Original Article

Development of a Community-Based Early Warning System (EWS) Model For Stunting Prevention in Nutritional Status Among Children Under Five Years

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ABSTRACT

Background: Stunting is one of the problems in the context of the triple burden of disease. Growth conditions below standard indicate growth obstacles in the child. This research aims to analyse the factors that influence EWS and to evaluate the application of the EWS model in improving nutritional status in toddlers. The purpose of the study is to develop an EWS for nutritional status in children.

Methods: This research used an explanatory design to determine EWS; quasi-experimental sampling was randomised (multistage random design) with 180 respondents in stage 1 and 38 respondents in stage 2—inclusion criteria: mothers who have children and are raising their own child. The research was conducted in the public health sector of Malang Regency. Data collection will be done using a questionnaire for each variable. Data analyzed with Partial Least Square, Wilcoxon Signed Rank Test, and Mann Whitney The results of this study showed that determining factors of EWS were body weight (X1.3), height (X1.4), birth length (X1.6), history of infection (X1.7), minimal weight gain (X1. 11), participation in integrated health service (X2.2), history of maternal infection (X3.2), birth interval (X3.3), land use (X4.2), food hygiene (X5.2), complementary feeding (X6. 1), responsive feeding (X6.2)..

Results: The EWS model's effectiveness is associated with minimal weight gain in children (ρ<0.001), but not with nutritional status (ρ=1.000) or upper arm circumference (ρ=0.207).

Conclusion: It is hoped that the development of this model can be an intervention with an integrated approach to improve the minimal weight gain which in the long term may enhance nutritional status.of children under five.

Keywords: Early Warning System; Nutritional Status; Community- Based Intervention, Pre-school Children

Implications for Practice:

- The Early Warning System model enhances clinical practice by enabling the timely identification of growth faltering through systematic monitoring of weight gain, infection history, and feeding patterns in children under five.
- The integration of this model into community and primary health care services can inform health policy by strengthening early detection pathways and supporting targeted nutrition and infection-prevention interventions.
- The applicability of the Early Warning System model in low- and middle-income countries with resource-limited settings underscores its value as a practical, scalable approach to improving early stunting prevention and community-based child health outcomes.

Introduction

Stunting remains a significant public health problem and part of the global triple burden of disease, characterised by impaired linear growth due to chronic malnutrition and recurrent infections during early life. According to the 2023 Indonesia Health Survey, the prevalence of stunting among children under five remains high, reflecting the persistence of nutritional and environmental risk factors. Previous studies have identified determinants such as low weight of birth weight, inadequate complementary feeding, infection history, and poor sanitation; however, most have not integrated these factors into a systematic model for early detection. Using the Health Promotion Model and Transcultural Nursing framework, this study emphasizes the need for a culturally adapted, community-based approach to identify and address stunting risks before irreversible growth delays occur. However, there is still a gap in research regarding the development and validation of an Early Warning System (EWS) that can be applied at the primary health care level to monitor early signs of stunting. Therefore, this study aims to develop and test the effectiveness of an EWS model for early detection of stunting and improvement of nutritional status among children under five.

The problem of stunting in the Malang City Health Center area is a serious concern because stunting has a long-term impact on children's growth and development. Various factors cause stunting, including poor nutrition, an unbalanced diet, infection and an unhealthy environment. Poor nutrition is one of the primary causes of stunting (Gelli et al. 2018). Public Health Center in Malang Regency, children experience malnutrition and certain micronutrient deficiencies. This lack of nutritional intake can inhibit a child's linear growth and result in low height. Apart from that, an unbalanced diet is also an essential factor in stunting.

Many children in this area do not get enough important nutrients such as protein, vitamins and minerals for optimal growth (Mosha et al. 2018; Shafiq et al. 2019). Unhealthy eating patterns, such as consuming processed foods and fast foods that are low in nutrients, are also a problem that needs to be addressed. Infection is another important factor that contributes to stunting. Chronic infections such as diarrhoea, malaria, or respiratory tract infections can interfere with nutrient absorption and increase a child's calorie needs, affecting the child's linear growth (Ngaisyah and Avianty 2020; Akombi et al. 2017; Beal et al. 2018; Brar et al. 2020). An unhealthy environment is also a problem when venting stunting. Environmental factors such as poor sanitation, limited access to clean water, and poor air quality can increase the risk of infection and affect children's nutritional status.

In overcoming the problem of stunting in the Malang Regency Health Center area, it is necessary to take action that involves the community, such as increasing public knowledge and awareness about the importance of good nutrition, changing healthy eating behaviour, and improving environmental conditions. Community Health Centers can also carry out stunting prevention and management programs integrated with various related parties, including community leaders, educational institutions and other community organizations (Perumal, Bassani, and Roth 2018; Bhutta et al. 2020a; 2020b). The role of feeding in the first two years of life is closely associated with the mother's ability to provide nutrition. In this age period, there is a risk of nutritional problems due to transition/weaning and infant-child feeding practices, especially in terms of food variety, quality of diet, availability and accessibility of nutritious food, exposure to infections and poor sanitation(Sjarief et al. 2015; Alaofè et al. 2017; Johari et al. 2015). The quality of food and nutrition depends on the mother's ability to properly feed children under five years old. It is supported by their nutrition knowledge (Yaya et al., 2020).

Mothers with higher education and knowledge influence children's parenting patterns, including feeding, food consumption patterns and nutritional status (Borkotoky, Unisa, and Gupta 2018; S. Gupta, Vemireddy, and Pingali 2019; V. Gupta et al. 2018; Laillou et al. 2020). Mothers with good education and knowledge influence children's parenting patterns, including feeding, food consumption patterns and nutritional status (Hastuti et al. 2023; Mediani 2020).

Nutritional problems are still a major point in every country, starting from the single burden (stunting), which occurs in 22.2% of the total number of children under five worldwide. The results of the 2018 Riskesdas showed the prevalence of stunting was 30.3% (very short 11.5% and short 19.3%), while in Malang Regency, the prevalence was 27.10% (very short 14.27% and short 12.83%). Based on a preliminary study conducted from reports on weighing operations in February 2021 of 138,155 children in 39 Community Health Centers in Malang Regency, 15,055 children experienced stunting (10.9%). The highest cases in the Malang Regency area include Pagak Community Health Center, with 506 children out of 1,288 children (39.2%). Ngajum Community Health Center has 562 children out of 2,122 (26.4%), and Pujon Community Health Center has 881 children out of 3,4 1 (26%). Efforts made by the Malang Regency Government under the coordination of the Malang Regency Regional Planning Agency to reduce the incidence of stunting are by increasing the area covered by integrated and cross-sectoral stunting management every year. There will be 22 stunting intervention locus in 2020, 32 in 2021 and 50 locus in 2022.

Prevention and handling of stunting needs to be carried out with an approach that involves the community, namely by integrating the roles of families, community leaders and local government. This community-based approach aims to increase community awareness and participation in overcoming the problem of stunting and increase the accessibility and quality of health services. In its implementation, the Malang Regency health centre needs to carry out early warnings of stunting, namely efforts to detect the risk of stunting in young children early. EWS of stunting involves various measurement and evaluation methods, such as measuring the child's height and weight and questionnaires related to nutritional intake and eating patterns (Hastuti, Mufarokhah, and Roesardhyati 2023; Rabaoarisoa et al. 2017; Gelli et al. 2018). With a community-based approach, the Malang Regency Health Center also needs to involve the role of families, community leaders and local government. Families can be empowered to provide good care and assistance to children, optimize a balanced diet and equate nutrition (Maru et al. 2018; Miller et al. 2019). Community figures can be agents of change who strengthen public awareness and knowledge about stunting and promote and support stunting prevention and management programs. Local governments, including Community Health Centers, can facilitate and support collaboration between families, community leaders, and other related parties. The EWS model for stunting prevention is underdeveloped. Through his community approach, it is hoped that can be formed between multiple parties to overcome the stunting problem. By increasing public awareness, the active role of families, and support from the government, it is hoped that stunting levels can decrease and young children can grow optimally. The aim of this study is to analyze developof an EWS model for stunting prevention among children under five years.

Methods

Study Design

This research uses a model development design where the stages in model development consist of two research stages. The study used an explanatory research design in phase 1 and a quasi-experiment in phase 2. The study has gathered information from mothers in the Integrated Health Service in Malang Regency. The population study included the Public Health Center from 17 areas. The total population is 180 mothers in stage 1 and 38 people in stage 2.

Participants

The sample for this study was recruited through cluster sampling to generalize the results. The clusters were created based on the mothers from 17 sub-districts in the Malang Regency region. Each sub-district was considered one cluster representing variations in demographic and environmental characteristics. From these clusters, several were randomly selected to ensure representativeness and reduce sampling bias. Within the chosen clusters, respondents were then selected proportionally according to the number of eligible mothers in each area. This approach allowed the researcher to efficiently reach a geographically dispersed population while maintaining the generalizability of the findings to the broader population of mothers in Malang Regency.

Sample size was calculated using Slovin with the level of significance (0.05). Based on this calculation, the minimum sample size of the study was recorded as 180 respondents in phase 1. Respondents were informed about the aim of this study and the procedure adopted for conducting the survey before recruit. They were also asked for informed consent to participate in this study. In phase 2 used purposive sampling for each group, 38 respondents (control and intervention). Inclusion criteria for mothers who have children and are raising their own child.

Instruments

Data for this study were collected using a questionnaire for each variable. Parameter from child factor (X1) are gender (X1.1), age (X1.2), weight (X1.3), height (X1.4), weight of birth (X1.5), length of birth (X1.6), history of infection (X1.7), early initiation of breastfeeding (X1.8), immunization (X1.9), minimal weight gain (X1.10); health service factor (X2) are health care system (X2.1), participation in integrated health service (X2.2); maternal factor (X3) are age of mother (X3.1), maternal infection (X3.2), spacing of birth (X3.3), pregnancy complication (X3.4); household factor (X4) are hygiene sanitation (X4.1), land use (X4.2), residential density (X4.3); food safety factor (X5) are avaibility of food ingredients (X5.1), food hygiene (X5.2); supplementary feeding factor (X6) are complementary feeding (X6.1) and responsive feeding (X6.2); EWS (Y). The instrument was validated by experts in nutrition and public health, and its reliability was tested using Cronbach's Alpha, yielding a coefficient value of $\alpha = 0.82$, indicating high internal consistency and suitability for further analysis.

Intervention

The intervention was implemented over a three-month period and involved several structured steps, including training, monitoring, and evaluation. In the first phase, health workers and community cadres received training on the Early Warning System (EWS) model, focusing on identifying stunting risk factors, recording data, and providing appropriate counselling. During the implementation phase, mothers and children were monitored through monthly Posyandu visits, where anthropometric measurements, infection history, and feeding practices were assessed using the EWS checklist. Fidelity monitoring was conducted by supervisors to ensure adherence to intervention protocols and data accuracy. Evaluation of outcomes was performed at the end of each month to measure progress in children's weight gain and early signs of nutritional improvement. Ethical procedures were strictly followed throughout the study, including obtaining informed consent, ensuring confidentiality of participant data, and maintaining participant safety during all assessments and interventions.

Data collection for this study was carried out over a six-month period from January to June 2024. Data were obtained through structured questionnaires and direct anthropometric measurements conducted during Posyandu visits. The data recording process was performed manually using printed forms and then entered electronically into a validated database to ensure accuracy and completeness. Prior to data collection, enumerators and health cadres received standardized training on data collection procedures, instrument use, and ethical considerations to ensure consistency and minimize measurement bias. Quality control was maintained through routine supervision, random spot checks, and double data entry verification, with periodic cross-checking between manual records and electronic files to detect and correct any discrepancies.

Data Collection

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Data Analysis

Partial Least Squares (PLS) analysis was used in this study to develop and validate the Early Warning System (EWS) model for stunting because it is suitable for complex models with multiple latent variables and does not require strict assumptions about data normality. PLS is particularly effective for exploratory research aimed at identifying predictive relationships among interrelated variables, such as child, maternal, household, and feeding factors.

The data obtained through the study were coded, entered and verified using IBM SPSS Statistics for Mac version 27.0 (IBM Corp. Released) to increase the quality of data analysis. The categorical study, including child factor, health service factor, maternal factor, household factor, food safety factor, supplementary feeding factor and EWS, was described through descriptive statistics and analysed with SPSS. The Wilcoxon Signed Rank Test was employed to assess pre- and post-intervention differences in nutritional outcomes since the data were not normally distributed, while the Mann–Whitney test compared differences between independent groups. Assumption testing was conducted prior to analysis to evaluate data normality, linearity, and multicollinearity. Effect size was calculated using Cohen's d and Odds Ratio (OR) to determine the magnitude and practical significance of the intervention outcomes, with interpretation guided by standard criteria (small: d=0.2; medium: d=0.5; large: d≥0.8). Confidence intervals (95% CI) were also reported to enhance the robustness and reliability of the statistical findings.

Table 1. Workflow of Data Collection and Analysis

Variable	Indicator	Instrument	Validity & Reliability	Scoring System	Category
Stage 1					
Child Factors (X1)	Weight, Height, Birth Weight, Birth Length, Infection, Immunization, Weight Gain	Anthropometric tools, structured questionnaire		Z-scores (WHO Anthro, 2006)	Normal / Stunted / Severely Stunted
Health Service Factors (X2)	Health service access, participation in Posyandu	Structured questionnaire	Cronbach's α = 0.78 (valid)	Frequency of visits per month	Good Enough Less
Maternal Factors (X3)	Maternal infection, birth interval, complications, and age	Questionnaire validated by medical records	Cronbach's α = 0.80 (valid)	Dichotomous (Yes/No), age category	Reproductive / High risk
Household Factors (X4)	Hygiene, sanitation, land use, density	Observation checklist	Cronbach's α = 0.85 (valid)	3-point Likert (Good–Poor)	Good / Fair / Poor
Food Safety Factors (X5)	Availability, food hygiene	Food safety questionnaire (FAO adapted)	Cronbach's α = 0.79 (valid)	3-point scale	Adequate / Moderate / Inadequate
Feeding Factors (X6)	Complementary & responsive feeding	IYCF Questionnaire (WHO, 2010)	Cronbach's α = 0.83 (valid)	4-point Likert	Good / Fair / Poor
EWS (Y)	EWS EWS score	Model validation via PLS	CR > 0.70; convergent &	Loading ≥ 0.6	Predictive accuracy

Variable	Indicator	Instrument	Validity & Reliability	Scoring System	Category
			discriminant validity		
Statistical Analysis	SEM- PLS using Smart PLS 3.0				
Stage 2					
EWS Implementation	Utilization of the EWS model by cadres and mothers in the early detection of stunting risk	Check list	Cronbach's α =0.84	EWS adherence score (range 0-100)	High (>75%) Moderate (50-75%) Low (<50%)
Nutritional Status	Weight-for-age (WAZ), height-for-age (HAZ), weight-for-height (WHZ)	Anthropometric measurements using a digital baby scale and microtoise	Standardized based on the WHO growth chart	Z-score via WHO Anthro software	Normal ≥ -2SD Underweight <-2SD
Feeding behavior change	Frequency and diversity of feeding responsiveness	Feeding behavior questionnaire	Cronbach's α = 0.081	Always= 4 Never= 1	Good Less
Cadre competence	Knowledge, attitude and skill in applying EWS	Cadre competency questionnaire and observation checklist	Cronbach's α =0.85	Score 0-100	Good Less
Statistical Analysis	Pre-post comparison within group, comparison between intervention and control groups	Wilcoxon Signed Rank Test (within group) and Mann-Whitney			

Notes: Instrument reliability α = 0.82; PLS construct validation. Software: SPSS 27.0, SmartPLS 3.0.
Stage 1 identifies determinant factors for EWS development.

Ethical Considerations

This study received ethical approval from the Ethics Committee of the Health Polytechnic of Malang, Indonesia, with certificate number 2043-KEPK/2024. After receiving explanations and research procedure instructions, all respondents voluntarily provided informed consent to participate in the research. The research procedure adhered to the principles outlined in the Declaration of Helsinki for research involving human participants. Ethical approval for this study was obtained from the institutional ethics committee prior to data collection, ensuring that all research procedures adhered to established ethical standards. Written informed consent was obtained from all participating mothers after they received a detailed explanation of the study's purpose, procedures, benefits, and potential risks. Participant confidentiality was strictly maintained by using coded identifiers instead of personal information, and all collected data were securely stored with restricted access. This study was conducted in full compliance with the principles outlined in the Declaration of Helsinki, ensuring respect for human dignity, privacy, and the protection of participants' rights throughout the research process.

Results

Stage 1

The research location is in Malang Regency, which has 29 Public Health Centers (PHC). The prevalence of stunting in the Public Health Center at Malang Regency is 10.9%, with a total of 138,155 children aged 28 days - 72 months in the Malang Regency Health Center Area, of which 15,055 children are stunted. The incidence of stunting for each age classification can be divided as follows: ages 0-6 months are 4%, ages 6-24 months are 33%, ages 2-3 years are 24%, and ages 3-6 years are 39%. There were 3,926 children aged 6-24 months who experienced stunting, with details from Tajinan Health Center with 13 people in the severe stunting category and 176 people with stunting out of a total of 4,826 children under five; Kepanjen Community Health Center with 87 people in the severe stunting category and 373 people with stunting out of a total number of toddlers of 5035 people; Singosari Community Health Center with 8 people in the severe stunting category and 205 people with stunting out of a total number of toddlers of 4923 people; Wajak Health Center with 13 people in the severe stunting category and 176 people with stunting out of a total number of toddlers of 4622 people; The Bululawang Community Health Center with the severe stunting category was 195 people and 714 stunted people out of a total number of toddlers of 3991 people, so the total number of children aged 6-24 months was 33%.

Phase 1 research was conducted at the Malang Regency Regional Health Center with respondents as mothers of toddlers who had children aged 6-24 months who experienced stunting who took part in the integrated health service, Malang Regency (Tajinan PHC, Kepanjen PHC, Singosari PHC, Wajak PHC, Bululawang PHC in accordance with recommendations based on the highest number of stunting cases and random selection of 5 PHCs in Malang Regency.

The description of this research variable will explain the results of the data collection that has been carried out on respondents. The results of respondents' answers have been categorized according to the operational definition.

The child factor (X1) variables in this study were formed by observed variables in **Table 2.** The results of the description of child factors are in the following table.

Table 2. Frequency Distribution of Child Factors in the Working Area of the Malang Regency Health Center in 2024 (n=180)

Variable	Category	Frequency (f)	Percentage (%)
Gender	Boy	79	44
	Girl	101	56
Age of Children	2- 3 years old	51	28
	3- 4 years old	89	49
	4- 5 years old	40	22
Weight	12,2 kg	100	8-20,2 kg
Height	128 cm	8,64	78- 139 cm
Birth of weight	2850 gram	350	1700- 4000
Length of weight	48,63 cm	2,72	40- 64
History of infection	Yes	179	99
	No	1	1
Early initiation of breastfeeding	Yes	68	38
	No	112	62
Breastfeeding	Yes	99	55
	No	81	45
Immunization	Complete	178	99

Variable	Category	Frequency (f)	Percentage (%)
	Incomplete	2	1
Minimal weight gain	220 gram	24,8	am

Table 3 illustrates the distribution of key determinants related to child characteristics, maternal conditions, household environment, food safety, feeding practices, and early stunting risk. The patterns indicate that biological vulnerabilities coexist with behavioral and environmental constraints. Although most children had complete immunization coverage, indicators such as high infection history and suboptimal breastfeeding practices highlight persistent gaps in early child care.

Health service engagement appeared strong, with nearly all respondents reporting adequate access and active participation in community health services. Maternal factors similarly reflected favorable demographic characteristics, with low reports of infection or pregnancy complications, suggesting that child-level risks may be influenced more heavily by postnatal care and environmental conditions rather than maternal health alone.

Household indicators revealed notable disparities, particularly in food availability and land use, pointing to structural limitations that may affect daily nutritional practices. This is reinforced by the finding that responsive feeding was universally poor, and complementary feeding remained inadequate for half of the sample, indicating consistent behavioral challenges in meeting children's nutritional needs.

Collectively, these multidimensional constraints correspond with the Early Warning System classification, in which 40% of children were identified as being at risk of stunting. This proportion underscores the intersection of biological, environmental, and caregiving factors, demonstrating the need for integrated community-based interventions to address stunting risk effectively.

Table 3. Distribution of Factors Related to Child, Health Services, Maternal, Household, Food Safety, Supplementary Feeding, and EWS (n = 180)

Variable Group	Variable	Category	Frequency (f)	Percentage (%)
Child Factors (X1)	Gender	Boy	79	44
		Girl	101	56
	Age	2–3 years	51	28
		3–4 years	89	49
		4–5 years	40	22
	History of Infection	Yes	179	99
		No	1	1
	Early Initiation of Breastfeeding	Yes	68	38
		No	112	62
	Breastfeeding	Yes	99	55
		No	81	45
	Immunization	Complete	178	99
		Incomplete	2	1
	Minimal Weight Gain	Avg. 220 g	—	—
Health Service Factors (X2)	Health Care System	Good	171	95

Variable Group	Variable	Category	Frequency (f)	Percentage (%)
		Enough	9	5
		Less	0	0
	Participation in the Integrated Health Service	Active	147	82
		Inactive	33	18
Maternal Factors (X3)	Age of Mother	20–25 years	51	28
		26–35 years	89	49
		36–40 years	40	22
	Maternal Infection	No	179	99
		Yes	1	1
	Pregnancy Complications	Yes	11	6
		No	169	94
Household Factors (X4)	Hygiene Sanitation	Good	91	51
		Less	89	49
	Land Use	Yes	71	39
		No	109	61
	Residential Density	High	77	43
		Low	103	57
Food Safety Factors (X5)	Availability of Food	Good	0	0
		Less	180	100
	Food Hygiene	Good	91	51
		Less	89	49
Supplementary Feeding Factors (X6)	Complementary Feeding	Good	91	51
		Less	89	49
	Responsive Feeding	Good	0	0
		Less	180	100
EWS Factor (Y)	EWS Category	At Risk of Stunting	72	40
		No Risk	108	60

Structural Equation Model Analysis in the Development EWS Model

The development of this research model uses inferential analysis, which is carried out using Structural Equation Modelling (SEM) with SmartPLS software ver 3.0 for Mac. Model evaluation using PLS is a non-parametric prediction model. Evaluation Data analysis in phase 1 research was carried out using SEM-PLS, which included testing the measurement model (outer model) to test the validity and reliability of indicators, and hypothesis testing.

A measurement model is needed to ensure that the indicators being measured are valid and reliable. The structural model is used to test the influence between exogenous and endogenous factors if the statistical T value is greater than the T-table with error tolerance α=0,05.

Testing the measurement model (outer model)

The outer model describes the relationship between the latent variable and its indicators. The measurement model is used to test the construct validity and reliability of the instrument. The indicator is said to be valid if the entire outer loading is >0.5 or has an average variance extracted (AVE) value > 0.5. An indicator is said to be valid if all variable dimensions have an outer loading value > 0.5 or have an average variance extracted (AVE) > 0.5. An indicator is said to be reliable if the composite reliability is > 0.6, then the indicator is said to be reliable.

Measurement model analysis aims to test whether valid indicators explain the construct or latent variable. Valid indicators are tested through three types of construct validity tests: the first is the convergent validity test, the second is the discriminant validity test, and the third is the significance test of the influence of the indicator on the construct. These three types of validity tests are used to strengthen the decision whether an indicator is retained in the model or removed from the model. The criteria used in the convergent validity test are that if the indicator has a factor loading value (outer loading) > 0.5, then it is concluded that the indicator is valid in explaining the construct or latent variable. In the discriminant validity test, if the indicator has a cross-loading value > 0.5, then it can be concluded that the indicator is valid in explaining the construct or latent variable, whereas in the significance test, if the indicator has a t-statistic value > 1.96, then it can be concluded that the indicator is significant in explaining the construct or latent variable.

Evaluation of the measurement model is a stage for evaluating the validity and reliability of a construct/latent variable in this research, namely child factors (X1), health service system factors (X2), maternal factors (X3), household factors (X4), food safety factors (X5), MPASI (X6) and *EWS* (Y1).

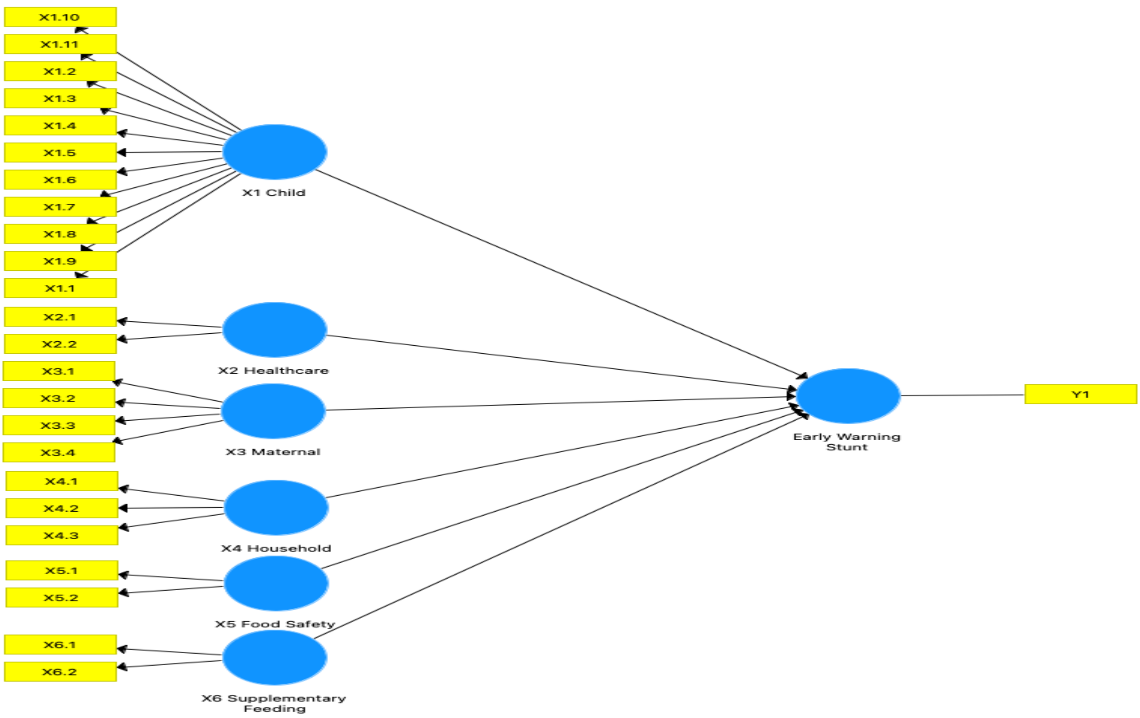

Figure 1. Construct *Outer Model* Research Development of EWS Model

Figure 1 shows that all indicators have an outer loading value of 0.5 except for the indicators gender (X1.1), age (X1.2), weight of birth (X1.5), early initiation of breastfeeding (X1.8), breastfeeding (X1.9), immunization (X1.10), health service system (X2.1), maternal age (X3.1), pregnancy complications (X3.4), sanitation (X4.1), residential density (X4.3), hygiene (X5.1) so that indicators with a value <0.5 are removed from the latent variable or construct. Based on the results of construct validity testing, using convergent validity tests, discriminant validity tests, and indicator causality tests on latent variables, there are still indicators that are not valid in explaining the construct or latent variable.

Test the significance of the influence of the indicators on the construct (Average Variance Extracted/AVE) in stage 1 of the research. AVE is the average value of the total factor loading of a construct squared. The reference criterion that a construct meets the discriminant validity test is if the AVE value is >0.5.

Table 4. Construct Testing Results Using Average Variance Extracted (AVE) Phase 1 Research Data

Variable	*Average Variance Extracted*	Result
X1 Children Factor	0,837	Valid
X2 Healthcare System Factor	0,637	Valid
X3 Maternal Factor	0,880	Valid
X4 Household Factor	0,502	Valid
X5 Food Safety Factor	0,684	Valid
X6 Supplementary Factor	0,678	Valid
Y1 EWS Model	0,773	Valid

Based on **table 4** shows that the AVE value for all constructs has a value of > 0.5, so it can be concluded that all construct variables are valid. From the results of the SEM-PLS analysis on the outer model with a value <0.5, a new model will be built to produce the following significance values **(Figure 2).**

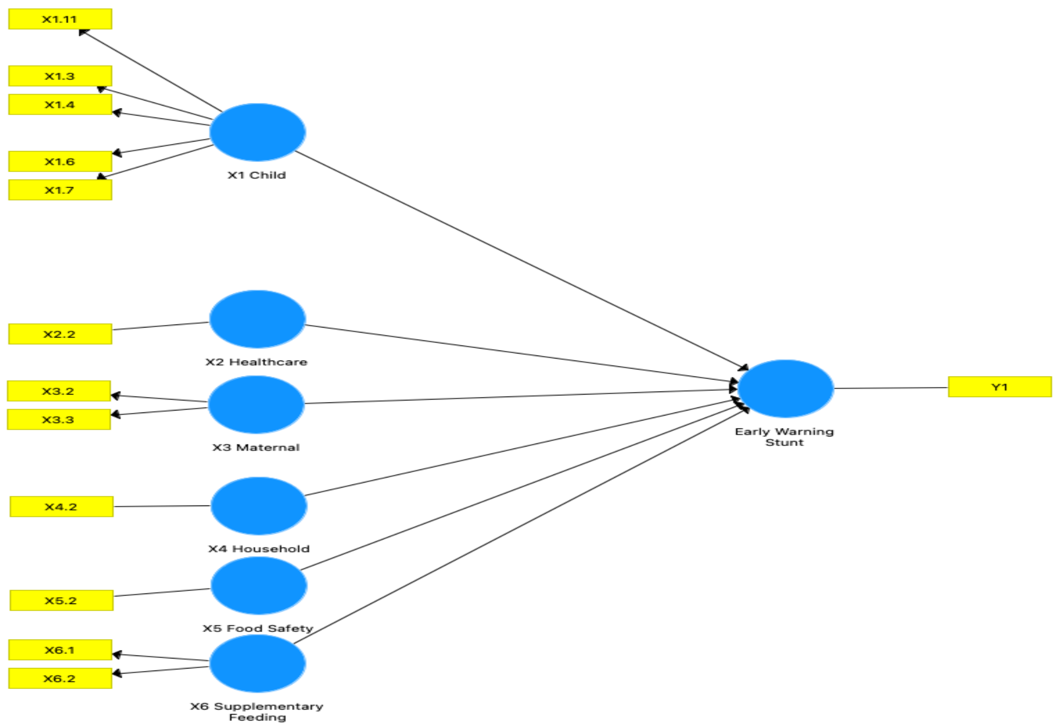

Figure 2. Construct PLS Algorithm (*outer model valid*) EWS Model

Significance testing is used to test whether there is an influence of exogenous variables on endogenous variables. The test criteria state that if the statistics value > T table (1.96) or the p-value < significant alpha 5% or 0.05, then it is stated that there is a significant influence of exogenous variables on endogenous variables.

First, look at the magnitude of the structural path coefficient or the magnitude of the relationship/influence of latent variables by looking at the T-statistic value carried out using a bootstrapping procedure. The following are the results of statistical test analysis using the bootstrapping procedure. Meanwhile, the results of the significance test of the EWS model analysis of the mother's ability to fulfil nutrition for children under 5 years.

Table 5. Model Analysis Hypothesis Test Results

No	Causality correlation	*Path Coefficient*	*T- statistic* (O/ STDEV)	*p-value*
1	X1 Child factor → Y EWS	0,214	2,956	0,004
2	X2 Healthcare system factor → Y EWS	0,324	5,688	0,000
3	X3 Maternal Factor → Y EWS	0,267	3,938	0,000
4	X4 Household Factor → Y EWS	0,265	4,824	0,000
5	X5 Food Safety Factor → Y EWS	0,304	4,866	0,000
6	X6 Supplementary Factor → Y EWS	0,254	4,698	0,000

Based on **Table 5,** the results presented, all six factors—child, healthcare system, maternal, household, food safety, and supplementary—showed a significant positive correlation with the Early Warning System (EWS) model ($p < 0.05$). The healthcare system factor had the highest path coefficient (β = 0.324, t = 5.688), indicating its strong influence on the EWS, suggesting that access to and quality of health services are critical in early detection and management of stunting risks. The food safety factor also demonstrated a strong effect (β = 0.304, t = 4.866), emphasizing the importance of safe and nutritious food availability for child growth. Meanwhile, maternal (β = 0.267) and household factors (β = 0.265) both significantly contributed to the EWS, reflecting the role of maternal knowledge, caregiving behavior, and home environment in child nutrition. The child factor (β = 0.214) and supplementary factor (β = 0.254) also had significant associations, indicating that intrinsic child characteristics and additional nutrition interventions influence EWS outcomes. Overall, these findings confirm that EWS is a multifactorial model influenced by both individual and systemic determinants of child growth and stunting risk.

Model fit

The final model in this research is that the EWS is influenced by child factors, health service system factors, maternal factors, household factors, food safety factors, and supplementary feeding factors.

Phase 2

The research was carried out in the Wagir Community Health Center Working Area, Malang Regency, where this location has 12 regions. Assessment of the characteristics of respondents based on the results of descriptive analysis is presented in the form of a frequency distribution table, which includes percentage and frequency values, mean values, and standard deviation. The following are the results of the test for equality of demographic characteristics of respondents between the treatment group and the control group before being given the intervention.

Table 6. Test of Equality of Respondent Characteristics Between Treatment Groups and Control Groups

No	Variable	Group: Intervention (n=38)	Group: Control (n=38)	p-value *equality*
1	Age of mother			
	17- 25 years	9 (23,7%)	6 (15,8%)	0.440[a]
	26- 35 years	18 (47,36%)	16 (42,10%)	
	36- 45 years	11 (28,94%)	16 (42,10%)	
2	Age of mother			
	Min- Max	21- 45	25- 43	0.458[b]
	Mean±SD	31,65±6,494	32,26±1,003	
3	Level of Education			
	Elementary school	2 (5,26%)	4 (10,52%)	0,483[a]
	Junior high school	8 (21,05%)	4 (10,52%)	
	Senior high school	19 (50%)	18 (47,36%)	
	Higher Education	9 (23,69%)	12 (31,6%)	
4	Occupation			
	Farmer	1 (2,63%)	0	0.569[a]
	Entrepreneurship	9 (23,69%)	8 (21,05%)	
	Housewife	28 (73,68%)	30 (78,95%)	
5	Age of children			
	6- 12 months	4 (10,52%)	4 (10,52%)	0.644[a]
	12- 24 months	34 (89,48%)	34 (89,48%)	
6	Age of Children			
	Min- Max	9- 22	10- 22	0.820[c]

No	Variable	Group		p-value *equality*
		Intervention (n=38)	Control (n=38)	
	Mean±SD	18,86±0,64	18,44±0,574	
7	Taking Care of Children			
	Alone	28 (73,68%)	30 (78,95%)	0.209[a]
	Helped by family	10 (26,32%)	8 (21,05%)	
8	Type of Children Birth			
	Spontan	29 (76,31%)	24 (63,15%)	0.212[a]
	Sectio secarea	9 (23,69%)	14 (36,84%)	

[a]*Chi-square test,* [b]*Mann-Whitney,independent-test*

Based on **table 6** shows that the largest age proportion is 17-25 years old at 47.36%, while the control group has the largest proportion at 26-35 years old and 36-45 years old at 42.10%, respectively. The highest proportion of mothers with a high school education was 50% in the treatment group and 50% in the control group. The highest proportion of mothers' jobs was housewives, 73.68% in the treatment group and 78.95% in the control group. The proportion of children aged mostly 12-24 months in each treatment group and control group was 89.48%.

Based on the equality test, respondents' characteristics were tested using the Chi-Square Test on a nominal data scale and the Mann-Whitney Test on ordinal data, while for interval or ratio data using the Independent t-test, with the results of the p-value equality test > 0.05 for respondent characteristics data, which includes age, occupation, education, age of children, taking care of their own children, and type of birth of children, which means that the characteristics of respondents in the treatment and control groups are stated to be equivalent.

Assumption tests were carried out before further statistical analysis. The assumption tests carried out in this research are the normality test and the homogeneity test. The data normality test was carried out using the Shapiro-Wilk test to determine whether the data were normally distributed with a sample size of less than 50, while the homogeneity test was carried out using Levene's test to determine whether the data obtained was homogeneous or not.

Child growth before and after the EWS model intervention, where the results of child growth measurements were carried out 1 month after the intervention was carried out. The following are the results of a descriptive analysis of child growth.

Table 7. Frequency Distribution of Child Growth in the Treatment Group and Control Group (n=38)

Variable	Intervention				Control			
	Pre		Post		Pre		Post	
	F	%	f	%	f	%	f	%
Nutrition								
Severely underweight	6	15,8	4	10,5	0	0	0	0
Underweight	4	10,5	4	10,5	8	21	8	21
Normal	28	73,7	30	79	30	79	30	79
Risk of being overweight	0	0	0	0	0	0	0	0

Based on **table 7** shows that almost all of the children's nutritional status in the two groups had a nutritional status in the normal weight category, which was measured through the results of a comparison of body weight according to age. In the treatment group, 6 children (15.8%) had severely underweight nutritional status, and 4 children (10.5%) were underweight.

The following are the results of inferential data analysis of child growth measurements carried out before and after the intervention, as follows:

Table 8 Differences in Child Growth

Variable	Intervention Group		Control Group		Test Analysis		
	Pre	Post	Pre	Post	Pre-pre	Post-post	Δ
	Mean±SD	*Mean*±SD	*Mean*±SD	*Mean*±SD			
Nutritional status	-0,73±1,71	-0,68±1,66	-0,32±1,64	-0,28±1,64	0,252	0,252	1,000
Minimal Weight Gain	0,84±0,369	168,42±73,90	0,71±0,45	1,78±0,41	0,172	0,000	0,000
Upper arm circumference	12,56±1,15	12,81±1,08	12,78±1,08	13,10±0,97	0,463	0,402	0,207

Based on **table 8** shows that the average value of children's growth has increased between before and after the intervention in both the treatment group and the control group. Based on the results of statistical tests using the Wilcoxon Signed Rank Test, it was found that there were differences in the growth of children aged 6-24 months who experienced stunting before and after being given intervention, with indicators of minimal weight gain (p=0.000). Meanwhile, nutritional status (p=1,000) and upper arm circumference (p=0.324) showed that there was no difference between before and after the intervention was given. Apart from that, the control group showed that there was no difference between the growth of children aged 6-24 months who experienced stunting before and after being given standard intervention with nutritional status indicators (p=1,000), minimal weight gain (p=0,761), and upper arm circumference (p=0,189).

Apart from that, other variables contained in this study from the results of the Mann-Whitney test showed that there was a significant difference in child growth between the treatment group and the control group, with indicators of minimal weight gain (p 0,000). Meanwhile, the nutritional status indicators (p=1,000) and upper arm circumference (p=0.207) show that there is no difference between the treatment group and the control group.

Discussion

Based on research results in it shows that EWS intervention for stunting can influence optimal child growth. This is in accordance with the Infant Young Child Feeding (IYCF) recommendations and guidelines for feeding infants and children (Kemenkes, 2018), where the principles of feeding babies and children include being timely, adequate, safe and given in the right way. Children need the right food intake to achieve optimal growth and development, especially in the first 1000 days of life. Unmet nutritional needs result in babies and babies experiencing malnutrition, poor nutrition, stunting, wasting, suboptimal brain intelligence, decreased immune system and problems with stunted growth and development, even death.

When introducing breastfeeding to children, it is recommended that, in the first 2 weeks at most, porridge and single fruit be introduced with a food frequency of 1-2 times a day. This introductory period is used to introduce various sources of carbohydrates, vegetables and fruit. In the following week, children must be introduced to protein, both animal and vegetable protein and additional sources of fat in the form of fine/strained porridge, which is given together with carbohydrates and vegetables, with a food frequency of 2-3 times a day, and they are introduced to snacks. This principle of food variation is the basis for compiling a daily menu so that children's macro and micronutrient needs can still be met. Meanwhile, the parenting pattern in providing food, in this case, is responsive feeding. Responsive feeding when feeding, responding to the child with a smile, maintaining eye contact, encouraging positive words, and giving the child soft food that can be held to stimulate active self-eating (finger snacks).

Studies conducted show that maternal empowerment based on self-regulated learning can influence the optimal growth of babies and children, especially in minimal weight gain. Meanwhile, EWS based on a community approach has no influence on indicators of nutritional status and upper arm circumference. This is possible because the child's weight measurement was carried out only once, which was carried out one month after the intervention was implemented. Minimum weight gain in children can be seen, and growth trends can be observed. The increase in child weight was quite significant in mothers who had children under five years after carrying out an EWS based on a community approach. Measuring the circumference of the upper arm showed that there was no difference before and after the measurement was given. This is because upper arm circumference is an anthropometric measurement, which is a single measurement to determine the occurrence of chronic energy deficiency, so the upper arm circumference cannot be used to measure changes in nutritional status in the short term (Al-Qahtani et al. 2021; Nickel and von dem Knesebeck 2020; Herlyawati and Damayanti 2020). Apart from seeing chronic energy deficiency, upper arm circumference has another function as an early indicator of the baby's nutritional status, namely, when there is a decrease in the size of the upper arm circumference. This condition can be an early sign and symptom of malnutrition disease. Upper arm circumference is used as a benchmark in measuring children's growth because it is easy, the results are fast, the price is low, and it does not require data on the child's weight and age (Abreha, Walelign, and Zereyesus 2020; Hasegawa, Ito, and Yamauchi 2017; Oguma et al. 2020).

EWS intervention is carried out so that the implementation of feeding for children under five years can improve well, so that babies and children can grow healthy and intelligent, have maximum body immunity, and provide good and correct feeding behaviour from an early age. Apart from that, according to the Ministry of Health's standards (2020) regarding Nutritional Status Assessment, it is shown that the upper arm circumference in babies is less sensitive, especially in children who experience nutritional problems. Children as individuals have life needs ranging from maintaining and improving health, growth and development and physical activity. Apart from that, the results of these anthropometric measurements can be used as initial screening, for example, in the case of weight not rising during 2 visits to the integrated health care, as a health service provider, you can identify whether the child has an infection, worms or other unknown causes.

Studies conducted show that there is a relationship between the mother's ability to fulfil nutrition needs and the growth of children under five years. The mother's role is very important in meeting the nutritional needs of children, stimulating and monitoring children's growth and development. Early detection and routine growth monitoring in health care facilities are important in preventing malnutrition in children. With earlier screening in terms of measuring weight, length or height, the child's head circumference, where the risks include chronic malnutrition and stunting, it is hoped that the earlier the treatment is, the better the prognosis. The mother's role is the main one in efforts to prevent and recognise stunting in toddlers. Mothers can monitor their children's growth and development by weighing them and measuring their height regularly through posyandu activities and recording them in the KIA book.

Nutritional disorders in infants and children are generally caused by poor-quality and poor food feeding patterns. The mother's ability to provide food results in nutritional disorders experienced by the child, which results in impaired child growth, which is caused by not being given breast milk, giving supplementary feeding too early and generally not containing enough macro and micronutrients. Apart from that, looking at the pattern of caring for children's food by mothers, there are still many mothers who provide prelacteal food or provide supplementary feeding too early, and the quantity and quality of the nutritional supplements provided are inadequate.

Causes of growth disorders in children include incorrect and inappropriate provision of Supplementary Feeding as well as not meeting nutritional requirements, both in terms of quantity and type, in children aged 6-24 months, where this age period is a critical growth period, so it needs to receive more special attention. The finding that nutritional status was not significantly affected may be explained by several factors. First, the study duration might have been too short to observe substantial changes in nutritional status, as improvements in this indicator typically require longer follow-up periods. Second, the Early Warning System (EWS) intervention may have primarily influenced immediate behavioural or environmental factors (such as feeding practices or health monitoring) that contribute to short-term weight gain, but not yet to overall nutritional improvement. Third, measurement sensitivity or variability in dietary intake, illness episodes, and growth patterns among participants could have reduced the statistical power to detect significant differences. Therefore, while EWS showed an effect on minimal weight gain, a longer intervention period or broader sample might be needed to demonstrate a significant impact on nutritional status.

The findings of this study demonstrate that the Early Warning System (EWS) model effectively improved minimal weight gain in children under five, although it did not significantly affect overall nutritional status or upper arm circumference. This result can be conceptually explained by the EWS's ability to enhance early detection and prompt response to minor deviations in growth trajectories—allowing health workers and caregivers to address issues such as inadequate feeding or infection before they progress. However, the short duration of intervention and the limited sensitivity of anthropometric indicators used to measure broader nutritional changes may have constrained the observable impact on overall status. Similar to findings by Bhutta et al. (2020) and Beal et al. (2018), early detection and community-based growth monitoring interventions show that consistent follow-up and integrated counselling are required to achieve measurable improvements in child nutrition. The EWS model's success in improving weight gain aligns with these studies, emphasising the importance of combining monitoring tools with behavioral and dietary support. Nevertheless, this study's limited sample size, short follow-up period, and reliance on self-reported data may have influenced the extent of observed effects. Future research should extend the intervention period and incorporate biochemical and dietary measures to provide a more comprehensive evaluation of the EWS model's effectiveness in improving child nutritional outcomes.

Conceptually, the Early Warning System (EWS) model contributes to the development of predictive modelling in community nutrition by integrating multidimensional factors—child, maternal, environmental, and behavioral—into a systematic framework for early identification of stunting risk. The model demonstrates how health data can be transformed into a decision-support tool that enhances precision in public health surveillance and supports evidence-based policymaking. Practically, the EWS model can be applied in community health programs such as the Integrated Health Service to strengthen early detection, guide nutrition counseling, and facilitate responsive interventions. However, this study has several limitations, including a relatively small sample size, data collection limited to a single region in Malang Regency, and a short follow-up period that may not fully capture long-term changes in nutritional status. Future studies should involve larger and more diverse populations with extended monitoring periods to validate the predictive capacity and generalizability of the EWS model across different community settings.

Implications and limitations

The findings of this study imply that the Early Warning System (EWS) model can serve as an effective predictive tool for identifying early risks of stunting by integrating multifactorial determinants such as child, maternal, household, food safety, healthcare system, and supplementary factors. Conceptually, this supports the development of predictive modeling in community health nursing, where early detection enables timely, targeted interventions to prevent growth faltering. Practically, the EWS framework can be adapted for use by healthcare workers at the primary care level to guide health education, improve maternal practices, and strengthen health service delivery related to child nutrition. However, several limitations should be noted. The study was conducted in a single region with a relatively small sample size, which may limit generalizability. Additionally, the short follow-up period restricted the ability to capture long-term effects on nutritional status and growth outcomes. Future studies should involve larger, more diverse populations and longer observation periods to validate and refine the predictive accuracy of the EWS model.

The Early Warning System (EWS) model provides a practical framework for strengthening community-based stunting prevention programs. Health workers and Posyandu cadres can use the EWS indicators to identify children at risk of growth faltering early and deliver timely counseling on feeding practices, infection prevention, and hygiene. Integrating the EWS into routine Posyandu monitoring can improve coordination between health providers and families, ensuring that interventions are implemented before growth problems become severe. Additionally, regular training and supervision for health personnel are essential to maintain data quality and ensure the consistent use of the EWS model in daily community health practice

Relevance to Practice

The EWS developed in this study offers a practical and immediately applicable tool for nurses, community health workers, and primary healthcare providers, particularly in resource-limited settings common to Low- and Middle-Income Countries (LMICs). By using simple, measurable indicators—such as minimal weight gain, infection history, and feeding practices—

the EWS allows frontline health personnel to rapidly identify children at risk of stunting and provide timely counseling or referrals before growth faltering becomes severe. The model can be seamlessly integrated into routine Posyandu or community health center workflows without requiring additional technology or high-cost equipment, making it feasible for implementation in underserved areas. For nursing practice, the EWS supports structured assessment, enhances decision-making, and prioritizes follow-up for high-risk children. At the service level, health facilities can adopt the EWS as part of their early detection protocols to strengthen growth monitoring and improve the continuity of care. For policymakers, the findings support the development of standardized, community-based surveillance systems that align with national stunting-reduction programs, ensuring that limited resources are directed toward children most in need. This practical approach enhances early intervention capability and can contribute to more efficient, targeted, and equitable child-nutrition programs in LMIC contexts.

Conclusion

The EWS are influenced by child factors, health service system, maternal, household, food safety, and supplementary feeding. The EWS model can affect minimal weight gain, but cannot affect the child's nutritional status and upper arm circumference. In its implementation, it needs to carry out EWS to detect early the risk of stunting in young children. EWS involves various measurement and evaluation methods, such as measuring the child's height and weight, as well as questionnaires related to nutritional intake and eating patterns. EWS, based on a community approach, also needs to involve the role of families, community leaders and local government. Families can be empowered to provide good care and assistance to children, as well as optimize a balanced diet and adequate nutrition. Community can be agents of change who strengthen public awareness and knowledge about stunting, as well as promote and support stunting prevention and management programs. Public Health Centers can facilitate and support collaboration between families, community leaders and various other related parties. Through this community approach, it is hoped that stunting levels can decrease and young children can grow optimally.

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CrediT Authorship Contributions Statement

Apriyani Puji Hastuti: Conceptualization, Methodology, Supervision, Writing - Original Draft

Shinta Wahyusari: Software, Validation, Formal Analysis, Writing - Review & Editing Visualization

Aldika Eka Servitia: Investigation, Resources, Data Curation, Project Administration

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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