Potential risk of stunting in children under five years living by the riverside: A systematic review

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ABSTRACT

Introduction: Stunting, or linear growth failure, is defined by a height-for-age z-score of below -2SD according to WHO growth standard. Stunting can have short-, medium-, and long-term consequences. Rivers have an important role in human life. In several riverside areas, households still depend on the river for their livelihoods and health. This study aimed to explore the prevalence of stunting in children living by the riverside and its related factors. Methods: Epidemiological studies published from PUBMED, MEDLINE via EBSCOHost, Science Direct, ProQuest, and Research Gate databases were systematically searched. The publication period was not restricted. Only open-access and English articles were examined. Results: A total of 20 from 1200 studies were reviewed. The prevalence of stunting ranged from 20% to 48.3%. The other outcomes besides stunting were wasting and underweight status. There were 83 risk factors studied, and the most studied variables were age, gender, diarrhoea, water source, parent’s education, immunisation, and inappropriate complementary feeding practices (6 to 13 studies). Household water sources from rivers and economic status were consistently correlated with stunting. Majority of the risk factors studied were related to nutrition. From the environmental aspect, the most studied risk factors were water sources and sanitation. Conclusion: Children living by the riverside face a significant risk of stunting attributed to the consistent correlation between household water sources from rivers and economic status, affecting various aspects of daily life beyond drinking water. Future research is needed to examine the impact of environmental factors and the behaviours of riverside communities.

Keywords: children, risk factor, river, riverside, stunting
INTRODUCTION

Stunting is the failure to achieve height growth, measured by a height-for-age z-score (HAZ) of <-2 standard deviation (SD) according to the World Health Organization (WHO) growth standards (Prawirohartono & Press, 2021; Vonaesch et al., 2018). In children, it is associated with many factors, including socioeconomic factors, dietary intake, recurrent infections, maternal nutritional status, infectious diseases, micronutrient deficiencies, and the environment (Stevens, Finucane, & Paciorek, 2016; WHO, 2018a).

Growth impairment can occur even in the foetus (Prendergast & Humphrey, 2014). The average length-for-age z-score (LAZ) for a baby in developing countries is -0.5 and will continue to decrease, even reaching -2.0 at the age of 18-24 months (Victora et al., 2010). However, growth impairment can continue after the age of 24 months when socio-economic influences (Alderman & Headey, 2018; Rajpal et al., 2020), education and home environment such as the use of a latrine or toilet can have a great effect between the ages of 24-59 months (Alderman & Headey, 2018; de Onis & Branca, 2016).

The disruption of growth of a child’s height can have short-term (Olofin et al., 2013), medium-term (Nguyen et al., 2021; Prendergast & Humphrey, 2014) and long-term consequences (De Lucia et al., 2018; Prendergast & Humphrey, 2014). In the short term, stunting can increase morbidity and mortality from infectious diseases, especially pneumonia and diarrhoea (Prendergast & Humphrey, 2014). The medium-term impact is related to child development such as cognitive abilities, education, and child behaviour (Cheung & Ashorn, 2010; Nguyen et al., 2021; Prendergast & Humphrey, 2014). Metabolic syndrome, usually associated with excess nutrition, is more common in adults who were stunted in early childhood than in those with normal growth (Victora et al., 2008).

Globally in 2016, as many as 22.9% or 154.8 million children under the age of 5 years suffered from stunting. In the same year, as many as 87 million stunted children lived in Asia, 59 million in Africa, and 6 million in Latin America and the Caribbean. Five sub-regions with child stunting rates that exceed 30% are West Africa (31.4%), Central Africa (32.5%), East Africa (36.7%), South Asia (34.1%), and Oceania (38.3%; excluding Australia and New Zealand) (WHO, 2018a). In 2018, around 22% of children under five worldwide were stunted. A 40% reduction in the number of stunted children is the global target for 2025 (Lissauer & Carroll, 2021).

Rivers have an important role in life. Although not in all countries, households still depend on natural capital for their livelihoods and health, including riverside areas (Ricketts et al., 2017). The river is a source of life used by a community for water resource, recreation, irrigation, and transportation (Ikhsan et al., 2021). In certain areas, the environmental health conditions of people living by the riverside do not meet WHO standards (Shinta et al., 2020). This is due to the lack of adequate sanitation facilities (Rahmadani & Ridlo, 2020) and disposal of solid and liquid waste (Bartram & Ballance, 1996; Pratama, et al., 2020; Verbyla et al., 2021). Additionally, people still defecate in public places and throw their trash into rivers (Shinta et al., 2020; Zahtamal et al., 2020). These situations will certainly have an impact on the health status of people living by the riverside, especially children.

A systematic literature review explored the prevalence of stunting and its risk factors in children who live by the riverside. Thus, the questions posed for this review were “what is the magnitude of the stunting problem in children...
under five who live by the riverside” and “what are the risk factors associated with stunting?”

**MATERIALS AND METHODS**

A review protocol was developed following the preferred reporting items for systematic review and meta-analysis PRISMA 2020 (Page et al., 2021). Literature searches were conducted in the following databases: PUBMED, MEDLINE via EBSCOHost, Science Direct, ProQuest, and ResearchGate. The publication period was not restricted. Eligibility was limited to peer-reviewed scientific articles published in the English language and open-access articles. Review articles, conference proceedings, book chapters, thesis dissertations, case reports, and all non-English language materials were excluded. The search used the following terms: (“children under five” OR child* OR preschool OR toddler*) AND (“Riverside” OR river* OR watershed*) AND (“risk factor” OR risk OR “determinant”) AND (Stunt* OR “growth disorders” OR “growth impairment” OR “growth failure” OR “growth faltering”). Another search strategy was used for the databases by limiting the number of Boolean connectors, such as “children under five” AND (“risk factor” OR determinant) AND “river” AND “stunting”.

The reviews included all epidemiological studies without being limited to the study design. The last literature search was 10th November, 2022. Data were organised according to the author, year of publication, country or national setting, sample size, study design, stunting risk factor, and outcomes. The eligible studies had to match the inclusion and exclusion criteria according to the PEO (Population, Exposure, and Outcome) approach (Table 1) (Munn et al., 2018). Qualitative studies and studies which had similar results from the same author(s) were excluded. The EndNote X9 reference manager program filtered duplicate studies and excluded research protocol or review studies.

**Table 1. The PEO Criteria for inclusion studies**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Children under five living at riverside</td>
</tr>
<tr>
<td>Exposure</td>
<td>Stunting risk factor or determinant</td>
</tr>
<tr>
<td>Outcome</td>
<td>Stunting</td>
</tr>
<tr>
<td>Study design</td>
<td>Epidemiological study</td>
</tr>
</tbody>
</table>

**RESULTS**

A total of 1200 studies from five databases were retrieved, while 39 and 56 studies were excluded because of duplication and research protocol or review studies, respectively. The next stage was filtering articles based on title, abstract and keywords. A total of 1054 articles were excluded because of they did not meet the specified inclusion criteria. Articles were excluded at this stage because they did not include the author's name (usually in large-scale or global study and collaborator authors), the outcome studied was not stunting (even though the study's sample was children under five years old), the location was not in a riverside area, and the sample was children aged more than 5 years. The number of studies that were assessed in full text were 51, but only 20 met the inclusion criteria (Figure 1).

Table 2 shows the summary of studies included in this review. The studies' publication year range was from 2006 to 2022. Geographically, most of the research was conducted in African countries; studies were also conducted in several countries in South America, South Asia, and Southeast Asia. Cross-sectional study was the most common...
study design. However, two cohort studies and one spatial study were discovered. This review included the space-time analysis study because it compared the prevalence of stunting by the riverside and other areas.

The prevalence of stunting ranged from 20% to 48.3%. The other outcomes shown besides stunting were wasting and underweight status. There were 83 risk factors studied, with the most studied variables being age, gender, diarrhoea, water source, parent’s education, immunisation, and inappropriate complementary feeding practices (6 to 13 studies). Table 3 describes the stunting risk factors studied (from the most studied to the least).

Household water sources from rivers and economic status were consistently correlated with stunting. Majority of the risk factors studied were related to nutrition, such as food diversity, breastfeeding and complementary food, as well as socio-demographic factors. From the environmental aspect, the most studied risk factors were water sources and sanitation. Figure 2 compares the significant and insignificant factors for stunting in children under five.

In Figure 2, socioeconomic class and water sources were consistently related to stunting. Although economic status and water sources had not been studied much, they need to be considered as important risk factors for

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**Figure 1.** PRISMA flowchart and selection process
### Table 2. Summary of studies

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Title</th>
<th>Country</th>
<th>Design study</th>
<th>Sample size</th>
<th>Result</th>
</tr>
</thead>
</table>
| Kinyoki et al., 2016 | Assessing comorbidity and correlates of wasting and stunting among children in Somalia using cross-sectional household surveys: 2007 to 2010 | Somalia | Cross-sectional study | 73,778 children under five years | - In geographical variation, a high risk of all forms of malnutrition in the southern regions, especially around the two main rivers of Juba and Shebelle, compared to the Northern regions of Somalia.  
- Prevalence of stunting 31%, underweight 58%, and wasting 21%.  
- (+): diarrhoea, acute respiratory infection, female child, child age, age of mother, household size, number under 5, female household head, high carbohydrate foods, high protein foods, fats, fruits, and vegetables. |
- There was a significant association between inappropriate complementary feeding practices and under-nutritional status of infants.  
- This study also found that children were at high risk of malnutrition when introduced to inappropriate complementary feeding practices such as complementary feeding at age of 0-3 months and not receiving meal diversity. |
| Fernandes, de Castro & Sartorelli, 2017 | Associated factors of malnutrition among African children under five years old, Bom Jesus, Angola | Bom Jesus, Angola | Cross-sectional study | 742 children under 5 years | - Prevalence of stunting: 22%, underweight 13%, and wasting 7%.  
- (+): Child’s age, male child, source of water from river or lake, parasite expulsion, and ear infection  
- (-): number of father’s children, fathers living with another family, parent’s age, father’s ethnicity, number of parent’s children, mother’s occupation, electricity, mother education level, number of mother’s children, number of siblings under 5 years old. |
<table>
<thead>
<tr>
<th>Author</th>
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</tr>
</thead>
</table>
| Udoh & Amodu, 2016 | Complementary feeding practices among mothers and nutritional status of infants in Akpabuyo Area, Cross River State Nigeria | Akpabuyo Area, Cross River State Nigeria | Cross-sectional study | 330 pairs of mothers and children aged 6-11 months                          | • Prevalence of stunting 24.6%, underweight 33.3%, and 26.4% wasting.  
• (+): Children who did not receive the minimum feeding frequency were more likely to be stunted than their peers who received the minimum feeding frequency and child’s age.  
(-): milk feeding frequency for non-breastfed child, hand washing with soap, diarrhoea in last 2 weeks, vitamin, minerals, supplements, hospital medicine offered in the previous 7 days. Child was sick in the previous 1 month, mother’s age, mother’s occupation, place of work, mother’s income, number of people in the household, parity, child’s gender, and birth order of child. |
| Rukambile et al., 2020 | Determinants of diarrhoeal diseases and height-for-age Z-scores in children under five years of age in rural central Tanzania | Tanzania                         | Kohort study          | 493 children under five years of age                                       | • The proportion of stunted children among the 24-34; 35-45; and 46-56 months age groups were 47.3%, 48.3%, and 33.3%, respectively.  
• The mean of diarrhoea incident was 2.3 with range of 0-16 incidents over 24 months  
• The source of water and animal kept inside the house overnight significantly correlated with both diarrhoea and stunting.  
• (+): language group of head of household, handwashing method in running water, hanging utensils after washing. |
| Guptan et al., 2007 | Early introduction of water and complementary feeding and nutritional status of children in Northern Senegal | Northern Senegal                 | Cross-sectional study | 374 children aged 6-23 months                                              | • Prevalence of stunting was 20% and wasting 16%.  
• (+): age, source of water not from river/pond. River or pond as the primary source of drinking water was also associated with recent diarrhoea. |
<table>
<thead>
<tr>
<th>Author</th>
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<th>Country</th>
<th>Design study</th>
<th>Sample size</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinyoki et al., 2016</td>
<td>Environmental predictors of stunting among children under-five in Somalia: cross-sectional studies from 2007 to 2010</td>
<td>Somalia</td>
<td>Spatial – time study</td>
<td>Data from household nutritional surveys in Somalia from 2007 to 2010 with a total of 1,066 clusters covering 73,778 children aged 6-59 months</td>
<td>• Overall, the distribution of stunting in Somalia suggested substantial spatial heterogeneity with prevalence consistently higher in the regions of the South-Central zones compared to those in the North where Agro-pastoral and riverine livelihoods found in South Central zone. The regions that consistently exceeded 40% prevalence were Bay, Gedo, Bakool, Mudug, Lower and Upper Juba. All these regions are in the South-Central zone.</td>
</tr>
<tr>
<td>Kehinde et al., 2021</td>
<td>Nutritional status of under five children in the Cameroonian Refugee Settlement in Ogoja, Cross River State, Nigeria</td>
<td>Nigeria</td>
<td>Descriptive cross-sectional study</td>
<td>211 children aged 6-59 months</td>
<td>• Prevalence of stunting was 41.7%, underweight 38.4%, and 26.8% wasting. • An overview of the risk of stunting based on the characteristics of the mother and household were as follows: 55.8% mothers’ age was 25-34 years, 79.8% mothers age at delivery of first child was 14-17 years, 96.2% households had one child under five years old, 45.2% household often hungry, 70.2% households had 5 or more family members. • An overview of the risk of stunting based on characteristics and caring practices of under-five children were as follows: mean of ages was 30.33 months, 56.7% children were females, 83.2% of children under-five were exclusively breastfed for six months. Majority (55.8%) of children under-five were not fully immunised, and 29.8% had diarrhoea preceding two weeks.</td>
</tr>
</tbody>
</table>
Prevalence and determinants of undernutrition among children under 5-year-old in rural areas: A cross-sectional survey in North Sudan

- Prevalence of stunting was 42.5%, underweight 32.7%, and 21% wasting.
- Stunting was highest among 48-60 months age group.
- Based on gender, boys had poorer indicators of undernutrition.
- (+): age, gender, poorer household sanitation, and socio-economic class. The number of family members, less distance between families, and the baby being weaned suddenly are considered risk factors for malnutrition.

Schistosomiasis, intestinal helminthiasis and nutritional status among preschool-aged children in sub-urban communities of Abeokuta, Southwest, Nigeria

- Prevalence of stunting was 39.5%, underweight 22.8%, and 11.4% wasting.
- There was no significant correlation between infected intestinal helminths, schistosomiasis, co-infection of schistosomiasis and intestinal helminths with stunting.
- Mean z-scores were generally lower in infected than non-infected children, but not significantly different.
- Children exposed to river were 61%. Bathing (20.2%) was the major activity predisposing to infection, and 63.6% bathed with water from the river at home. 13.2% households still depended solely on water from the river for domestic usage.
- From sanitation aspect, 16.2% of the parent/caregiver engaged in open defaecation in surrounding bushes and 1.8% directly into the river.
- From hygiene aspect, only 9% children had washed their hands with soap before eating. 63.55 had dirty fingers, and 92.3% had slippers/shoes.

<table>
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<tr>
<th>Author</th>
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<th>Country</th>
<th>Design study</th>
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<th>Result</th>
</tr>
</thead>
</table>
| Sulaiman et al., 2018 | Prevalence and determinants of undernutrition among children under 5-year-old in rural areas: A cross-sectional survey in North Sudan | River Nile state (RNS) in North Sudan | Cross-sectional study | 1477 children under 5 years     | - Prevalence of stunting was 42.5%, underweight 32.7%, and 21% wasting.  
- Stunting was highest among 48-60 months age group.  
- Based on gender, boys had poorer indicators of undernutrition.  
- (+): age, gender, poorer household sanitation, and socio-economic class. The number of family members, less distance between families, and the baby being weaned suddenly are considered risk factors for malnutrition. |
| Adeniran et al., 2017 | Schistosomiasis, intestinal helminthiasis and nutritional status among preschool-aged children in sub-urban communities of Abeokuta, Southwest, Nigeria | Abeokuta, Southwest, Nigeria | Cross-sectional study | 241 children aged 0-71 months     | - Prevalence of stunting was 39.5%, underweight 22.8%, and 11.4% wasting.  
- There was no significant correlation between infected intestinal helminths, schistosomiasis, co-infection of schistosomiasis and intestinal helminths with stunting.  
- Mean z-scores were generally lower in infected than non-infected children, but not significantly different.  
- Children exposed to river were 61%. Bathing (20.2%) was the major activity predisposing to infection, and 63.6% bathed with water from the river at home. 13.2% households still depended solely on water from the river for domestic usage.  
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Mengesha et al., 2021

**The prevalence of stunting and associated factors among children under five years of age in Southern Ethiopia: Community based cross-sectional study**

- **Prevalence of stunting** was 37.7%.
- *Factors:* age (older), family size (more than five members), number of under-five children in the household (two or more), wealth status, source of drinking water (river, pond, or a spring), access to diversified diet, and household food security status.

Sanchez et al., 2015

**Needs, acceptability, and value of humanitarian medical assistance in remote Peruvian Amazon riverine communities**

- **Prevalence of stunting** 20%, wasting 3%, mean of Hb 11.2g/dL, and prevalence of anaemia 37%. Prevalence of one or more intestinal parasites was 62%.
- **Immunisation and reported health status:** only 71% of children over 1 year completed the full Peruvian immunisation schedule. The caretakers reported that 49% of their children had a cough, 34% had a fever, and 29% had diarrhoea 2 weeks before surveys. They also reported that 61% of their children had good physical well-being and 67% had good emotional well-being.

Kempton et al., 2021

**An assessment of health outcomes and methylmercury exposure in unduruku indigenous women of childbearing age and their children under 2 years old**

- **Of 16 infants,** four (25%) were found to be moderately to severely stunted and only one infant found to be underweight.
- **Anaemia was found** in 6 of 12 infants aged 6-24 months.
- **Of 16 infants,** 3 (18.75%) had H-Hg levels over 6.0 µg/g.

Anticona & Miguel San, 2014

**Anaemia and malnutrition in indigenous children and adolescents of the Peruvian Amazon in a context of lead exposure: a cross-sectional study**

- **Prevalence of stunting in children aged 0-4 years** was 42.1%, underweight 31.6%, and wasting 6.5%.
- *Factors:* underweight, age group, and blood lead levels ≥5µ/dL
Table 2. Summary of studies (continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Country</th>
<th>Design study</th>
<th>Sample size</th>
<th>Result</th>
</tr>
</thead>
</table>
| Benefice et al., 2006 | Nutritional status of Amerindian children from the Beni River (lowland Bolivia) as related to environmental, maternal and dietary factors | Beni River (lowland Bolivia) | Cross-sectional study          | 354 children aged 0-10 years old (175 children aged less than 5 years old) | - Prevalence of stunting in children less than 5 years was 41%.
- During survey, main alleged cause of children's illness was simple diarrhoea (20%).
- This study found 75% children positive for at least one helminth.
- After adjusting for age, risk factors for malnutrition (height-for-age) were ethnic group, clinical status, and food diversity. |
| Yori et al., 2014 | Santa Clara de Nanay: the MAL-ED cohort in Peru                      | Santa Clara de Nanay, Peru   | Cohort Study. Data were analysed descriptively. | 270 households with children under 5 years | - Prevalence of stunting was 46.3% and 0.2% wasting.
- 20.3% of children in the cohort were stunted at 3 months of age; this rose to 38.2% by 12 months, 43.7% by 24 months, and 55.9% by 36 months of age.
- Risk factors studied: Access to clean water, improved toilet/sanitation, maternal level of education electricity in household, cooking with fuel, charcoal or wood, wall material from wood, household without concrete or wood floor, roofing material made of thatch, iron, etc. |
| Roche, Creed-Kanashiro et al., 2011 | Infant and young child feeding in the Peruvian Amazon: the need to promote exclusive breastfeeding and nutrient-dense traditional complementary foods | Peru                         | Descriptive cross-sectional study | 32 children aged 0-23 months                                             | - Prevalence of stunting was 39.4%.
- Only 12.6% of mothers had stopped breastfeeding before 1 year of age.
- Adequate intake of energy and protein from complementary food in comparison with WHO recommendation.
- Vitamin A, iron, zinc, and calcium were still inadequate in comparison with WHO recommendations. |
### Table 2: Summary of studies (continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Country</th>
<th>Design study</th>
<th>Sample size</th>
<th>Result</th>
</tr>
</thead>
</table>
| Muldiawan, et al., 2008 | Can early initiation to breastfeeding prevent stunting in 6-59 months old children? | Jambi Province, Indonesia                     | Cross-sectional study from National Nutrition Survey in Jambi province in 2015 | 2,502 children aged 6-59 months | - Prevalence of stunting: 27.5% (95% CI: 25.2-29.9)
|                   |                                                                      |                                              |                                                                             |                              | • (+): Early initiation of breastfeeding, birth weight, diarrhea, house structure, water source, living in rural region, parent’s ethnicity and age |
| Febry et al., 2022 | Identification of food diversity factors to overcome stunting in toddlers on the Musi River suburbs, Palembang South Sumatra, Indonesia | South Sumatera, Indonesia                    | Cross-sectional study                                                      | 170 children aged 6-59 months | • Only 54.7% households had food diversity for children’s diets.
|                   |                                                                      |                                              |                                                                             |                              | • Factors related to food diversity in household were mother’s education and food availability. |
| Islam et al., 2014 | Nutritional status of under 5 children belonging to tribal population living in riverine (Char) areas of Dibrugarh district, Assam | Dibrugarh district, Assam, India             | Cross-sectional study                                                      | 500 children under five years | • Prevalence of stunting was 30.4%, underweight 29%, and 21.6% wasting. |
|                   |                                                                      |                                              |                                                                             |                              | • Prevalence of stunting was highest in the age group 48-60 months (58.6%), followed by 57.3% in the age group 36-48 months. |
|                   |                                                                      |                                              |                                                                             |                              | • (+): gender, socioeconomic class, literacy status of both parents, exclusive breastfeeding, colostrum, age of introducing complementary foods |
|                   |                                                                      |                                              |                                                                             |                              | (-): number of family members and pre-lacteal feed given. |

(+) Significant risk factor
(-) Insignificant risk factor
Table 3. Research variables related to stunting in children under five years

<table>
<thead>
<tr>
<th>No</th>
<th>Research variable</th>
<th>No</th>
<th>Research variable</th>
<th>No</th>
<th>Research variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>29</td>
<td>Birth order of child</td>
<td>57</td>
<td>Number of parent’s children</td>
</tr>
<tr>
<td>2</td>
<td>Gender</td>
<td>30</td>
<td>Type of house floor</td>
<td>58</td>
<td>Feeding frequency</td>
</tr>
<tr>
<td>3</td>
<td>Diarrhoea</td>
<td>31</td>
<td>Parent’s literacy</td>
<td>59</td>
<td>Mother’s illness</td>
</tr>
<tr>
<td>4</td>
<td>Water source</td>
<td>32</td>
<td>Source of safe water (pipe/deep well/others)</td>
<td>60</td>
<td>Milk feeding frequency</td>
</tr>
<tr>
<td>5</td>
<td>Parent’s education</td>
<td>33</td>
<td>Birth weight</td>
<td>61</td>
<td>Mother’s income</td>
</tr>
<tr>
<td>6</td>
<td>Immunisation</td>
<td>34</td>
<td>House structure</td>
<td>62</td>
<td>Animal kept inside the house</td>
</tr>
<tr>
<td>7</td>
<td>Inappropriate complementary feeding practices</td>
<td>35</td>
<td>Living in rural region</td>
<td>63</td>
<td>Language group of head of household</td>
</tr>
<tr>
<td>8</td>
<td>Early initiation to breastfeeding</td>
<td>36</td>
<td>Length at birth</td>
<td>64</td>
<td>Hanging utensils after washing</td>
</tr>
<tr>
<td>9</td>
<td>Exclusive breastfeeding</td>
<td>37</td>
<td>Cold</td>
<td>65</td>
<td>Handwashing with running water</td>
</tr>
<tr>
<td>10</td>
<td>Sanitation</td>
<td>38</td>
<td>Shortness of breath in previous month</td>
<td>66</td>
<td>Use of dry utensils</td>
</tr>
<tr>
<td>11</td>
<td>Parent’s occupation</td>
<td>39</td>
<td>Quality of water source</td>
<td>67</td>
<td>Water source sharing with animal</td>
</tr>
<tr>
<td>12</td>
<td>Age of mother</td>
<td>40</td>
<td>Number of household members</td>
<td>68</td>
<td>Interaction of human-animal.</td>
</tr>
<tr>
<td>13</td>
<td>Number of children under 5 years</td>
<td>41</td>
<td>Good physical well-being</td>
<td>69</td>
<td>Receiver of hygiene education</td>
</tr>
<tr>
<td>14</td>
<td>Number of people in the household</td>
<td>42</td>
<td>Good emotional well-being</td>
<td>70</td>
<td>Riverine livelihood</td>
</tr>
<tr>
<td>15</td>
<td>Parent’s ethnicity</td>
<td>43</td>
<td>H-hg level</td>
<td>71</td>
<td>Prelacteal feed given</td>
</tr>
<tr>
<td>16</td>
<td>Hand washing with soap</td>
<td>44</td>
<td>Underweight</td>
<td>72</td>
<td>Maternal adiposity</td>
</tr>
<tr>
<td>17</td>
<td>Fever</td>
<td>45</td>
<td>Blood lead level</td>
<td>73</td>
<td>Maternal stature</td>
</tr>
<tr>
<td>18</td>
<td>Female household head</td>
<td>46</td>
<td>High exposure to oil activity</td>
<td>74</td>
<td>Mother’s age at delivery of first child</td>
</tr>
<tr>
<td>19</td>
<td>Vitamin A</td>
<td>47</td>
<td>Anaemia</td>
<td>75</td>
<td>Household often hungry</td>
</tr>
<tr>
<td>20</td>
<td>Parasite infection</td>
<td>48</td>
<td>Acute respiratory infection</td>
<td>76</td>
<td>Family income</td>
</tr>
<tr>
<td>21</td>
<td>Food diversity</td>
<td>49</td>
<td>Household size</td>
<td>77</td>
<td>Type of cooking fuel</td>
</tr>
<tr>
<td>22</td>
<td>Socioeconomic class</td>
<td>50</td>
<td>High-carbohydrate foods</td>
<td>78</td>
<td>Type of wall</td>
</tr>
<tr>
<td>23</td>
<td>Visiting community base health service</td>
<td>51</td>
<td>High-protein foods</td>
<td>79</td>
<td>Dirty fingers</td>
</tr>
<tr>
<td>24</td>
<td>Cough</td>
<td>52</td>
<td>Fats</td>
<td>80</td>
<td>Had slippers/shoes</td>
</tr>
<tr>
<td>25</td>
<td>Boiling drinking water</td>
<td>53</td>
<td>Fruits and vegetable</td>
<td>81</td>
<td>Food security status</td>
</tr>
<tr>
<td>26</td>
<td>MUAC of mother</td>
<td>54</td>
<td>Suspected measles</td>
<td>82</td>
<td>Breastfeeding</td>
</tr>
<tr>
<td>27</td>
<td>Electricity</td>
<td>55</td>
<td>Number of father’s children</td>
<td>83</td>
<td>Inadequate nutrition intake</td>
</tr>
<tr>
<td>28</td>
<td>Number of mother’s children</td>
<td>56</td>
<td>Father lives with another family</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
stunting. The majority of studies showed that the age of the child was related to stunting (11 of 12); the older the age of the child, the higher the prevalence of stunting. Parent’s occupation, vitamin A supplementation, hand wash, and immunisation have also consistently been shown to be unrelated to stunting. However, apart from parental occupation, these three insignificant variables should be investigated further because they were found in three studies to be significantly related to stunting. Early breastfeeding initiation, inappropriate complementary feeding practices, parent’s ethnicity, number of children under the age of five in the household, exclusive breastfeeding, gender, and diarrhoea had all been extensively studied (more than five studies), but the evidence had been inconclusive. The remaining variables were not included in Figure 2, because they were only found in two or fewer studies.

**DISCUSSION**

**Socio-demography**

Socio-demography is a study exploring the determinants and consequences of population size, distribution and composition of the demographic process (Murdock, 2019). Referring to the determinants of stunting by WHO, these social and demographic factors are the foundation of various factors that directly cause stunting (WHO, 2014). This study found that the most studied socio-economic-demographic factors related to stunting were age of children, gender, parental education and occupation, parental ethnicity, and socio-economic class. A study on children aged 0-36 months in 179 demographic and health
surveys from 64 low- and middle-income countries (1993-2015) showed a trend of decreasing average HAZ in children with increasing age (Roth et al., 2017). This finding is in line with the prevalence of stunting found in other studies in which children aged over 24 months have a greater risk of experiencing stunting than children aged under 24 months (Adhikari et al., 2019; Atlas, 2020; Blankenship et al., 2020; Khan et al., 2019; Mengesha et al., 2021; Mutunga et al., 2021; Rajpal et al., 2020; Roba et al., 2021). The risk of stunting between males and females in this study was still inconclusive. The results of the study found that females were more at risk of experiencing stunting in Asia (Khatun et al., 2004), and vice versa in research in the African region (Wamani et al., 2007).

Economic vulnerability can occur in communities living in riverside areas. Research from Brazil found that the majority of riverside residents were involved in the agricultural sector, with 65.8% having a family income of up to 1 minimum wage (Rodrigues et al., 2020). Furthermore, in the urban area, households that do not have adequate income will be forced to live near the river. This condition is very likely to form a slum area, which is identical with poor sanitary and drainage. This study found economic status to be consistently correlated with stunting. This finding is considered very important because they are related to the family’s ability to meet the nutritional needs of children, prevent infectious diseases, and access a healthy home environment.

Maternal health
Factors of nutritional status and maternal health can lead to stunting in children. In this study, from the aspect of maternal health, the variables found were age of the mother, mid-upper arm circumference (MUAC) of the mother, number of mother’s children, mother’s illness, maternal adiposity, maternal stature, and mother’s age at delivery of the first child. Maternal age was found to be significant in four studies, while the others were only present in one to two studies. Therefore, maternal health still cannot be concluded in this research. Malnutrition during preconception, pregnancy and breastfeeding, mother’s short stature, intrauterine growth restriction (IUGR), premature birth, and teenage pregnancy have been shown to be associated with stunting (Beal et al., 2018). Pregnant women require approximately 10-15% more energy than non-pregnant women. A deficiency of energy and protein causes pregnant women to be unable to meet the nutritional needs for foetal growth and development (Achadi et al., 2020; Li et al., 2020).

Short adult women represent a history of suboptimal growth in height, not only due to genetic factors, but also a long history of malnutrition and chronic recurrent infections. This affects organ development. Short pregnant women are at risk of having low birth weight (LBW), small-for-gestational age (SGA), or short babies (Achadi et al., 2020). Several studies have found a strong correlation between mothers who have a short stature and stunting in children (Beal et al., 2018; Li et al., 2020; Oddo et al., 2012; Rachmi et al., 2016; Svefors et al., 2019).

Household condition
Stunting can occur as a result of household conditions. This study found that the variables related to stunting were the number of children under 5 years of age, density of people in the house, electricity, type of house floor, wall, cooking fuel, house structure, high exposure to oil activity, animal kept inside the house, interaction between humans and animals, and hunger and food security status.
Food security refers to the ability of individuals or groups to accomplish access to good, safe and nutritious food. Family food security status is a crucial factor that can affect the nutritional status of family members, especially children under 5 years (Fadzila & Tertiyus, 2019; Helmyati et al., 2019; Raharja et al., 2019; Safitri & Nindya, 2017). The number of family members also plays a role in household food availability. A large number of children and family members will affect the food intake of children in the family (Helmyati et al., 2019; Titaley et al., 2019).

The quality of housing can affect people’s health. The various characteristics of housing by the riverside depend on their socio-economic developmental level and cultures. The slum residential areas may be found in urban rivers with low socioeconomic levels. Otherwise, a high-quality living environment can be realised with the support of urban planning and development.

Poor housing is associated with a wide range of health conditions such as respiratory diseases including asthma, cardiovascular diseases, injuries, mental health, and infectious diseases including tuberculosis, influenza, and diarrhoea (WHO, 2018b). The improved housing criteria based on the United Nations are improved drinking water, improved sanitation, sufficient living area, and finished building materials (Tusting et al., 2020).

**Water sanitation and hygiene (WaSH)**

WaSH can be a determining factor in the incidence of stunting (Cumming & Cairncross, 2016; Helmyati et al., 2019). Inadequate WaSH can result in malnutrition (WHO, 2019). Mechanisms that play a role in the link between WaSH and malnutrition include recurrent diarrhoea, worm infections (soil-transmitted helminths, STH) such as *Ascaris lumbricoides*, *Trichuris triichiura*, *Ancylostoma duodenale*, and *Necactor americanus*, and subclinical conditions of the gastrointestinal tract. The exposure to enteric pathogens and symptomatic and asymptomatic infections mediates the impact of WaSH on undernutrition (Budge et al., 2019; Helmyati et al., 2019; WHO, 2019; Zavala, et al., 2021).

Of these three factors, water sources from rivers are consistently associated with stunting. As a result of human activities, both chemical and biological river water pollution can occur. Human activities strongly influence the concentration of faecal coliform. The presence of faecal coliform almost always indicates water contamination by faeces, both human and animal (Bartram & Ballance, 1996). Several studies showed contamination of river water by faecal coliform (Pratama et al., 2020), *Cryptosporidium spp*, *Giardia spp* (Tandukar et al., 2018), and *Escherichia coli* (Verbyla et al., 2021).

In addition to biological pollution, chemicals originating from industry or mining can pollute river water. We found one study on H-Hg levels in children, which exceeded maximum level (Kempton et al., 2021) and one study on blood lead levels, which correlated with stunting (Anticona & Miguel San, 2014).

**Breastfeeding**

The most efficient method for ensuring that children receive adequate nutrition is through breastfeeding. Breast milk is believed to benefit infant growth because of its appropriate nutrient composition for children’s nutritional requirements (Sirajuddin et al., 2020). Inadequate breastfeeding in the WHO framework related to stunting includes non-exclusive breastfeeding, early initiation of breastfeeding, and weaning (Beal et al., 2018). A study in Indonesia found that stunting occurred outside the age
period of breastfeeding (Sirajuddin et al., 2020). In this study, two of four articles found non-exclusive breastfeeding as a risk factor, but this was still inconclusive.

Dietary intake
Food diversity and the amount of food a child eats per day are significant determinants of stunting and underweight status in children under 5 years of age (Hashmi et al., 2021; Motbainor, Worku & Kumie, 2015). Adequacy of child nutrition includes adequacy of macronutrients and micronutrients; whereby carbohydrates, proteins, and fats fulfill the macronutrient needs (Sudargo, Aristasari & Afifah, 2018). Deficiency of some common micronutrients are vitamin A, zinc, ferum, and iodine (Black et al., 2008), which can affect various aspects of physiology, including immune function and neurodevelopment (Prendergast & Humphrey, 2014).

Inappropriate complementary feeding practices have been extensively studied and showed their potential as a risk factor for stunting. The other variables related to dietary intake were food diversity, high carbohydrate, protein, and fat foods, fruits and vegetables consumption, feeding frequency, and inadequate nutrition intake. They were only found in 1-2 articles; therefore, no conclusion could be drawn from them.

Infection
According to WHO, infectious diseases in children that cause stunting include both clinical and subclinical, namely digestive infections (diarrhoea, environmental enteropathy, and worm parasitic infections), respiratory tract infections, and malaria (Beal et al., 2018). Infectious diseases including diarrhoea, respiratory infections, and fever are associated with stunting in children aged 6–59 months living in urban and rural poor areas (Bardosono, Sastroamidjojo & Lukito, 2007). Additionally, Semba et al. (2007) reported that children aged 12-59 months who received complete, partial, or no immunisation had a stunting prevalence of 37%, 47%, and 54%, respectively (Semba et al., 2007). Diarrhoea as a risk factor for stunting was found in five and three articles for parasite/helminth infection. However, both are still inconclusive evidence.

Infectious diseases are highly correlated with the environment. A study found that almost half of the children living by the riverside had experienced diarrhoea in the previous month, with sanitation and water sources as significant risk factors (Susanti, 2019). The other study found that upstream river pollution caused by bathing and sanitary practices explained as many as 7.5% of all diarrhoea-related deaths annually (Garg et al., 2018). Therefore, poor environmental conditions can increase the risk of infectious diseases. Recurrent infections in children will eventually lead to malnutrition, including stunting.

CONCLUSION
The river is a source of life for the communities around it. The prevalence of stunting in children under five years living by the riverside ranged from 20% to 48.3%. Household water sources from rivers and economic status were consistently correlated with stunting. Water sources were an important risk factor for stunting in children living by the riverside. This was not only limited to the use of river water as a source of drinking water, but also for cooking, bathing, sanitary practices, and cleaning food equipment. Although the studied variables aligned with established stunting determinants, further investigation is required to explore the influence of environmental factors and the behaviours of individuals residing by the riverside.
Stunting in children living by the riverside

Authors’ contributions
Bambang W, Ririn A and Ridha R, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Umar FA, Tri YM, Defriman D and Miko H, reviewed the manuscript.

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Conflict of interest
Authors declare no conflict of interest in this research.

References


Stunting in children living by the riverside


