

Soil-transmitted helminths infection and undernutrition in pediatrics : A Literature Review

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Abstract

Chronic STH infection can lead to disability, which become a serious matter for pediatric populations because it causes poor growth and impaired development. Undernutrition is presumed to be the leading cause for this chronic disability since STH impede the digestive system in various ways. Malnutrition itself also disrupts immune system and made children more susceptible to infections, creating a vicious circle. This literature review is conducted to evaluate latest findings whether STH infection and malnutrition is still a major issue that relates to one another. Published literatures from 2018 – 2023 searched through Scopus, PubMed, and ScienceDirect databases are assessed and evaluated according to PRISMA 2020 guideline. A total of 14 cross-sectional studies fit the inclusion and exclusion criteria of this study. Undernutrition is still commonly found among children with STH infection although the association varies. Stunting is the type of undernutrition that was most found to be significantly associated with STH infection. The STH species most found to alter nutrition status is *A. lumbricoides*, while hookworm is the least.

Keywords: Soil-Transmitted Helminths ; Anthropometric Index ; Undernutrition ; Pediatrics

1. Introduction

The burden of soil-transmitted helminths (STH) infection is still one of the most prevalent in the world, infecting around 1.5 billion people or 24% of world population. Ascariasis which infects 807 – 1121 million people is the most widespread between others STH, followed by Trichuriasis which infects 604 – 795 million people and hookworm which infects 576 – 740 million people [1]. Due to the high prevalence, soil-transmitted helminthiases are considered as Neglected Tropical Disease (NTD). Endemic areas are related to climate and socioeconomic status, typically in rural tropical and subtropical areas with low sanitation, although this infection can be found in urban places as well [2,3].

STH infection rarely causes mortality. However, these worm infections often cause morbidity which has a positive association to the intensity of the infection, although not linearly. Intensity of Ascariasis and Trichuriasis peaks in preschool-age children (PSAC) and school-age children (SAC) [4]. Children do not tend to have a good hygiene practice yet; hence, tend to bear heavier infection [5]. In the other hand, hookworm infection is typically higher in adolescent and adults [4,6]. It is presumed that this trend is related to agricultural occupations that may handle human excreta [4].

Chronic STH infection can lead to disability, which become a serious matter for pediatric populations because it causes poor growth and impaired development, mainly in cognitive ability [4]. Undernutrition is presumed to

be the leading cause for this chronic disability since STH are intestinal parasite that impede the digestive system in various ways.

Ascaris lumbricoides and hookworm reside in the small intestine where nutrient absorption occurs. *Ascaris lumbricoides* cause abnormalities of jejunal mucosa and vitamin A malabsorption [7–9]. In heavier adult worm burden, especially in children who has smaller intestinal lumen, adult *Ascaris lumbricoides* might fill the lumen and causes volvulus, intussusception, gastrointestinal bleeding, small intestine obstruction and perforation [7,10]. Iron-deficiency anemia (IDA) is often seen on chronic hookworm infection because adult hookworm suck blood of their host. *Ancylostoma duodenale* ingests 0.15 – 0.25 mL of blood per day while *Necator americanus* ingests 0.03 mL of blood per day. Hookworm also may hinder with the absorption of folic acid and vitamin B12 [7,11]. Unlike the other STH species, adult *Trichuris trichiura* live in large intestine thus it does not directly interfere with nutrient absorption. Its pathophysiology is mainly causing mucosal damage and chronic inflammation. This worm species may also cause IDA from chronic bleeding because it can cause dysentery in heavier burden, but it is not as prevalent as IDA from hookworm infection [8,10].

Whereas STH infection can cause malnutrition through each worms' pathophysiology, malnutrition itself also disrupts immune system and made children more susceptible to infections and diseases including STH infection, creating a vicious circle [8,12–14]. Therefore, it is important to take a closer look into this problem. However, both STH infection and malnutrition has more risk factors other than each other. This literature review is conducted to evaluate latest findings published from 2018 – 2023 whether STH infection and malnutrition is still a major issue that relates to one another.

2. Methods

This literature review is conducted according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 guideline. Published literatures are searched through Scopus, PubMed, and ScienceDirect databases. The inclusion criteria are (1) published from 2018 – 2023 in English or Indonesian (2) has pediatric population, (3) single or multiple STH infections (*Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus*), (4) screens nutritional status through height-for-age (HAZ), weight-for-age (WAZ), weight-for-length/height (WHZ), or body mass index-for-age (BAZ), and (5) analyses the association or correlation between STH infection and nutritional status.

Studies will be excluded if (1) STH infection and other infections are combined in statistical analysis, (2) there is an intervention to the population from the researcher (such anthelmintic therapy, supplements, or WASH intervention), (3) doesn't include original data (such as reviews, book chapter, editorials), or (4) full text is not able to be retrieved.

The protocol used for literature search is: (("soil-transmitted helminth") OR ("ascaris lumbricoides") OR ("trichuris trichiura") OR hookworm) AND (children OR pediatrics) AND (("nutritional status") OR malnutrition). The first inclusion criteria is directly applied to the search. All data are collected and inputted into Mendeley Reference Manager. Duplicates will be removed. The rest of the literatures will be identified from the title and abstract. Studies with relevant abstract will be continued to full text screening to be evaluated.

3. Results

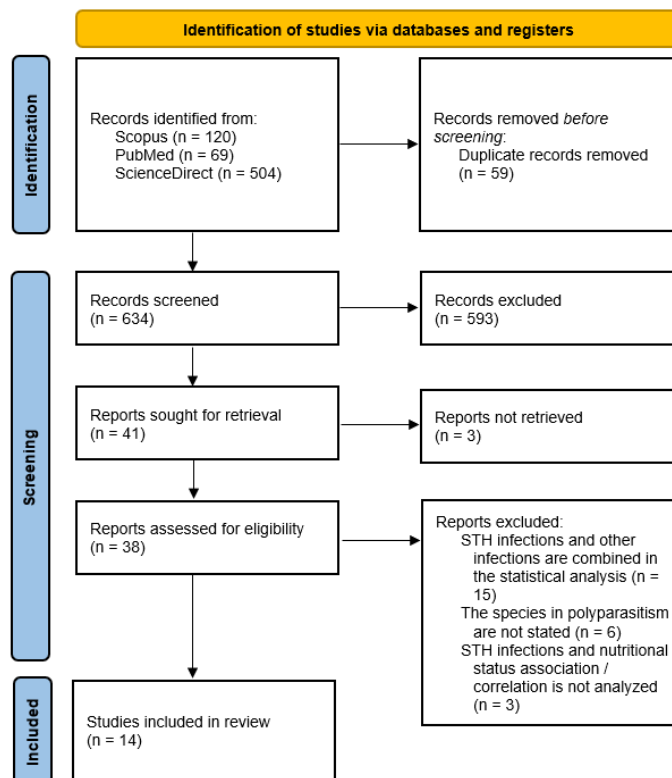


Fig. 1. Flowchart of literature search based on PRISMA 2020

From the initial search, there are a total of 693 literatures included which then reduced into 634 articles after removing duplicates. Through title and abstract screening, 593 articles are excluded. The full texts of the remaining 41 articles are searched, and there are 3 articles that are unable to be retrieved. After evaluating the full text of 38 articles, a total of 14 cross-sectional studies fit the inclusion and exclusion criteria of this study. There are 4 studies conducted in Ethiopia, 2 studies each in Indonesia and Brazil, and 1 study each in Sri Lanka, Nigeria, Peru, Philippines, Ecuador, and Malaysia.

Table 1. Synthesis of article review

No	Author	Location	Sample age and size	Findings
1.	Galgamuwa et al. (2018) [15]	Sri Lanka	489 children aged 1 – 12 years old	Malnutrition was not significantly associated with <i>A. lumbricoides</i> infection. Children with no <i>A. lumbricoides</i> infection had higher mean values of HAZ, WAZ and WHZ than infected children, but mean Z-scores of nutritional indicators were not significantly associated with intensity of <i>A. lumbricoides</i> infection. Heavy <i>A. lumbricoides</i> infections were significantly correlated with a decrease in WHZ scores ($\beta = -0.20$ [CI = $-0.31 - -0.03$], $p = 0.020$).

Table 1. Synthesis of article review (continuation)

No	Author	Location	Sample age and size	Findings
2.	Moncayo et al. (2018) [16]	Three regions of Ecuador	920 children aged 6 – 16 years old	There is a significant association between malnutrition with <i>A. lumbricoides</i> infection (OR 1.94 [CI: 1.27 – 2.97]) and <i>T. trichiura</i> infection (OR 1.89 [CI: 1.25 – 2.88]) in bivariate analysis. Moderate-heavy intensity of <i>A. lumbricoides</i> is significantly associated with malnutrition in multivariate analysis (AOR 1.85 [CI: 1.04 – 3.31], $p = 0.037$). Hookworm infection was not associated with malnutrition.
3.	Molla & Mamo (2018) [11]	Yirgacheffee, South Ethiopia	433 children aged 6 – 15 years old	STH infected children were more likely to be undernourished but this association was not significant ($p = 0.213$).
4.	Ihejirika et al. (2019) [17]	Two zones in Imo State, South Eastern part of Nigeria	300 children from 1200 selected children aged 5 – 13 years old to determine IPI prevalence and nutritional status	Most STH-infected children had normal nutritional status. Malnutrition was higher in children with heavy and moderate intensity of STH infection than children with light intensity of STH infection, but is not statistically significant ($p = 0.319$).
5.	Mekonnen et al. (2020) [18]	Jimma Town, Southwest Ethiopia	404 children aged 6 – 14 years old from 4 schools	<i>T. trichiura</i> infection was significantly associated with stunting (AOR = 2.0 [CI = 1.2 – 3.3]), but <i>A. lumbricoides</i> and hookworm infections were not. None of STH infection was significantly associated with wasting.
6.	Amqam et al. (2020) [19]	Makassar, Indonesia	82 children aged 9 – 12 years old from 8 schools	No significant association between helminthiasis and underweight (OR = 0.535, $p = 0.397$).
7.	Almeida et al. (2020) [20]	Maranhao State, Northeastern Brazil	259 children aged 11 – 15 years old	No significant association between <i>A. lumbricoides</i> infection with stunting nor underweight. No significant association between hookworm infection with stunting.
8.	Calegar et al. (2021) [21]	States of Piauí and Rio de Janeiro, Brazil	421 children aged 1 – 14 years old	Children with <i>A. lumbricoides</i> infection was significantly associated with lower means of HAZ ($p = 0.001$), WAZ ($p = 0.001$), and WHZ ($p = 0.006$). Children with hookworm infection was significantly associated with lower means of HAZ ($p = 0.015$) and WAZ ($p = 0.012$). Both HAZ and WAZ were independently influenced by <i>A. lumbricoides</i> infection.
9.	Belizario Jr et al. (2021) [14]	Eastern Samar & Western Samar, Philippines	331 PSAC and 656 SAC	A total of 44.6% PSAC and 41.7% SAC with STH infection were stunted. STH infection was significantly associated with stunting in PSAC ($p = 0.015$) and SAC ($p = 0.01$). Children infected with <i>A. lumbricoides</i> was significantly associated with stunting, whether in PSAC ($p = 0.004$) nor in SAC ($p = 0.025$). SAC infected with <i>T. trichiura</i> was significantly associated with stunting ($p = 0.005$).
10.	Djuardi et al. (2021) [22]	East Nusa Tenggara, Indonesia	393 PSAC from 22 villages	Among children infected with STH, 29.4% were underweight, 35.6% were stunted, and 15.6% were wasted. Single STH infection was significantly associated with lower risk of stunting (OR 0.506 [CI: 0.278 – 0.921], $p = 0.026$), especially in moderate intensity (OR 0.508 [CI: 0.272 – 0.948], $p = 0.033$). No significant association found between each STH species infection nor multiple infection with underweight, stunting, nor wasting.

Table 1. Synthesis of article review (continuation)

No	Author	Location	Sample age and size	Findings
11.	Muslim et al. (2021) [23]	Inland Jungle Villages (IJV) & Resettlement Plan Scheme (RPS), Malaysia	416 Negritos (indigenous) children aged 2 – 19 years old	STH polyparasitism had 3.7 odds for being underweight in IJV, 2.3 odds for being underweight in RPS, and 1.9 odds for being stunting in RPS. <i>T. trichiura</i> infection had 3.1 odds for being underweight in RPS. No significant association found between any STH infection with wasting in IJV nor RPS.
12.	Segoviano-Lorenzo et al. (2021) [12]	San Juan Bautista, Peruvian Amazon	572 children aged 6 – 59 months old	No statistically significant association between stunting and any STH infections (single nor multiple) in univariate (OR = 1.32 [95% CI = 0.89 – 1.96], $p = 0.173$) nor multivariate analysis (AOR = 1.17 [95% CI = 0.74 – 1.83], $p = 0.504$).
13.	Geleto et al. (2022) [24]	Southern Ethiopia	405 children under 5 years old	STH infection was significantly associated with undernutrition (AOR: 1.88 [CI 1.22 – 2.91], $p = 0.004$). <i>A. lumbricoides</i> was significantly associated with increased risk of severe stunting (AOR 3.04 [CI 1.48 – 6.26], $p = 0.003$) and severe wasting (AOR: 3.51 [CI 1.79 – 6.91], $p = 0.001$).
14.	Yeshanew et al. (2022) [25]	Mettu town, Southwest Ethiopia	392 schoolchildren aged 5 – 16 years old	<i>T. trichiura</i> infection was significantly associated with increased risk of undernutrition (AOR 0.49 [CI 0.31–0.83]), while <i>A. lumbricoides</i> infection and hookworm infection were not.

There are studies that analyzed each type of undernutrition (stunting, underweight, wasting) and there are studies that analyzed undernutrition as a whole. Amongst studies that accounted undernutrition as a whole, STH infection was shown to be associated and not associated with undernutrition in one study each [11,24]. *Trichuris trichiura* infection has two studies that shows significant association, one between the two also shows increasing risk of undernutrition in multivariable analysis [16,25]. *Ascaris lumbricoides* infection has one study that shows association with undernutrition and two that do not [15,16,25]. However, the one study that found significance also found increasing risk of undernutrition with heavier intensity after adjusting potential confounder [16]. There is no study that found significant association between hookworm infection and undernutrition.

There are more studies that found association between low HAZ index or stunting and STH infection than studies that did not find any. Each species of STH infection was significantly associated with stunting in at least one study. There is also a study that found multiple STH infection increases risk of stunting [23]. One study in East Nusa Tenggara, Indonesia found that single STH infection, especially moderate intensity, in children under five lowers the risk of stunting compared to no infection in the bivariate analysis [22].

Findings regarding wasting and underweight were not that many compared to findings regarding stunting. There is only one finding that showed association between wasting with STH infection, which is *Ascaris lumbricoides* infection [19]. Although not directly associated with wasting or thinness, there are also studies that found association between decreased WHZ with *Ascaris lumbricoides* infection [15,21]. More findings were not supporting any association between STH infection and wasting [18,22,23].

There are only one studies that found increased risk of underweight with STH infection, which is in *Trichuris trichiura* infection and multiple STH infection [23]. Though not directly associated with underweight, *Ascaris lumbricoides* and hookworm infection were associated with lower WAZ score [21]. In contrast, there are four studies that were not supporting any association between STH infection and underweight [15,19,20,22].

4. Discussion

Undernutrition is a condition where the demand of nutrient exceeds the supply of nutrient. It may present in the form of stunting, underweight, and wasting or thinness which can be detected through anthropometric indicators, respectively height-for-age (HAZ), weight-for-age (WAZ), and weight-for-length/height (WHZ) or body mass index-for-age (BAZ). The global prevalence of undernutrition has been showing a decreasing trend over the past years. Joint Child Malnutrition estimated the global prevalence of stunting was 22.3% and wasting was 6.8% in children under five in 2022 [26]. A child can have more than one type of undernutrition because they share the same risk factors and effects [9,13,23]. However, there are no estimation prevalence for the combined conditions.

An acceleration in reducing undernutrition is still needed to achieve 2030 SDG target. All forms of malnutrition can be prevented, including risk managements. Helminth infections are long thought to be one of the diseases that contribute to childhood malnutrition, either the primary underlying cause of undernutrition or as an exacerbating factor of undernutrition [9].

According to the reviewed studies, *Ascaris lumbricoides* and *Trichuris trichiura* infections were more prevalent compared to hookworm infection. This reflects the global prevalence of STH infection which recorded higher incidences of *Ascaris lumbricoides* and *Trichuris trichiura* infections compared to hookworm infection [1]. There are multiple STH infections found as well, but only in two studies [22,23]. In studies that also determine intensity of infections, the cases of moderate-heavy STH infections were not as abundant as light STH infections. With WHO prophylaxis chemotherapy (PC) carried out, the incidence of moderate-heavy infections is possibly due to irregularity in taking anthelmintics while the incidence light infections is possibly due to reinfection, which need intervention and modification of risk factors to reduce parasite transmission [14].

4.1. STH infection and stunting

Amongst all the undernutrition indicators, stunting was the one that is most analyzed. Stunting is a predictor for long-term or recurrent undernutrition that will lead to long-term disability, which explain the amount of study detecting significant association of stunting with STH infection since malnutrition is presumed to be a chronic effect from STH infection [15,24,27]. *Ascaris lumbricoides* and hookworm cause abnormality in small intestinal mucosa and disrupts nutrition intake, while *Trichuris trichiura* which resides in the large intestine mainly causes chronic inflammation and dysentery [8]. *Ascaris lumbricoides* was found to be independently influence HAZ negatively in a study despite the low prevalence, suggesting that even a low prevalence of infection must be put attention into [21]. However, this study did not account the intensity of infection which may influence how the infection affects children nutritional status.

Interestingly, a study in Indonesia found that single STH infection lowers risk of stunting. Nonetheless, this result was explained by the finding that older age lowers the risk of stunting even after adjusting the potential confounders (36–47 months: AOR 0.428 [95% CI: 0.210–0.875], $p = 0.020$; 48–60 months: AOR 0.315 [95% CI: 0.132–0.749], $p = 0.009$), meanwhile STH infection status and heavier intensity of STH infection were more prevalent in older infants in the study [22].

4.2. STH infection and wasting

Wasting or thinness can be detected through two anthropometric indicators, WHZ and BAZ. Wasting itself is an indicator used for detecting acute malnutrition either due to nutrient shortage or failure to gain weight. Because wasting causes more acute effects such as greater mortality risk, it demands more acute intervention

as well [14,24,27]. It is also suggested that wasting can lead to stunting because adequate weight is needed to have healthy height growth [13].

From the reviewed literatures, only *Ascaris lumbricoides* that was shown having significant association with decreased WHZ index nor wasting [15,21,24]. A meta-analysis also mentioned that *Ascaris lumbricoides* might affect nutritional status acutely although the acute pathway is still unknown [9]. This might be because decreased appetite and gastrointestinal symptoms ranging from diarrhea to small intestine bowel obstruction in heavier *Ascaris lumbricoides* adult worm burden may causes impaired weight gain through inadequate nutrition intake [8,9,16].

4.3. STH infection and underweight

Underweight can be detected through WAZ indicator. Compared to the previous two nutritional indexes, WAZ does not differentiate between acute and chronic malnutrition, hence it is hard to interpret this index [27]. There is one study that show significant association of underweight with STH infection nor *Trichuris trichiura* [23]. There is also another study that show significant association of low WAZ with *Ascaris lumbricoides* nor hookworm [21]. This indicates that STH infection, regardless of the species, affects both acute and chronic pathway to undernutrition. However, *Ascaris lumbricoides* was suggested to have more acute effects compared to *Trichuris trichiura* and hookworm since it got more findings of wasting which indicates acute malnutrition. Nonetheless, further study is still needed to confirm this.

5. Conclusion

Undernutrition is still commonly found among children with STH infection although the association varies between studies. Stunting which indicates chronic or recurrent malnutrition is the type of undernutrition that was most found to be significantly associated with STH infection. The STH species most found to alter nutrition status is *Ascaris lumbricoides*, while hookworm is the least found to alter nutrition status.

Acknowledgements

Author would like to express gratitude to all the parties involved in the making of this review.

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