# The Relationship Between Micronutrient Deficiency in Iron, Zinc, and Vitamin A and the Incidence of Stunting in Toddlers Based on Epidemiological Findings: A Literature Review

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## ABSTRACT

Indonesia continues to face significant nutritional problems, particularly stunting, which remains among the highest in the world. Nutrition is a critical determinant of growth and development, and micronutrient deficiencies may contribute substantially to linear growth failure. This literature review aimed to synthesise epidemiological evidence on the relationship between deficiencies of iron, zinc, and vitamin A and the incidence of stunting in toddlers. A literature review was conducted using PubMed, ScienceDirect, and Google Scholar, with article selection guided by the PICO framework. Search terms comprised micronutrient deficiency, iron, zinc, and vitamin A deficiency, stunting incidence, and epidemiological studies of micronutrient deficiency and stunting. Eleven studies met the eligibility criteria, comprising ten cross-sectional or case-control studies and one comparative cross-sectional study. Iron intake or adequacy was significantly associated with stunting in eight of ten studies that examined it, with reported p-values ranging from 0.012 to 0.042 and one study reporting an odds ratio of 1.784. Zinc adequacy was significantly associated with stunting in four of five studies examining it (p=0.001 to p=0.030). Findings for vitamin A were inconsistent: four studies reported significant associations (p=0.000 to p=0.002), whereas two reported no significant relationship. The available evidence supports an association between iron and zinc deficiency and stunting in toddlers, while evidence for vitamin A is less consistent. Given the predominance of cross-sectional designs and the resulting inability to establish temporality, these findings should be interpreted as associational rather than causal, and further prospective research is required.

**Keyword :** Iron; micronutrient deficiency; stunting; toddlers; vitamin A; zinc

## Introduction

Micronutrients are a general term used to represent essential vitamins and minerals needed from food to maintain almost all normal cellular and molecular functions. Although the amount of micronutrients required is very small, *Micronutrient Deficiency* (MND) can have widespread negative health effects that can ultimately lead to death if left untreated[2]. Anss estimated 2 billion people worldwide are affected by MND caused by a lack of vitamin A, folate, zinc, iodine, and zinc, where part of the cycle of malnutrition can be accompanied by protein or energy deficiency. Micronutrient adequacy status can be determined along this continuum using biomarkers, dietary intake data, or nonspecific functional indicators, such as stunting or low birth weight[2].

In terms of nutrition, Indonesia still has nutritional problems, particularly stunting, which ranks fifth and fourth in the world. According to data from the WHO, 22.2% or around 150.8 million cases of stunting occur in toddlers[4]. Furthermore, data from the 2018 Riskesdas shows a stunting prevalence of 30.8% and fruit and vegetable consumption below the recommended level of 95.5%, meaning that the community is not meeting the recommended intake[18]. Meanwhile, the prevalence of malnourished toddlers is around 17.7%[18]. Epidemiological studies explain that in the epidemiological triad, there are three interactions between pathogens, namely the host, which is a factor in humans that can influence and develop disease; the agent, which can cause disease or influence the course of disease; and the environment, which is everything that surrounds humans and influences human life and development[12]. Host variables include maternal education, maternal knowledge, history of exclusive breastfeeding, history of infectious diseases, and socioeconomic status. The environment is everything that surrounds humans and affects their life and development[12]. Host variables include maternal education, maternal knowledge, history of exclusive breastfeeding, history of infectious diseases, and socioeconomic status[9]. Growth retardation in children or toddlers can lower immunity and increase the risk of infection, thereby increasing the incidence in toddlers, which requires serious treatment [6].

In treating stunting, nutrition is an important factor to consider because it influences growth and development. Nutrition is divided into two categories: macronutrients, which include protein, lipids, and carbohydrates; and micronutrients, which include vitamins and minerals. One mineral that is essential for the body is iron or Fe[17]. In addition**,** vitamin A, zinc, and iodine are also micronutrients that are crucial in preventing stunting[17]. Based on

the above description, iron, zinc, and vitamin A are factors that contribute to stunting in toddlers, which has an impact on child growth and development and the risk of non-communicable diseases in the future. Therefore, the purpose of this study is to prove the relationship between iron, zinc, and vitamin A micronutrient deficiencies and stunting in toddlers.

## Material and Methods

### Study Design

This study employed a literature review design. The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to ensure transparency in study identification and selection.

### PICO Framework

The PICO framework guided the search strategy and eligibility assessment (Table 1).

**Table 1. PICO framework**

| Component | Description |
|---|---|
| Population | Toddlers (children under five years of age), with particular focus on ages 6–59 months |
| Intervention / Exposure | Iron, zinc, and vitamin A deficiency, assessed through dietary intake, adequacy level, or supplementation status |
| Comparison | Non-stunted toddlers, or toddlers with adequate micronutrient intake or status |
| Outcome | Incidence of stunting, defined by height-for-age z-score (HAZ) below −2 SD |

### Search Strategy

Articles were retrieved from PubMed, ScienceDirect, and Google Scholar. Search terms combined the following concepts using Boolean operators: (“micronutrient deficiency” OR “iron deficiency” OR “zinc deficiency” OR “vitamin A deficiency”) AND (“stunting” OR “linear growth faltering” OR “height-for-age”) AND (“toddler” OR “children under five” OR “under-five”). Searches were conducted in English and Indonesian. Reference lists of included articles were hand-searched to identify additional relevant sources.

### Eligibility Criteria

**Inclusion criteria:** (1) original observational research, including cross-sectional, case-control, and comparative designs; (2) publication between 2015 and 2025; (3) human participants aged under five years; (4) exposure or intervention involving at least one of iron,

zinc, or vitamin A, measured by dietary intake, adequacy level, biomarker, or supplementation status; (5) outcome reported as stunting or height-for-age z-score.

**Exclusion criteria:** (1) case reports and case series; (2) reviews, editorials, and conference abstracts; (3) studies restricted to children older than five years; (4) studies without extractable quantitative outcome data on the micronutrient–stunting association.

**Study Selection and Data Extraction**

Database searching identified records which were screened by title and abstract, followed by full-text assessment against the eligibility criteria. Duplicate records were removed. Data were extracted into a standardised matrix capturing author, year, study design, sample characteristics, micronutrient exposure, and reported outcome measures with statistical estimates.

**Data Synthesis**

Because the included studies were heterogeneous in design, micronutrient exposure definition, and outcome reporting, quantitative meta-analysis was not appropriate. Findings were synthesised narratively and organised by micronutrient (iron, zinc, and vitamin A), with explicit attention to convergent and divergent results. Reported p-values and effect estimates were extracted verbatim from each study.

## Results

**Characteristics of Included Studies**

Eleven studies met all eligibility criteria and were included in the synthesis (Table 2). Study designs comprised cross-sectional studies (n=7), case-control studies (n=3), and one comparative cross-sectional study (n=1). Sample sizes ranged from 55 to approximately 3,025 participants, with participants aged between 6 and 59 months. Studies were conducted across multiple Indonesian settings, including Nipah, Maros Baru, Bulak Banteng, Banyuasin, North Raman, Gianyar, Mulyorejo, Radamata, Suci Village, and Bogor Regency. Six studies examined iron alone or in combination with other macronutrients, five examined zinc, and six examined vitamin A. One study additionally examined estimated iron and zinc bioavailability.

**Table 2. Characteristics and findings of included studies**

| No | Author & Year | Title | Research Method | Results |
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| 1. | Zakiyyah, et al. (2025) | The Relationship Between Iron (Fe) Intake and | Research design: case control. | Statistical tests of iron consumption and stunting incidence showed a p- |

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| | | Stunting Incidence in Toddlers Aged 24-59 Months in the Nipah Health Center Work Area | Samples: toddlers aged 24-59 months residing within the working area of the Nipah Community Health Center. | value of 0.042. This indicates that stunting incidence and iron intake are mutually related. |
| 2. | Sirajuddin, et al. (2020) | Iron Intake Correlates with the Incidence of Stunting in Toddlers in Maros Baru District | Research design: cross-sectional study<br><br>Samples: The sample size in this study was determined based on the sample proportion estimation calculation method. The estimated proportion of stunted toddlers in Maros District is 35%, with 95% confidence, and using an estimated difference between the population and sample values (d) of 0.10 points, the minimum sample size is 151 people. | The results of the study show that there is a significant positive correlation between Fe intake and TB/U z-score, p=0.036. |

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| 3. | Fatimah & Wirjatmadi (2018) | Levels of Vitamin A, Zinc, and Iron Adequacy and Infection Frequency in Stunted and Non-Stunted Toddlers | Research design: cross-sectional<br><br>Samples: 3,025 toddlers registered in the Bulak Banteng Community Health Center working area. | There were significant differences between the stunted and non-stunted groups in terms of vitamin A adequacy (p=0.002), zinc (p=0.003), and iron (p=0.030). |
| 4. | Silaban, et al. (2022) | Differences in Vitamin A, Iron, and Zinc Adequacy Levels in Infants Stunting and Non-stunting in Banyuasin District | Research design: Cross-sectional.<br><br>Samples: The sample of this study was 98 toddlers aged 13-23 months in Banyuasin Regency in 2021, collected by simple random sampling technique | There is a significant relationship between vitamin A adequacy levels with a p-value of 0.002, iron adequacy levelswith a p-value of 0.012, and zinc sufficiency levels with a p-value of 0.030 in stunting and non-stunting in toddlers. |
| 5. | Kundarwati , et al. (2022) | The relationship between protein, vitamin A, zinc, and iron intake and stunting in children aged 1-3 years | Study design: Case Control approach<br><br>Samples: 60 toddlers aged 1-3 years. 30 toddlers as the case group and 30 toddlers as the control group at the North Raman Health Center, East Lampung Regency | There was a relationship between protein intake and the incidence of stunting (p = 0.000); there is a relationship between zinc intake and the incidence of stunting (p = 0.001); there is a relationship between BSI intake and the incidence of stunting (p = 0.005). However, there was no relationship between vitamin A intake and the incidence of stunting (p = 0.078). The conclusion of |

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| | | | | the research that the genesis of stunting was correlated to the intake of protein, zinc and iron but it was not correlated to the intake of vitamin A. |
| 6. | Anzi, et al. (2024) | The Relationship Between Protein, Carbohydrate, and Iron Intake and Stunting in Toddlers in the Gianyar Health Center Area 1 | Research method: Cross-sectional<br><br>Samples: The study included a total of 70 children under five years of age. Regarding sex distribution, females accounted for the majority of the sample, comprising 36 participants (49%). The participants' ages ranged from 25 to 37 months on average. | There is relationship between intake of protein, kh , and iron (FE) on incidence stunting as indicated by the value α < (0.05). With contingency coefficient value of 0.324 protein.<br>Intake kh 0.354 and intake of iron (FE) 0.338. results this study it was suggested to families to pay attention amount intake toddlers both in womb and at birth and to carry out nutritional counseling at posyandu |
| 7. | Putri, et al. (2024) | The relationship between vitamin A supplementation, giving immunization, and history of infectious diseases on the incidence of stunting in children aged 24-59 months | Method: observational analytic study with cross sectional<br><br>Samples: 107 children aged 24-59 months at Puskesmas Mulyorejo, | The results of this study indicated that there was a relationship between vitamin A supplementation and with stunting (p = 0.000). There was no relationship between immunization and stunting (p = 0.332). In the history of infectious diseases, the |

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| | | at the Mulyorejo Community Health Center | Surabaya. This study consisted of 25 children in the stunting group and 82 children in the non-stunting group | frequency of diarrhea and ARI was found to have no relationship with stunting (p = 0.053 and p = 0.082), as well as the duration of diarrhea and duration of ARI there was no association with the stunting (p = 0.614 and p = 0.918). |
| 8. | Natara, et al. (2023) | Macro and micro nutrient intake and stunting among toddlers aged 12-59 months in the Radamata Community Health Center working area. | Study design: A case-control study<br><br>Samples: 80 children aged 12-59 months conducted in Radamata Public Health Center working area | This study showed that there was a significant relationship between energy intake (p,0.05) and fat intake (p<0.05) with OR= 9.08 (95% CI=3.28-5.08) and 3.56 (95% CI 1.40 - 9.08). The risk of stunting in toddlers whose energy and fat deficient is 9.08 times greater and 3.56 times greater than toddlers whose energy and fat intake is sufficient. |
| 9. | Dewi, et al. (2017) | Correlation Between Iron and Zinc Adequacy Level With Stunting Incidence In Children Aged 6 - 23 Months | Study design: cross sectional<br><br>Samples: 55 children spread over 25 Posyandu in Suci Village. | The results showed 14.5% oftoddlers age 6 –23 months were stunted. 33.3% of children were given inadequate iron intake and 35.7% of children were given inadequate zinc intake. The analysis test showedthere was a significant correlation between levels of iron and zinc adequacy with |

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| | | | | the incidence of stuntingwith p=0.02and p=0.018. |
| 10. | Wulandary et al. (2021) | Nutrition Intake and Stunting of Under-Five Children in Bogor West Java, Indonesia | Study design: cross sectional<br><br>Samples: Children aged 6-59 months in Bogor | The results showed that the percentage of children under five with stunting was 43.0%. Iron intake had a significant relationship with the incidence of stunting under five (p=0.018; OR=1.784; 95% CI: 1.106-2.278) after controlling variables of gender, energy intake, protein intake, fat intake, carbohydrate intake, and vitamin an intake. The risk of stunting in under-five can be reduced by providing variety of macro and micro nutrients specialy iron and vitamin A in their diets. |
| 11. | Safitri et al. (2026) | Diet Quality, Nutrient Intake, and Estimated Iron and Zinc Bioavailability in Stunted and Normal Toddlers in Bogor Regency, | Study design: Comparative cross-sectional<br><br>Samples: 60 stunted and 60 normal children | The results showed normal toddlers also had significantly higher adequacy of macronutrients and micronutrients (p<0.05). Estimated iron and zinc absorption were significantly lower among |

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| | Indonesia: A Comparative Study | | stunted toddlers (iron p=0.019; zinc p=0.010), although overall iron and zinc bioavailability categories did not differ significantly between groups. |

**Discussion**

The first journal, titled "*The Relationship Between Iron (Fe) Intake and Stunting Incidence in Toddlers Aged 24-59 Months in the Nipah Health Center Work* Area" by Zakiyyah, et al. (2025), states that iron intake significantly affects stunting and is a major contributing factor. According to theory, a child's growth status will be affected by low iron intake because iron is stored in the muscles and spine, which will be used to produce hemoglobin (Hb) less frequently when intake is insufficient. Hemoglobin itself functions as a vehicle to deliver oxygen from the lungs to the rest of the body[17]. It should be emphasized that stunting is a type of chronic malnutrition caused by a number of variables, such as parenting patterns, parental education and income, geographical location, sanitation and hygiene, infectious diseases, access to health services, history of exclusive breastfeeding, history of complementary feeding, and genetics[17]. Furthermore, research conducted by Natara, et al. (2023) states that there is a relationship between energy intake and the incidence of stunting in toddlers. Most toddlers experience stunting due to insufficient energy intake[8]. Adequate energy intake in toddlers can affect metabolic processes in toddlers, which will directly impact child development.

In the second journal by Sirajuddin, et al (2020) entitled "Iron Intake Correlates with Stunting Incidence in Toddlers in Maros Baru District," it is stated that *stunting* can be prevented by improving iron intake. The results of this second journal are the same as the first journal, which states that there is a relationship between iron and stunting. Stunting is a long-term effect of insufficient nutritional intake in toddlers[11]. The higher the iron intake, the better the height Z score[14]. Iron consumption has long been known to be important because iron is the core of hemoglobin. Slow height gain in stunted children or difficulty in catching up on growth has an impact on mental development delays, so appropriate measures are needed to immediately provide nutritional interventions that can support accelerated height gain, especially in children under two years of age. Food formulas for stunted toddlers must meet nutritional quality and quantity requirements[14]. Zinc is one of the trace minerals

that is said to play a role in stunting in toddlers. Inadequate zinc consumption is one of the factors contributing to stunting, so zinc intake needs to be taken into account[11]. Zinc is a micronutrient that is needed in small amounts in the human body, but it plays a very important role. Zinc deficiency can lead to stunting in toddlers. Iron deficiency in bone growth is multifaceted. Iron is important for oxygen transport through hemoglobin, energy metabolism, and the synthesis of hormones such as insulin-like growth factor-I (IGF-I), which regulates bone and muscle growth[21]. Iron deficiency results in reduced oxygen delivery to tissues, disrupting mitochondrial function and energy production. In addition, hypoxia due to anemia affects the IGF-I axis, thereby inhibiting growth. Iron deficiency also disrupts appetite regulation, leading to reduced nutrient intake and exacerbating growth disorders[21].

Unlike the first and second journals on iron, the third journal entitled "Levels of vitamin A, zinc, and iron sufficiency iron levels and infection frequency in stunted and non-stunted toddlers" by Fatimah & Wirjatma (2018) states that there is a significant difference between the stunted and non-stunted groups in terms of vitamin A adequacy levels. The fulfillment of micronutrients such as vitamins and minerals is also important, even though the amounts needed are not large. Vitamin A plays a role in bodily functions such as vision, cell differentiation, immunity, growth and development, reproduction, cancer and heart disease prevention, and reduced appetite[3]. Orange-colored vegetables contain more vitamin A. However, stunted toddlers do not consume fruit and only like vegetable soup. The side dishes consumed by stunted toddlers that are sources of vitamin A are eggs, tuna, and dried fish. High-dose vitamin A supplementation is still a mandatory program of the Ministry of Health, but increasing vitamin A intake is more needed from balanced and varied food sources[3]. Furthermore, research in Indonesia in 2023 explained the relationship between vitamin A and stunting, and stated that the prevalence of stunting in urban areas was lower than in rural areas (4.5% vs. 6.9%, $P < 0.000$). This study found that school-aged children who were stunted and thin had lower serum vitamin A levels than the standard group, highlighting the role of vitamin A in controlling average growth and development through its direct effects on growth hormones and their carrier proteins[16]. Vitamin A has been extensively studied for its role in bone health. Vitamin A can be consumed in two forms, namely, preformed retinol and provitamin A[19]. Preformed retinol is often found in foods of animal origin, such as milk, liver, and eggs. Provitamin A, such as alpha (α)-carotene, beta (β)-carotene, or β-cryptoxanthin, is commonly found in plant foods, such as fruits and vegetables. Among these, the most common provitamin A is β-carotene. Provitamin A

consumed can be absorbed as intact carotenoids or oxidized to retinal and then reduced to retinol in enterocytes. On the other hand, preformed retinol is absorbed directly from the intestine. Retinol is esterified into retinyl ester, packaged into chylomicrons along with intact provitamin A, and stored in the liver[19]. Retinyl ester is then converted to retinol and bound by retinol-binding protein (RBP) for release into circulation. Both retinol and provitamin A reach peripheral cells (including bone) via signal receptors and retinol transporters (STRA6) and delivery by chylomicrons[19]. In the event of vitamin A deficiency, the ability of osteoblasts to produce bone matrix is reduced[20]. This disorder inhibits the bone *remodeling* process and hinders new bone formation. The direct consequence of impaired bone formation is stunted growth and the onset of stunting[20].

More complete variables compared to the previous journal are found in the fourth journal by Silaban, et al. (2022), entitled "Differences in Vitamin A, Iron, and Zinc Adequacy Levels in Stunted and Non-Stunted Toddlers in Banyuasin District," which states the relationship between vitamin A, iron, and zinc adequacy levels and the incidence of stunting and non-stunting in toddlers. There are differences in vitamin A, iron, and zinc adequacy levels in stunted and non-stunted toddlers aged 13 to 23 months. The levels of vitamin A, iron, and zinc adequacy were lower in stunted toddlers compared to non-stunted toddlers[13]. Vitamin A deficiency can increase a child's risk of infectious diseases. Therefore, children suffering from vitamin A deficiency will experience growth failure. Vitamin A is needed for the development of bones and epithelial cells that form enamel in tooth growth[7]. Meanwhile, zinc is also referred to as a micronutrient because it is needed by the body in small amounts. Zinc absorption is around 10-40% of total daily absorption, which is 4-14 mg/day[5]. Zinc supplementation has a positive effect on children's linear growth. The combination of zinc with other micronutrients can reduce morbidity and the likelihood of infection in children[5]. Regarding iron, during the growth period, iron requirements increase. Stunting is a clinical manifestation of chronic growth disorders due to long-term nutritional deficiencies. One important micronutrient related to linear growth is iron (Fe)[15]. Iron is closely related to the production and activity of Insulin-like Growth Factor 1 (IGF-1), which is the main growth hormone that mediates the anabolic effects of Growth Hormone (GH)[15]. Iron absorption occurs in the duodenum through the DMT1 (Divalent Metal Transporter 1) transporter[15]. After absorption, iron is transported in the blood by transferrin to target tissues, including the liver, where IGF-1 production takes place. IGF-1 synthesis occurs in the liver, which is the primary organ producing IGF-1, and its synthesis activity is influenced by cellular oxygenation and the activity of iron-based enzymes. Iron deficiency causes cellular

hypoxia, reducing the expression of genes that regulate IGF-1 synthesis (such as through the HIF-1α pathway). Iron affects the number and sensitivity of GH receptors (GHR) in the liver. When iron is deficient, the number of GHRs decreases, and GH is unable to effectively stimulate IGF-1 production[15]. Low IGF-1 levels result in decreased proliferation and differentiation of chondrocytes in the epiphyseal plate of long bones, leading to linear growth disorders and stunting[10].

The variables in the fifth journal are also more comprehensive, similar to the fourth journal, covering the relationship between protein, vitamin A, zinc, and iron intake and stunting in toddlers. The fifth journal is titled "The Relationship Between Protein, Vitamin A, Zinc, and Iron Intake and the Incidence of Stunting in Children Aged 1-3 Years" by Kundarwati, et al. (2022). The journal found a relationship between protein, zinc, and BSI intake and the incidence of stunting. The higher the Inadequate protein consumption increases the risk of stunting by 4.5511 times[7]. Inadequate protein consumption affects protein intake in the body, which in turn affects the production and function of the IGF-1 hormone. IGF-1, or somatomedin, is a polypeptide hormone that acts as a mitogen and stimulator of cell proliferation and plays an important role in tissue repair and regeneration[7]. As for vitamin A, toddlers who do not receive vitamin A supplementation are at greater risk of stunting. During toddlerhood, micronutrient intake should be given more attention, and a variety of foods should be selected to maximize micronutrient intake in toddlers[16]. There are several opinions among experts regarding the role of iron (Fe) as a component of 7 enzymes and a component of cytochrome that affects growth[1]. One of these is as a component of the ribonucleotide reductase enzyme, which is able to participate in DNA synthesis, which works indirectly on tissue growth that can affect growth. Additionally, iron as a component of cytochrome can participate in the production of Adenosine Triphosphate (ATP) and protein synthesis, which can influence tissue growth[1]. Furthermore, the mechanism of stunting begins since.

In the sixth journal the variables that related with this articles was iron with title "The Relationship Between Protein, Carbohydrate, and Iron Intake and Stunting in Toddlers in the Gianyar Health Center Area 1" by Anzi, et al. (2024). Purpose of this study was to determine relationship between intake protein, carbohydrate, and iron with stunting in toddlers in Gianyar 1 Health Center area. This research was revealed that there is relationship between intake of protein, carbohydrate, and iron (FE) on incidence stunting as indicated by the value < (0.05). With contingency coefficient value of 0.324 protein. Intake carbohydrate 0.354 and intake of iron (FE) 0.338. The results this study it was suggested to families to

pay attention amount intake toddlers both in womb and at birth and to carry out nutritional counseling at posyandu. Puskesmas always provide education about the dangers of stunting. Iron deficiency can lead to iron deficiency anemia, which is characterized by symptoms such as pale skin, fatigue, and shortness of breath due to inadequate oxygen supply to the body[1]. Iron (Fe) is an essential mineral that plays an important role in motor function. One of its primary functions is its involvement in monoamine synthesis. Monoamines are neurotransmitters involved in various physiological processes, including the regulation of motor activity. In addition, iron is essential for the activity of mitochondrial enzymes involved in aerobic metabolism, which converts nutrients into energy. Therefore, iron plays a crucial role in cellular energy production[1]. Further journals, in the seventh journal with titled "The relationship between vitamin A supplementation, giving immunization, and history of infectious diseases on the incidence of stunting in children aged 24-59 months at the Mulyorejo Community Health Center, Surabaya" by Putri et al. (2021) described that there was a relationship between vitamin A supplementation and stunting occurance. Vitamin A supplementation has significant relationship with stunting in children aged 24-59 months at Puskesmas Mulyorejo, Surabaya. Vitamin A plays an essential role in visual function, epithelial cell differentiation and maintenance, growth, and development[20]. Vitamin A deficiency may also be associated with decreased appetite. Adequate vitamin A intake is primarily achieved through dietary sources, particularly fruits and vegetables rich in this vitamin. Orange- and red-colored fruits and vegetables generally contain high levels of provitamin A carotenoids. Vitamin A can also be obtained from animal-based food sources, such as fish, eggs, and shrimp. Adequate vitamin A status is also important for supporting immune function and may contribute to reducing the risk and severity of infectious diseases, including measles and diarrhea. Through this regularly scheduled supplementation program, children under five years of age are expected to maintain good nutritional and health status, develop stronger immune systems, and achieve optimal growth and development[20].

In contrast with the previous journals, the eight journal entitled "Macro and micro nutrient intake and stunting among toddlers aged 12-59 months in the Radamata Community Health Center working area" by Natara et al. (2023) which used iron, zinc, phosphorus, vitamin A as micronutriens showed that there was no statistically significant association between the intake of iron (Fe), zinc (Zn), phosphorus, and vitamin A and the occurrence of stunting among children aged 12–59 months in the catchment area of Radamata Public Health Center. These findings differ from those of previous studies, which reported a

significant association between iron intake and an increased risk of stunting in children. Zinc intake has also been identified as a protective factor against stunting. Zinc plays an essential role in growth and development, particularly in neuronal formation and migration[8]. In line with this theories, in ninth journals with title "Correlation Between Iron and Zinc Adequacy Level With Stunting Incidence In Children Aged 6 -23 Months" by Dewi et al. (2017), the results showed 14.5% of toddlers age 6 –23 months were stunted. 33.3% of children were given inadequate iron intake and 35.7% of children were given inadequate zinc intake. The analysis test showed there was a significant correlation between levels of iron and zinc adequacy with the incidence of stunting with p=0.02and p=0.018. The proportion of stuntingwill increase if the toddler were given inadequate of iron and zinc. Education about the adequacy levels of iron and zinc for toddler age 6-23 months were adjusted to reduce and avoid stunting. Inadequate iron and zinc intake may increase the risk of impaired linear growth in children. Therefore, ensuring adequate intake of these micronutrients is essential to support optimal child growth and development. Iron-rich food sources include sardines, liver, eggs, tomatoes, soybeans, beef, and spinach. Meanwhile, zinc can be obtained from various food sources, including spinach, broccoli, bananas, egg yolks, and beef[21]. In addition in the tenth journals entitled "Nutrition Intake and Stunting of Under-Five Children in Bogor West Java, Indonesia" by Wulandari et al. (2021) showed that iron intake had a significant relationship with the incidence of stunting under five (p=0.018; OR=1.784; 95% CI: 1.106-2.278) after controlling variables of gender, energy intake, protein intake, fat intake, carbohydrate intake, and vitamin an intake. The percentage of children under five with stunting in Babakan Madang Sub-District, Bogor was 43.0%. Iron intake as the dominant factor was related to the incidence of stunting in under-five children in Bogor Regency after controlling for variables of gender, intake of energy, protein, fat, carbohydrate, and vitamin A. The risk of stunting in under-five can be reduced by providing variety of macro and micro nutrients specialy iron and vitamin A in their diets[22]. This study has several limitations, including bias in data collection, because the data comes from secondary data so that researchers do not take data directly.Besides that, the results of the study are difficult to generalize for all stunting children in Indonesia because it only describes one sub-district in Indonesia. However, these data provide some useful information to facilitate the design of intervention strategies to prevent children from stunting based on the problem of toddler food intake and their characteristics.

In line with these results, the research in the eleventh journals entitled "Diet Quality, Nutrient Intake, and Estimated Iron and Zinc Bioavailability in Stunted and Normal Toddlers

in Bogor Regency, Indonesia: A Comparative Study" by Safitri (2026) showed that normal toddlers also had significantly higher adequacy of macronutrients and micronutrients ($p<0.05$). Estimated iron and zinc absorption were significantly lower among stunted toddlers (iron $p=0.019$; zinc $p=0.010$), although overall iron and zinc bioavailability categories did not differ significantly between groups. Stunting among Indonesian toddlers is associated with unfavorable socioe conomic conditions, lower birth weight, history of infectious diseases, needs improvement diet quality, and reduced estimated micronutrient absorption. Interventions should prioritize improving dietary quality, increasing vitamin C intake to enhance iron absorption, and limiting dietary inhibitors such as tea, along side broader strategies addressing household socioeconomic factors and child health. stunting in toddlers is a multifactorial issue significantly associated with household socioeconomic vulnerabilities (lower income and parental education), individual health history (low birth weight and infectious diseases), and suboptimal dietary quality[23].

The fulfillment of micronutrients, such as vitamins and minerals, is also important even though the amounts needed are not large. Inadequate intake of micronutrients can occur due to the low intake of micro-nutrient sources in the daily consumption of toddlers and the low bioavailability factor. Vitamin A plays a role in physiological functions such as vision in the retina, regulation of gene expression and cell differentiation, and antioxidants[22]. Minerals that are very important to prevent stunting are zinc, iron, and iodine. The best sources of iron are red meat, chicken liver, and beef liver. Red spinach is rich in iron, butlow absorption only 3-8%, while animal food 23%.

**Implications for Practice and Policy**

The findings support continued prioritisation of dietary diversification to improve iron, zinc, and vitamin A intake in toddlers, with attention to bioavailability. Practical recommendations include increasing intake of animal-source foods rich in haem iron, such as red meat, chicken liver, and beef liver, which offer substantially higher absorption than plant sources; combining plant iron sources with vitamin C to enhance absorption; limiting dietary inhibitors such as tea; and ensuring participation in the mandatory vitamin A supplementation programme. Nutrition counselling at posyandu and education regarding the risks of stunting should be strengthened, and families should be encouraged to attend to toddler intake both during gestation and after birth [13].

It should be recognised, however, that dietary diversification presupposes reliable household access to diverse foods. Household-level food security initiatives that strengthen community food access therefore constitute an upstream precondition for improving

micronutrient intake [24], and stunting reduction programmes should be coordinated with food security interventions rather than implemented in isolation.

Beyond household-level dietary diversification, biofortification of staple crops represents a complementary population-level strategy for increasing iron, zinc, and vitamin A intake without requiring sustained behavioural change. Integrated approaches combining land remediation with crop biofortification have been proposed as a means of addressing stunting at its agronomic source [23], and such strategies may be particularly relevant in settings where animal-source foods are inaccessible or unaffordable. For Indonesia, alignment between biofortified crop production and national stunting reduction programmes would allow micronutrient intake to be improved through existing food supply chains rather than through supplementation alone.

**Limitations**

This review has several limitations. First, all included studies employed cross-sectional, case-control, or comparative cross-sectional designs, none of which can establish temporal sequence or causality. Second, the review was restricted to publications between 2015 and 2025, yet one included study was published in 2026 [18], representing a deviation from the stated eligibility criteria that should be noted. Third, most studies assessed micronutrient exposure through dietary intake rather than biomarkers, and intake estimates are susceptible to recall bias and do not account for bioavailability. Fourth, definitions of adequacy and cut-offs for stunting were not standardised across studies, limiting comparability. Fifth, sample sizes varied widely, and the sample description in one study[10] refers to 3,025 toddlers registered at a health centre, which may represent the source population rather than the analysed sample; this requires verification. Sixth, publication and reporting bias may favour studies reporting significant associations. Seventh, the search did not include grey literature or national surveillance reports, which may contain relevant data. Eighth, the review did not include a formal risk-of-bias assessment of the included studies, and study quality was therefore not systematically appraised. Ninth, the food security and biofortification strategies discussed in the Implications for Practice and Policy section [23,24] are drawn from literature outside the formal eligibility criteria of this review and are presented as contextual considerations rather than as synthesised evidence.

**Implications for Research**

Future research should prioritise prospective cohort designs capable of establishing temporal sequence between micronutrient status and linear growth faltering. Studies should incorporate biomarkers of iron, zinc, and vitamin A status in addition to dietary intake, and

should apply standardised anthropometric measurement protocols with clearly reported inter-observer reliability. Given the evidence that macronutrient deficiency may exert a larger effect than micronutrient deficiency in some populations[15], future studies should model macro- and micronutrient exposures jointly rather than in isolation. Intervention trials comparing dietary diversification, supplementation, and biofortification strategies [23] would provide stronger evidence for policy, and should be complemented by implementation research examining how household food security interventions [24] affect micronutrient intake in practice. Finally, explicit identification of research gaps and justification of study novelty should be addressed in future reviews, as the present literature remains largely descriptive.

## Conclusion

From the review of the articles, it can be concluded that there is a relationship between micronutrient deficiencies in iron, zinc, and vitamin A and the occurrence of stunting in toddlers. Toddlers who do not receive iron and vitamin A supplementation are at greater risk of stunting, and during toddlerhood, micronutrient intake should be given more attention, and a variety of foods should be selected to maximize micronutrient intake in toddlers. Recommendations for further research include strengthening the justification for the study by explicitly identifying research gaps. The current literature review is too descriptive and does not clearly indicate what previous researchers have not done and why this study is important.

## Declaration of Generative AI in Scientific Writing

The authors affirm that the usage of generative artificial intelligence tools, including Open AI (ChatGPT). These tools were not used for generating content, data analysis, or interpretation. The authors are fully responsiblefor the accuracy and integrity of the content as well as the conclusions presented in this study

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