

# Determination Prevalence of Stunting: Logistic Regression Analysis of Maternal and Child Health Factors

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## ABSTRACT

**Background:** Stunting remains a significant public health issue in Indonesia, with long-term impacts on child growth and development. Maternal and child health is considered a key factor during pregnancy and early childhood. This study aimed to investigate the association between maternal and child health practices and stunting in toddlers using logistic regression analysis.

**Methodology:** A cross-sectional design was used in 140 mother-child pairs proportionally selected from four community health centers in urban Surabaya. Data were collected through a structured questionnaire, medical records, and anthropometric measurements. Statistical analysis was performed with a 95% confidence level, with significance determined at  $p < 0.05$ .

**Results:** Multivariable logistic regression analysis showed that routine antenatal care was a protective factor against stunting (OR = 0.136; 95% CI: 0.028-0.671;  $p = 0.014$ ), indicating a substantially lower likelihood of stunting among children whose mothers attended regular ANC. Implementation of early initiation of breastfeeding was also independently protective (OR = 0.165; 95% CI: 0.032-0.852;  $p = 0.031$ ). In contrast, complementary feeding before 6 months was the strongest risk factor for stunting (OR = 7.793; 95% CI: 2.486-24.432;  $p < 0.001$ ). Other variables were not statistically significant after adjustment.

**Conclusions:** This study concluded that regular antenatal care and early breastfeeding are protective factors against stunting, while introducing complementary foods before 6 months of age carries significant risks. It is recommended that strengthening antenatal care (ANC) services, adherence to Early Initiation of Breastfeeding (IMD), and early initiation of complementary feeding (MP-ASI) be prioritized in stunting prevention programs.

**Keywords:** Stunting, Maternal Health, Child Health, Antenatal Care, Breastfeeding

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## INTRODUCTION

Stunting is one of the most serious public health problems in developing countries, including Indonesia, due to its long-term consequences for physical growth, cognitive development, economic productivity, and human capital.<sup>1</sup> According to the World Health Organization (WHO), stunting reflects chronic undernutrition occurring primarily during the first 1,000 days of life and is influenced by maternal nutritional and health status before and during pregnancy, antenatal care, infant and young child feeding practices, child nutritional status, and environmental and health service conditions.<sup>1,2</sup> Empirical evidence on the relative influence of maternal and child health factors on stunting remains limited in several regions of Indonesia, particularly in high-prevalence areas.<sup>1,3</sup> Therefore, analyzing stunting determinants using logistic regression is essential to provide a scientific basis for developing more targeted nutrition and public health strategies.<sup>4</sup>

The 2022 Indonesian Nutritional Status Survey (SSGI) reported a national prevalence of 21.6%, down from 24.4% in 2021, but still above the WHO threshold of 20%.<sup>5</sup> East Java has experienced a downward trend in stunting prevalence over the past three years. In 2021, the prevalence reached 23.5%, decreased to 19.2% in 2022, and further dropped to 17.7% in 2023.<sup>6</sup> Stunting can have a negative effective impact on children's health, development and productivity in the future.<sup>7</sup> There are many potential causes of stunting in Indonesia, including direct factors such as maternal nutritional status, breastfeeding practices, complementary feeding practices, and exposure to infections, as well as indirect factors such as education, food systems, health care, and water and sanitation infrastructure and services.<sup>8</sup> Maternal nutritional status is a strong predictor of fetal growth and birth outcomes and has been associated with intrauterine growth restriction (IUGR) and low birth weight (LBW). Maternal undernutrition, defined as having a body mass index <18.5, has intergenerational consequences, as it has been found to be an important determinant of child malnutrition, and its impact persists throughout the life cycle, affecting developmental and economic outcomes.<sup>9</sup> Stunting has serious consequences, including impaired linear growth, cognitive deficits, gut dysbiosis, endocrine disorders, anemia, and an increased risk of chronic diseases later in life.<sup>10</sup>

Indonesia's efforts to address stunting involve various interventions involving various sectors, programs, and levels. These efforts have shown progress in reducing stunting rates, but challenges remain and targets remain to be achieved. Therefore, efforts needed to address stunting include increased interventions, convergence, innovation, and robust data.<sup>7</sup> In accordance with government policy, food security is the foundation of the government's efforts to improve public health through the National Nutritional Food Policy, an initiative that aims to provide free

nutritious food for children to address the problems of malnutrition and stunting that still occur in Indonesia.<sup>11</sup> However, empirical evidence on the simultaneous effects of maternal and child health factors on stunting can occur in both urban and rural communities.<sup>12</sup> Addressing this research gap is essential to provide evidence that strengthens data-driven nutrition and public health planning.

Therefore, this study aims to analyze maternal and child health factors associated with stunting among children under five using logistic regression analysis, to identify key determinants and provide a scientific foundation for more effective and context-specific intervention policies.

## METHODOLOGY

**Research Type:** This study employed an analytical observational design using a cross-sectional approach to examine the relationship between maternal and child health factors and the prevalence of stunting. The cross-sectional design was selected because it allows for the simultaneous measurement of exposures (maternal and child factors) and outcomes (stunting status) within a defined population at a single point in time, enabling the identification of potential associations.

**Ethical approval:** This study received ethical approval from the Ethics Committee of Surabaya Health Polytechnic under approval number EA/1886/KEPK-Poltekkes\_Sby/V/2023.

**Population and Sample/Informants:** The study population included all mothers with children aged 0 to 59 months who lived in the area where the health center was located. The sample was drawn using a stratified proportional random sampling method to ensure that every village in the area was represented. The sample size was determined following the Rules of Thumb for logistic regression analysis, which require a minimum of 5-10 participants for each predictor variable. With 12 independent variables, at least 120 participants were required. To account for potential non-response or dropout, the sample size was increased to 140 participants.

The sample size in this study was determined using the events per variable (EPV) principle, which is often used in logistic regression analysis. Peduzzi and colleagues (1996) recommend that the required sample size should be based on a minimum of 10 outcome events for each predictor variable in the model, not simply on the number of subjects per variable.<sup>13</sup> By analyzing 21 independent variables, a minimum of 120 outcome events were required to ensure that the model estimates were stable and statistically valid.

The sample size for this study was 140 mother-child pairs. This decision was made considering the stunting rate in Surabaya (approximately 4.8% according to the 2022 Indonesian Nutritional Status Survey/

SSGI), to ensure that the sample size met the EPV criteria, which is  $\geq 10$  for each variable. The sample size was then enlarged beyond the minimum requirement to anticipate potential nonresponse or incomplete data.

**Research Location:** This study was conducted at four community health centers (Puskesmas) under the Surabaya City Health Office, Indonesia: Mojo, Tanah Kali Kedinding, Menur, and Jagir. These sites were selected because they represent urban areas with high population density, diverse socioeconomic characteristics, and significant numbers of children under five, making them relevant for stunting research. All centers actively provide maternal and child health services, including growth monitoring and nutrition programs, ensuring data availability and supporting study implementation.

**Instrumentation or Tools:** Data were collected using a structured questionnaire that had been tested for validity and reliability. This included data on respondent characteristics, maternal health history, infant and young child feeding practices, and environmental factors. Stunting data were obtained by measuring children's height and calculating Z-scores for height for age (H/A) based on the WHO Child Growth Standards.

**Data Collection Procedures:** Data collection was conducted through a combination of structured interviews, review of maternal and child medical records (KIA books), and direct anthropometric measurements in accordance with standard procedures established by WHO. Trained data collectors conducted direct interviews with mothers or primary caregivers to gather information on maternal health behaviors during pregnancy, child feeding habits, and household characteristics. Maternal and child medical records were reviewed to verify information such as antenatal care visits, use of iron and folic acid tablets, immunization status, and growth monitoring records. Anthropometric data, including height/weight and weight, were measured using calibrated instruments. Measurements were taken twice to ensure accuracy and reduce the possibility of observer bias. All collected data were recorded using standardized forms, checked daily by field supervisors for completeness and consistency, and then entered into a secure electronic database. Quality control included repeated data recording and random checks of records to minimize the possibility of errors.

**Data Analysis:** Data analysis was conducted in several stages. Univariate analysis was used to describe the frequency distribution of each variable. Bivariate analysis employed the Chi-square test to examine the association between each independent variable and stunting. Variables with p-values  $< 0.25$  in bivariate analysis were included in the multivariate analysis, which was performed using binary logistic regression to identify determinants of stunting. A significance level of 0.05 (95% confidence interval) was applied in all statistical tests.

## RESULTS

Table 1 describes the attributes of the mothers in this study, indicating that most were in their productive age range, from their late twenties to early thirties, with a predominance of secondary education (high school/vocational high school) and housewives. This profile reflects the general situation of families in urban Surabaya, where maternal education level and employment status can influence health knowledge, parenting practices, and access to health services. These factors are crucial because they can influence the quality of nutritional interventions and stunting prevention efforts in children. Meanwhile, the characteristics of toddlers indicate that most were born with normal length and weight, were the first or second child, and lived in families with a relatively small number of children (1-2 children).

**Table 1: Characteristics of mothers and children (n = 140)**

Variable	Participants (%)
<b>Maternal Characteristics</b>	
<b>Mother's Age</b>	
20-25 years	34 (24.3)
25-30 years	45 (32.1)
31-35 years	39 (27.9)
36-40 years	22 (15.7)
<b>Education</b>	
Primary/Junior High School	8 (5.7)
Senior High School/Vocational	114 (81.4)
Higher Education (Diploma/Bachelor)	18 (12.9)
<b>Occupation</b>	
Housewife	94 (67.1)
Working	46 (32.9)
<b>Child Characteristics</b>	
<b>Stunting Status</b>	
Stunted (HAZ $< -2$ )	30 (21.4)
Not Stunted (HAZ $\geq -2$ )	110 (78.6)
<b>Birth Length</b>	
$\leq 48$ cm	51 (36.4)
$> 48$ cm	89 (63.6)
<b>Birth Weight</b>	
Low ( $< 2500$ g)	24 (17.1)
Normal ( $\geq 2500$ g)	116 (82.9)
<b>Birth Order</b>	
First-born	67 (47.9)
Second-born	51 (36.4)
Third-born or later	25 (15.7)
<b>Interval to Older Sibling</b>	
$\leq 2$ years	40 (28.6)
$\geq 3$ years	46 (32.9)
First-born (no older sibling)	60 (42.9)
<b>Number of Children in Family</b>	
1-2 children	96 (68.6)
$\geq 3$ children	44 (31.4)
<b>Sex</b>	
Male	72 (51.4)
Female	68 (48.6)
<b>Age Group (months)</b>	
24-35	48 (34.3)
36-47	52 (37.1)
48-59	40 (28.6)

**Table 2: Stunting status among children by anthropometric and demographic characteristics (n = 140)**

Variable	Stunted (HAZ < -2) (%)	Not Stunted (HAZ ≥ -2) (%)	Total (%)
<b>Overall stunting status</b>			
Stunted	30 (21.4)	-	30 (21.4)
Not stunted	-	110 (78.6)	110 (78.6)
<b>Birth Length</b>			
≤ 48 cm	15 (29.4)	36 (70.6)	51 (36.4)
> 48 cm	15 (16.9)	74 (83.1)	89 (63.6)
<b>Birth Weight</b>			
Low (< 2500 g)	10 (41.7)	14 (58.3)	24 (17.1)
Normal (≥ 2500 g)	20 (17.2)	96 (82.8)	116 (82.9)
<b>Birth Order</b>			
First-born	12 (17.9)	55 (82.1)	67 (47.9)
Second-born	11 (21.6)	40 (78.4)	51 (36.4)
Third-born or later	7 (28.0)	18 (72.0)	25 (15.7)
<b>Interval to Older Sibling</b>			
≤ 2 years	12 (30.0)	28 (70.0)	40 (28.6)
≥ 3 years	8 (17.4)	38 (82.6)	46 (32.9)
First-born (no older)	10 (16.7)	50 (83.3)	60 (42.9)
<b>Number of Children in Family</b>			
1-2 children	18 (18.8)	78 (81.2)	96 (68.6)
≥ 3 children	12 (27.3)	32 (72.7)	44 (31.4)
<b>Sex</b>			
Male	18 (25.0)	54 (75.0)	72 (51.4)
Female	12 (17.6)	56 (82.4)	68 (48.6)
<b>Age group (mo.)</b>			
24-35	12 (25.0)	36 (75.0)	48 (34.3)
36-47	11 (21.2)	41 (78.8)	52 (37.1)
48-59	7 (17.5)	33 (82.5)	40 (28.6)

Stunting occurs in approximately 20% of the total population, and this condition is more common in children with low birth weight and height, and in families with many children. These findings confirm that biological factors present from birth and family structure remain the primary determinants of stunting risk. Meanwhile, the distribution of children's age and gender is quite balanced, indicating that the risk of stunting is not only focused on certain demographic groups.

Table 2, which shows the distribution of stunting status among children by anthropometric and demographic characteristics, indicates that approximately one in five children in the study population is stunted. Key anthropometric factors at birth are closely related to this outcome, as children born with shorter height and low birth weight exhibit higher rates of stunting compared to those born with normal height. Birth order also plays a role, with children born third or later more likely to be stunted than those born first or second. These results highlight the role of early life conditions as an important factor in children's growth and development.

Family characteristics and other demographic information contribute to the risk profile. Shorter birth intervals (<2 years) and larger family sizes (≥3 children) are associated with increased rates of stunting, suggesting that resource allocation and caregiving capabilities may be limited in these families. Boys tend to be more affected than girls, and stunting appears to be more common in the younger age group (24-35 months). Overall, these findings emphasize

that stunting is influenced not only by biological factors at birth, but also by family dynamics and demographic patterns that influence nutrition, care practices, and the availability of health resources.

Bivariate analysis was performed using Fisher's exact test with a significance level of  $\alpha = 0.05$ . The strength of the association was estimated using the Mantel-Haenszel Odds Ratio (OR). The results of the analysis are shown in Table 3.

Table 3 presents the results of the bivariate analysis, which shows that routine antenatal care, counseling on Fe-Folate, promotion and implementation of early breastfeeding initiation, promotion and implementation of exclusive breastfeeding, and promotion of balanced nutrition have a significant relationship with the occurrence of stunting ( $p < 0.05$ ), with an odds ratio value of <1 indicating that these variables act as protective factors. Conversely, the provision of complementary foods before the age of 6 months significantly increases the risk of stunting (OR = 5.33;  $p = < 0.001$ ). Other variables did not show a significant relationship with the incidence of stunting ( $p \geq 0.05$ ). Although some variables have OR >1 or <1, because the p value  $\geq 0.05$ , the relationship cannot be declared statistically significant. For some variables, the OR cannot be calculated (NA) because there are cells with a value of 0, indicating a very small number of cases in one category.

To further explore the independent factors contributing to stunting, all variables meeting the eligibility criteria in the bivariate analysis were entered into a binary logistic regression model.

**Table 3: Bivariate analysis of health intervention and stunting (n = 140)**

Intervention Provided to the mother	Stunting Incident		Odds Ratio# (95%CI)	p-value (2-sided)*
	Stunted (n=30)(%)	Non-Stunted (n=110)(%)		
Antenatal Care Routine	22 (73.3)	105 (95.5)	0.13 (0.04–0.44)	<0.001
Iron & Folic Acid Counselling	26 (86.7)	108 (98.2)	0.12 (0.02–0.69)	0.006
Consumption of Fe-Folate Tablets	22 (73.3)	80 (72.7)	1.03 (0.41–2.57)	0.947
Promotion of IMD	22 (73.3)	103 (93.6)	0.19 (0.06–0.57)	0.001
Implementation of IMD	23 (76.7)	104 (94.5)	0.19 (0.06–0.62)	0.003
Exclusive Breastfeeding Promotion	24 (80.0)	106 (96.4)	0.15 (0.04–0.58)	0.002
Exclusive Breastfeeding Practice	23 (76.7)	102 (92.7)	0.26 (0.08–0.78)	0.012
Balanced Nutrition Promotion	24 (80.0)	105 (95.5)	0.19 (0.05–0.68)	0.005
Complementary Feeding Before 6 Months	20 (66.7)	30 (27.3)	5.33 (2.24–12.70)	<0.001
Complementary Feeding After 6 Months	28 (93.3)	97 (88.2)	1.88 (0.40–8.81)	0.419
Processed Animal Protein Intake	29 (96.7)	108 (98.2)	0.54 (0.05–6.13)	0.611
Complete Immunization	30 (100)	103 (93.6)	-	0.346
Vitamin A Administration	30 (100)	110 (100)	-	1
Iron Supplementation	18 (60.0)	82 (74.5)	0.51 (0.22–1.19)	0.118
Zinc Supplementation	28 (93.3)	92 (83.6)	2.74 (0.60–12.54)	0.178
Iodine Supplementation	30 (100)	105 (95.5)	-	0.585
Deworming Administration	30 (100)	109 (99.1)	-	1
Growth Monitoring	28 (93.3)	102 (92.7)	1.10 (0.22–5.47)	0.909
Environmental Hygiene Counseling	30 (100)	108 (98.2)	-	1
Clean Water Access Counseling	30 (100)	108 (98.2)	-	1
Sanitation Counseling	30 (100)	107 (97.3)	-	1

\* Fisher's Exact Test; #Mantel-Haenszel; CI – Confidence Interval; Odds ration calculated using binary logistic regression, Variables with p < 0.25 were included in the multivariate model"

**Table 4: Results of multivariate logistic regression analysis on stunting incidence (n = 140)**

Variable	aOR (Exp B)	95% Confidence Interval	p-value
Antenatal Care Routine	0.136	0.028 - 0.671	0.014
Iron & Folic Acid Counselling	1.202	0.075 - 19.387	0.897
Promotion of IMD	0.638	0.120 - 3.395	0.598
Implementation of IMD	0.165	0.032 - 0.852	0.031
Exclusive Breastfeeding Promotion	0.276	0.045 - 1.679	0.162
Exclusive Breastfeeding Practice	0.254	0.062 - 1.044	0.057
Balanced Nutrition Promotion	0.593	0.078 - 4.490	0.613
Complementary Feeding Before 6 Months	7.793	2.486 - 24.432	0.000

aOR – Adjusted Odds Ratio; Omnibus Test  $\chi^2 = 44.020$ ;  $p < 0.001$ , Cox & Snell  $R^2 = 0.270$ , Nagelkerke  $R^2 = 0.417$ , Hosmer-Lemeshow Test  $\chi^2 = 5.860$ ;  $p = 0.210$  (good fit model)

The final model shows the adjusted relationship between each predictor and stunting after controlling for potential confounding variables. The results of the multivariate analysis are presented in Table 4.

Table 4, the results of the multivariate analysis, shows that there are three variables that have a significant influence on the incidence of stunting. Mothers who regularly undergo Antenatal Care (ANC) are less likely to give birth to children who experience stunting ( $p = 0.014$ ; OR = 0.136; 95% CI: 0.028–0.671). This indicates that regular ANC functions as a protector because it reduces the risk of stunting by approximately 86% after considering other variables in the model. Similarly, the implementation of Early Initiation of Breastfeeding (IMD) has been shown to provide protection against stunting ( $p = 0.031$ ; OR = 0.165; 95% CI: 0.032–0.852). Thus, children who receive IMD are less likely to experience stunting, which is approximately 83% when compared to children who do not receive IMD. Conversely, the introduction of complementary foods before 6 months of age was a very strong risk factor for stunting ( $p = 0.000$ ; OR = 7.793; 95% CI: 2.486–24.432). These re-

sults indicate that children who receive complementary foods early have a nearly eightfold higher risk of stunting compared to children who do not receive complementary foods before 6 months of age.

Meanwhile, several other variables, such as Iron and Folic Acid Counselling, Early Initiation of Breastfeeding (IMD) Promotion, Exclusive Breastfeeding Promotion, Exclusive Breastfeeding Practices, and Balanced Nutrition Promotion, did not show a statistically significant impact in the multivariate model ( $p > 0.05$ ). This indicates that, after taking other variables into account, the contribution of each of these variables to stunting was not statistically significant in the applied logistic regression model.

## DISCUSSION

This study analyzes maternal and child health aspects associated with stunting in toddlers in Surabaya, Indonesia. Multivariable logistic regression analysis identified three key factors: routine antenatal care, Early Initiation of Breastfeeding (IMD), and the

introduction of complementary foods before 6 months of age. These findings contribute to the growing body of evidence on the factors contributing to stunting in urban Indonesia and emphasize the importance of maternal health services and infant feeding practices.

Regular antenatal care (ANC) visits serve as a protective factor against stunting. In this study, mothers who regularly attended ANC visits were significantly less likely to have stunted children compared to mothers who did not attend regular ANC visits (OR = 0.136; 95% CI: 0.028-0.671;  $p = 0.014$ ), indicating a strong and statistically significant protective effect. This suggests that ANC allows for early detection of pregnancy risks, monitoring maternal nutritional status, and providing education on nutrition and infant care practices. This finding reinforces the role of antenatal care as a critical intervention for child growth.<sup>14</sup> Antenatal visits enable early detection of maternal risk factors<sup>15,16</sup> such as anemia, malnutrition, and pregnancy complications, while also ensuring fetal growth monitoring and provision of nutrition education<sup>16</sup>. Previous study in Nepal reported similar associations, where mothers attending four or more antenatal visits.<sup>17</sup> Regular antenatal care (ANC) visits do not directly prevent stunting but support critical preventive pathways, including maternal nutritional monitoring, early identification of pregnancy complications, and health education, which collectively contribute to improved birth outcomes and reduced stunting risk in early childhood.<sup>18-20</sup> Epidemiologically, ANC utilization is associated with increased maternal nutrient intake,<sup>21</sup> micronutrient adherence, and more appropriate breastfeeding and feeding practices, which collectively contribute to improved child linear growth. Routine antenatal care can detect early high-risk pregnancy conditions such as anemia and a history of chronic energy deficiency which are also risk factors for stunting.<sup>5</sup> Maternal nutrition plays a vital role in fetal growth, infant health and survival, and the child's long-term development. Mothers provide all the nutrients needed during the first 1,000 days, which covers the period from conception to the first six months of a child's life.<sup>22</sup> This has been proven by research Pudjirahaju A et al<sup>21</sup> that explains stunting prevention can be achieved through proper maternal and childcare practices, including early initiation of breastfeeding, exclusive breastfeeding, appropriate complementary feeding, and complete immunization.<sup>21</sup>

Initiated breastfeeding immediately after birth (EIBF) plays a crucial role in protecting against stunting in children, as it directly supports optimal early nutritional intake. In this study, children who received EIBF had an 83.5% lower risk of stunting compared to children who did not receive EIBF (OR = 0.165; 95% CI: 0.032-0.852;  $p = 0.031$ ), indicating a strong and statistically significant protective association. EIBF also provides immunological protection and supports the continuation of exclusive breast-

feeding.<sup>23</sup> Susianto et al. reported that early breastfeeding initiation ensures adequate colostrum intake, which enhances infant immunity and increases the likelihood of exclusive breastfeeding, thereby ensuring sufficient nutritional intake and preventing stunting.<sup>24</sup> Consistent with these findings, global evidence shows that breastfeeding within the first hour of life increases the probability of exclusive breastfeeding<sup>23</sup> and reduces the risk of infection and linear growth impairment in infants.<sup>24</sup> Furthermore, colostrum is a rich source of bioactive molecules that support neonatal development and the systemic transfer of immunoglobulins, thereby strengthening innate immune defence.<sup>25</sup> Early Beyond its nutritional function, breastfeeding has numerous benefits for both mother and child.<sup>25</sup> The early provision of colostrum supplies immunoglobulins and growth factors that are essential for intestinal mucosal maturation and infection prevention, which are key biological determinants of chronic growth failure.<sup>25</sup>

Providing complementary foods (MP-ASI) before 6 months of age is a significant risk factor for stunting. This is because it can disrupt the continuation of exclusive breastfeeding and increase the risk of infection and nutritional deficiencies during a crucial period of growth. In this study, children given MP-ASI before 6 months of age were almost eight times more likely to experience stunting than children who began receiving MP-ASI at 6 months of age or later (OR = 7.793; 95% CI: 2.486-24.432;  $p < 0.001$ ), which indicates a large and statistically significant risk effect. These findings are in line with global evidence showing that introducing complementary foods too early reduces breast milk intake and increases the risk of enteric infections, which directly contribute to impaired linear growth.<sup>26</sup> Cohort studies in low- and middle-income countries also show that infants who receive complementary foods before the recommended age have a higher risk of stunting than infants who maintain exclusive breastfeeding until 6 months.<sup>27</sup> The findings of this study are in line with research (Yunitasari E et al<sup>28</sup>, 2022) which shows that providing complementary foods before the age of 6 months is associated with suboptimal feeding practices and has a negative impact on nutritional status and child growth, thereby increasing the risk of stunting.<sup>28</sup> Other research findings indicate that the maturation of the baby's digestive tract and immune system is not optimal before the age of 6 months, so that exposure to complementary foods too early increases the risk of malabsorption and intestinal inflammation that accelerates the development of chronic growth failure.<sup>29</sup>

This study shows that maternal health and early feeding practices play a significant role in determining the risk of stunting in children. Regular antenatal care (ANC) visits and early initiation of breastfeeding (IMD) were shown to be protective factors, highlighting the importance of timely maternal health services and optimal breastfeeding practices to support child growth. Conversely, introducing complemen-

tary foods before six months of age was a highly significant risk factor, highlighting the infant's vulnerability to poor feeding practices during the crucial first 1,000 days of life. Overall, the results of this study suggest that stunting prevention is more successful through early promotional and preventive interventions, particularly through maternal health monitoring, breastfeeding support from birth, and adherence to the ideal age for introducing complementary foods. This is more effective than separate postnatal interventions.

The associations found in this study align with international literature highlighting maternal health and infant feeding as important factors in stunting. However, some differences emerged. For example, immunization and vitamin supplementation did not show a significant association, in contrast to studies conducted in rural Indonesia and Ethiopia, where these factors acted as protective factors. This difference may reflect differences in baseline coverage; in urban Surabaya, immunization rates are quite high, reducing variation and limiting statistical associations. Similarly, growth monitoring did not show a significant impact, possibly due to irregular follow-up or limited caregiver participation. This suggests that while biomedical interventions remain important, behavioural and nutritional practices have a more significant impact on stunting outcomes in this population.

The findings of this study have significant implications for public health policy and practice. Strengthening the reach and quality of routine antenatal care should be a key policy priority, as it has been shown to be effective as a protective factor against stunting, particularly through early risk identification and the provision of nutritional advice to mothers. Furthermore, the implementation of early breastfeeding initiation must be consistently ensured in health care settings by improving health workers' adherence to applicable service standards. In essence, the high risk of stunting in children receiving complementary foods before 6 months of age demonstrates the importance of improving education and monitoring of infant and young child feeding practices at the family and community levels. Incorporating these interventions into the First 1,000 Days of Life program is expected to increase the effectiveness of stunting prevention efforts sustainably.

## STRENGTH AND LIMITATIONS

This study used multivariate logistic regression to identify maternal and child health factors associated with stunting, offering a comprehensive view in an urban Indonesian context. However, several limitations should be acknowledged. The number of stunting cases was relatively low, raising concerns about the adequacy of the incidence per variable (EPV) and the possibility of overfitting. The wide confidence intervals for some predictors suggests limited accuracy. There may be residual bias caused by unmeas-

ured socioeconomic or environmental factors. Furthermore, the cross-sectional study design limits causal inferences, and the results should be interpreted as statistical associations rather than as confirmed evidence of a protective effect.

## CONCLUSION

This study concludes that regular antenatal care and early introduction of breastfeeding serve as protective factors against stunting, while the provision of complementary foods before 6 months of age is a very significant risk factor. This study highlights the significance of promotional and preventive efforts during the First 1,000 Days of Life. Therefore, local governments must strengthen policies to increase the reach and quality of antenatal care by maximizing the role of community health centers (Puskemas), village midwives, and health cadres. Furthermore, monitoring the implementation of Early Initiation of Breastfeeding (IMD) in various health facilities, as well as strengthening regulations and public education to prevent early introduction of complementary foods (MP-ASI), must be integrated into regional stunting reduction acceleration programs.

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**Availability of Data:** The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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