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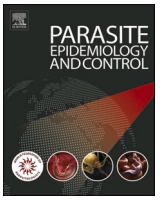

# Factors influencing stunted growth in children: A study in Bandung regency focusing on a deworming program

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ABSTRACT

The prevalence of neglected tropical diseases, specifically those caused by soil-transmitted helminths (STHs) and other parasites that infest the intestine as part of their life cycle, remains a problem in Indonesia. We assessed the effects of deworming programs and socioeconomic and ecological factors on the incidence rate of infections with STHs and other parasites in an urban area of the Bandung Regency. We recruited 361 children with stunted growth who met the inclusion criteria, and 48 of those children were at high risk of STH infection. The study was conducted between September 2020 and September 2021. We collected possible socioeconomic factors influencing the incidence rate of infections. We found the incidence rate of STH infections among the children with stunted growth to be 3.6%. We confirmed infections with *Cyclospora* and *Cryptosporidium* after a Ziehl-Nieelsen stool smear examination in two of the 48 children at risk of infection. We found 43.75% of the children had short stature and weight below the normal limits, while stunting and severe stunting were associated with *Ascaris lumbricoides* infection (44.70%, $p = 0.035$). Parents of children with stunted and severely stunted growth were more likely to have a low education level, lack knowledge about deworming program, and to be earning a low income. The mother's occupation had a particularly strong influence on the severity of the stunting (89.58%, $p = 0.012$). Our results show that deworming programs can affect the growth and development of children and that socioeconomic and ecological factors also play a role.

## 1. Introduction

Helminthiasis is a neglected tropical disease and is most common in countries where access to clean water and sanitation is difficult and are densely populated, have low levels of education, and poor access to health services (Torlesse et al., 2016; Hardjoedi et al., 2017; Kassaw et al., 2019; Gabrie et al., 2016). Soil-transmitted helminths (STHs) are the most common helminths causing human disease and belong to a class of nematodes that dwell in the soil before becoming infective to humans. >1.5 billion people, or 24% of the world's population, are infected with STHs (Torlesse et al., 2016). The highest number of STH infections occurs in Asia (Southeast Asia has the highest prevalence of STH infections). The STHs include roundworms (*Ascaris lumbricoides*), whipworms (*Trichuris*

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*trichiura*), hookworms (*Ancylostoma duodenale* and *Necator americanus*), and threadworms (*Strongyloides stercoralis*) (Clarke et al., 2019). Helminthiasis is a major public health problem in tropical and subtropical low-to-middle income countries, including Indonesia (WHO, 2018).

Reports from the Indonesian Ministry of Health showed that the prevalence of the soil-transmitted helminthiasis infection was 2.5% to 62.0% (MHRI (Ministry of Health Republic of Indonesia), 2017). Studies have consistently reported that *A. lumbricoides* is the causative agent of most STH infections, followed by *Trichuris trichiura (*MHRI (Ministry of Health Republic of Indonesia*), 2017;* Vilcins et al., *2018;* Sanchez et al., *2015)*. Children are highly vulnerable to helminthiasis infections (Fauziah et al., 2022). Of all age groups, school-aged five to 12 year-old children are the most vulnerable as they often consume food contaminated with feces (Sanchez et al., 2015; Oliveira et al., 2015). The prevalence of helminthiasis in school-aged children reaches 60–80% (Vilcins et al., 2018). The pre-school 24 to 59 month-old children rank second with a prevalence of 20–30% (Berraies et al., 2014).

STH Infection has been considered to increase the risk of acquiring stunting, represents the impaired growth and development that children experience from poor nutrition, repeated infections, and/or inadequate psychosocial stimulation (WHO, 2018). Many focus group discussions center around stunting. Stunting remains high worldwide, with a global prevalence of 21.3%, with low- and middle-income countries contributing the highest proportions. The prevalence of stunting in Southeast Asia in children younger than five years was 24.7%; in 2018; in Indonesia it was 30.8% although it decreased to 27.7% in 2019 but the problem remains significant. West Java is a province with a large population and high birth rate, and it has a prevalence of stunting, ranking 18th at 31.1%. Among the 17 general sustainable development goals (SDGs) to be achieved by 2030, the second SDG is to eliminate hunger, achieve food security and good nutrition, and improve sustainable agriculture; reducing the number of stunted and wasted children younger than five years by 40% by 2030 is one of the achievement indicator goals (Torlesse et al., 2016).

Malnutrition due to chronic or recurrent inadequate nutritional intake or chronic systemic inflammation causes chronic growth disorders, usually evidenced by age-related stunting, which predisposes children to infections owing to the widespread disruption of their immune functions. However, the influence of effector leukocytes, inflammatory mediator activity, and leukocyte trafficking under these conditions is poorly understood. The loss of intestinal barrier integrity coupled with reduced gastric acid secretion makes the gastrointestinal tract vulnerable to pathogens, including parasites such as helminths (Kassaw et al., 2019; Gabrie et al., 2016). Therefore, this study was designed to assess the environmental and malnutrition factors that may contribute to the incidence of parasitic infections and stunting, and to provide the government (especially in West Java) with information that should allow for the development of effective preventive measures to complement deworming programs.

## 2. Materials and methods

### 2.1. Study Site and Population

This study, targeting children with stunted growth aged 24 to 59 months, was conducted in the Bandung Regency (West Java), Indonesia, which consists of 31 districts, 266 villages, nine urban villages (Central Bureau of Statistics of Bandung Regency, 2019).

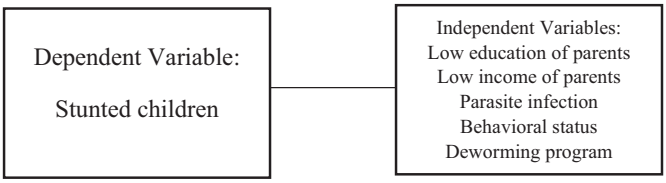
### 2.2. Study Size and Sampling

The sample size was calculated to determine the prevalence of helminthiasis in stunted children using the formula $n = p(1-p)\left(\frac{Z\alpha}{d}\right)^2$, where n is the sample size, p is the estimate of STH infection prevalence, Zα is the standard deviation obtained from the standard normal distribution table for the selected confidence level, and d is the margin of error.

Multistage random sampling was performed by selecting children from 11 districts, 39 villages, and 30 health centers using the randomization function (RAND) in MS Excel (Microsoft, USA). A sample of 361 children with stunted growth, aged between 24 and 59 months, from a total of 1544 children with stunting data was obtained. Anthropometric measurements were performed using standardized tools (microtoise/stadiometer and Seca weighing scales). The World Health Organization Child Growth Standards (WHOCGS) was used as the assessment tool for nutritional status[14]. Children were diagnosed with stunting if they were more than two height-for-age standard deviations below the median, and severe stunting was diagnosed if they were more than three standard deviations below the median. After calculating the incidence of STH infection from the analysis of 361 samples, 48 individuals with stunting were selected from STH prevalent areas to assess the influence of socioeconomic and ecological factors on their growth and development, and on their risk of other parasitic infections.

For this study, we gathered primary data from children with stunted growth in the Bandung Regency and secondary data from the clinical records of children who met the following inclusion criteria: age 24–59 months, permanent residence in the study area, without congenital birth anomalies, and consumption of antihelmithic drugs within six months before participation. The data was inputted into prepared research forms that were edited, verified, and coded before data analysis. Parents/guardians were questioned regarding their sociodemographic factors and relevant behaviors. A qualitative structured questionnaire was used to collect data on demographic characteristics and risk factors. Stool samples were examined using the Kato-Katz method to identify helminth infections or the acid-fast staining method to identify protozoan infections (*Cryptosporidium spp.* and *Cyclospora spp.*). Two parasitologists performed the examinations to ensure the quality of the results.

### 2.3. Measurement of Variables




Stunting was defined as a height-for-age *Z*-score below 2 in the World Health Organization (WHO) growth reference standard.

STH infection was confirmed when worm eggs (*A. lumbricoides*, *Trichuris trichiura,* and hookworms) were detected in a stool sample. According to the WHO, **a** mild-grade infection with *A. lumbricoides* has 1 to 4999 eggs per gram of stool, a moderate-grade infection has 5000 to 49,999 eggs per gram of stool, and a severe-grade infection has >50,000 eggs per gram of stool (World Health Organization, 2017).

A protozoan infection was confirmed when Giardia, Cryptosporidium, or both infections resulted in an optical density (OD) >0.08 (Octoviani et al., 2023).

### 2.4. Data Management and Analysis

The collected data were statistically processed using the SPSS software version 24 for Windows. All data were analyzed in the bivariate and multivariate stages. The Kolmogorov–Smirnov test determined whether the variables were normally distributed (*p*-value <0.05, indicates a non-normal distribution). Descriptive data were expressed as frequencies (n) and proportions (%) of sociodemographic characteristics. To investigate the overall research question, the prevalences and 95% confidence intervals, according to the age of each participant, was calculated. Finally, the differences in the prevalences of sociodemographic characteristics and behavioral variables using *chi*-square tests and *t*-tests were calculated.

## 3. Results

Characteristics of the participants are shown in Table 1, including their diverse body weight distributions and nutritional statuses. The mean height of males was higher than that of females, but the difference was not statistically significant.

STH infections were present in 13 of 361 stunted children aged 24–59 months (incidence rate, 3.6%), with 69% residing in the Pameungpeuk district (Table 2). We also evaluated 48 children with stunting from areas with confirmed STH infections to explore the possible associations between stunting, environmental conditions, and the presence of STH infections.

The majority of parents of the participants were elementary (43.75%) or junior high school (41.67%) graduates. The majority of the fathers were laborers. The occupational status of the mothers was significantly associated with the presence of stunting.

There were no significant associations between stunting and sex, age, height, birth order of the child, number of siblings, number of people living in the house, father's education level or occupation, father's income, or mother's education level.

Severely emaciated participants were more likely to be in the severely stunted category ($p = 0.017$). This result confirms the association between body weight and stunting. Similarly, the employment status of the mother was significantly associated with the presence of stunting ($p = 0.012$). Interestingly, all participants with severe stunting had working mothers.

A majority of participants (93.75%) with stunted growth had access to a private toilet/latrine at home. A majority of participants also had a water source 10 m or less from their toilet. Of the 48 participants with STH infection risks, five (10.42%) had a history of persistent diarrhea. In terms of the sanitation facilities available to the 48 participants, it was found that 93.75% used private sanitation facilities and the majority had septic tanks in their house. It was found that 81.25% of the participants washed their hands with water and soap before eating and 91.67% washed their hands with water and soap after defecation. The majority of participants (95.83%) used footwear while playing. Similarly, the majority of participants had clean hands and toe nails.

There were no significant associations between environmental factors and stunting (Table 3); however, some low *p*-values indicate

**Table 1**
Characteristics of Participants.

| Characteristics | | *n* | Mean | Standard Deviation | p |
|---|---|---|---|---|---|
| | | | 43.8 | 10.25 | |
| Age (months) | Male | 22 | 45.2 | 8.79 | 0.202 |
| | Female | 26 | 42.5 | 11.36 | |
| Body weight (Kg) | | | 17.14 | 20.57 | |
| | Male | 22 | 12.41 | 1.78 | 0.001 |
| | Female | 26 | 11.27 | 1.78 | |
| Height (cm) | | | 87.60 | 5.95 | |
| | Male | 22 | 89.61 | 5.16 | 0.472 |
| | Female | 26 | 85.90 | 6.14 | |

**Table 2**
List of Residential Districts of Participants.

| District | Frequency ($n = 361$) | STH | | Protozoa | |
|---|---|---|---|---|---|
| | | *Ascaris lumbricoides* | *Trichuris trichura* | *Cyclospora* | *Cryptosporidium* |
| | | Positive, *n* (%) | Positive, *n* (%) | Positive, *n* (%) | Positive, *n* (%) |
| Baleendah | 12 | 0 | 0 | 0 | 0 |
| Cikalong | 33 | 0 | 0 | 0 | 0 |
| Cimaung | 15 | 0 | 0 | 0 | 0 |
| Margaasih | 10 | 0 | 1 (8) | 0 | 0 |
| Nagrak | 26 | 0 | 0 | 0 | 0 |
| Padamukti | 23 | 0 | 0 | 0 | 0 |
| Pameungpeuk | 36 | 9 (69) | 0 | 1 (50) | 1 (50) |
| Rahayu | 18 | 2 (15) | 0 | 0 | 0 |
| Rancamanyar | 17 | 0 | 0 | 0 | 0 |
| Soreang | 42 | 0 | 0 | 0 | 0 |
| Sudi | 27 | 0 | 0 | 0 | 0 |
| Sukajadi | 27 | 0 | 0 | 0 | 0 |
| Sawahlega | 28 | 0 | 1 (8) | 0 | 0 |
| Cibiru Hilir | 24 | 0 | 0 | 0 | 0 |
| Linggar | 23 | 0 | 0 | 0 | 0 |

potential factors that should be explored further.

The results from Table 4 showed that only 35.42% of the participants had a fever, 12.50% reported headaches, 89.58% showed no signs of weakness, and 95.83% showed no signs of pallor.

There were no significant associations between stunting and nutritional status or clinical symptoms (fever symptoms, fever duration, headache, weakness, or pallor) (Table 4).

Helminthiasis with *A. lumbricoides* and *T. trichiura* were the most common STH infections. Our results suggest that *A. lumbricoides* infection is associated with stunting in the study cohort.

The majority of the participants not infected with *A. lumbricoides* exhibited stunted growth, whereas those with an infection exhibited severely stunted growth. There were some participants infected with *Cyclospora* and *Cryptosporidium*.

## 4. Discussion

The nutritional status of children with stunted growth in several districts of the Bandung Regency was assessed. There was an STH infection incidence rate of 3.6% in children with stunted growth. Most children with helminthiasis belonged to the 2–5 years age range, a group in which interventions against stunting can be effective. Our study revealed the overall incidence rate of STH in children with stunted growth was higher than that reported in a study in Cameroon (Helen et al., 2012; Clarisse et al., 2016; Stella et al., 2015). A different study showed a low prevalence rate (2.5%) of helminthiasis in children with stunted growth in selected rural, semi-urban, and urban communities in the Mount Cameroon area (Judith et al., 2015); and, another study reported a prevalence rate of 0.5% in Northern Tanzania (David et al., 2014). Overall, these results suggest that nutritional and chronic infection prevention interventions, such as deworming programs, should be regularly promoted to achieve optimal pediatric outcomes.

A WHO report estimated the prevalence of STH infection in Asian countries to be >20% (Xiao et al., 2015; Dold and Holland, 2011; WHO, 2010). Poor hygiene, particularly at home, is thought to be a cause for the high prevalence of *A.lumbricoides* infections. Water, food, soil, and hands are easily contaminated by worm eggs in places with inadequate sanitation and fecal management facilities, unsafe water, and inhabitants with poor hygiene practices (Menzies et al., 2014). For this study, we selected risk factors after considering that intestinal parasite transmission is linked to the presence of toilets, unclean water sources, poor drinking water sources, unhygienic practices, poor fecal disposal systems, poor socioeconomic status, and the presence of multiple parasites in human communities.

We found that the only variable showing a significant association with the presence of STH infection was the use of personal sanitation facilities; however, this result cannot be generalized. We also assessed the association between socioeconomic variables and growth measurements to identify the malnutrition-vulnerable groups. Our results provide updated data regarding the growth patterns of short-statured children. We found a significant correlation between nutritional status and maternal employment. This result emphasizes the importance of the quality of childcare. Our findings suggest that the working status of mothers can affect the rate of stunting in their children. The majority of the children with severely stunted growth had working mothers. This could be due to the inability of the working mother to provide appropriate care to her children, resulting in infections and malnutrition in situations with poor access to clean water, sanitation, handwashing facilities, and environmental conditions. Malnourished children undergo poor physical and cognitive development (Ketema et al., 2022). A research study in Adama, Ethiopia reported favorable findings on stunting (33.8%) (Menzies et al., 2014). Our findings on working mothers and the nutritional status of their children are consistent with those in Sodo, Wolayta, Southern Ethiopia (Eshete et al., 2017), Nigeria (Udoh and Amodu, 2016), and Sri Lanka (Ubeysekara et al., 2015). Moreover, the prevalence of underweight children in our study area is comparable to that reported in Nigeria (Ubeysekara et al., 2015). Children of working mothers from poor households are more likely to have stunted growth and be underweight (Banerjee et al.,

**Table 3**
Socioeconomic and Environmental Factors Associated with Stunting.

| | Frequency ($n = 48$) | | Proportions (%) | Stunted growth *n* (%) | Severely stunted growth *n* (%) | p |
|---|---|---|---|---|---|---|
| Socioeconomic distribution in field | | | | | | |
| Sex | Male | 22 | 45.83 | 11 (50.00) | 11 (50.00) | 0.790 |
| | Female | 26 | 54.17 | 12 (46.20) | 14 (53.80) | |
| Body weight | Obese | 3 | 6.25 | 1 (33.30) | 2 (66.70) | 0.017 |
| | Normal | 24 | 50.00 | 16 (66.70) | 8 (33.30) | |
| | Underweight | 14 | 29.17 | 6 (42.90) | 8 (57.10) | |
| | Severely underweight | 7 | 14.58 | 0 (0.00) | 7 (100.00) | |
| | Obese | 4 | 8.33 | 1 (25.00) | 3 (75.00) | |
| Nutritional status | Normal | 41 | 85.42 | 21 (51.20) | 20 (48.80) | 0.707 |
| | Wasted | 3 | 6.25 | 1 (33.30) | 2 (66.7) | |
| Child birth order | 1st | 21 | 43.75 | 10 (47.60) | 11 (52.40) | 0.469 |
| | 2nd | 16 | 33.33 | 11 (68.80) | 5 (31.30) | |
| | 3rd | 9 | 18.75 | 2 (22.20) | 7 (77.80) | |
| | 5th | 1 | 2.08 | 0 (0.00) | 1 (100.00) | |
| | 6th | 1 | 2.08 | 0 (0.00) | 1 (100.00) | |
| Number of siblings | 1 | 18 | 37.50 | 8 (44.40) | 10 (55.60) | 0.469 |
| | 2 | 18 | 37.50 | 12 (66.70) | 6 (33.30) | |
| | 3 | 10 | 20.83 | 3 (30.00) | 7 (70.00) | |
| | 5 | 1 | 2.08 | 0 (00.00) | 1 (100.00) | |
| | 6 | 1 | 2.08 | 0 (00.00) | 1 (100.00) | |
| Number of people living in the house | 3 | 8 | 16.67 | 4 (50.00) | 4 (50.00) | 0.293 |
| | 4 | 17 | 35.42 | 9 (52.90) | 8 (47.10) | |
| | 5 | 11 | 22.92 | 6 (54.50) | 5 (45.50) | |
| | 6 | 6 | 12.50 | 1 (16.70) | 5 (83.30) | |
| | 8 | 2 | 4.17 | 1 (50.00) | 1 (50.00) | |
| | 10 | 1 | 2.08 | 0 (00.00) | 1 (100.00) | |
| Father's education | No answer | 3 | 6.25 | 8 (38.10) | 13 (61.90) | 0.313 |
| | Elementary School | 21 | 43.75 | 10 (58.80) | 7 (41.20) | |
| | Junior High School | 17 | 35.42 | 4 (44.40) | 5 (55.60) | |
| | High School | 9 | 18.75 | 1 (100.00) | 0 (0.00) | |
| | University graduate | 1 | 2.08 | 11 (42.30) | 15 (57.70) | |
| Father's occupation | Labor | 26 | 54.17 | 3 (37.50) | 5 (62.50) | 0.413 |
| | Private Employee | 8 | 16.67 | 2 (100.00) | 0 (0.00) | |
| | Farmers | 2 | 4.17 | 5 (83.30) | 1 (16.70) | |
| | Staff-employed | 6 | 12.50 | 2 (33.30) | 4 (66.70) | |
| | More | 6 | 12.50 | 16 (44.40) | 20 (55.60) | |
| Father's income | IDR 2 million (equivalent to 125 USD) | 36 | 74.99 | 6 (60.00) | 4 (40.00) | 0.431 |
| | >IDR 2–3.5 million (equivalent to 125–225 USD) | 10 | 20.84 | 1 (100.00) | 0 (0.00) | |
| | >IDR 3.5 million (equivalent to >225 USD) | 1 | 2.08 | 0 (0.00) | 1 (100.00) | |
| | No answer | 1 | 2.08 | 9 (47.40) | 10 (52.60) | |
| Mother's education | Elementary school | 19 | 39.58 | 10 (50.00) | 10 (50.00) | 1.000 |
| | Junior high school | 20 | 41.67 | 3 (37.50) | 5 (62.50) | |
| | High school | 8 | 16.67 | 1 (100.00) | 0 (0.00) | |
| | University graduate | 1 | 2.08 | 23 (53.50) | 20 (46,50) | |
| Mother's occupation | Not working | 43 | 89.58 | 0 (0.00) | 5 (100,00) | 0.012 |
| | Working | 5 | 10.42 | 12 (50.00) | 12 (50,00) | |
| BPJS insurance participation | No | 24 | 50.00 | 12 (50.00) | 12 (50,00) | 0.772 |
| | Yes | 25 | 50.00 | 11 (5.80) | 13 (54,20) | |
| | Yes | 2 | 4.17 | 1 (50.00) | 1 (50.00) | |
| Behavioral Variables | | | | | | |
| Toilet availability | Privately owned | 45 | 93.75 | 20 (44.40) | 25 (55.60) | 0.063 |
| | Public | 3 | 6.25 | 3 (100.00) | 0 (0.00) | |
| Clean water source | Tap/PAM | 7 | 14.58 | 4 (57.10) | 3 (42.90) | 0.427 |
| | Spring water | 3 | 6.25 | 2 (66.70) | 1 (33.30) | |
| | Dug well | 13 | 27.08 | 6 (46.20) | 7 (53.80) | |
| | Electric pump Well | 15 | 31.25 | 7 (46.70) | 8 (53.30) | |
| | Manual pump well | 10 | 20.83 | 4 (40.00) | 6 (60.00) | |
| Distance from water source to toilet facility | $\leq$ 10 m | 35 | 72.92 | 5 (38.50) | 8 (61.50) | 0.419 |
| | >10 m | 13 | 27.08 | 18 (51.4) | 17 (48.60) | |
| History of persistent diarrhea | No | 43 | 89.58 | 21 (48.80) | 22 (51.20) | 0.706 |
| | Yes | 5 | 10.42 | 2 (40.00) | 3 (60.00) | |
| Use of sanitation facilities | Personal | 45 | 93.75 | 20 (44.40) | 25 (55.60) | 0.063 |
| | Communal | 3 | 6.25 | 3 (100.00) | 0 (0.00) | |

(*continued on next page*)

**Table 3** (*continued*)

| | Frequency ($n = 48$) | | Proportions (%) | Stunted growth *n* (%) | Severely stunted growth *n* (%) | p |
|---|---|---|---|---|---|---|
| Presence of septic tanks | No | 14 | 29.17 | 7 (50.00) | 7 (50.00) | 0.853 |
| | Yes | 34 | 70.83 | 16 (47.10) | 18 (52.90) | |
| Hand-washing before eating | Water only | 9 | 18.75 | 3 (33.30) | 6 (66.70) | 0.322 |
| | Water and soap | 39 | 81.25 | 20 (51.30) | 19 (48.70) | |
| Hand-washing after defecation | Water only | 4 | 8.33 | 2 (50.00) | 2 (50.00) | 0.931 |
| | Water and soap | 44 | 91.67 | 21 (47.70) | 23 (52.30) | |
| Use of footwear during Play | Yes | 46 | 95.83 | 22 (47.80) | 24 (52.20) | 0.952 |
| | No | 2 | 4.17 | 1 (50.00) | 1 (50.00) | |
| Hand and nail hygiene | Clean | 42 | 87.50 | 20 (47.60) | 22 (52.40) | 0.913 |
| | Dirty | 6 | 12.5 | 3 (50.00) | 3 (50.00) | |
| Toenail hygiene | Clean | 41 | 85.42 | 20 (48.80) | 21 (51.20) | 0.771 |
| | Dirty | 7 | 14.58 | 3 (42.90) | 4 (57.10) | |
| Worm prophylaxis habits | Yes | 25 | 52.08 | 13 (52.00) | 12 (48.00) | 0.553 |
| | No | 23 | 47.92 | 10 (43.50) | 13 (56.50) | |

**Table 4**
Clinical Symptoms and Incidence Rate of STH Infection Associated with Stunting.

| | | Frequency ($n = 48$) | Proportions (%) | Stunted growth *n* (%) | Severely stunted growth *n* (%) | p |
|---|---|---|---|---|---|---|
| Clinical Symptoms | | | | | | |
| Fever symptoms | No | 31 | 64.58 | 16 (51.60) | 15 (48.40) | 0.485 |
| | Yes | 17 | 35.42 | 7 (41.20) | 10 (58.80) | |
| Fever duration (days) | 0 | 29 | 60.42 | 16 (55.20) | 13 (44.80) | 0.265 |
| | 1 | 2 | 4.17 | 1 (50.00) | 1 (50.00) | |
| | 2 | 6 | 12.50 | 1 (16.70) | 5 (83.30) | |
| | 3 | 5 | 10.42 | 3 (60.00) | 2 (40.00) | |
| | 5 | 2 | 4.17 | 0 (0.00) | 2 (100.00) | |
| | 6 | 3 | 6.25 | 2 (66.70) | 1 (33.30) | |
| | 7 | 1 | 2.08 | 0 (0.00) | 1 (100.00) | |
| Headache | None | 42 | 87.50 | 20 (47.60) | 22 (52.40) | 0.913 |
| | Yes | 6 | 12.50 | 3 (50.0) | 3 (50.00) | |
| Frequent weakness | No | 43 | 89.58 | 20 (46.50) | 23 (53.50) | 0.570 |
| | Yes | 5 | 10.42 | 3 (60.00) | 2 (40.00) | |
| Pallor | No | 46 | 95.83 | 22 (47.80) | 24 (52.20) | 0.952 |
| | Yes | 2 | 4.17 | 1 (50.00) | 1 (50.00) | |
| STH infection | | | | | | |
| Helminthiasis | Negative | 35 | 72.92 | 20 (54.10) | 17 (45.90) | 0.105 |
| | Positive | 13 | 27.08 | 3 (27.30) | 8 (72.70) | |
| *Ascaris lumbricoides* | Negative | 37 | 77,09 | 21 (55.30) | 17 (44.70) | 0.035 |
| | Positive | 11 | 22.91 | 2 (20.00) | 8 (80.00) | |
| *Trichuris trichura* | Negative | 46 | 95.66 | 22 (46.80) | 25 (53.20) | 0.307 |
| | Positive | 2 | 4.34 | 1 (100.00) | 0 (0.00) | |
| *Cyclospora* | Negative | 47 | 97.92 | 23 (48.90) | 24 (51.10) | 0.307 |
| | Positive | 1 | 2.08 | 0 (0.00) | 1 (100.00) | |
| *Cryptosporidium* | Negative | 47 | 97.92 | 22 (46.80) | 25 (53.20) | 0.307 |
| | Positive | 1 | 2.08 | 1 (100.00) | 0 (0.00) | |

2021). This is supported by studies from Hossana, Ethiopia (Moges et al., 2015), Tanzania (Victor et al., 2014), Northern Ghana (Saaka et al., 2015), and Nepal (Osei et al., n.d.; Singh et al., 2014). Household food insecurity and pediatric undernutrition are important factors in this study. Sociodemographic factors, poor parenting practices, infections, and food insecurity are positively correlated with child malnutrition (Mulu and Mengistie, 2017).

Studies in other developing countries suggest that stunting is less common in early childhood when children are breastfed (Derso et al., 2017). However, inappropriate complementary feeding practices and higher nutritional requirements increase the risk of linear growth impairment with age. When working mothers cease breastfeeding, they may introduce supplements and breast milk substitutes earlier than non-working mothers. Therefore, children born to working mothers face less optimal breastfeeding, an earlier introduction to complementary foods, and receive less optimal care. The need for maternal employment has increased rapidly due to the rising demand for household income as a result of rising food prices (Mekuanint et al., 2014). Adequate hygiene and sanitation practices can help prevent childhood infections, which are the second most direct cause of pediatric malnutrition (Kwami et al., 2019; Ademas et al., 2021).

Environmental and geographical factors also contribute to a high STH infection rate in children. Environmental factors included the

presence of rivers, household conditions, the presence of large livestock or bushes around the house, and the condition of the sewage system. Geographical factors cause differences in the prevalence of STH infections in each region, including the development of STH, personal hygiene, ownership of latrines, and social culture. We found areas in the Bandung Regency, namely the Pameungpeuk district, with a higher STH infection rate than others and children were infected with more than one parasite. According to a study by Faridah et al (Faridah et al., 2021),. most houses in the Pameungpeuk district have nearby livestock pens (<1 m) and the ground surface is soil. Household conditions also affect the risk of STH and protozoan infections. The soil contains STH eggs and larvae, which inhabit it as part of their life cycle before entering the human body. Therefore, soil contact increases the risk of an STH infection in children if personal hygiene is not maintained.

The WHO has defined a double burden of malnutrition as the simultaneous presence of a high rate of undernutrition along with a high rate of being overweight or obese in any population (Wang et al., 2002). The cutoffs used to define a high prevalence of undernutrition are thinness >20%, stunting/short stature >30%, and overweight/obese children and adults >30% (Rolland-Cachera et al., 2002). The double burden of malnutrition is particularly prevalent in low- and middle-income areas, such as the districts studied in this report, and they are driven by rapid dietary changes characterized by increased consumption of unhealthy foods (Rolland-Cachera et al., 2002).

In 2004, El Mouzan *et al (*El Mouzan et al., *2012)* using WHO child growth standards reported a prevalence of wasting of 12.7% and stunting of 13.7% in a national sample of children under the age of five years in Saudi Arabia. Alshammari *et al (*Alshammari et al., *2017)* reported prevalence rates of wasting at 6.9%, stunting at 5.7%, and being overweight or obese at 32% in a cohort of 1107 children and adolescents (aged 5–8 years) in the Hail region. The high prevalence of being underweight and very underweight (29.17% and 14.58%) and the low rate of being overweight or obese (6.25%) in the Bandung Regency suggests a shift in BMI associated with an epidemic of stunting in children in the district. Although thinness can be a marker of malnutrition, thin children are not necessarily malnourished. Thinness is influenced by genetic and biological factors in different populations; these factors cause changes in body composition with growth, and differences in the timing and speed of growth acceleration (Ogden et al., 2014; Deurenberg et al., 2002).

In this study, we showed that 43.75% of our cohort exhibited stunting with weight below the normal limit. Both stunting and severe stunting were linked to a high risk of *A. lumbricoides* infection (44.70%, $p = 0.035$). Despite the presence of underweight children some with stunted growth maintained a normal body weight, indicating that the majority of stunted children in our study had a normal body weight (33.30%). It is worth discussing that not all stunting is caused by malnutrition; therefore, the management of stunting is not always supplementary feeding; instead, interventions need to be applied based on the etiology. For example, in the present study, helminthiasis was the main cause of stunting.

The height achieved by any given individual is a result of genetic, environmental, and sociocultural conditions, in addition to the quality of nutrition received during growth. Stunting is primarily caused by chronic malnutrition. However, contributing factors vary from region to region. In some low-income areas, parasitic infections contribute to stunting by causing loss of appetite, diarrhea, and malabsorption (Erismann et al., 2017; Katona and Katona-Apte, 2008). We believe that in the Bandung Regency, familial/genetic causes are more important than undernutrition as contributing factors to stunting. In a study in Riyadh of 110 patients, 57 (51.8%) were found to have genetic short stature, while endocrine and nutritional causes were found to contribute to short stature in the remaining 53 (48.2%) (Short stature in children, 2012). In contrast, familial short stature was a minor cause of short stature (<5%) in a large case series with participants from other countries (Jawa et al., 2016; Essaddam et al., 2020).

Many developing countries (Jordan, Cameroon, Pakistan, and Palestine) with lower economic development and living standards than Indonesia have lower prevalence rates of stunting (5%–10%) (Jawa et al., 2016; Essaddam et al., 2020; Monteiro et al., 2024), which further supports our assumption that malnutrition is not the main factor causing stunting among the children of the Bandung Regency. However, we recognize the negative impact of undernutrition and poor environmental conditions on the development of disadvantaged subgroups of children, and our results show statistically significant differences in socioeconomic indices between short- and normal-stature children, and between underweight and overweight/obese children.

The results of our study suggest that deworming programs can promote healthy growth and development in children; however, most children with an STH infection had an associated socioeconomic factor as a contribution to the field factors. For example, children of working mothers had a higher risk of severely stunted growth than those of non-working mothers. Thus, interventions to improve socioeconomic and ecological factors should be considered. This is in line with WHO recommendation which involves the regular mass distribution of anthelmintic drugs to a risk-populations, can significantly lessen the burden of STH (World Health Organization, n.d.). Another study found that regular deworming program for STH infection has been demonstrated to prevent anemia in preschool-aged children by preventing iron loss due to hookworm infection, additionally, its supports better growth, and enhanced motor and language development (Girum and Wasie, 2018).

This study has some limitations: our study cohort was small; in addition, all participants were children with stunted growth, and we did not compare their data with those of normal height children as controls. Further studies are required to investigate the underlying causes of stunting among children in the Bandung Regency to identify preventable or modifiable etiologies.

## 5. Conclusion

Factors influencing the severity of stunting in children who are severely stunted is an infection with *A. lumbricoides* and in short children a protozoan infection, and although not statistically significant, the presence of a deworming program Thus, this program can be a strategy for preventing helminthiasis in severely stunted children.

## Ethics approval and consent to participate

This research was part of a main study entitled "The Relation of vitamin D, confounding and comorbid factors of stunting in an infant in Bandung District", approved by the Health Research Ethical Committee, Medical Faculty of Universitas Padjadjaran (No. 1170/UN6.KEP/EC/2019).

## Consent for publication

Not applicable.

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## CRediT authorship contribution statement

**Riyadi Adrizain:** Writing – original draft, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lia Faridah:** Data curation. **Nisa Fauziah:** Formal analysis. **Afiat Berbudi:** Supervision, Formal analysis, Conceptualization. **Deviyanthi Nur Afifah:** Writing – original draft. **Djatnika Setiabudi:** Writing – review & editing, Supervision, Conceptualization. **Budi Setiabudiawan:** Writing – review & editing, Supervision, Conceptualization.

## Declaration of competing interest

There is no conflict of interest.

## Data availability

Data supporting the write-up and conclusion of this article are provided with the articles.

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