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The impact of nutritional status and dietary intake on children's exposure to hazardous substances in food

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ABSTRACT

Introduction: Exposure to harmful substances in food is a significant factor contributing to stunting and nutritional problems in children, as it impacts their growth and development. While healthy diets are well-documented, direct links between dietary intake and harmful substance exposure are less explored. This study investigates key risk factors influencing such exposure in children.

Objectives: This study aimed to analyses the impact of nutritional status, dietary intake, and exposure to harmful substances in children.

Materials And Methods: A cross-sectional study involving 780 children in 30 elementary Schools, collected data on dietary intake, nutritional status, and laboratory testing for harmful substances like borax, formalin, Rhodamine B, and cyclamate using Qualitative Test Kit. Food samples were obtained from school vendors and commonly consumed items. Data were analysed using Chi-Square tests and binary logistic regression to assess the relationships between variables.

Results: Among the children, 50% were aged 8–9 years, and 53.8% were female. Most had good nutritional status (69.2%), and 88.2% had sufficient dietary intake. However, 69.1% were exposed to harmful substances in food. Poor nutritional status increased exposure risk by 3.11 times (PR = 3.11; 95% CI: 1.75 - 5.51; p = 0.000), and insufficient dietary intake raised it by 13.26 times (PR = 13.26; 95% CI: 8.37 - 21.02; p = 0.000).

Conclusion: A child's nutrition and food safety are deeply connected. Poor nutrition makes children more susceptible to harmful substances, highlighting the importance of ensuring both a healthy diet and stricter food safety measures. By prioritizing better nutrition and safer food choices, we can help protect children's health and support their growth.

Keywords: *nutritional status; food intake; exposure hazardous substances; children's health food safety*

BACKGROUND

Stunting in children is a serious issue resulting from prolonged inadequate nutritional intake, beginning during pregnancy and continuing until the age of 24 months.[1] Various risk factors contribute to stunting, including family socioeconomic status, inadequate nutrient intake, maternal knowledge about nutrition and protein consumption, and the availability of basic sanitation facilities.[2, 3, 4,5] Moreover, maternal knowledge about infant and young child feeding and family support also play critical roles in preventing stunting. [6 ,7]

Stunting is not only a health problem affecting physical growth but also leads to complex health issues, such as anemia and reduced cognitive development.[8, 9] In Indonesia, stunting among toddlers is a significant public health concern that requires cross-sector collaboration and has been prioritized in the national health agenda, as outlined in the 2020–2024 RPJMN.[10, 11] Risk factors include sanitation, access to clean water, dietary patterns, and maternal knowledge about nutrition.[8, 6.]

Evidence suggests a strong connection between harmful substances in food and the risk of stunting in children. Nutrients like iron, protein, and other micronutrients are essential for child growth and development. Martiani et al. (2021) found a significant relationship between iron intake and child development in stunting cases.[12] Similarly, Asiah et al. (2020) emphasized the importance of increasing nutrient intake, particularly iron and zinc, to prevent further stunting.[13] Harmful substances in food, such as synthetic dyes like Rhodamine B, have also been linked to stunting risk. Sari et al. (2020) highlighted the need for maternal awareness about

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the dangers of Rhodamine B to safeguard children's nutritional intake.[14] Studies like those by Nurlailia et al. (2021) underscore the importance of food safety by identifying borax in food products in Banyuwangi, while Sari et al. (2022) identified methanil yellow in snacks sold at elementary schools in Banda Aceh.[15] These findings underline the role of hazardous substances, such as borax and synthetic dyes, in increasing stunting risk and the need for their control to ensure child health.

Despite existing studies, few have specifically identified and analysed various harmful substances in food and their direct relationship with stunting risk. There is a need for more comprehensive research to understand the extent of exposure to such substances and the factors influencing it. This study employs laboratory analysis to identify harmful substances, such as borax and methanl yellow, commonly found in food. The findings aim to provide a deeper understanding of how exposure to these substances contributes to stunting and the severity of the issue.

This study emphasizes the critical need to identify harmful substances in food as a preventive measure against stunting. While previous research has linked dietary intake of harmful substances to stunting risk, this study takes a more specific approach, focusing on the direct analysis of harmful substances and their effects on stunting in children. The novelty of this research lies in its comprehensive approach, combining laboratory analyses of harmful substances such as borax and methanil yellow with an investigation of their relationship to stunting risk. By identifying these substances, this study seeks to provide valuable insights into the factors contributing to stunting and to lay the foundation for effective preventive strategies through better control of harmful food contaminants.

MATERIALS AND METHODS

This study is an analytical observational research with a cross-sectional design. This study was conducted in 2024 across 30 elementary schools in Jambi City, involving 212 food samples collected from food vendors near the schools. Children's dietary intake, consumption patterns, and exposure to harmful substances was assessed using questionnaires. The collected food samples was analysed in a laboratory to identify harmful substances, such as borax, synthetic dyes (Rhodamine B), formalin, and cyclamate, which are known to pose health risks. These harmful substances examined using a Qualitative Test Kit (Fast Test Formaldehyde test kits, Fast Test Cyclamate test kits, Fast Test Rhodamine B test kits, and Fast Test Borax test kits) and further validated through laboratory tests. The test was conducted at the Biomedical Laboratory of Jambi University.

Children's physical growth, including measurements of height, weight, and head circumference, was monitored periodically during the study period. Children's physical growth measured using standardized procedures. Height measured using a stadiometer with the child standing upright without shoes. Weight was recorded using a calibrated digital scale. Head circumference measured with a non-stretchable measuring tape positioned above the eyebrows and ears. All measurements follow WHO growth assessment guidelines and taken by trained personnel to ensure accuracy. This data help assess the prevalence of stunting among the studied population. Statistical analyses then be performed to evaluate the relationship between exposure to harmful substances in food and the risk of stunting in children. This includes univariate, bivariate analyses using the Chi-Square test to assess associations between categorical variables and multivariate analyses using logistic regression.

The study adheres to strict ethical research principles, including obtaining informed consent and ensuring data confidentiality. Ethical approval has been granted by the Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Jambi, under approval number 877/UN21.8/PT.01.04/2024.

RESULT

Characteristic Of Respondent

Based on the findings regarding respondent characteristics, the majority of children were between 8–9 years old, representing 50% of the sample, while the 6–7 months age group comprised 23%, and the 10–12 months age group accounted for 27%. In terms of gender distribution, girls made up 53.8% of the respondents, compared to 46.2% boys.

Regarding nutritional status based on weight-for-height (WHZ), most children had good nutritional status, accounting for 69.2%. However, 16.9% of children were classified as undernourished, while 13.84%

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were categorized as over nourished. These findings highlight ongoing nutritional challenges, particularly for children in the undernourished category, which requires targeted attention.

The dietary intake survey revealed encouraging results, with 88.2% of children demonstrating adequate dietary intake, while only 11.8% showed insufficient intake. Despite these positive findings, significant concerns remain about daily consumption patterns, as 69.1% of children were found to be exposed to harmful substances in their food, while only 30.8% were not exposed.

These results underscore that although children generally have good nutritional status and dietary intake, the quality of food, particularly regarding exposure to harmful substances, requires greater attention to safeguard their health and well-being. Detailed findings are presented in Table 1.

Table 1. Characteristic Distribution of Children Respondent

	Characteristic	Frequency	Percentage (%)
Age (years)	6-7	180	23
	8-9	390	50
	10-12	210	27
Gender	Female	420	53.8
	Male	360	46.2
Nutritional Status Based on	Malnutrition	132	16.9
Weight/Height	Good Nutrition	540	69.2
	Overnutrition	108	13.84
	Sufficient	688	88.2
Food Intake Survey	Insufficient	92	11.8
Exposure Status	Exposed to Hazardous Substances	539	69.1
	Not Exposed to Hazardous Substances	241	30.8

Laboratory Analysis Results

Based on the laboratory analysis of food samples, no samples were found to contain formalin or cyclamate, with 100% of the samples being free from both substances. This indicates that all tested food items were safe from the use of formalin and cyclamate. However, borax was detected in 12.7% of the samples (28 samples), indicating exposure to this harmful substance in some of the foods, although the majority of samples (87.23%) were not contaminated with borax. The types of food in which borax was detected include *bakso*, fried sausages, nuggets, *cireng, mie ayam, siomay*, and *batagor.* As for the synthetic dye Rhodamine B, only 0.45% of the samples (1 sample) tested positive for the substance, with 99.54% of the samples free from this artificial dye. The types of food in which Rhodamine B was detected include *es sirup*.

The analysis results suggest that the majrity of food samples are free from harmful substances. However, attention is still needed regarding the use of borax, which was found in a small proportion of the samples. The detailed findings can be seen in Table 2.

Table 2. Food Samples from School Surroundings

	Characteristic	Frequency	Percentage (%)
Formalin	Detected	0	0
	Not Detected	220	100
Borax	Detected	28	12.7
	Not Detected	192	87.23
Rhodamine B	Detected	1	0.45
	Not Detected	219	99.54
Cyclamate	Detected	0	0
	Not Detected	220	100

Result of bivariate test, there is a highly significant relationship between exposure to harmful substances, nutritional status, and dietary intake. Children with poor nutritional status are 3.11 times more likely to be exposed to harmful substances compared to children with good nutritional status, with a p-value of 0.000, indicating a statistically significant relationship. In terms of dietary intake, children with insufficient

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food intake are 13.26 times more likely to be exposed to harmful substances compared to those with adequate dietary intake. This relationship is also highly significant, with a p-value of 0.02.

Overall, these results suggest that nutritional status and the quality of dietary intake play a major role in increasing the risk of children being exposed to harmful substances. Children with poor intake and nutritional status are more vulnerable to exposure to harmful substances in the food they consume. The findings can be seen in Table 3**.**

Table 3. Result of Bivariate Analysis

Variabel	**Hazardous Substance Exposure**		**PR* (95% CI**)**	**p**
	Exposed	**Not Exposed**		
Nutritional Status				
Poor Nutrition	139 (25.7%)	20 (8.3%)	3.11 (1.75 - 5.51)	0.000
Good Nutrition	400 (74.3%)	221 (91.7%)		
Total	**539**	**241**		
Food Intake				
Poor Intake	89 (16.5%)	3 (1.2%)	13.26 (8.37 - 21.02)	
Good Intake	450 (83.5%)	238 (98.7%)		0.000
Total	**539**	**241**		

Note: Bivariate analysis used the Chi-Square test, with p < 0.05 considered significant
** PR = Prevalence Ratio*
***CI = Confident Interval*

Based on the results of the multivariate analysis, several independent variables showed a significant effect on exposure to harmful substances. Children with poor nutritional status are 3.11 times more likely to be exposed to harmful substances compared to children with good nutritional status (PR = 3.11; 95% CI: 1.75 - 5.51; p = 0.000). This indicates that poor nutritional status is a significant risk factor for exposure to harmful substances. Furthermore, dietary intake also proved to have a highly significant impact. Children with insufficient dietary intake are 13.26 times more likely to be exposed to harmful substances compared to children with adequate dietary intake (PR = 13.26; 95% CI: 8.37 - 21.02; p = 0.000). This suggests that poor dietary intake significantly contributes to the risk of exposure to harmful substances.

The gender variable did not show a significant effect on exposure to harmful substances, with girls having an prevalence ratio of 0.95 (95% CI: 0.65 - 1.35; p= 0.785), indicating no significant difference between girls and boys in terms of the risk of exposure to harmful substances. Age also did not have a significant impact on exposure to harmful substances, with an prevalenc ratio of 1.05 (95% CI: 0.98 - 1.12; p = 0.142), indicating that a child's age does not significantly contribute to the risk of exposure to harmful substances. These results emphasize the importance of maintaining good nutritional status and quality dietary intake in reducing the risk of children being exposed to harmful substances in food. This can be seen in Table 4.

Table 4. Multivariat Analytic of Status of Exposure to Harmful Substances

Variable	Adjusted OR	95% CI	p
Nutritional Status			
Poor Nutrition	3.11	1.75 - 5.51	0.000
Good Nutrition	1.00 (Ref)		
Food Intake			
Poor Intake	13.26	8.37 - 21.02	0.000
Good Intake	1.00 (Ref)		
Gender			
Female	0.065	0.65 - 1.35	0.545
Male	1.00 (Ref)		
Age	1.05	0.98 - 1.12	0.142

Note: Multivariate analysis used the Logistic Regression Test

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DISCUSSION

Age and Gender

Based on the analysis, no significant influence was found from gender and age on exposure to harmful substances. Both male and female children had nearly the same risk of exposure, while age also did not influencing this risk. This may be because the primary factors determining exposure are more closely related to consumption patterns and the quality of food consumed, rather than biological characteristics such as gender or age.[16] Several previous studies also support this finding, where the risk of exposure to harmful substances is more influenced by environmental factors, access to healthy food, and daily eating habits, rather than factors like gender or age.[17,18]

The Relationship Between Nutritional Status and Exposure to Harmful Substances.

This study found that children with poor nutritional status were significantly more likely to be exposed to harmful substances (OR = 3.11; 95% CI: 1.75 - 5.51; p = 0.000). Malnourished children may have limited dietary diversity, making them more reliant on inexpensive, processed foods that often contain harmful additives. Nutritional education can reducing this risk by improving awareness of food safety, promoting healthier food choices, and encouraging proper meal preparation. Studies show that parents with better nutritional knowledge are more likely to select safer, nutrient-rich foods and avoid items containing harmful substances. These substances are frequently used in the food industry and can have negative health impacts, particularly on individuals with poor nutritional status.[19]

Formalin, commonly used as a preservative, can cause various health issues, including digestive system disturbances and organ damage. Studies indicate that individuals with poor nutritional status are more vulnerable to the toxic effects of formalin due to a lack of nutrients that aid the body's detoxification processes.[20] Additionally, borax and rhodamine B, which are often found in processed foods, can disrupt metabolism and cause poisoning, especially in children who have higher nutritional needs for growth and development.[21] Cyclamate, an artificial sweetener, has also been linked to health problems, including potential carcinogenicity. This study found that children with poor nutritional status had a significantly higher risk of exposure to harmful substances, including artificial sweeteners like cyclamate. Although our laboratory analysis did not detect cyclamate in the tested food samples, the presence of other hazardous substances such as borax and Rhodamine B indicates the potential risk of food contamination in school environments. Prior studies suggest that chronic exposure to non-nutritive sweeteners may alter gut microbiota and metabolic processes, particularly in malnourished individuals who already have compromised physiological functions. Thus, it is crucial to strengthen food safety regulations and improve nutritional interventions to minimize health risks in this vulnerable population. However, the evidence regarding cyclamate’s carcinogenicity remains controversial and requires further research for clarification.[22]

These findings suggest that good nutritional status can serve as a protective factor against the harmful effects of these substances. Nutritional education and awareness of healthy eating are essential in this context. A study by Wulandari et al found that good nutritional knowledge is positively correlated with better nutritional status.[23] Individuals who understand nutrition well tend to make healthier food choices and avoid foods containing harmful substances. Therefore, efforts to enhance nutritional knowledge, particularly among mothers and children, can help reduce the risk of exposure to harmful substances and improve overall nutritional status.[24] Moreover, interventions focused on improving nutritional knowledge and understanding the dangers of harmful substances in food can assist communities in making healthier choices. Thus, good nutritional status not only contributes to individual health but also helps mitigate the negative effects of exposure to harmful substances.

Food Intake and Exposure to Harmful Substances

Inadequate or poorly balanced food intake can increase the risk of exposure to harmful substances, which are often found in unsafe foods. Our study found that children with inadequate or poorly balanced food intake were significantly more likely to be exposed to harmful substances in food. Specifically, children with insufficient dietary intake had a 13.26 times higher risk of exposure compared to those with sufficient intake (OR = 13.26; 95% CI: 8.37 - 21.02; p = 0.000). This suggests that inadequate food intake not only affects nutritional status but also increases vulnerability to contaminated food sources.

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This finding aligns with previous studies highlighting the risks associated with unsafe food consumption. Sari et al. (2020) emphasize the dangers of food colorants like Rhodamine B, which are often found in snacks consumed by children. Their study found that children with unbalanced diets tend to consume more processed foods containing harmful additives, leading to potential health risks.[25] Similarly, Kusumastuti's research indicates that foods containing borax and formalin, such as certain crackers, are more frequently consumed in communities with limited awareness of food safety, further increasing the risk of exposure. Poor nutritional intake can also reduce the body's ability to detoxify harmful substances.[26] In this context, research by Handayani emphasizes that public knowledge about selecting healthy foods and detecting harmful substances is crucial for reducing health risks. Communities with better knowledge of healthy eating are more likely to avoid foods containing harmful substances, thereby reducing the risk of exposure.[22]

Cyclamate, as an artificial sweetener, also shows a significant relationship with food intake. Research shows that individuals consuming processed and fast foods high in cyclamate are at higher risk of health complications, especially if their nutritional intake is insufficient. Poor eating patterns in early childhood can persist into adulthood and increase the risk of chronic diseases. Another study by Yanadewi et al. (in press) also emphasizes this point.[27]

The findings of this research provide important implications for health policy and the promotion of healthy eating habits. By identifying significant relationships between nutritional status, food intake, and exposure to harmful substances, the government and health institutions can design programs that focus on improving the nutritional quality of children's diets. This includes increasing access to nutritious foods and educating parents about the dangers of harmful substances in food.

Additionally, stricter regulations on harmful ingredients in food, especially those frequently consumed by children, are needed. Educational campaigns emphasizing the importance of healthy eating and the harmful effects of exposure to toxic substances should also be intensified, with a focus on more vulnerable groups such as children with poor nutritional status. These campaigns can involve schools and local communities to ensure broader and more effective dissemination of information.

The findings of this research provide important implications for health policy and the promotion of healthy eating habits. By identifying significant relationships between nutritional status, food intake, and exposure to harmful substances, targeted interventions can be developed to improve children's dietary quality and food safety. One key recommendation is strengthening school meal programs by providing subsidized, nutritionally balanced meals and ensuring that school food vendors comply with safety regulations. Public nutrition education should also be intensified through nationwide campaigns to raise awareness among parents and caregivers about food safety and the dangers of chemical additives, as well as integrating food safety education into school curricula. Additionally, stricter food safety regulations are needed, including stronger enforcement against the use of hazardous food additives like borax, formalin, and synthetic dyes, along with regular inspections of school canteens and markets. Community-based interventions, such as farmer-to-school programs, urban gardening, and local health worker training, can further support access to safe and nutritious foods. By implementing these measures, policymakers and health authorities can help reduce children's exposure to harmful substances while ensuring better nutritional outcomes.

Limitations of the Study

This study has several limitations that should be considered. First, the study used a cross-sectional design, which can only describe the relationship between variables at a single point in time and cannot directly explain cause-and-effect relationships. Therefore, the results of the study cannot confirm whether exposure to harmful substances causes changes in nutritional status or vice versa. The data collection related to food intake and exposure to harmful substances was conducted through surveys and interviews, which relied on the respondents' memory. This could lead to information bias or inaccuracies in the reports provided. Furthermore, limitations in access to more detailed laboratory data for some samples may have affected the final results. Other variables such as socioeconomic status, parents' education level, and access to healthy food were not analyzed in-depth in this study, even though these factors may play a role in influencing exposure to harmful substances and children's nutritional status. Therefore, future research should consider these factors to provide a more comprehensive and accurate picture.

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CONCLUSION

This study highlights that nutritional status and dietary intake are the primary factors influencing children's exposure to harmful substances. Children with poor nutritional status and inadequate food intake face a significantly higher risk of consuming contaminated food. These findings emphasize the importance of improving nutrition and food safety awareness to minimize exposure risks. Strengthening policies on food quality and enhancing nutritional education programs can protecting children's health.

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