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SUSTAINABLE IODIZED SALT FORTIFICATION REDUCES THE RISK OF UNDERWEIGHT AMONG UNDER-FIVE CHILDREN

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ABSTRACT

Objective: Underweight is related to many factors including family and socioeconomic factors. Stunting is defined as early-life linear growth retardation that is associated with increased morbidity and mortality, decreased physical, neurodevelopmental, and economic capacity. Underweight is more common in stunted children than in wasting/thin children. The purpose of this study is to examine the risk factors for underweight in under-five children in the stunting locus area, West Java, Indonesia

Method: The study used a cross-sectional study design from May to August 2023 and involved 309 under five children who met the inclusion and exclusion criteria. The data used includes the household socioeconomic factors, hygiene and sanitation factors, and children characteristics. The dependent variable was the nutritional status of children as measured by the weight-for-age index. The children were classified as underweight if their z-score was less than -2 standard deviation (< -2 SD). Bivariate analysis employed the chi-square test. Multiple logistic regression test was used for multivariate analysis with a significance value <0.05.

Results: Results showed that 20.4% of children were underweight. Logistic regression test showed that the usage of less iodized salt raised the risk of underweight in children (OR: 1.789; 95% CI: 1.004-3.218), while low father's education increased the risk of underweight (OR: 1.895; 95% CI: 1.070-3.354).

Conclusion: Local government support of sustainable iodized salt fortification is required, as is the inclusion of social aspects of the family and gender in the implementation of nutrition programs.

Keywords: sustainability, fortification, public policy, social factor, implementation.

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A FORTIFICAÇÃO SUSTENTÁVEL DE SAL IODIZADO REDUZ O RISCO DE BAIXO PESO ENTRE CRIANÇAS MENORES DE CINCO

RESUMO

Objetivo: O baixo peso está relacionado a muitos fatores, incluindo fatores socioeconômicos familiares. O nanismo é definido como retardo de crescimento linear no início da vida que está associado ao aumento da morbidade e mortalidade, diminuição da capacidade física, do neurodesenvolvimento e econômica. O baixo peso é mais comum em crianças com baixa estatura do que em crianças debilitadas/magras. O objetivo deste estudo é examinar os fatores de risco de baixo peso em crianças menores de cinco anos na área do locus de nanismo, Java Ocidental, Indonésia.

Método: O estudo utilizou um ¹⁸ estudo transversal de maio a agosto de 2023 e envolveu 309 crianças menores de cinco anos que atendiam aos critérios de inclusão e exclusão. Os dados utilizados incluem os fatores socioeconômicos do agregado familiar, fatores de higiene e saneamento e características das crianças. A variável dependente foi o estado nutricional das crianças medido pelo índice peso por idade. As crianças foram classificadas como abaixo do peso se o escore z fosse ¹⁵ inferior a -2 desvio padrão (< -2 DP). A análise bivariada empregou o teste qui-quadrado. O teste de regressão logística múltipla foi utilizado para análise multivariada com valor de significância <0,05.

Resultados: Os resultados mostraram que 20,4% das crianças estavam abaixo do peso. O teste de regressão logística mostrou que o uso de menos sal iodado aumentou o risco de baixo peso nas crianças (OR: 1,789; IC 95%: 1,004-3,218), enquanto a baixa escolaridade do pai aumentou o risco de baixo peso (OR: 1,895; IC 95%: 1.070-3.354).

Conclusão: É necessário o apoio do governo local à fortificação sustentável com sal iodado, assim como a inclusão dos aspectos sociais da família e do gênero na implementação de programas de nutrição.

Palavras-chave: sustentabilidade, fortificação, políticas públicas, fator social, implementação.

²² 1 INTRODUCTION

In 2015, the United Nations adopted 17 Sustainable Development Goals (SDGs) to address ^{the} issues of inequality, poverty, and climate change. The goal is to eradicate malnutrition by 2030 (United Nations, 2015). One of the most common malnutrition in developing countries is underweight. Illnesses, insufficient diets, and environmental and socioeconomic factors can all lead to being underweight (Habaasa, 2015). Underweight is an ⁶ important indicator of community health and nutritional status, and it is visible when a child is thin or short for his age (Fenta et al., 2020). Although the global number of underweight children has decreased from 14.1% in 2015 to 12.6% in 2020, this decrease is not equally spread across the globe, with Southeast Asia accounting for almost 30% of all underweight children (WHO, 2020).

In Indonesia, the prevalence of underweight is 17.1% based on the ²⁵ results of the 2022 Indonesian Nutrition Status Survey (Indonesia Ministry of health, 2023). According

to the World Health Organization's classification of the severity of the problem underweight, the prevalence of underweight in the range of 10%-19% falls into the moderate category (WHO, 2005). However, as compared to the Indonesian government's goal of reducing underweight prevalence, underweight prevalence in 2022 is targeted at 14% (Indonesia Ministry of Health, 2021). It means that Indonesia's underweight prevalence remains higher than the government's national target. It should be highlighted that the risk of morbidity and mortality in underweight or severe underweight children is not eliminated, both are at increased risk.

Underweight is related to many factors including family socioeconomic factors (Li et al., 2020) such as wealth index and educational level. Birth order, sex of child, and existence of diarrhea had a significant effect on underweight among children under the age of five (Birhan & Belay, 2021), as well as birth spacing (Kamal & Moniruzzaman, 2022), hygiene and sanitation (Adhikari et al., 2017; Geda et al., 2021), and smoking patterns among household members (Nadiyah et al., 2013). Underweight children are a significant risk factor for infection, particularly in developing countries, owing to malnutrition and poor hygienic standards (Dobner & Kaser, 2018).

Underweight can be a result of insufficient nutrient intakes and frequent illnesses (Menalu et al., 2021). One of important nutrient intakes for growing children is iodine. Iodine is a mineral found in a variety of foods. Iodine is required by the body to produce thyroid hormones. These hormones regulate the body's metabolism and a variety of other vital functions. Thyroid hormones are also required by the body for proper bone and brain development during pregnancy and infancy. Iodine is essential for everyone, but especially for infants and pregnant women (Farias et al., 2020). The diet in many countries could not meet iodine requirements unless salt is fortified with iodine. Iodine fortification of salt has an impact on the prevalence of underweight children under the age of five (Kumar & Berkman, 2015).

Stunting locus village is a prioritized village for reducing stunting cases. Stunting is a chronic nutritional problem caused by a lack of nutrition over time, resulting in stunted growth in children. Stunting refers to a child who simply appears too short for his or her age. A child who has an age and sex-specific z-score for length/height-for-age of less than -2 SD (<-2 SD) is considered stunted (WHO, 2006).

Underweight is more common in stunted children than in wasting/thin children (Chikhungu, 2022). The pattern of risk factors for underweight occurrence in high

stunting issue areas should be determined. This would identify the nutrition programs to address the underweight issue in stunting locus area by taking important risk factors into account. Based on the above, the purpose of this study is to investigate the risk factors for underweight incidents among under-five children in stunting locus area, West Java, Indonesia.

2 THEORETICAL FRAMEWORK

Malnutrition in children under the age of five is a major public health concern because it leads to both mortality and morbidity, especially in developing countries such as Indonesia, where the incidence of malnutrition remains quite high. One of the signs of malnutrition is being underweight. Underweight reflects a nutritional deficiency, which has a prolonged impact on health and has effects for the overall well-being of the population.

Underweight people have been identified as a risk factor for a variety of diseases, including hypotension, anemia, fatigue, low bone mineral density, and malaise (Kodama, 2010). Underweight in children is a significant health issue with serious consequences for health, growth, and well-being.

Children under the age of five are most susceptible to malnutrition in developing countries because of insufficient nutritional intake, lacking of appropriate care, and imbalance of household food distribution (M yalew, 2014). In nations with low and middle incomes, the incidence of underweight in children is a significant indicator of overall health and nutrition security conditions (Atsu et al., 2017). Illnesses, insufficient diets, and environmental and socioeconomic factors can all lead to being underweight (Habaasa, 2015).

Stunting is defined as early-life linear growth retardation that is associated with increased morbidity and mortality, decreased physical, neurodevelopmental, and economic capacity, and an increased risk of metabolic disease in adulthood (Prendergast & Humphrey, 2014). The association between stunting and underweight, was measured by the odds ratio (OR) of 15.87 (Asmare & Agmas, 2022). The pattern of risk factors for underweight occurrence in high stunting issue areas should be determined. This would identify short-term and long-term nutrition programs to address the problem of underweight in stunting locus villages by taking important risk factors into account.



3 METHODOLOGY

3.1 DESIGN STUDY

This research was conducted in stunting locus area, Ciampea Udik, West Java, Indonesia, using a cross-sectional study design. The research was started from May to August 2023. The research locations included all nine integrated healthcare centers in stunting locus area, Ciampea Udik.

3.2 SAMPLING

The number of children aged 0-59 months who live in Ciampea Udik Village is 555 children. The research sample included 309 children. The technique of multistage random sampling was used to collect samples from under-five children. First, using cluster proportional sampling techniques, the number of children collected from each integrated health center was estimated proportionally to the total number of children in Ciampea Udik Village. Second, stage of sampling was carried out using the technique of purposive sampling, which is based on inclusion and exclusion criteria.

The inclusion criterias were as follows: 1). Have lived in the village of Ciampea Udik for at least 6 months; 2). Parents of children willing to be interviewed during the study; 3). Parents of children can communicate well. The exclusion criterias were: 1). Children and their parents are unable to participate in the research until the end; 2). Children change residences and 3). Results of z-score measurements of body weight for age < -6 or > 5 (WHO, 2006).

3.3 PROCESSING AND ANALYSIS OF DATA

The data used includes the household socio-economic (including father's and mother's education, family income, and daily food expenditure), hygiene and sanitation factors (the habit of washing hands with soap and the father's smoking habit in the house), and children characteristics (age, gender, weight, and birth spacing). The dependent variable was the nutritional status of children based on the weight-for-age index.

The household questionnaire and questionnaire filling guidelines were used to collect socioeconomic data using interview techniques. Respondents were family heads, housewives, or household members who can provide information. For parent's education, If the last completed education was junior high school/equivalent, it was considered low.



Parents who completed senior high school/equivalent or above were classified as having a high level of education.

The cut off for the 2023 Bogor Regency Regional Minimum Wage of 4,520,212 IDR per month was used to analysis family income (Idris, 2023). Family income was divided into two categories, less than regional minimum wage (< of 4,520,212 IDR per month) and equal to or greater than regional minimum wage (\geq of 4,520,212 IDR per month). Family daily food shopping was classified using cut off of 50,000 IDR per day, the it was divided into two categories, namely less than 50,000 IDR and 50,0000 IDR or more per day.

Family hygiene and sanitation factors include the mother or caregiver's⁴ habit of washing hands with soap and the father's habit of smoking in the house. If the mother/caregiver has a habit⁷ of washing her hands with soap, it was classified as less risky behavior (WHO, 2006); if she does not have a habit of washing her hands with soap, it was classified as risky behavior. If the father of the children has habit of smoking inside the house, it was considered risky; if he does not smoke inside the house, it was considered less risky.

Birth spacing is the number of years between the birth of sample and the previous child. Children who are the first child or have a birth spacing of three years or more from the previous child were considered less risky. Birth spacing of less than three years was classified as risky (Molitoris et al., 2019).

The iodine rapid test reagent was used to determine the iodine content of salt used daily to prepare food for children. To test the level of iodine in salt, place 1 tablespoon of salt in a white and clean container. The salt was dripped 1-2 times with iodine rapid test reagent, and the change in color was observed. If there was no color change, the salt does not contain iodine. If the salt turned a light blue color, it only has less than 30 ppm iodine. If the color changes to dark blue/dark purple, the salt contains at least 30 ppm iodine. In this study, less iodine salt is salt that does not contain iodine and/or has less than 30 ppm, while salt that contains iodine at least 30 ppm was classified for adequate iodine (National Standardization Agency of Indonesia, 2010)

Data on child weight was collected using digital scales³⁵ with an accuracy of 0.1 kg. The child was weighed while wearing minimal clothing, and heavy diapers are removed. The WHO Anthro software (WHO, 2007)¹¹ was used to calculate the child's age based on his birth and measurement date. The nutritional status of weight for age was determined

using z-score calculations in the WHO Anthro application. The z-score analysis is continued if the z-score is more than -6, and or less than 5 (> -6 or < 5). A z-score that exceeds these limits was considered an outlier, and the child were excluded from the study. Children were considered underweight if their z-score is less than -2 SD (< -2 SD), and normal if their z-score is -2 SD or more (≥ -2 SD) and less than +1 SD ($\leq +1$ SD) (WHO, 2006)

Univariate analysis was used on each variable to generate frequency and percentage distributions. Chi-square test was employed for bivariate analysis. Multiple logistic regression test with backward wald method was used for multivariate analysis with a significance level < 0.05 . This research has obtained ethical approval from the Research Ethics Commission of Universitas Esa Unggul.

4 RESULTS AND DISCUSSION

The majority of children under five (55.3%) were male. Underweight children was 20.4%, about 16.8% having underweight and 3.6% having severely underweight. The average of z-score of weight for age was $-1.18 + 0.99$ SD with a minimum value of -3.86 and a maximum of 0.96 (Table 1).

The stunting locus village is the one where stunting is emphasized. Stunting is a national public health concern. In this study, stunting was experienced by 71.4% of underweight children, while thin/wasting was indicated by only 9% of underweight children ($p < 0.005$). A significant relationship between underweight and stunting was also discovered in a study of 2399 children in Gambia (Asmare & Agmas, 2022). The majority of children who are underweight are suffering from stunting, which has long-term health consequences. In 2023, the government goals to reduce the number of underweight children by 13% (Indonesia Ministry of Health, 2021). As a result, the percentage of stunted children in the Ciampea Udik stunting locus village remains higher than the national target. Even mild underweight increases the risk of morbidity and mortality (Hossain et al., 2023).

The majority of under five children (60%) have a birth spacing of at least three years with their previous children. Almost one-third (30%) of children are the first child. As many as 10% of them have a birth spacing of less than three years. Iodine use in stunting locus villages was varied. Non-iodized salt was still used by 21% of families. As



many as 36.2% of families use salt with less iodine content (<30 ppm), while 42.7% use salt with adequate iodine content (>30 ppm).

From socioeconomic factors, 50% of fathers have a higher education while 50% have a lower education. Meanwhile, the proportion of mothers with low education (56%) was higher than the proportion of mothers with high education (44%). The majority (79%) of families in the stunting locus village earn less than the regional minimum wage (4,520,212 IDR), while the remaining 21% earn more. The majority of families (72%) spent more than 50,000 IDR on daily food shopping, but there were still families (28%) who spend less 50.000 IDR. In terms of hygiene and sanitation, most (97%) mothers wash their hands with soap; however, 3% of mothers do not usually wash their hands with soap. As many as 38% of fathers still smoke inside the home (Table 2).

Table 2 shows the results of bivariate analysis, the prevalence of underweight is higher in families who use less iodized salt, as well as in families with low education and income. However, only the father's education variable is statistically significant. The bivariate analysis revealed that there was no significant relationship between birth spacing and underweight. Despite using the same birth spacing cut-off (3 years) as this study, research in Ethiopian children (Asmare & Agmas, 2022; Hintsu & Gereziher, 2019) revealed differences, the study found an association between birth spacing and underweight. The research conducted in Ethiopia (Fenta et al., 2020) also did not find a significant relationship between birth spacing and underweight.

There was no significant relationship between family income and underweight, despite the fact that it appeared that more children from lower-income families were underweight than children from higher-income families. Some research found the relationship between economic status and underweight (Murarkar et al., 2020; Nguyen & Nguyen, 2020). The difference in these results could be related to the larger number of samples used in the previous two studies, which allowed the results to be statistically significant.

Table 1. Weight-for-age z-score and underweight prevalence in stunting locus village (n=309)

Weight-for-age, z-score	Mean ± SD	-1,18 ± 0,99
	Min-Max	-3,86 – 0,96
Nutritional status, n (%)	Underweight	63 (20,4%)
	Normal	246 (79,6%)
Gender, n (%)	Male	171 (55,3%)
	Female	138 (44,7%)

Source: Author (2023)

Table 2. Characteristics of children under five in stunting locus village based on observed variables (n=309)

Variable	Nutritional status				Total		p	
	Normal		Underweight		n	%		
	n	%	n	%	n	%		
Birth spacing	≥3 years	24	8%	7	2%	31	10%	0,814
	<3 years	222	72%	56	18%	278	90%	
Iodized salt use	Inadequate (<30 ppm)	135	44%	42	14%	177	57%	0,060
	Adequate (≥ 30 ppm)	111	36%	21	7%	132	43%	
Fathers' education	Low	115	37%	38	12%	153	50%	0,037*
	High	131	42%	25	8%	156	50%	
Mother's education	Low	138	45%	36	12%	174	45%	0,499
	High	108	35%	27	9%	135	44%	
Income family	< Regional minimum wage	190	61%	53	17%	243	79%	0,154
	≥ Regional minimum wage	56	18%	10	3%	66	21%	
Daily food expenditure	< 50.000 IDR	74	24%	13	4%	87	28%	0,090
	≥ 50.000 IDR	172	56%	50	16%	222	72%	
Habit of washing hands with soap	No	7	2%	1	0%	8	97%	0,490
	Yes	239	77%	62	20%	301	3%	
Father's smoking habit in the house	Yes	96	31%	20	6%	116	38%	0,179
	No	150	49%	43	14%	193	62%	

*p<0,05; Regional minimum wage: 4.520.212 IDR
Source: Author (2023)

The amount of money for daily food spending is observed here to see further the use of income for food expenditure. There was no significant relationship discovered between the amount of money spent on family daily food shopping and the prevalence of underweight in children. The number of underweight children is higher in the group of families with food spending greater than 50.000 IDR, indicating that the amount of money spent on daily food shopping does not determine the risk of underweight in children. This could be due to differences in nutritional knowledge, mindsets, and behaviors among households when purchasing food for their children. According to a study using national data from South Africa, the amount of household expenditure is unrelated to nutritional problems (underweight, stunting, and wasting) in children under the age of five (May & Timæus, 2014)

Several studies in India (Panda et al., 2016; Sabud et al., 2020), Ethiopia (Demilew & Alem, 2019), and Bangladesh (Jubayer et al., 2022) showed that food security is not the only way to reduce nutritional problems in children; these studies also showed that the behavior of mothers or caregivers washing hands with soap is related to the incidence of underweight in children. In this study, there was no significant relationship between

the behavior of washing hands with soap and underweight. This could be due to the variable data on handwashing with soap obtained through interview techniques rather than direct observation of the mother's daily habits when her hands are dirty, preparing food, or breastfeeding.

The father's habit of smoking inside the house is not a significant factor in underweight children. The same result was discovered in an Indonesian study of 482 poor families, which discovered that the z-score of children's body weight for age from between non-smoker fathers and smoker fathers was not significantly different (Wijaya-Erhardt, 2019). According to the study, there was no significant relationship between the father's habit of smoking inside the house and underweight, despite the fact that the group of fathers smoking inside the house had more underweight children than the group of fathers who did not smoke inside the house. The father's habit of smoking inside the house was found to be significantly associated with the incidence of stunting. The study supports previous research in Indonesia which found the significant association between father's habit of smoking inside the house with stunting (Nadiyah et al., 2013).

Table 3. Multiple regression analysis of risk factors for underweight in children under five.

Variable	OR	95% CI	p
Constant	0,145		0,000
Use of inadequate iodized salt	1,789	1,004-3,218	0,048*
Low father's education	1,895	1,070-3,354	0,028*

* $p < 0,05$, the fittest model at the sixth iteration

Source: Author (2023)

²¹ Table 3 shows the results of a multiple logistic regression analysis that tested all variables at the same time. Based on the Hosmer and Lemeshow Test for goodness of fit, the regression model is acceptable with a significance value of 0.491 (> 0.05). The model's accuracy is 79.6%. There are 93.2% other factors outside the model that explain the status variable underweight in children at the stunting locus village based on the test result of Nagelkerke R Square of 6.8%.

The multivariate logistic regression test was used to examine the effect of many independent variables on a categorical dependent variable. According to the logistic regression test, the use of less iodized salt and a low father's education were significant variables related to underweight occurrences in children at the locus of stunting ($p < 0.05$).
⁴ The use of less iodized salt increases the risk of underweight in children by 1.8 times more than the use of adequate iodized salt (OR: 1.789; 95% CI: 1.004-3.218).



Furthermore, low father education increases the risk of underweight in children 1.9 times more than high father education (OR: 1.895; 95% CI: 1.070-3.354).

This study revealed that using less iodized salt was significantly associated with the occurrence of underweight which is consistent with previous research in India (Kumar & Berkman, 2015) and across countries (Krämer et al., 2016) that found using less iodized salt increases the risk of being underweight.

Iodine is an essential micronutrient that is found in thyroid hormone. Adequate iodine intake is required for normal growth and development. Growth can be restricted if the iodine requirement is not reached (Farebrother et al., 2015). Inadequate iodine intake can result in low thyroid hormone levels. Thyroid hormones are responsible for many of the developmental cycle's major functions, including skeleton and peripheral tissue growth and development. Thyroid hormone is also closely related to the function of growth hormone/GH (Farebrother et al., 2018).

The diet in many countries could not meet iodine requirements unless salt is fortified with iodine. By 2020, 124 countries have implemented legislation requiring salt iodization, with 21 countries remaining in the voluntary iodization stage. As a result, iodized salt is used by 88% of the world's population (Zimmermann & Andersson, 2021). Indonesia has mandated salt fortification with iodine, as specified in Indonesian National Standard 3556:2016, a revision of the Standard 3556:2010 which the iodine used is revised to form KIO₃. Iodine levels in salt must be at least 30 mg/kg (BSN, 2016). However, many salts remain have iodine levels below 30 ppm or do not contain iodine. This could be due to lacking monitoring and evaluation, a lack of multi-sector collaboration, long-term resource allocation, indications of external interventions interfering with policy implementation, and ineffective implementation strategies in law enforcement, salt trading, and producer empowerment (Mahbub et al., 2014). Local government support is required to ensure the sustainability of salt fortification with an adequate amount of iodine.

Low father education raises the risk of underweight children by 1.9 times that of highly educated fathers. Underweight children were also found more frequently in the low maternal education group than in the high maternal education group, but only the father's education was found to have a significant relationship both in bivariate and multivariate analyses. This demonstrates that the husband's support as the head of the household has a significant impact on the nutritional status of children under the age of



five. The support of a husband can reduce the likelihood of underweight children (Oyekale & Oyekale, 2009).

Many studies showed that a low father's education increases the risk of underweight in children (Bekele & Fetene, 2021; Das & Gulshan, 2017; Fandir et al., 2022; Muche et al., 2021; Sangroula & Uprety, 2020). Decisions, knowledges, attitudes, behaviors, and habits of fathers in the household, which are based on their level of education, influence the nutrition status of under-five children. This reflects patriarchal traditions (Wang, 2019). In order to promote healthy child development, factors such as family social status and gender may also play an important role in policy implementation.

5 CONCLUSIONS

Underweight in children under five is still a public health issue. The use of inadequate iodized salt and father's low education are significant risk factors for underweight children. The need for local government support for the sustainability of iodized salt fortification, as well as the inclusion of social aspects of the family in the nutrition and health program policies.

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