *Ascaris lumbricoides* eggs in the soil and the occurrence of *Ascaris lumbricoides* infection in children. However, research conducted by Nasr, et al. (2020) and Nasr, et al. (2013) showed that there is no significant association between the habit of consuming soil (geophagy) and the occurrence of *Ascaris lumbricoides* infection in children. This may be because the soil consumed is soil that is not contaminated with *Ascaris lumbricoides* eggs. Another possibility is that the participants in the study were recently infected with *Ascaris lumbricoides*, so the *Ascaris lumbricoides* eggs were not detected in the fecal examination (Younga et al., 2007). Although not showing a significant relationship between geophagy and the occurrence of *Ascaris lumbricoides* infection in children, the research conducted by Nasr, et al. (2020) and Nasr, et al. (2013) found that 60.6% and 39.2% of children who practiced geophagy experienced *Ascaris lumbricoides* infection. This indicates a connection between the presence of *Ascaris lumbricoides* eggs in the soil and the occurrence of *Ascaris lumbricoides* infection in children. The habit of children playing in the soil and consuming soil while playing cannot be fully controlled. Therefore, to prevent the entry of infective *Ascaris lumbricoides* eggs from the soil into the children's bodies, hygiene habits such as hand washing need to be applied to children.

All the articles state that there is a significant association between handwashing habits and the occurrence of *Ascaris lumbricoides* infection in children. Research conducted by Nasr, et al. (2020) showed a significant association between the habit of washing hands before meals and the occurrence of *Ascaris lumbricoides* infection in children ($p = 0.022$). Children who do not wash their hands before meals have a 1.42 times (95% CI = 1.03; 1.71) higher risk of being infected with *Ascaris lumbricoides* compared to children who wash their hands before meals (Nasr et al., 2020). Research conducted by Pasaribu et al. found that handwashing habits can reduce the risk of *Ascaris lumbricoides* infection in children by up to 0.38 times (Pasaribu et al., 2019) Aw et al. (2021) research showed a significant association between the habit of washing hands after using the toilet and the occurrence of *Ascaris lumbricoides* infection in children ($p = 0.028$). The habit of washing hands after using the toilet can reduce the risk of *Ascaris lumbricoides* infection by up to 0.6 times (95% CI = 0.38; 0.94). Research conducted by Nasr et al. (2013) showed a significant association between the habit of washing hands before meals ($p < 0.001$) and after defecation ($p < 0.001$) and the occurrence of *Ascaris lumbricoides* infection in children. Children who do not wash their hands before meals and after defecation have 2.1 times (95% CI = 1.4; 3.1) and 2.6 times (95% CI = 1.8; 3.8) higher risk of being infected

with *Ascaris lumbricoides*, respectively (Nasr et al., 2020). Research conducted by Nasr, et al. (2013) found that the habit of family members washing hands before meals and after defecation is significantly associated with the occurrence of *Ascaris lumbricoides* infection in children. The habit of family members washing hands before meals and after defecation can reduce the risk of *Ascaris lumbricoides* infection in children by up to 0.5 times (95% CI = 0.2; 0.8) and 0.4 times (95% CI = 0.2; 0.7), respectively. The association between handwashing habits and the occurrence of *Ascaris lumbricoides* infection occurs because hands are one of the means of *Ascaris lumbricoides* transmission. *Ascaris lumbricoides* eggs can attach to human hands after touching contaminated soil or after defecation (Hohmann et al., 2001). These eggs can be ingested by humans if they do not wash their hands before consuming food. This is consistent with research conducted by Hohmann, et al. (2001) Tefera, et al. (2017) and Al-Murisi, et al. (2022) which found a significant association between *Ascaris lumbricoides* infection in children and the habit of washing hands after defecation and before meals.

One article found a significant association between toilet usage habits and the occurrence of *Ascaris lumbricoides* infection in children, which is the research conducted by Pasaribu et al., which found that handwashing habits can reduce the risk of *Ascaris lumbricoides* infection in children by up to 0.3 times (Pasaribu et al., 2019). Three articles stated that there is no significant association between toilet usage and the occurrence of *Ascaris lumbricoides* infection in children, which is the research conducted by Nasr, et al. (2020), Aw, et al. (2021) and Nasr, et al. (2020). This may be because these studies did not clearly specify the conditions of the toilets used for defecation. It is possible that the toilets used did not meet proper standards. Although not finding a significant association, the research conducted by Nasr, et al. (2020) and Nasr, et al. (2013) found that 63.9% and 39.3% of children who had the habit of defecating in open places suffered from *Ascaris lumbricoides* infection. This indicates that the habit of using a toilet cannot be completely ignored in controlling *Ascaris lumbricoides* infection. The importance of toilet usage needs to be taught to children. In addition, the provision of proper toilets needs to be implemented in the children's living areas. According to WHO, toilets should be made of sturdy and easily cleanable materials, equipped with a water seal to prevent odors and the entry of insects and rodents through the toilet, protected from rainwater, and connected to a proper disposal system such as a septic tank to prevent feces leakage into the environment (World Health Organization, 2018)

One article found a significant association between the habit of washing fruits and the occurrence of *Ascaris lumbricoides* infection in children, which is the research conducted by Nasr, et al. (2020). The habit of not washing fruits before consumption increases the risk of *Ascaris lumbricoides* infection by 1.44 times (95% CI = 1.02; 1.76). *Ascaris lumbricoides* infection occurs due to the habit of Orang Asli children consuming rambutan fruit (*Nephelium lappaceum*) that has fallen to the ground. Before consuming the fruit, Orang Asli children peel the rambutan skin using their mouths without washing it (Nasr et al., 2020) On the other hand, research conducted by Nasr, et al. (2013) and Nasr, et al. (2013) found no significant association between the habit of washing fruits and vegetables before consumption and the occurrence of *Ascaris lumbricoides* infection in children. This may be due to other factors influencing *Ascaris lumbricoides* infection caused by food contamination, one of which is the habit of consuming raw or improperly cooked vegetables^[33]. However, although the research conducted by Nasr, et al. (2013) did not find a significant association between the habit of washing fruits and vegetables and the occurrence of *Ascaris lumbricoides* infection, it was found that 38.1% of children who did not have the habit of washing fruits suffered from *Ascaris*

lumbricoides infection. Additionally, 42.9% of children who did not have the habit of washing vegetables suffered from *Ascaris lumbricoides* infection. Research conducted Nasr, et al. (2013) also found no significant association between the habit of washing fruits and vegetables and the occurrence of *Ascaris lumbricoides* infection, but 39.1% of children who did not have the habit of washing fruits and 62.3% of children who did not have the habit of washing vegetables suffered from *Ascaris lumbricoides* infection. Therefore, the habit of washing fruits and vegetables before consumption cannot be entirely disregarded in controlling the occurrence of *Ascaris lumbricoides* infection. This habit needs to be implemented to prevent *Ascaris lumbricoides* infection through the consumption of fruits and vegetables.

The research conducted by Nasr, et al. (2020) found no significant association between nail-cutting habits and the occurrence of *Ascaris lumbricoides* infection ($p = 0.436$). The same result was also shown in the research conducted by Nasr et al. on 484 Orang Asli children under 15 years old in Malaysia in 2013. There was no significant association between nail-cutting habits and the occurrence of *Ascaris lumbricoides* infection ($p = 0.691$) (Nasr et al., 2013). These results contradict the research conducted by Tefera and Mebrie (2014) and Sacolo Gwebu, Chimbari, and Kalinda (2019) which found a relationship between nail-cutting habits and the occurrence of *Ascaris lumbricoides* infection. The non-significant association between nail-cutting habits and the occurrence of *Ascaris lumbricoides* infection could be attributed to other factors related to the presence of *Ascaris lumbricoides* eggs on hands and nails, such as handwashing habits. However, even though the research conducted by Nasr, et al. (2020) and Nasr, et al. (2013) did not find a relationship between nail-cutting habits and *Ascaris lumbricoides* infection in children, the research by Nasr, et al. (2020) found that 64.2% of children who did not have a regular nail-cutting habit experienced *Ascaris lumbricoides* infection. The research by Nasr, et al. (2013) also found that 38.3% of children who did not have a regular nail-cutting habit experienced *Ascaris lumbricoides* infection. This indicates that nail-cutting habits are still related to the occurrence of *Ascaris lumbricoides* infection. Additionally, children still lack awareness of the importance of hygiene habits. One common habit among children is finger-sucking (Shrestha et al., 2012). If there are infectious *Ascaris lumbricoides* eggs on the nails, they can be ingested when children suck their fingers. Therefore, implementing nail-cutting and handwashing habits in children is crucial. When washing hands, it is recommended to use soap and thoroughly clean the area under the nails.

4. Conclusion

Based on a systematic literature review, the conducted research sheds light on the prevalence of *Ascaris lumbricoides* infection in Southeast Asia, revealing a range from 37.4% to 63.1%. Intriguingly, a critical gap is identified in the existing literature, with no articles discussing the relationship between the presence of *Ascaris lumbricoides* eggs on hands, nails, food, and soil and the occurrence of infection in preschool-age and school-age children in the region. The systematic analysis also highlights significant associations, indicating that handwashing habits, especially before meals and after defecation, along with toilet usage and washing fruits before consumption, are linked to the occurrence of *Ascaris lumbricoides* infection in children. Conversely, no significant associations were found between washing vegetables before consumption and nail-cutting habits with the occurrence of *Ascaris lumbricoides* infection in children in Southeast Asia. This comprehensive review provides valuable insights into the current state of knowledge on *Ascaris lumbricoides* infection in the region, emphasizing areas that warrant further investigation and research attention.

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