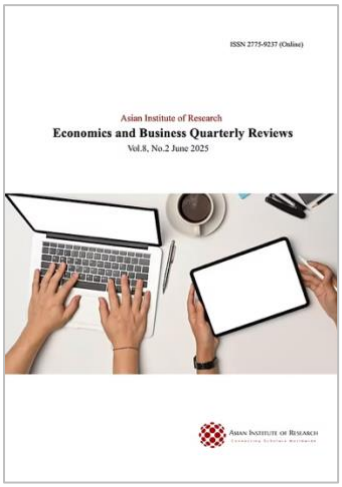

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Mapping the Dynamic Interplay of Parental Readiness and Food Security in Child Nutrition: Insights from Causal Loop Diagrams

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Abstract
Stunting in toddlers in Indonesia is still a major challenge that impacts the health, cognitive development, and productivity of future generations. This study aims to identify and analyze the dynamic relationship between parental readiness and food security on children's nutritional status, focusing on the results of Focus Group Discussions (FGD) in West Java using the (Causal Loop Diagram) CLD approach. The results of the FGD show that factors such as family dynamics, parental knowledge and education, attitudes and behaviors, and socio-economic conditions interact in a complex manner and form a feedback loop that affects children's nutritional status. There are also aspects of food security including affordability, utilization, accessibility, and availability of food - also play an important role in determining the quality and diversity of children's nutritional intake. The CLD analysis revealed that this involved important stakeholders in West Java, such as Pergizi (association of nutrition and food experts in Indonesia), the Indonesian Midwifery Association, the West Java Provincial Food and Animal Husbandry Security Service, and Academics from the Faculty of Medicine from Padjadjaran University, which showed the existence of a reinforcing loop and balancing loop that clarifies the relationship between factors and highlights the importance of cross-sector interaction in efforts to reduce stunting. The CLD from this FGD provides an in-depth understanding of the systemic mechanisms underlying the comprehensive problem of stunting and is expected to be a reference for formulating more effective and sustainable intervention strategies in the future.

Keywords: Stunting, Parental Readiness, Causal Loop Diagram, Focus Group Discussion

1. Introduction

Stunting in toddlers is a significant public health problem both in Indonesia and globally. According to UNICEF and WHO (2023) around 22% of children under the age of five in the world experience stunting, with the highest prevalence in low- and middle-income countries. In Indonesia, the prevalence of stunting decreased from 36.8% in 2007 to 21.6% in 2022, but is still far from the national target of 14% in 2024. Stunting has a broad impact on children's physical and cognitive development, reduces productivity in adulthood, and contributes to a continuous cycle of poverty (2,3)

The main factors influencing the incidence of stunting include parental readiness and family food security. Parental readiness includes knowledge, attitudes, parenting behavior, and socio-economic conditions that support optimal child growth. Meanwhile, food security is related to the availability, accessibility, and affordability of sufficient and nutritious food. The combination of these two factors greatly determines the nutritional status of children and is the main focus of efforts to prevent stunting (4).

Various studies have examined the relationship between food security and parenting practices with the incidence of stunting. Studies in Indonesia by Paramashanti & Paratmanitya (2016) and Musyayadah & Adiningsih (2019) showed a significant correlation between household food security and the risk of stunting. However, most of these studies are still partial and have not integrated parental readiness factors comprehensively. International studies also emphasize the importance of parental education and behavior in determining children's nutritional status (7,8), but the dynamic interaction between parental readiness and food security is still less explored systematically.

The dynamic systems approach offers an effective framework for understanding the complexity of the interaction of these factors. Methods such as CLD allow mapping of causal relationships and feedback between social and health variables in the context of stunting(9). Several previous studies have used this approach to model food security and access to health services but the role of parents as central actors in stunting prevention has not been analyzed in depth using this method.

This study proposes the main hypothesis that parental readiness - including knowledge, attitudes, parenting behaviors, and socio-economic conditions - plays a significant role in influencing children's nutritional status through complex interactions with food security factors. The secondary hypothesis states that these interaction patterns vary geographically and socio-economically, thus requiring a multisectoral and contextual approach. This hypothesis is based on dynamic systems theory which emphasizes the importance of understanding feedback mechanisms in social and health systems (Sterman, 2000).

To test these hypotheses, this study uses a mixed methods design with a primary focus on qualitative analysis through FGD with various stakeholders in West Java. Qualitative data were further analyzed using CLD modeling to map the dynamic relationship between parental readiness factors and food security aspects such as food availability, accessibility, and affordability. This approach allows for an in-depth and systemic understanding of the complexity of factors that influence toddler nutritional status.

The results of the study are expected to provide theoretical contributions by enriching the understanding of the systemic interaction between parental readiness and food security in the context of stunting. In practice, these findings are expected to be a strong empirical basis for designing more effective and sustainable multisectoral interventions in reducing the prevalence of stunting in Indonesia. The dynamic systems approach and mixed methods are also expected to be new methodological contributions in nutrition and public health research.

2. Method

This research method uses a qualitative approach with the main focus on FGD involving various stakeholders such as academics, health practitioners, and food security officials in the West Java region. A detailed explanation will be described below.

2.1 Research Design

This study used a descriptive qualitative study design combined with dynamic system modeling to gain a deeper understanding of the factors influencing stunting in children under five. The research strategy focused on exploring the experiences, perceptions, and interactions among key stakeholders through structured FGD. Qualitative data generated from the FGDs were then analyzed thematically and used as the basis for constructing a CLD, which maps the dynamic relationships and feedback patterns between key variables such as parental preparedness and food security. This design was chosen because it allows for the identification of complex systemic mechanisms

that are not accessible through conventional quantitative approaches. With the division of methods into clear subsections including participants, procedures, measurement and analysis, and research design readers can easily navigate each stage of the study, assess the appropriateness of the methods, and replicate the study in similar contexts. For very specific details of procedures or instruments, additional information can be provided in the appendix or supplementary online materials.

2.2 Participants

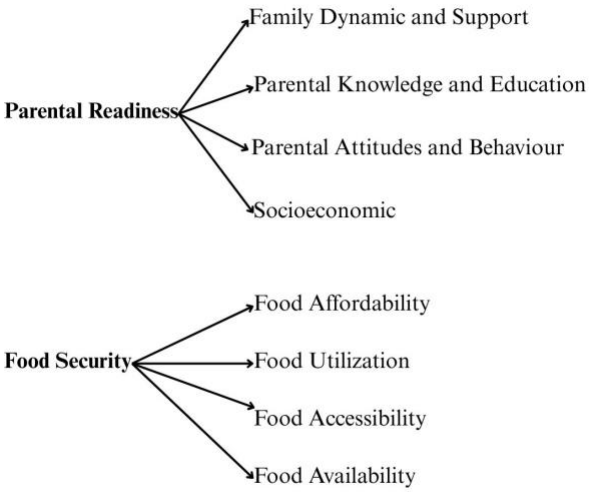
Participants in this study consisted of various stakeholders relevant to the issue of stunting in West Java, including academics from the Faculty of Medicine at Padjadjaran University, health practitioners such as midwives, officials from the Food and Agriculture Security Service (DKPP), and nutritionists from Pergizi West Java. Participants were selected purposively based on their roles and experiences in stunting prevention and food security programs in the region. Inclusion criteria included active involvement in related programs and in-depth knowledge of factors that influence the nutritional status of toddlers, while exclusion criteria were absence from FGD sessions and lack of direct involvement in stunting issues. The number of participants was adjusted to achieve rich and representative data in a qualitative context, taking into account the diversity of perspectives. The selection of West Java as the research location was based on the fact that this province is the most populous in Indonesia, with a population of more than 50 million people (10), and has a significant prevalence of stunting, which is around 20.2%, which reflects the general national condition (11). West Java represents a wide demographic and socio-economic diversity, ranging from urban to rural areas, so research results in this region can provide a comprehensive and relevant picture of the Indonesian context as a whole.

2.3 Participant (Subject) Characteristics

The research procedure began with a preparation stage that included identifying key stakeholders related to the stunting issue in West Java, such as midwifery academics from state universities, the Indonesian Midwives Association, officials from the Food and Agriculture Security Service (DKPP), and nutrition experts from Pergizi West Java. After determining the participants, the researchers prepared a FGD guideline containing key topics around parental readiness, food security, and agricultural factors relevant to stunting. The FGD was carried out face-to-face at an agreed location with an experienced facilitator who ensured that the discussion was systematic and that all participants could express their views. During the FGD, the discussion was audio-recorded with the consent of the participants and accompanied by a note-taker to record important points and the dynamics of group interactions. After the FGD was completed, the discussion data were collected in the form of transcripts and field notes for further analysis. There was no intervention or experimental manipulation carried out in this study, so the entire process focused on extracting qualitative data through professionally facilitated focus group discussions.

2.4 Analysis and Measurement

Data analysis in this study was conducted qualitatively with a thematic analysis approach to the results of FGDs that had been transcribed verbatim. The analysis process began by reading and reviewing the FGD transcripts thoroughly to identify key themes related to parental readiness, food security, and other factors that influence the nutritional status of toddlers. Each theme and subtheme that emerged was then systematically coded to ensure data consistency and traceability. Furthermore, these thematic findings were used as the basis for constructing a CLD, which maps dynamic relationships, feedback patterns (reinforcing and balancing loops), and interactions between key variables identified from the discussion. Data validity was maintained through source triangulation, namely by comparing FGD results from various stakeholders (academics, health practitioners, food security officials, and nutritionists), as well as conducting member checking with participants to ensure data interpretation was in accordance with their experiences. The reliability of the analysis was strengthened by the discussion of the research team in the coding and theme drawing process as follows:



by coding and theme drawing, the results obtained can be scientifically accounted for and replicated in similar studies. This approach allows for a deep understanding of the systemic mechanisms that influence stunting, although this study did not proceed to the CLD simulation stage, but stopped at the construction and interpretation of diagrams as a systemic analysis tool.

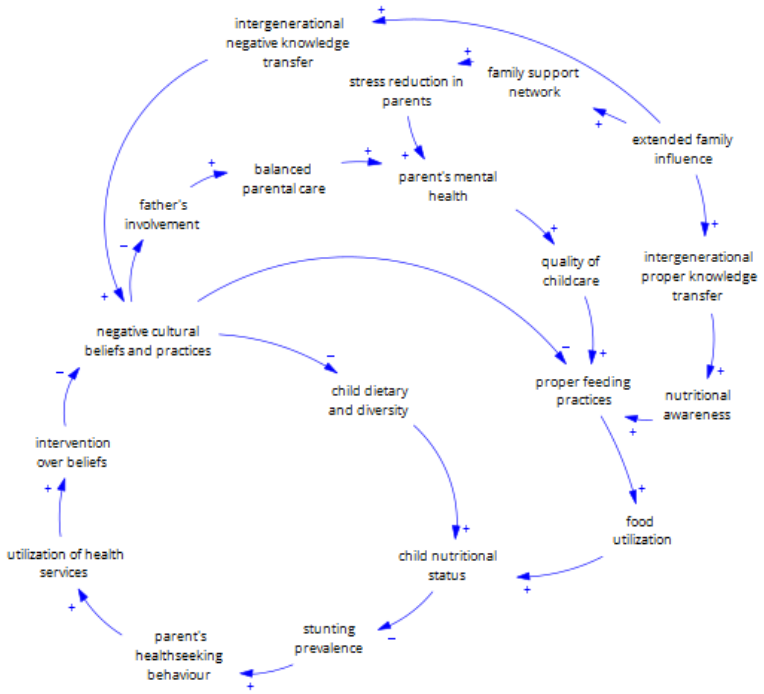
3. Results

This section presents the main findings of the study based on the analysis of FGD and the construction of CLDs. The results are organized according to the key pillars identified in the research, namely parental readiness and food security, with each pillar further detailed into its main components. The findings highlight the dynamic interactions and feedback mechanisms among the factors influencing child nutrition and stunting in West Java. Visualizations in the form of CLDs are provided to illustrate the complex relationships and systemic patterns that emerged from the qualitative data. All results are presented regularly to provide a comprehensive overview of the determinants and interconnections relevant to stunting reduction efforts.

3.1 Parental Readiness

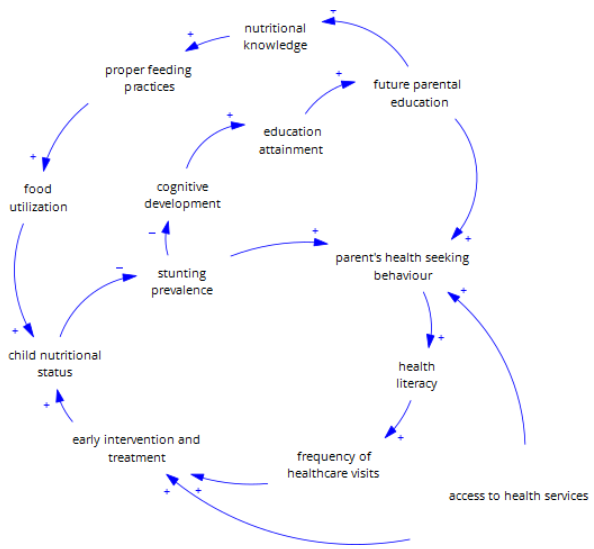
This section presents the main findings related to parental readiness as an important pillar in efforts to prevent stunting in toddlers. Based on the results of FGD and CLD analysis, parental readiness was identified as a very determining factor, including family dynamics and support, parental knowledge and education, attitudes and behaviors in parenting, and family socio-economic conditions. Each of these aspects interacts with each other and forms a complex feedback pattern, which directly or indirectly affects the nutritional status and risk of stunting in children. In the following section, the research results are presented systematically according to the parental readiness sub-pillars, complemented by CLD visualizations to illustrate the dynamic relationships between factors found in this study.

3.1.1 Family dynamic and support



This CLD shows the dynamic relationship between various factors that influence children's nutritional status and stunting prevalence. The diagram maps father involvement, family support, intergenerational knowledge transfer, and the influence of the extended family on parental mental health, parenting quality, and proper feeding practices. The diagram also illustrates the role of negative cultural beliefs, parental health-seeking behavior, and interventions on these beliefs in influencing health service utilization and children's nutritional status. Factors such as nutritional knowledge, nutritional awareness, food utilization, and children's dietary diversity are also connected in a feedback system that influences nutritional status and stunting prevalence. This diagram displays several reinforcing and balancing pathways between variables.

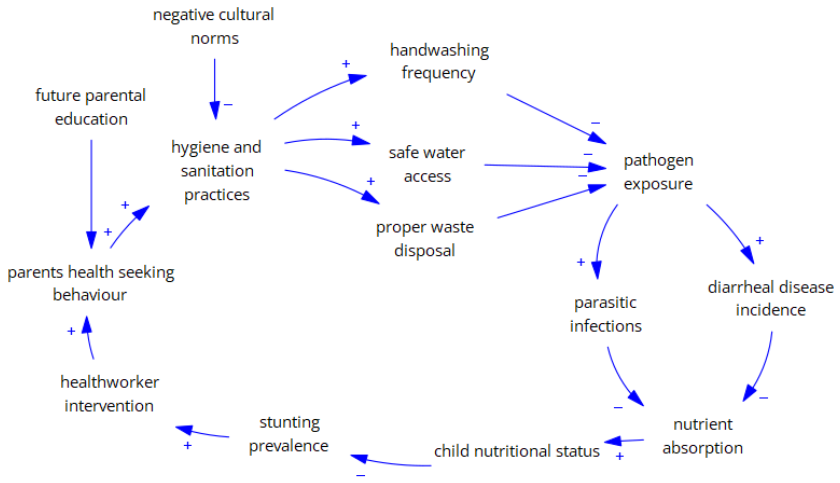
3.1.2 Parental Knowledge and Education



This CLD objectively shows the relationship between nutritional knowledge, future parental education, educational attainment, parental health-seeking behavior, health literacy, access to health services, frequency of visits to health facilities, early intervention and treatment, child nutritional status, food utilization, proper feeding practices, cognitive development, and stunting prevalence. Each variable is connected by an arrow indicating a positive or negative relationship between factors, forming a feedback loop that illustrates how changes in one

variable can affect other variables in the system. This diagram maps the sequence and interrelationships between factors without providing an interpretation or explanation of the meaning of these relationships.

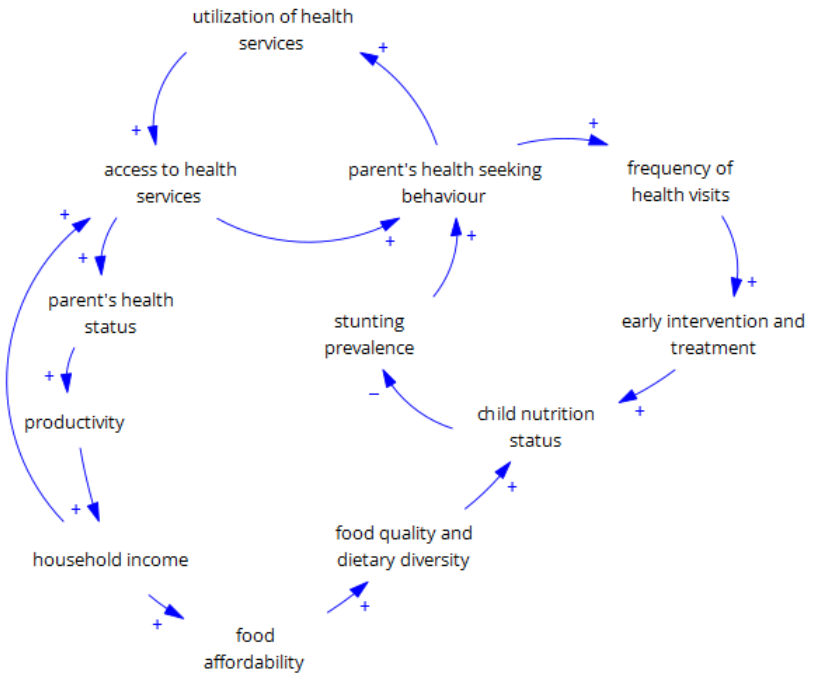
3.1.3 Parent's Attitude and behaviour



This CLD objectively maps the relationship between negative cultural norms, hygiene and sanitation practices, handwashing frequency, access to clean water, proper waste disposal, pathogen exposure, parasitic infections, diarrheal disease incidence, nutrient absorption, child nutritional status, and stunting prevalence. The diagram shows that negative cultural norms are related to hygiene and sanitation practices, which in turn affect handwashing frequency, access to clean water, and proper waste disposal. These factors are related to the level of pathogen exposure, which then affects the incidence of parasitic infections and diarrheal diseases. The incidence of diarrheal diseases impacts nutrient absorption, which is related to child nutritional status and stunting prevalence. The diagram also includes the relationship between future parental education, parental health-seeking behavior, and health worker interventions on stunting prevalence. All variables in the diagram are associated with positive or negative signs, indicating the direction of the relationship between factors in the system without providing further interpretation.

3.1.4 Sosioeconomic

This CLD objectively maps the relationship between food affordability, household income, productivity, parental health status, access to and utilization of health services, parental health-seeking behavior, frequency of visits to health facilities, early intervention and treatment, child nutritional status, food quality and diversity, and stunting prevalence.

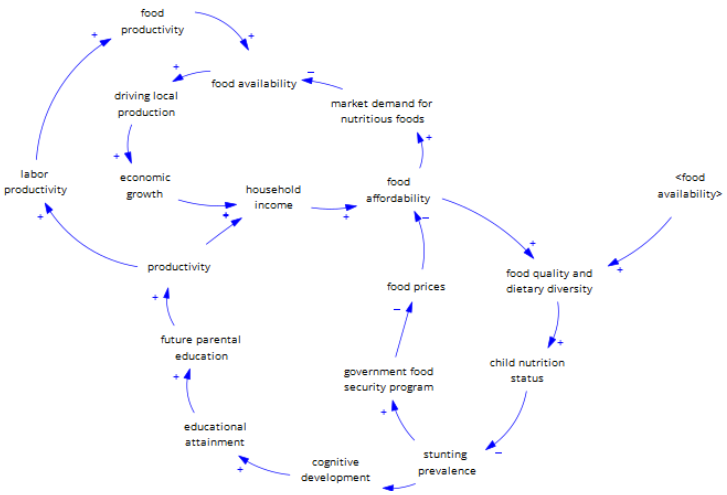


This diagram shows that increasing food affordability is associated with increasing household income, which in turn increases parental productivity and health status. Good parental health status is associated with better access to health services, which then increases health service utilization. Optimal health service utilization encourages parental health-seeking behavior, increases the frequency of visits to health facilities, and enables early intervention and treatment. This is associated with improving child nutritional status, increasing food quality and diversity, and decreasing stunting prevalence. All variables in this diagram are interconnected through positive or negative relationships, forming a feedback pattern in the system without further interpretation.

3.2 Food Security

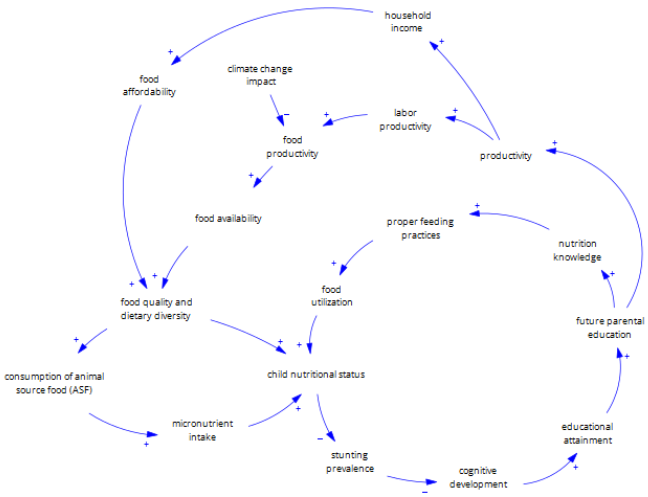
This CLD objectively maps the relationship between food affordability, household income, productivity, parental health status, access to and utilization of health services, parental health-seeking behavior, frequency of visits to health facilities, early intervention and treatment, child nutritional status, food quality and diversity, and stunting prevalence. This diagram shows that increasing food affordability is associated with increasing household income, which in turn increases parental productivity and health status. Good parental health status is associated with better access to health services, which then increases health service utilization. Optimal health service utilization encourages parental health-seeking behavior, increases the frequency of visits to health facilities, and enables early intervention and treatment. This is associated with improving child nutritional status, increasing food quality and diversity, and decreasing stunting prevalence. All variables in this diagram are interconnected through positive or negative relationships, forming a feedback pattern in the system without further interpretation.

3.2.1 Food Affordability



The CLD in this section objectively maps the relationship between food productivity, food availability, market demand for nutritious food, household income, food affordability, food prices, government food security programs, food quality and diversity, child nutritional status, cognitive development, educational attainment, labor productivity, and economic growth. This diagram shows that increasing food productivity can increase food availability, which in turn affects market demand for nutritious food and household income. Higher household income is associated with better food affordability, which is also affected by food prices and government food security program interventions. Good food affordability is associated with improved food quality and diversity, which has an impact on child nutritional status and a decrease in stunting prevalence. Good child nutritional status supports cognitive development and educational attainment, which then increases labor productivity and economic growth, so that this cycle again strengthens food productivity and food availability. All variables in the diagram are connected through positive or negative signs, forming a feedback pattern in the system without further interpretation.

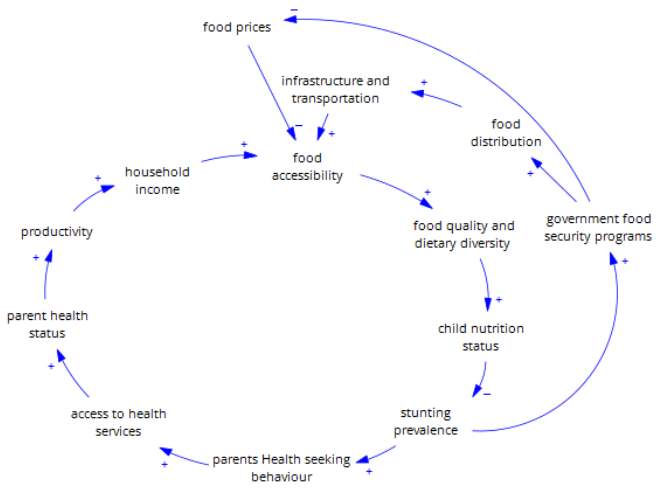
3.2.2 Food Utilization



The CLD in this section objectively maps the relationship between food productivity, food availability, market demand for nutritious food, household income, food affordability, food prices, government food security programs, food quality and diversity, child nutritional status, cognitive development, educational attainment, labor productivity, and economic growth. This diagram shows that increasing food productivity can increase food availability, which in turn affects market demand for nutritious food and household income. Higher household income is associated with better food affordability, which is also affected by food prices and government food security program interventions. Good food affordability is associated with improved food quality and diversity, which has an impact on child nutritional status and a decrease in stunting prevalence. Good child nutritional status

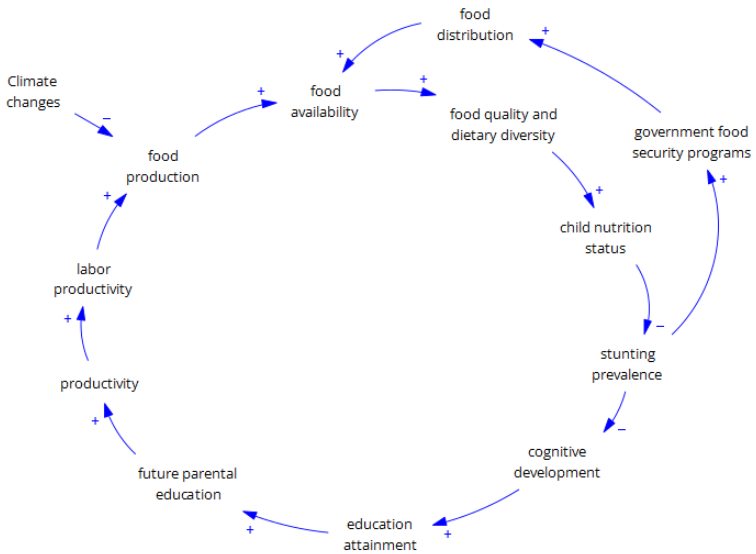
supports cognitive development and educational attainment, which then increases labor productivity and economic growth, so that this cycle again strengthens food productivity and food availability. All variables in the diagram are connected through positive or negative signs, forming a feedback pattern in the system without further interpretation.

3.2.3 Food Accessibility



This CLD objectively maps the relationship between food accessibility, food prices, infrastructure and transportation, food distribution, government food security programs, food quality and dietary diversity, child nutrition status, stunting prevalence, parents' health-seeking behavior, access to health services, parent health status, productivity, and household income. This diagram shows that food accessibility is influenced by food prices and infrastructure and transportation, which are also related to food distribution and government food security programs. Food accessibility is related to food quality and dietary diversity, which in turn affects child nutrition status and stunting prevalence. Stunting prevalence is related to parents' health-seeking behavior, which has an impact on access to health services, parent health status, and productivity. Productivity is related to household income, which in turn affects food accessibility. All variables in this diagram are interconnected through positive or negative relationships, forming a feedback pattern in the system without further interpretation.

3.2.4 Food Availability



This CLD objectively maps the relationships between climate change, food production, food availability, food distribution, food quality and diversity, government food security programs, child nutritional status, stunting

prevalence, cognitive development, educational attainment, future parental education, productivity, and labor productivity. The diagram shows that climate change affects food production, which impacts food availability. Increased food availability is associated with better food distribution, which can improve food quality and diversity. Government food security programs also play a role in improving food quality and diversity, which then affects child nutritional status and reduces stunting prevalence. Reduced stunting supports cognitive development and educational attainment, which contribute to future parental education, productivity, and labor productivity. Increased labor productivity will again strengthen food production, forming a feedback pattern in the system without further interpretation.

3.3 Master of Undernutrition CLD

This combined CLD objectively maps the dynamic relationships between factors that influence child nutritional status and stunting prevalence. The variables connected in this system include parental preparedness (such as cross-generational knowledge, family support, education, attitudes, behaviors, and socio-economic conditions), feeding practices, health literacy, access to and utilization of health services, hygiene and sanitation practices, access to clean water, waste disposal, exposure to pathogens, infections, and parental health-seeking behavior. In addition, food security factors such as food affordability, availability, accessibility, and utilization, food productivity, food prices, food distribution, and government food security programs are also mapped in this diagram. All of these variables are interconnected through positive or negative relationships that form feedback patterns (reinforcing and balancing loops), which illustrate how changes in one factor can affect other factors in the system, without providing interpretation or explanation of the meaning of these relationships.

4. Discussion

The results of this study confirm that stunting in toddlers in Indonesia is a multidimensional phenomenon influenced by complex interactions between parental readiness, food security, and environmental and socio-economic factors. CLD analysis identified patterns of reinforcing and balancing feedback involving cross-generational knowledge transfer, clean living behavior, nutritional literacy, access and utilization of health services, household income, and affordability, availability, accessibility, and utilization of food. Each of these factors does not stand alone, but is interrelated in a system that affects children's nutritional status and stunting prevalence, as also found in dynamic system studies on complex public health issues (Homer & Hirsch, 2006; Poelman et al., 2023).

This study strengthens the evidence that parental readiness—including knowledge, attitudes, behaviors, and family support—plays a central role in stunting prevention. Negative knowledge transfer across generations and inappropriate cultural beliefs reinforce incorrect feeding practices, lower children's nutritional status, and increase the risk of stunting (Bella et al., 2020; Abdulaziz et al., 2024). In contrast, father involvement, extended family support, and good nutritional literacy create a positive reinforcement cycle that reduces the prevalence of stunting. These findings are in line with a study in Yogyakarta that showed that poor parental feeding style doubled the risk of stunting compared to good parenting style (14). The developed CLD system also emphasizes the importance of family and community-based interventions, as described in the family empowerment and community-based intervention models (15–17).

Food security, including affordability, availability, accessibility, and utilization of food, has been shown to be a major determinant of children's nutritional status. Systematic studies have shown that household food insecurity is consistently associated with stunted cognitive and physical development in children, even after controlling for economic factors (18). The CLD in this study highlights that household income, food prices, and government food security programs form a reinforcing cycle that can improve dietary quality and diversity, reduce stunting prevalence, and increase family productivity (19,20). However, the impacts of climate change on food productivity and food distribution remain a major challenge that must be anticipated in multisectoral policies (21).

These findings are consistent with global literature emphasizing the need for a dynamic systems approach and multisectoral interventions to effectively reduce stunting ((19,21) Studies in the Netherlands and the United States have shown that changing the local food environment requires cross-sectoral collaboration and adaptation at multiple policy levels (Homer & Hirsch, 2006). In Indonesia, policies such as Presidential Regulation No. 72 of 2021 concerning the Acceleration of Stunting Reduction and strengthening the Posyandu Prima program have become examples of cross-sectoral integration, but implementation challenges still arise in terms of culture, food distribution, and inequality of access between regions (23).

The importance of adopting a systems thinking lens is further emphasized by (24), who distinguishes between *ontological* and *cognitive* complexity in managing systemic public health challenges. In the context of stunting, ontological complexity arises from the interrelated elements of food security, parental behavior, and socioeconomic status, while cognitive complexity reflects the divergent stakeholder perspectives across government, healthcare, and community actors. Jackson argues that insufficient conceptualization of this complexity often leads to ineffective policy responses. Integrating *Critical Systems Thinking* (CST) enables decision-makers to utilize multiple perspectives—including technical, cultural, political, and environmental dimensions—to design more adaptive and participatory interventions. This perspective aligns with the findings of this study, which advocate for multisectoral approaches and reinforce the need to go beyond linear cause-effect assumptions when addressing child nutrition.

This study has several limitations. First, the data used are qualitative and FGD-based, so generalization to the entire Indonesian population needs to be done with caution. Second, the CLD developed was not simulated quantitatively, so it cannot yet predict the impact of the intervention numerically. Third, the scope of the study area is limited to West Java, although this province is quite representative due to its socio-economic diversity and large population (25). Fourth, the potential for participant bias remains even though source triangulation has been carried out.

The results of this study emphasize the need to strengthen nutrition education and health literacy for parents through community programs and formal education (14,26), integration of food security programs with health and education interventions involving various stakeholders from the family, community, to government levels (19), and the development of local culture-based interventions to address negative knowledge transfer and cultural beliefs that do not support healthy parenting practices (Bella et al., 2020). In addition, increasing access and affordability of nutritious food through innovations in food distribution, subsidies, and strengthening the family economy is very important (7,23)in addition to increasing the role of fathers and extended families in supporting child care and monitoring child growth and development (15)

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Conflicts of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics approval: Written informed consent was obtained from all individual participants included in the study prior to their participation in the Focus Group Discussions. All participants were informed about the objectives, procedures, potential risks, and benefits of the research, and their anonymity and confidentiality were strictly maintained throughout the study.

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4. Syarah Nurul Amaliah, STP, MM
5. Bdn. Rinjani Inez, SST., MM., MH.

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