

How do socioeconomic indicators and fiscal decentralization affect stunting? Evidence from Indonesia

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Abstract

Purpose – Stunting has emerged as a prominent concern on a global scale. Over the past seven years, the average prevalence has consistently exceeded the World Health Organization standards. This study aims to investigate the roots and model of stunting.

Design/methodology/approach – The samples were collected from 406 regencies (counties) and municipalities across 34 provinces in Indonesia from 2017 to 2022 and used the dynamic panel data analysis.

Findings – The findings showed that the food security index, poverty line, women's years of schooling, the specific allocation of funds and hopeful family program negatively influenced stunting. Otherwise, village funds and fiscal decentralisation positively affect stunting. The results also confirmed that stunting had a dynamic impact. In addition, the effect of income per capita, the poverty severity index and government funds for education and health on stunting rates were inconclusive.

Practical implications – The policy implication of the study suggests that the government must consider the budgetary concerns of each region and focus on the regions that exhibit different needs.

Originality/value – This paper will contribute to the literature about the modelling of determinants of Stunting in Indonesia.

Keywords Income per capita, Human capital, Fiscal decentralisation, Government socio-spending, Stunting, Panel data model

Paper type Research paper

1. Introduction

Indonesia has the fourth-largest population in the world and boasts an expansive territory geographically divided into three distinct regions: West, Central and East. This nation comprises 38 provinces and 514 regencies/cities. The expansion of provinces and regencies/cities corresponds to the adoption of fiscal decentralisation, which has been in effect since 2000. The objective of the fiscal decentralisation system in Indonesia is to enhance regional autonomy, hence fostering an increase in community welfare.

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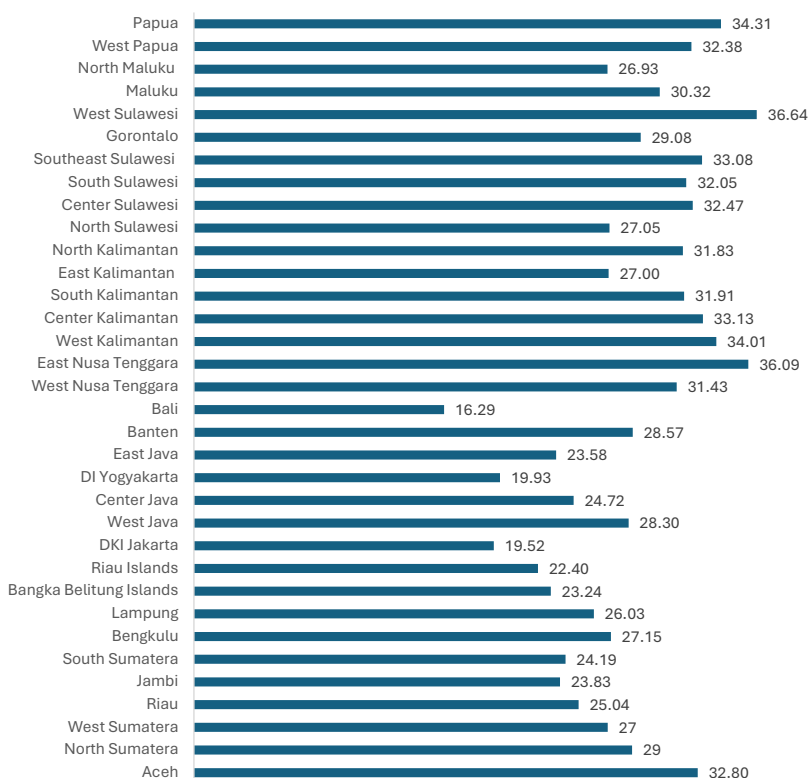
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Indonesia still needs to improve its human resources quality. Indonesia's Human Development Index remains comparatively lower than other Association of Southeast Asian Nations countries, such as Malaysia and Thailand. Additionally, the outbreak of COVID-19, which commenced in late 2019 and persisted until 2023, led to a deterioration in individuals' well-being. Even though the allocation of funds to the National Economic Recovery Programme has significantly increased, fundamental human development issues, such as stunting, still exist and become critical problems.

Stunting is the impaired growth and development that children experience from poor nutrition, repeated infection and inadequate psychosocial stimulation (WHO, 2015). The pervasive problem of stunting has emerged as a global concern. Indonesia's programme to suppress stunting aligns with WHO standards mandating that the prevalence rate of stunting should be below 20%. This means that goals are aligned between the global community and Indonesia to accelerate the reduction of stunting rates. However, only three of 34 provinces in Indonesia currently have an average prevalence of less than 20%.

Figure 1 indicates the average prevalence of stunting from 2017 to 2022 at the province level, where West Sulawesi had the highest value of 36.64. East Nusa Tenggara Province was second with an average score of 36.09, and Papua Province was third with a value of 34.09.



Source: Data Processed by Authors from Statistical Central Bureau /BPS (2023)

Figure 1. Average stunting prevalence in 34 provinces in Indonesia 2017–2022

The lowest average was found in Bali Province at 16.29, followed by DKI Jakarta Province at 19.52% and the Special Region of Yogyakarta (DIY) at 19.33%. In addition, the average of the ten provinces with the highest Poverty Severity Index (PSI) from 2017 to 2022 is 1,032, where Papua Province had the highest average score of 2.26, West Papua Province had an average score of 2.07, while East Nusa Tenggara Province had an average score of 1.06. Moreover, the women's average years of schooling in ten provinces with the Lowest Years of Schooling from 2017 to 2022 is at elementary school. Papua Province has the lowest average length of school for women and the highest PSI (Statistical Central Bureau/BPS (2023)).

Many studies related to stunting have been conducted, with a particular focus on identifying determining factors. [Wigle et al. \(2020\)](#) found that poverty reduction contributed to 61% of the observed decrease in stunting rates. Income level impacts reducing stunting rates ([Rengma et al., 2016](#); [Roediger et al., 2020](#); [Van Tuijl, 2021](#)). [Wu et al. \(2010\)](#) urged that government intervention is essential to increase income, particularly for low-income people, which will affect consumption levels ([Laumer, 2020](#); [Murphy, 2015](#)). In addition, [Hoddinott et al. \(2013\)](#) and [Berman and Ahuja \(2010\)](#) argued that government spending in the health sector could reduce stunting rates. [Emamian et al. \(2014\)](#); [Fenske et al. \(2013\)](#) and [Roediger et al. \(2020\)](#) have emphasized maternal education in preventing stunting. Another factor determinant of stunting rates is Food Security ([M'Kaibi et al., 2017](#)). [Oderinde et al. \(2022\)](#) concluded that government intervention, such as increasing food production, is vital to food security.

The results of several studies related to the main determinacies factors of stunting are inconclusive, yet the role of fiscal and budgetary factors and women's education, especially in Indonesia. Therefore, this study aims to analyse the impact of specific allocation funds – such as physical allocation funds for education and health, as well as social funds, including the Hopeful Family Programme and Village Fund – on stunting. Additionally, the study incorporates economic performance indicators, SDGs indicators, human capital, fiscal decentralisation and government spending to provide a comprehensive understanding of stunting determinacies.

We argued that aspects of education and health can impact stunting rates. This is why the government should focus on budget allocations in the educational and health sectors. There is evidence of a persistent upward trend in budgetary allocations in the educational and health sectors, and we need to confirm its impact on reducing stunting. [Bhutta et al. \(2020\)](#) confirm that education, particularly maternal education, significantly impacted the reduction of stunting rates. Therefore, the role of women as mothers is significant in stunting issues and in line with SDG indicators.

Consequently, the government's role in reducing stunting rates through budget interference is critical ([Yang et al., 2022](#)). Apart from similar problems faced by other studies in several other countries, the Indonesian government's efforts to reduce stunting rates through several fiscal stimuli, such as village funds and social security programmes, are expected to reduce the stunting level significantly in Indonesia. This paper will contribute to determining the factors of stunting, especially the role of women's education, village funds and social security programmes in Indonesia's case.

The rest of the discussion will be structured into a literature review of the main issues of stunting in Section 2, followed by a methodology consisting of variables, sources of data, an empirical model and a panel data specification model in Section 3. This will be followed by result analysis and discussion in Sections 4, which will be closed by conclusions and implications of the study in Section 5.

2. Literature review

Sustainable development (SD) emphasises the need for a holistic and multisectoral approach to addressing stunting. Efforts to achieve one goal, such as ending hunger or promoting

gender equality, can reduce stunting rates. Likewise, progress in addressing stunting can contribute to achieving multiple SDGs, such as improved child health, reduced poverty and enhanced human capital development (M'Kaibi *et al.*, 2017; Oderinde *et al.*, 2022).

Now, stunting become a crucial problem worldwide, and understanding the determinant factors is one of the success keywords of solutions. Household poverty impacts stunting levels (Rabaoarisoa *et al.*, 2017; Reyes *et al.*, 2004; Wigle *et al.*, 2020). Almeida *et al.* (2020) confirmed that poverty significantly impacts the prevalence of stunting. Furthermore, Dirghayu *et al.* (2021) made a similar assertion that the prevalence of poverty influences stunting by affecting the availability and accessibility of food (Panda *et al.*, 2020; Turesky *et al.*, 2021). Food availability is closely related to food security.

In addition to the availability and accessibility, Mahadevan and Hoang (2015) described other factors measured in the Food Security Index. Four indicators are structured in the index:

- food availability, which refers to availability issues at the macro level;
- food access, which refers to total calorie intake;
- food utilisation, which refers to dietary diversity; and
- vulnerability.

Barros *et al.* (2023) concluded that the degree of food security can impact children's nutritional and health quality and indirectly affect the stunting level. Furthermore, consumption level will impact nutritional quality, affecting a child's weight and height (Cetthakrikul *et al.*, 2018).

Human capital (HC) underscores the importance of holistic investments in many sectors, such as education, health care, nutrition and social support systems, to enable individuals and families to provide the best possible environment for children to thrive. Addressing HC deficits and enhancing the capabilities of individuals and communities can significantly reduce the prevalence of stunting and its long-term consequences (Rabaoarisoa *et al.*, 2017).

Furthermore, government expenditures in village funds and the Social Safety Net are associated with handling stunting rates (Indra and Khoirunurrofik, 2022; Leroy *et al.*, 2009). Uchimura and Jütting (2009) discovered that fiscally decentralised regions had lower mortality rates than those that were not. However, Indonesian samples produced distinctive results. The study conducted by Irab *et al.* (2022) showed that the fiscal independence factor did not significantly influence a reduction in stunting rates. However, a reduction in stunting is more influenced by social and health factors, such as food availability. This result is similar to that of Mahadevan and Hoang (2015), who argued that food availability, which refers to the quality and quantity of food available on the market, whether from production, imports or food aid, and the aspect of accessibility influences a reduction in stunting rates.

The relationship between government socio-spending (GSS) and stunting is intricately linked to the allocation, efficiency and effectiveness of public resources in addressing the multifaceted causes of stunting. Adequate and targeted government spending on healthcare, nutrition, social safety nets and infrastructure, alongside efficient implementation and robust monitoring and evaluation, can contribute to significant reductions in stunting and improved health outcomes for children (Rifat *et al.*, 2018). The business cycle in which the economy is in good condition (boom phase) can be used by the public or private sector to build up supplies of production or output (saving) to anticipate periods of recession (bust phase). This concept also relates to fiscal policy's procyclical and countercyclical nature (Schumpeter, 1983).

Meanwhile, the relationship between fiscal decentralisation (FD) and stunting is intertwined with the broader issues of governance, public service delivery and social and economic development. FD can offer opportunities to tailor interventions, enhance local

capacity and accountability and build direct trust with the citizens. However, its effectiveness in reducing stunting depends on how it is implemented, monitored and supported by comprehensive policies and programmes targeting the underlying determinants of malnutrition and poor child health (Uchimura and Jütting, 2009; Wgle *et al.*, 2020; Yang *et al.*, 2022).

Then, we argued that household income, poverty and education are essential factors in stunting because previous studies found that food quality and health affect stunting. Some findings stated that poverty and education are finally caused by household income. Therefore, government intervention through government social spending (social security) is one solution to ensure the minimum level of consumption and education. In conclusion, as policymakers and other stakeholders, governments must focus on public health and development. They should prioritise strategies that strengthen human capital, empower caregivers and create accessible and supportive environments for optimal child growth and development, ultimately reducing the burden of stunting and contributing to healthier, more prosperous societies.

3. Research methods

3.1 Variable measurement and data sources

This study analysed stunting levels using a comprehensive set of variables, including economic performance, SDGs, human capital, government spending and fiscal decentralisation. The unit of analysis for the study consisted of 406 regions and cities across 34 provinces in Indonesia, spanning the years 2017–2022 and the frequency of data is yearly. Data sources included the Indonesian Ministry of Finance, the Ministry of Health and the Central Statistical Bureau (BPS).

Income/capita (ICap) presents the economic performance (EF); the Food Security Index (FSI) and Poverty Severity Index (PSI) present the sustainable development goals (SDGs); Women Years of Schooling (WYoS) presents the human capital (HC) development; there are some kinds of government socio-spending in Indonesia. For this reason, government spending (GS) consists of the social transfer of Village Fund (VF), Hopeful Family Programme (HFP), Specific Allocation Fund (SAF), Physical Assignment Fund for Education (PAFE) and Physical Assignment Fund for Health (PAFH). Region Independence Index (RGI) indicates Fiscal decentralisation (FD).

The research variables are as follows:

According to Presidential Regulation No. 72 of 2021 concerning the Acceleration of Stunting Reduction, the definition of stunting is a disorder of child growth and development caused by chronic malnutrition and repeated infections. The stunting children are measured by weight according to height (W/H), height according to age (H/A) and weight according to age (W/A).

Income per capita (ICap) presents the economic performance indicator. It is measured by income per capita.

The Food Security Index (FSI) assesses availability, affordability and food utilisation. The poverty level will be presented by the Poverty Severity Index (PSI), which offers insight into impoverished individuals' expenditure distribution. The higher the index value, the higher the expenditure inequality among low-income people. Another proxy of poverty is the poverty line or threshold, the minimum level of income deemed necessary to achieve an adequate standard of living in a country. The Poverty Line (PL) is the sum of the Food Poverty Line (FPL) and the Non-Food Poverty Line (NFPL). Residents with an average per capita monthly expenditure below the Poverty Line are categorised as poor.

Women's years of schooling (WYoS) is the average length of schooling for women.

Village Funds (VF) and Hopeful Family Programmes (HFP) are funds from the central government that support regional governments in safeguarding the community from potential social risks.

Specific allocation funds (SAF) refer to funds derived from the state budget, revenues and expenditures designated for specific areas. The primary objective of these funds is to provide financial support for special activities that pertain to regional issues and align with national priorities ([Undang-undang Nomor 33 Tahun, 2004](#)).

Physical assignment: The state revenue and expenditure budget allocates funds for education (PAFE) and health (PAFH) to specific regions to support the needs for facilities and infrastructure in these fields. Region Dependency Index (RGI) presents fiscal decentralisation. The region independence variable is the ability of regions to fund local government expenditures, as reflected in the budget. This is measured through locally generated revenue divided by the transfer and assistance from the central government, provincial government and regional loans.

3.2 Empirical model

[Equation \(1\)](#) states that countries' stunting levels depend on socioeconomic indicators (SEI) and fiscal decentralisation (FD):

$$\text{Stunting} = f(\text{SEI}, \text{FD}) \quad (1)$$

Then, we derive [equation \(1\)](#) into the conceptually more detailed function [[equation \(2\)](#)], where stunting is a function of socioeconomic indicators, including economic performance (EF), sustainable development (SD), human capital (HC) and government socio-spending (GSS). Fiscal decentralisation (FD) is presented by the Region Dependency Index (RGI):

$$\text{Stunting} = f(\text{EF}, \text{SD}, \text{HC}, \text{GSS}, \text{FD}) \quad (2)$$

To adopt all the measurements, we derived [equation \(2\)](#) based on the proxies of each concept, including in the application model, as follows:

$$\text{Stunting} = f(\text{ICap}, \text{FSI}, \text{PSI}, \text{PL}, \text{WYOS}, \text{VF}, \text{HFP}, \text{SAF}, \text{PAFE}, \text{PAFH}, \text{RGI}) \quad (3)$$

The income per capita shows economic performance. Suppose economic management performs well. In that case, per-capita income increases, household consumption increases and parents' ability to fully support the needs of the pregnant mother should reduce the possibility of stunting (see, among others: [Leroy et al., 2019](#); [Indra and Khoirunurrofik, 2022](#); [Dirghayu et al., 2021](#)).

The Food Security Index (FSI) increases a household's consumption availability, affordability, food utilisation security and stunting decrease ([Cetthakrikul et al., 2018](#)). The higher the index value of the Poverty Severity Index (PSI), the higher the expenditure inequality among low-income people, and then consumption decreases and stunting increases ([Rabaoarisoa et al., 2017](#); [Reyes et al., 2004](#); [Wigle et al., 2020](#)). Otherwise, when the poverty line measures the poverty level, stunting decreases if the poverty line increases.

Women's years of schooling (WYoS) decrease, and their cognitive ability is lower than their understanding of health, so stunting decreases.

Village Funds (VF) and Hopeful Family Programmes (HFP) allocate central government funding to regional governments and encompass many expenditures that are supposed to have a negative relationship with stunting. In addition, specific allocation funds (SAF),

physical assignment, funds for education (PAFE) and health (PAFH) are expected to impact stunting negatively (Indra and Khoirunurrofik, 2022; Leroy *et al.*, 2019).

The Region Dependency Index (RGI) increases regions' ability to fund local government expenditures; stunting will decrease (Uchimura and Jütting, 2009; Wigle *et al.*, 2020).

This study used a combination of time series and cross-sectional data. Consequently, panel data analysis accounted for variations in individual behaviour, namely, the disparities in stunting prevalence across different districts or cities. Using panel data enables examining the association between the independent and dependent variables, specifically stunting overall and by district or county. Simultaneously, examining trends derived from the variable data amenable to analysis is feasible.

The estimation of the model was conducted in two stages. First, a static panel model analysis was performed, which involved estimating three models: the common effect model (CEM), the fixed effect model (FEM) and the random effect model (REM). Second, the dynamic panel model approach considers the interdependence between the occurrence of stunting and changes in stunting. This study used two distinct models, the first difference GMM (FDGMM) and the system GMM (SGMM) models.

3.2.1 Static panel data analysis. The static panel model in this research was carried out by identifying predictor variables that influence stunting and occur between districts/cities in Indonesia. It was expressed with the following equation:

$$\text{Stunting}_{i,t} = \beta_0 + \beta_1 \text{ICap}_{i,t} + \beta_2 \text{FSI}_{i,t} + \beta_3 \text{PSI}_{i,t} + \beta_4 \text{PL}_{i,t} + \beta_5 \text{WYoS}_{i,t} + \beta_6 \text{VF}_{i,t} + \beta_7 \text{HFP}_{i,t} + \beta_8 \text{SAF}_{i,t} + \beta_9 \text{PAFE}_{i,t} + \beta_{10} \text{PAFH}_{i,t} + \beta_{11} \text{RGI}_{i,t} + \alpha_{it} \quad (4)$$

where α_{it} is the error received; i shows the cross-section of districts/cities 1 to n ; and t shows the period from year 1 to year t .

Based on equation (1), all variables that influence stunting in districts/cities in Indonesia were estimated using equation (4):

$$\text{Stunting}_{i,t} = \beta_{0i} + \beta_1 \text{ICap}_{i,t} + \beta_2 \text{FSI}_{i,t} + \beta_3 \text{PSI}_{i,t} + \beta_4 \text{PL}_{i,t} + \beta_5 \text{WYoS}_{i,t} + \beta_6 \text{VF}_{i,t} + \beta_7 \text{HFP}_{i,t} + \beta_8 \text{SAF}_{i,t} + \beta_9 \text{PAFE}_{i,t} + \beta_{10} \text{PAFH}_{i,t} + \beta_{11} \text{RGI}_{i,t} + \alpha_{it} \quad (5)$$

Even though β_0 is a constant, in the fixed effect model from equation (3), the value can vary for each county/district and will not remain constant over a lengthy period; this phenomenon is known as inter-time variation. The random effect analysis will be proven based on equation (3). Even though the equation derived from equation (3) indicates that 0_i is constant, we presume there is a random variable with an average value of 0 so that the constant can be expressed as:

$$\beta_{0i} = \beta_0 + \varepsilon_i, i = 1, 2, \dots, N \quad (6)$$

where ε_i is the error term with an average value of 0 and variance σ^2 , we used equations (2) and (3) to form the following equation:

$$\text{Stunting}_{i,t} = \beta_0 + \beta_1 \text{ICap}_{i,t} + \beta_2 \text{FSI}_{i,t} + \beta_3 \text{PSI}_{i,t} + \beta_4 \text{PL}_{i,t} + \beta_5 \text{WYoS}_{i,t} + \beta_6 \text{VF}_{i,t} + \beta_7 \text{HFP}_{i,t} + \beta_8 \text{SAF}_{i,t} + \beta_9 \text{PAFE}_{i,t} + \beta_{10} \text{PAFH}_{i,t} + \beta_{11} \text{RGI}_{i,t} + \psi_{it} \quad (7)$$

$$\psi_{it} = \varepsilon_i + u_{it} \quad (8)$$

The combined error term ψ_{it} comprises two distinct components, specifically ε_i , which represents the error term of the cross-section component u_{it} , which is the error term of the combination of time series and cross-section components. The model selection process involves Hausman and Breusch–Pagan tests to choose the most efficient models.

3.2.2 Dynamic panel data analysis. To understand the existence of the dynamic effect of stunting, we used the dynamic panel model, which is built with the following basic model:

$$y_{it} = \rho y_{it-1} + Z_{it}Y + c_i + u_{it} \quad (9)$$

where y_{it-1} is an exogenous variable derived from endogenous variables as a predetermined variable; z_{it} is a matrix of exogenous variables; c_i is a random effect; and u_{it} is an error with a mean value of zero and a fixed variance.

The dynamic panel data model estimation for a solution with AR (1) and Two-Stage least squares (2SLS) can generate consistent results despite inefficiency because it does not produce minimum variance (Arellano and Bond, 1991). Arellano and Bond suggested using Δy_{it-2} as an instrument of Δy_{it-1} , which will result in a more effective estimator (Anderson and Hsiao, 1982). Therefore, we used an estimator with GMM (General Method of Moments) to estimate $\alpha_1, \dots, \alpha_p, \beta_1, \beta_2$, as seen in equation (9):

$$y_{it} = y_{it-1}\alpha_1 + \dots + y_{it-p}\alpha_p + x_{it}\beta_1 + z_{it}\beta_2 + c_i + u_{it} \quad (10)$$

where x_{it} is a matrix of exogenous variables, z_{it} is a matrix of predetermined variables, c_i is a random effect and u_{it} is an error term.

The transformation from equation (1) into the variables used in the research [equation (1)] occurred by substituting all independent variables for stunting to obtain a dynamic panel model, which is expressed by the following equation:

$$\begin{aligned} \text{Stunting}_{i,t} = & \beta_0 + \beta_1 \text{Stunting}_{i,t-1} + \beta_2 \text{ICap}_{i,t} + \beta_3 \text{FSI}_{i,t} + \beta_4 \text{PSI}_{i,t} + \beta_5 \text{WYoS}_{i,t} + \beta_6 \text{RGI}_{i,t} \\ & + \beta_7 \text{VF}_{i,t} + \beta_8 \text{HFP}_{i,t} + \beta_9 \text{SAF}_{i,t} + \beta_{10} \text{PAFE}_{i,t} + \beta_{11} \text{PAFH}_{i,t} + \psi_{it} \end{aligned} \quad (11)$$

$$\psi_{it} = \varepsilon_i + u_{it} \quad (12)$$

Arellano and Bond (1991) stated that equation (8) would have several technical problems. First, there is a causal relationship between the independent variables, and the independent variables are probably related to the error term. The best solution to overcome this problem is to use the first difference GMM to transform equation (10) into the first difference form as follows:

$$\begin{aligned} \Delta \text{Stunting}_{i,t} = & \beta_0 + \beta_1 \Delta \text{Stunting}_{i,t-1} + \beta_2 \Delta \text{ICap}_{i,t} + \beta_3 \Delta \text{FSI}_{i,t} + \beta_4 \Delta \text{PSI}_{i,t} + \beta_5 \Delta \text{WYoS}_{i,t} \\ & + \beta_6 \Delta \text{RGI}_{i,t} + \beta_7 \Delta \text{VF}_{i,t} + \beta_8 \Delta \text{HFP}_{i,t} + \beta_9 \Delta \text{SAF}_{i,t} + \beta_{10} \Delta \text{PAFE}_{i,t} \\ & + \beta_{11} \Delta \text{PAFH}_{i,t} + \Delta \psi_{it} \end{aligned} \quad (13)$$

$$\Delta \psi_{it} = \Delta \varepsilon_i + \Delta u_{it} \quad (14)$$

To improve the quality of the Arellano and Bond's (1991) model and Sofilda *et al.* (2023), enhancements were made to the estimation procedure when there was one exogenous

variable, namely, the endogenous variable on the right side of the equation that demonstrates the existence of a correlation between several exogenous error term variables. [Arellano and Bover \(1995\)](#) did not carry out a first difference transformation; instead, they used a transformation (separating variables where the right side of the entirely exogenous equation is endogenous and has exogenous properties) that satisfies the orthogonal condition.

This study implemented the dynamic panel data model using first difference GMM (FDGMM) and system GMM (SGMM) estimation techniques. In the assessment phase of the dynamic panel data model, the instrument's validity was examined using the Sargan test, which seeks to determine whether there is a correlation between the instrument variables and the error components associated with decision-making. Autocorrelation testing is to test the consistency of estimation results using Arellano and Bond using AR (2) where decision-making is carried out if the *p*-value of AR (2) > 0.05, then Ho is accepted, which means there is no autocorrelation or the test results are consistent ([Sofilda et al., 2023](#)).

4. Finding and discussion

The data analysis was based on four models. In Model (1), the analysis was based on the overall sample of 406 regions or countries (districts and cities). In Model (2), for Western Indonesia, its sample is 227 regions or cities. In Model (3), the analysis was based on Central Indonesia, and its sample is 128 regions or cities. Model (4) presents Eastern Indonesia with a sample of 51 regions or cities. Based on the robustness test results for the four estimates in this study, the best model is the FEM and SGMM.

[Table 1](#) shows the correlations between all research variables. All the correlation coefficients are below 0.6. The highest is the correlation between FSI and PSI, at 0.5698, and between the ICAP and SAF, at 0.5443. The rest of the correlations are less than 0.4, indicating no potential multicollinearity problems exist.

[Table A1 \(Appendix\)](#) shows the static panel data analysis results. For stunting Model 1–Model 4, we found that the Breusch–Pagan test showed a significance of 1%, and if the null hypothesis was rejected, then REM is efficient. So, we conducted the Hausman test states a significance of 1%; the null hypothesis was rejected, then FEM is efficient except for Model 3. The best Model to estimate stunting is the fixed-effect model (FEM) for Models 1, 3 and 3 and REM for Model 3. After that, we conducted AR(1) and Wald tests for autocorrelation and heteroscedasticity tests, and overall, the models had those problems; therefore, we used the Panel's corrected standard errors as the final models, as shown in [Table 2](#).

Table 1. Correlation of variables

Variables	ICAP	FSI	PL	PSI	WYOS	VF	HFP	SAF	PAFE	PAFH	RGI
ICAP	1										
FSI	0.2557	1									
PL	0.0871	−0.2826	1								
PSI	−0.1634	−0.5698	0.2275	1							
WYOS	0.1126	0.4121	0.0823	−0.3632	1						
VF	0.4194	0.1225	−0.053	0.0425	−0.1513	1					
HFP	0.419	0.2369	−0.1848	−0.119	−0.1182	0.5418	1				
SAF	0.5443	0.2672	0.1307	−0.1451	0.0587	0.456	0.3031	1			
PAFE	0.2187	0.1206	0.0361	−0.0485	−0.046	0.3665	0.359	0.2942	1		
PAFH	0.0326	0.007	0.0461	0.1013	−0.053	0.1403	0.079	0.1104	0.2027	1	
RGI	0.4498	0.2958	−0.0567	−0.184	0.1318	0.2023	0.2985	0.3185	0.0589	0.013	1

Source: Authors' calculation

Table 2. Result of static panel data analysis (panels corrected standard errors)

Variables	Model stunting			
	Model 1	Model 2	Model 3	Model 4
ICAP	-0.0171 (0.0167)	0.0341* (0.0184)	0.0637** (0.0264)	-0.0344 (0.0253)
FSI	-0.150*** (0.0327)	-0.236*** (0.0350)	-0.115*** (0.0258)	-0.126*** (0.0154)
LNPL/PL	-7.169*** (2.121)	-1.98e-05*** (7.4e-06)	-2.1e-05*** (5.7e-06)	9.1e-06*** (3.5e-06)
PSI	0.172 (0.212)	-1.832** (0.925)	2.339*** (0.419)	-0.634** (0.246)
WYOS	-0.364*** (0.133)	-0.185 (0.256)	-1.400*** (0.359)	-0.520*** (0.173)
VF	0.00724** (0.00349)	0.0172*** (0.0040)	0.0205*** (0.0070)	0.0087* (0.0052)
HFP	0.00347 (0.0147)	0.0031 (0.0143)	-0.0081 (0.0279)	0.0008 (0.0268)
SAF	-0.00752** (0.00340)	-0.0073** (0.0034)	-0.0110* (0.0056)	-0.0023 (0.0035)
PAFE	-0.00720 (0.0273)	-0.0178 (0.0327)	-0.0193 (0.0327)	0.0114 (0.0236)
PAFH	0.0248** (0.0119)	0.0054 (0.0202)	0.0117 (0.0176)	0.0104 (0.0077)
RGI	-0.0114 (0.0331)	0.0385 (0.0290)	-0.0663 (0.0533)	-0.263** (0.105)
CONSTANT	136.4*** (29.30)	55.33*** (6.781)	58.41*** (5.777)	38.75*** (2.142)
<i>The goodness of the fit model</i>				
R^2 Adj.	0.184	0.156	0.263	0.310
Wald test	1087.15 (0000)	230.14 (0000)	453.37 (0000)	5684.81 (0000)
Obs $N \times T$	2,436	1,362	768	306

Notes: The parenthesis is the standard error, except for the F (Walt), which is the p -value. *** $p \leq 1\%$, ** $p \leq 5\%$ and * $p \leq 1\%$

Source: Authors' calculation

Model 1 shows that the food security index, poverty lines, women's years of schooling and specific allocation of funds negatively influence stunting and are statistically significant at 1%–5%. Conversely, village funds and health fund allocations positively influence stunting and are statistically significant at the level of percent. This means that village funds are primarily used for expenses that are unrelated to the stunting reduction program, such as providing additional iron supplement tablets, food in the form of animal protein for children aged 6–24 months and conducting pregnancy checks and providing additional food for pregnant women to meet the nutritional and iron content of pregnant women. This result is also proven by the effect of allocating funds for health, which indicates a positive influence on stunting and implicitly, the health funds were not enough.

However, the rest of the determinant factors did not influence stunting because of Indonesia's historical focus on economic progress in the western regions, a legacy of the centralised system before 2000. Despite the fiscal decentralisation era that began in 2000, equal progress across regions has not materialised, as indicated by persistently low per capita income and uneven regional independence. Additionally, the government's social programs, such as the Family Hope Programme, aimed at reducing stunting among pregnant women and toddlers, have not achieved the intended outcomes.

Model 2 presented that income per capita, food security index, poverty lines, poverty severity index and specific allocation funds have negative impacts on the prevalence of stunting and are statistically significant at 1%–5%. Otherwise, village funds positively impact the prevalence of stunting and are significant at 1%. In other words, the allocation of village funds in this area is effectively managed but cannot reduce stunting; however, using the specific allocation funds can strongly reduce stunting, particularly in health care.

In addition, the regional dependency index, hopeful family programme and physical allocation of funds for education and health do not demonstrate statistical significance. It is

also observed that the use of funds from the Family Hope programme needs to be improved, thereby impeding the reduction of the stunting rate. The allocation of funds for physical health did not directly impact reducing the prevalence of stunting in Western Indonesia during the same year.

Model 3 showed the food security index, poverty line, women's years of schooling and specific allocation funds negatively influencing stunting rates, with a significant 1%. In reverse, income per capita, the poverty severity index and village funds positively impact stunting and are statistically significant at 1%–5%. However, the Hopeful Family Program and the physical allocation of funds for education and health are insignificant. In addition, the income per capita is significant despite being inconsistent with the theory that it should have a negative impact. This result implies that the income per capita in these regions is still lower.

Model 4 demonstrated that the food security index, poverty severity index, women's years of schooling and the regional dependency index negatively influenced stunting and statistical significance of 1%–5%. Otherwise, the poverty lines and specific allocation of funds positively influenced stunting and were significant at 1 and 10%. However, the income per capita variable, the allocation of funds for education and the physical allocation of funds for health do not significantly impact stunting in Eastern Indonesia. Consequently, the budget allocation designated for the Eastern region of Indonesia needs to be revised to address the prevailing issue of stunting.

Table 3 shows the DGMM and SGMM analysis results of equation (13). Each model was analysed using the one-step and two-step models 1 through 4. The overidentifying restrictions test or the Sargant test indicates that the null hypothesis cannot be rejected at the 5% significance level, and there is no serial correlation, as demonstrated by the fact that AR (1) is significant, but AR (2) is not. Consequently, both models (DGMM and SGMM) are valid for two steps, but SGMM provides better outcomes because the coefficient of delayed stunting is more significant for all Models in SGMM than in DGMM.

The study's results suggest that based on SGMM's two-step analysis, the initial disparity observed in Stunting-1 favourably impacts Stunt towards all models at a significance level of 1%. In contrast, the findings indicate that the income per capita variable is not statistically significant across all models. This suggests that the average income per capita in all regions of Indonesia remains considerably low. The Food Security Index demonstrates a negative impact on the Stunt variable in both Model 1 and Model 2, with a significance level of 1 and 10%. However, the lack of significance in models 3 and 4 indicates that Indonesia's Central and Eastern regions exhibit a high degree of vulnerability regarding food security.

The poverty severity index does not significantly influence Model 1 but substantially influences Models 2, 3 and 4. According to theoretical expectations, the variable representing the number of years of schooling for women has a negative coefficient; however, it is found to be statistically insignificant across all models. In all models except Model 4, which represents Eastern Indonesia, the regional dependency index has a substantial impact at a statistically significant level of 1%. This observation indicates that fiscal decentralisation has not gone well in Eastern Indonesia.

Village funds are social assistance the central government provides to low-income individuals. According to the theory, these funds have an effect and are significant at the 5% and 10% levels for models 1 and 2. Meanwhile, they are insignificant for Central and Eastern Indonesia. The hopeful family programme variable in the dynamic Model had a significant 1% negative effect on the Stunt for all three models (Models 1, 2 and 3). Specific allocation funds hurt stunting and are negligible for all models. However, the physical allocation fund for education and health is only significant at 5% and 10% for Model 2.

Table 3. Result of dynamic panel data analysis

Variables	Model 1		Model 2		Model 3		Model 4	
	DGMM	SGMM	DGMM	SGMM	DGMM	SGMM	DGMM	SGMM
Constant	97.590*** (8.070)	63.062*** (7.767)	108.17*** (12.504)	81.097*** (12.265)	115.034*** (14.768)	111.880*** (14.120)	-35.092 (77.272)	12.769 (26.396)
$STUN_{i,t-1}$	0.512*** (0.042)	0.683*** (0.034)	0.519*** (0.050)	0.733*** (0.042)	0.335*** (0.084)	0.406*** (0.062)	2.471 (2.141)	0.940** (0.419)
$ICap_{i,t}$	-0.003 (0.130)	0.099 (0.076)	0.266 (0.243)	0.035 (0.123)	-0.155 (0.218)	-0.290 (0.186)	0.072 (0.302)	0.008 (0.172)
$FSI_{i,t}$	-0.127*** (0.051)	-0.026 (0.050)	-0.181* (0.094)	-0.171* (0.097)	-0.029 (0.084)	-0.056 (0.084)	-0.064 (0.120)	-0.064 (0.071)
$PSI_{i,t}$	-0.287 (0.594)	-0.579 (0.625)	3.418 (2.120)	6.082*** (2.279)	1.873 (1.442)	2.455* (1.385)	-2.348 (1.640)	-1.365*** (0.595)
$WYoS_{i,t}$	-9.753 (1.033)	-7.132 (1.044)	-10.718 (1.646)	-8.129 (1.563)	-11.926 (1.901)	-11.824 (1.826)	-0.664 (3.581)	-0.731 (2.123)
$VF_{i,t}$	-0.014* (0.008)	-0.005 (0.008)	-0.041** (0.016)	-0.018 (0.015)	-0.041 (0.033)	-0.019 (0.029)	0.002 (0.013)	0.001 (0.008)
$HFP_{i,t}$	-0.033*** (0.005)	-0.042 (0.005)	-0.021*** (0.006)	-0.031*** (0.006)	-0.051*** (0.015)	-0.058*** (0.013)	-0.061 (0.084)	-0.013 (0.032)
$SAF_{i,t}$	-0.001 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.001 (0.001)	0.000 (0.002)	0.002 (0.002)	-0.006 (0.007)	-0.002 (0.003)
$PFE_{i,t}$	0.021 (0.021)	0.026 (0.014)	0.033* (0.019)	0.044** (0.020)	0.013 (0.025)	0.008 (0.026)	0.029 (0.069)	-0.005 (0.031)
$PFH_{i,t}$	0.000 (0.009)	0.001 (0.010)	-0.028 (0.018)	-0.033* (0.019)	0.016 (0.013)	0.019 (0.014)	-0.016 (0.035)	0.001 (0.016)
$RGI_{i,t}$	0.150*** (0.048)	0.192 (0.050)	0.097* (0.005)	0.135*** (0.059)	0.495*** (0.144)	0.511*** (0.143)	-0.079 (0.303)	-0.005 (0.170)
Sargan-test	492.406***	22.310*	332.093***	21.440*	152.6659***	19.199*	1.290	5.301
AR-1	-6.909***	-7.150***	-4.6375***	-4.907***	-55.5597***	-4.908***	-0.723	-1.743*
AR-2	-1.145	-1.782	0.2626	-1.785*	0.570	-1.785*	-1.166	-1.430
N × T	1,622	2,029	908	1,135	510	639	204	255

Notes: The parenthesis is the standard error. The significance levels are as follows: *** is 1%, ** is 5%, and * is 10%
Source: Authors' calculation

The instrument validity assessment for the DGMM method revealed that the primary model, west and central samples exhibit significance at the 1% level, rendering the instrumental variables ineffective. However, within the east sample group, instrumental variables were deemed valid. In contrast, for SGMM estimation, the Arellano–Bond results at the second order exhibited non-significance at the 5% level, thus satisfying the autocorrelation assumption across all parameter estimates. Moreover, tests of instrument validity for all SGMM parameter estimates indicated non-significant outcomes at the 5% level, thereby confirming the validity of instrumental variables across all parameter estimates. Consequently, all parameter estimates using the SGMM method conform to the model specification tests, with only the east parameter estimates passing the model specification test when using the DGMM method. Based on the model specification tests and parameter significance assessments, it can also be deduced that the SGMM estimation method is better suited for capturing the intricacies of the data behaviour.

The dynamic model's results, which looked at the effect of stunting in the previous year on stunting, were significant in all models at the 1% level in Models 1, 2 and 3 and at the 5% level in Model 4. This shows that the number of stunting figures in the previous year will influence the stunting rate the following year.

5. Discussion

Based on the findings of static and dynamic models, the impact of the income per capita variable was mixed. The majority of the findings obtained in this study support the conclusions drawn by [Rengma *et al.* \(2016\)](#), [Roediger *et al.* \(2020\)](#) and Van Tuijl (2021), who asserted that there is a significant association between income level and a decrease in stunting prevalence. The food security index substantially impacts the prevalence of stunting in Indonesia. The findings demonstrate a strong association between the food security index and the prevalence of stunting in Indonesia, aligning with the objectives outlined in the SDGs. This relationship remains consistent across various models, including static and dynamic approaches, providing robust evidence to support this claim. The findings align with the study conducted by [M'Kaibi *et al.* \(2017\)](#) in Kenya.

The poverty lines and some of the severity index significantly influence stunting; these results confirm [Wigle *et al.* \(2020\)](#), in which the minimum poverty level influences stunting. In addition, this result shows that the number of years of education women complete notably impacts stunting, except for West Indonesia. These results are also confirmed by several studies, such as [Fenske *et al.* \(2013\)](#), [Emamian *et al.* \(2014\)](#), [Bhutta *et al.* \(2020\)](#) and [Roediger *et al.* \(2020\)](#), in which the level of education, especially for women (maternal education), has a significant effect on the prevalence of stunting. The higher the level of education of women/mothers, the greater their capacity to assimilate health-related information or education related to health, especially in decision-making regarding consumption to fulfil nutritional needs. The limited access to education and the substandard quality of education in the Eastern region may be a consideration for the insignificant relationship.

The Region Independence Index influences stunting. This analysis demonstrates that fiscal decentralisation has exerted a discernible influence on the autonomy of a given region, enabling it to mitigate stunting rates effectively. However, such an impact has not been observed in Eastern Indonesia, despite the government's provision of special autonomy funds explicitly allocated to Papua Province in the eastern part of the country.

The village fund variable significantly positively impacts overcoming the stunting problem. This influence is evident across all models in terms of static analysis. This exciting result indicates that village funds were not used to reduce stunting through specific programmes.

However, considering dynamic analysis, this influence is negative and limited to Indonesia's Western region. These results are from a study conducted by [Indra and Khoirunurrofik \(2022\)](#), which also used data from districts/cities in Indonesia and found that village funds significantly affected stunting prevalence.

Other social transfers, such as the Hope Family Programme for the dynamic model, substantially impact stunting reduction, except in Eastern Indonesia. This result is also consistent with [Leroy *et al.* \(2019\)](#) finding that government spending, particularly transfers, substantially affects the quality of nutrients absorbed. The social safety net allocation, in this case, the Hope Family Programme, will increase food availability and accessibility, particularly for basic needs, to influence the type of food consumed by beneficiaries in regions with a high prevalence of stunting. The specific allocation fund substantially affects the static model but has a negligible effect on the dynamic model. Regarding the physical assignment, the Fund for Education and Health in the dynamic Model has a significant impact on Western Indonesia, supporting previous findings by [Hoddinott *et al.* \(2013\)](#) and [Berman and Ahuja \(2018\)](#) that government intervention, particularly health, has a significant impact on reducing stunting rates.

6. Conclusion

This study demonstrates that the economic performance indicator, the effect of income per capita on stunting overall, is inconclusive, and it shows that Indonesia's average income per capita remains considerably low across all regions. Concerning the SDGs represented by the food security index and the poverty severity index, the food security index substantially impacts stunting in Indonesia and robust results in static and dynamic models. The poverty line and poverty severity index relate to reducing stunting. This result indicates that based on regional division, Central and Eastern Indonesia have a high level of poverty severity and a close relationship with low income per capita. Human capital, measured explicitly by women's years of schooling, exerts a noteworthy impact on stunting. However, its influence becomes statistically insignificant in the dynamic model. Based on the available data, it is evident that the average duration of education for women in Indonesia remains relatively low, particularly in the Eastern region, where the average falls below six years, indicating a failure to complete elementary school.

Fiscal decentralisation, a policy initiative implemented for over two decades, seeks to enhance regional autonomy to promote the welfare of communities. The findings of the Region Independence Index indicate a notable impact on stunting within the dynamic model, except for the Eastern Indonesia region. In the context of governmental expenditure, the allocation of community social assistance, consisting of village funds and home-family programmes, has significantly influenced overcoming the stunting problem, both for static models in all models and dynamic models only in the Western region of Indonesia. Other social transfers, such as the Hope Family Programme for the dynamic model, significantly reduce stunting, except for the Eastern Indonesia region. The Specific Allocation Fund substantially affects the static Model but has a negligible effect on the dynamic Model. Regarding physical distribution, the Fund for Education and Health's dynamic Model significantly impacts Western Indonesia.

Based on the preceding conclusions, interesting results were discovered regarding Indonesia's decline in stunting rates. The biggest challenge for the Indonesian Government is stunting in Central and, especially, Eastern Indonesia. To decrease the Poverty Severity Index, the Indonesian government must devote special attention to increasing income equality and decreasing inequality. Additionally, the central and regional governments must continue to ensure the stability of food security and promote increased regional autonomy to lessen dependence on the central government. Social assistance programmes must also be

monitored and directed to achieve the government's strategy to reduce stunting. Budget allocations for education and health must be increased because this will reduce stunting, improve the quality of human resources, and, ultimately, achieve community welfare through the SDGs.

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Table A1. Result of static panel data analysis

Variables	Model stunting			
	Model 1	Model 2	Model 3	Model 4
ICAP	0.132 (0.0812)	0.475*** (0.142)	0.0954** (0.0371)	0.0341 (0.161)
FSI	-0.192*** (0.0364)	-0.246*** (0.0717)	-0.115** (0.0456)	-0.101** (0.0509)
LNPL/PL	-29.14***- (2.677)	-7.48e-05*** (8.66e-06)	-4.5e-05*** (5.8e-06)	-1.98e-05 (1.21e-05)
PSI	0.281 (0.413)	-0.162 (1.452)	2.107** (0.835)	-0.0583 (0.390)
WYOS	0.454 (0.982)	0.136 (1.452)	-2.047*** (0.535)	2.013 (2.114)
VF	-0.0134** (0.00624)	-0.0387*** (0.0111)	0.0111 (0.0099)	0.00667 (0.00736)
HFP	0.00494 (0.00340)	0.0106*** (0.00407)	-0.0242*** (0.0089)	0.0291 (0.0277)
SAF	-0.00216** (0.000872)	-0.00275** (0.00114)	-0.00582*** (0.0016)	0.00300 (0.00215)
PAFE	0.0235** (0.0112)	0.0230 (0.0153)	-0.0171 (0.0189)	-0.0120 (0.0277)
PAFH	0.0230*** (0.00733)	-0.0186 (0.0142)	0.0128 (0.0104)	0.0252** (0.0116)
RGI	0.0339 (0.0284)	0.00403 (0.0346)	0.0419 (0.0590)	-0.0853 (0.102)
Constant	415.1*** (29.40)	73.43*** (9.134)	71.18*** (4.707)	31.87*** (10.54)
<i>The goodness of the fit model</i>				
R^2 Adj.	0.246	0.280	0.3406	0.061
F test	59.86 (0.0000)	39.79 (0.0000)	323.87 (0.0000)	1.45 (0.1501)
BP test	847.24 (0.0000)	296.06 (0.0000)	380.83 (0.0000)	73.25 (0.0000)
Hausman test	20.35 (0.0261)	42.34 (0.000)	10.96 (0.3607)	25.00 (0.0053)
Wald test	2.3e + 05 (0.000)	1.2e + 05 (0.000)	7631.92 (0.000)	23438.76 (0.000)
AR(1)	186.328 (0.0000)	116.608 (0.0000)	77.635 (0.0000)	227.108 (0.0000)
Obs N × T	2,436	1,362	768	306
Notes: The parenthesis is the standard error, except for the F (Walt), BP-LM, Hausman and F tests, which are p-values. *** $p \leq 1\%$, ** $p \leq 5\%$ and * $p \leq 1\%$ Source: Authors' calculation				

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