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Analysis of Factors Causing Stunting in Toddlers in Tanjungpinang City

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ABSTRACT

Stunting is a manifestation of chronic linear growth restriction produced by interacting biological, nutritional, environmental, and social processes rather than by a single exposure. This study analyzes factors associated with stunting among children under five in Tanjungpinang City and develops a locally relevant determinant framework using structured secondary-data analysis and an integrative synthesis of recent peer-reviewed evidence. Official local data were drawn from the 2023 Indonesia Health Survey and the Tanjungpinang City Medium-Term Development Plan 2025–2029, including 2024 routine E-PPGBM growth-monitoring records. Peer-reviewed studies published mainly during 2017–2026 were synthesized across maternal and prenatal conditions, birth outcomes, infant and young-child feeding, dietary diversity, infection and water-sanitation-hygiene conditions, socioeconomic status and food security, household environmental exposure, and health-service performance. The 2023 survey estimated stunting prevalence in Tanjungpinang at 15.2%, whereas 2024 routine monitoring recorded 332 stunted children among 11,130 measured children (3.0%); these figures are not directly interchangeable because they arise from different measurement systems and population frames. Routine 2024 data also showed subdistrict variation, from 1.7% in Tanjungpinang Barat to 4.7% in Tanjungpinang Kota, and higher recorded prevalence among boys than girls. The literature consistently indicates that low birth weight and prematurity, maternal nutritional constraints and anemia, inadequate complementary feeding and dietary diversity, poor WASH and recurrent infection, low socioeconomic resources and maternal education, and uneven access to effective health services can jointly increase stunting risk.

Keyword: Stunting, Toddlers, Determinants, Nutrition

INTRODUCTION

Stunting, conventionally identified when a child's height-for-age z score is below -2 standard deviations from the World Health Organization Child Growth Standards median, remains one of the most persistent manifestations of chronic undernutrition. The 2025 UNICEF-WHO-World Bank Joint Child Malnutrition

Estimates reported that 150.2 million children under five, or 23.2% of the global under-five population, were stunted in 2024. Although the global prevalence has declined, progress remains insufficient to meet the 2030 nutrition target. The importance of stunting extends beyond attained height. Linear growth faltering is a population marker of sustained biological and social adversity and is associated with developmental, educational, health, and economic consequences across the life course (Leroy & Frongillo, 2019; MAL-ED Network Investigators, 2017).

Contemporary research no longer interprets stunting as the product of insufficient food intake alone. Evidence from low- and middle-income countries describes a layered causal architecture involving prenatal growth restriction, low birth weight and prematurity, maternal nutritional status, suboptimal breastfeeding and complementary feeding, poor dietary diversity, repeated infection, unsafe water and sanitation, food insecurity, low parental education, poverty, and limitations in health-system access or program implementation (Vilcins et al., 2018; Molani Gol et al., 2022; Nadhiroh et al., 2023). These determinants interact: infection can reduce nutrient absorption and appetite, inadequate dietary quality can weaken immune resilience, low household resources can constrain both food choice and sanitation, and maternal disadvantage can affect fetal growth before postnatal feeding begins.

Indonesia provides a particularly important setting for this multilevel perspective because stunting occurs across highly diverse geographical, socioeconomic, and service environments. A national review identified consistent links with nonexclusive breastfeeding, lower household socioeconomic status, preterm birth, shorter birth length, low maternal stature and education, and poor WASH conditions (Beal et al., 2018). Subsequent multilevel and national analyses have reinforced the importance of determinants operating beyond the child, including household resources, community context, maternal education, rural-urban disparities, and geographic inequality (Mulyaningsih et al., 2021; Ayuningtyas et al., 2022; Laksono et al., 2022; Widyaningsih et al., 2022). A 2023 Indonesian systematic review and meta-analysis further identified low birth weight, prematurity, insufficient antenatal care, food insecurity, unimproved drinking water and sanitation, and rural residence as recurrent risk factors (Gusnedi et al., 2023).

The nutritional pathway is also strongly supported in the Indonesian literature. Household dietary diversity has been associated with reduced odds of stunting in East Java, while national analyses of children aged 6–23 months have shown that inadequate minimum dietary diversity is linked to stunting (Mahmudiono et al., 2017; Samosir et al., 2023). Studies of complementary feeding in Aceh and Indonesia more broadly indicate that timing, feeding practices, food-group diversity, and caregiver behavior are important components of nutritional adequacy during the first two years of life (Ahmad et al., 2018; Nurrizka et al., 2021). Evidence from 37 stunting-priority districts additionally demonstrates recurring shortfalls in micronutrients such as iron, folate, calcium, zinc, vitamin B12, and vitamin C across age groups, illustrating why energy sufficiency alone cannot represent dietary quality (Fahmida et al., 2024).

Environmental exposure is equally important. Indonesian studies link improved sanitation with a lower likelihood of stunting, while analyses of water and sanitation conditions suggest that household and community sanitation can influence child growth through repeated exposure to enteric pathogens and impaired nutrient utilization (Rah et al., 2020; Cameron et al., 2021). The wider WASH literature in Indonesia documents persistent gaps in sanitation, hygiene, implementation research, and behavioral change (Satriani et al., 2022).

Environmental pathways may also include household tobacco smoke; research among poor Indonesian families has reported an association between parental smoking exposure and stunting, although such evidence remains more limited and context-specific than the evidence for birth outcomes, diet, socioeconomic conditions, and WASH (Muchlis et al., 2023).

Maternal and prenatal conditions connect intergenerational disadvantage with child growth. National and subnational studies report relationships between stunting and maternal nutritional status, maternal education, antenatal care, low birth weight, and prematurity (Sartika et al., 2021; Laksono et al., 2022; Siramaneerat et al., 2024). A systematic review of maternal anemia found that most included studies supported an association with stunting or impaired linear growth, highlighting the importance of nutritional intervention before and during pregnancy (Nadhiroh et al., 2023). Indonesian evidence also shows clustering of micronutrient deficiencies and stunting in lower socioeconomic groups, demonstrating that maternal-child nutrition and socioeconomic conditions should be interpreted together rather than as independent domains (Ernawati et al., 2021).

Tanjungpinang City, the capital of the Riau Islands Province, requires a localized analysis because city-level averages may mask substantial heterogeneity in child growth, household conditions, and service coverage. The 2023 Indonesia Health Survey estimated a stunting prevalence of 15.2% for Tanjungpinang City (Ministry of Health of the Republic of Indonesia, 2024). By contrast, routine E-PPGBM records identified 332 stunted children among 11,130 measured children in 2024, equivalent to 3.0% (Tanjungpinang City Government, 2025). The same routine dataset recorded prevalence of 2.9% in Tanjungpinang Timur, 3.3% in Bukit Bestari, 4.7% in Tanjungpinang Kota, and 1.7% in Tanjungpinang Barat (Tanjungpinang City Government, 2025). The large difference between the 2023 survey estimate and the 2024 routine-monitoring figure should not be interpreted as a one-year causal decline because survey-based and programmatic surveillance data differ in sampling, coverage, measurement procedures, and denominator construction.

This measurement distinction is substantive for local policy. Survey prevalence is designed to estimate population conditions through a sampling framework, whereas routine E-PPGBM data are generated through service-based growth monitoring and depend on the children measured and entered into the information system. Routine systems are indispensable for identifying children, following growth trajectories, and managing services, but they can produce different prevalence estimates from representative surveys if coverage and measurement completeness vary. Therefore, a rigorous local article should not simply ask which source is 'correct'; it should ask what each data system measures, how comparable the estimates are, and which determinants need to be measured directly to explain child-level stunting risk.

The main research gap is the absence of a recent, integrated analytical framework that combines Tanjungpinang's local surveillance pattern with the strongest contemporary evidence on Indonesian stunting determinants. Existing studies provide substantial evidence for specific domains, but their findings are dispersed across maternal nutrition, birth outcomes, feeding practices, WASH, household socioeconomic conditions, environmental exposure, and program implementation. A city-level evidence synthesis can therefore provide a defensible foundation for subsequent primary research without fabricating individual-level associations that are not present in the available aggregate data.

Accordingly, this study aims to (1) describe the most recent publicly available stunting pattern for Tanjungpinang City; (2) synthesize recent evidence on determinants associated with stunting, emphasizing Indonesian studies published within the last decade; (3) construct an integrated determinant framework appropriate for an urban-coastal city context; and (4) define a research and intervention agenda that can be tested using future primary child-level data. The term 'causing' in the article title is therefore treated analytically as a causal hypothesis domain, while the empirical conclusions use the more precise language of determinants and associations because the current design does not establish individual-level causal effects.

RESEARCH METHOD

This study applied a structured secondary-data analysis combined with an integrative review of recent peer-reviewed research. The design was selected because no individual-level primary dataset was supplied for the present article. Consequently, the analysis does not estimate new odds ratios for Tanjungpinang children and does not attribute stunting in any individual child to a specific exposure. Instead, it combines descriptive local evidence with a structured synthesis of determinants repeatedly identified in Indonesian and international studies.

The local data corpus comprised two main sources. First, the 2023 Indonesia Health Survey (Survei Kesehatan Indonesia, SKI) was used for the city-level survey estimate of stunting (Ministry of Health of the Republic of Indonesia, 2024). Second, the Tanjungpinang City Medium-Term Development Plan (RPJMD) 2025–2029 was used to extract the 2024 E-PPGBM routine monitoring table by subdistrict and sex (Tanjungpinang City Government, 2025). The local variables extracted were number of children measured, number classified as stunted, and routine prevalence for Tanjungpinang Timur, Bukit Bestari, Tanjungpinang Kota, and Tanjungpinang Barat. The routine city total was calculated from the reported numerator and denominator and checked against the published percentage.

The literature component prioritized journal articles published between 2017 and 2026, thereby keeping the core evidence within approximately the most recent decade. Searches were targeted around combinations of the terms childhood stunting, linear growth, Indonesia, toddlers, under-five children, low birth weight, prematurity, maternal anemia, breastfeeding, complementary feeding, dietary diversity, micronutrient deficiency, food insecurity, water sanitation hygiene, infection, socioeconomic status, maternal education, smoking exposure, health services, and stunting policy. Priority was given to systematic reviews, meta-analyses, national datasets, multilevel analyses, and peer-reviewed Indonesian studies with direct relevance to the determinant domains.

Evidence was organized using a multilevel determinant framework. Distal and intermediate domains consisted of household socioeconomic resources and food security, parental education, health-service access and program convergence, and WASH/environmental conditions. Proximal domains consisted of maternal nutrition and pregnancy conditions, birth outcomes, infant and young-child feeding, dietary quality and micronutrient adequacy, and infection or inflammation. The synthesis focused on whether evidence showed consistent directionality and plausible mechanisms rather than on combining effect estimates from heterogeneous designs.

Three analytical procedures were used. First, descriptive comparison characterized the local survey and routine estimates while explicitly retaining their data-source differences. Second, narrative evidence mapping identified

determinant domains that were repeatedly supported by Indonesian studies or systematic reviews. Third, a local-priority matrix classified domains by strength of recent Indonesian evidence, feasibility for primary measurement in Tanjungpinang, and relevance for program response. These categories are ordinal synthesis judgments and are not effect sizes, causal probabilities, or audit scores.

The study followed an evidence-discipline rule for interpretation. City-level aggregate prevalence cannot identify which individual factors caused stunting, ecological variation between subdistricts cannot be used to infer individual risk, and differences between SKI and E-PPGBM cannot be interpreted as a direct trend without harmonized measurement. Statements about factors are therefore grounded in peer-reviewed evidence from Indonesia and comparable settings and are presented as hypotheses requiring child-level validation in Tanjungpinang.

To make the analytical logic explicit, the determinant domains were arranged as a multilevel pathway linking distal household and service conditions to proximal maternal, dietary, infection, and birth-related mechanisms. The framework is intended as a hypothesis-generating structure for Tanjungpinang rather than as proof of locally estimated causal effects, and it reflects determinant patterns repeatedly reported in Indonesian evidence (Beal et al., 2018; Mulyaningsih et al., 2021; Gusnedi et al., 2023).

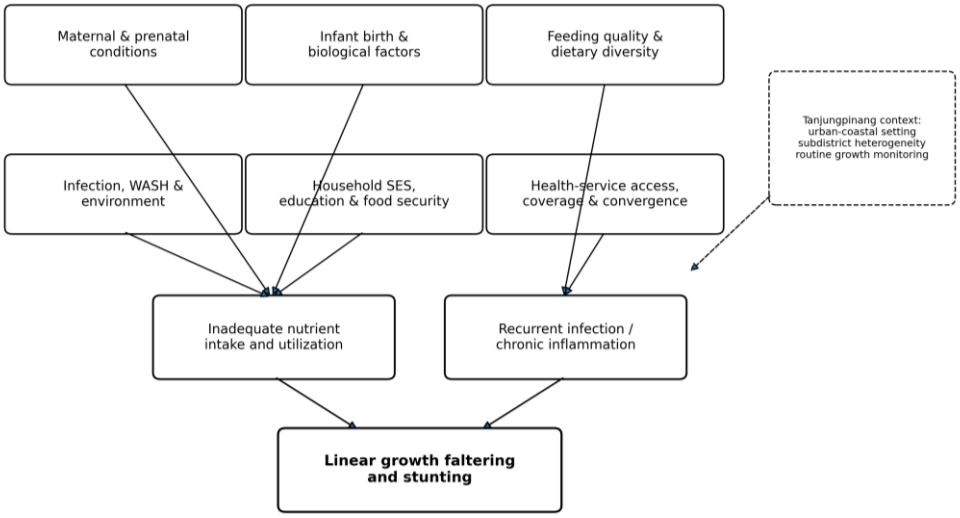

Figure 1. Multilevel determinant pathway of childhood stunting applied to Tanjungpinang City
Source: Developed by the authors, 2025

Figure 1 illustrates that childhood stunting is best interpreted as the cumulative outcome of interacting pathways rather than as the consequence of a single exposure. Distal socioeconomic, environmental, and service conditions can shape maternal health, birth outcomes, feeding quality, and infection risk, while these proximal processes jointly influence linear growth. The arrows therefore represent plausible pathways for local testing and should not be read as effect-size estimates for Tanjungpinang (Beal et al., 2018; Mulyaningsih et al., 2021; Gusnedi et al., 2023).

RESULTS AND DISCUSSION

1. Local Stunting Pattern and the Meaning of Different Data Systems

The local evidence indicates two different prevalence signals. SKI 2023 estimated stunting in Tanjungpinang City at 15.2%, reflecting a survey-based population estimate (Ministry of Health of the Republic of Indonesia, 2024). The

2024 E-PPGBM routine dataset recorded 332 stunted children among 11,130 children measured, equivalent to 3.0% (Tanjungpinang City Government, 2025). The numerical gap is large, but it should be interpreted primarily as a surveillance-method issue rather than as evidence that stunting fell by more than twelve percentage points within one year. Routine nutrition information and representative surveys can differ because routine systems depend on service contact, measurement coverage, data entry, and operational denominator definitions.

Within the 2024 routine system, heterogeneity is visible across subdistricts. Tanjungpinang Kota recorded the highest overall routine prevalence at 4.7%, followed by Bukit Bestari at 3.3%, Tanjungpinang Timur at 2.9%, and Tanjungpinang Barat at 1.7% (Tanjungpinang City Government, 2025). The number of measured children also differed substantially, from 918 in Tanjungpinang Kota to 5,406 in Tanjungpinang Timur (Tanjungpinang City Government, 2025). This means that both prevalence and service denominator size should be examined when prioritizing follow-up. A smaller subdistrict can show a higher percentage with fewer absolute cases, while a larger subdistrict can contribute more stunted children even at a lower percentage.

Routine data also show a consistent male-female difference. Citywide, 212 of 6,069 measured boys were classified as stunted (3.5%) compared with 120 of 5,061 girls (2.4%) (Tanjungpinang City Government, 2025). The same direction was recorded in all four subdistricts (Tanjungpinang City Government, 2025). Sex differences in growth vulnerability have been observed in some stunting studies, but local routine data alone cannot establish a biological causal explanation. The appropriate interpretation is that sex should be retained as an adjustment variable in future Tanjungpinang analyses and that measurement quality and age distribution should also be examined before attributing the difference to sex-specific susceptibility.

Table 1. Routine E-PPGBM stunting indicators by subdistrict and sex, Tanjungpinang City, 2024

Subdistrict	Measured Boys	Measured Girls	Measured Total	Stunted Total	Male (%)	Female (%)	Total (%)
Tanjungpinang Timur	2,980	2,426	5,406	159	3.3	2.5	2.9
Bukit Bestari	1,602	1,408	3,010	100	4.1	2.5	3.3
Tanjungpinang Kota	500	418	918	43	5.0	4.3	4.7
Tanjungpinang Barat	987	809	1,796	30	2.3	0.9	1.7
Tanjungpinang City	6,069	5,061	11,130	332	3.5	2.4	3.0

Source: Routine E-PPGBM data reported in the Tanjungpinang City RPJMD 2025–2029 (Tanjungpinang City Government, 2025).

The local distribution demonstrates why a city-level causal study should be built from individual records rather than only from aggregate prevalence. To determine which factors explain stunting, each child's anthropometric status should be linked to age, sex, birth weight and gestational age, maternal height and nutritional status, antenatal care, feeding history, dietary diversity, recent morbidity, immunization, household sanitation and water, parental education, household economic conditions, smoking exposure, and access to nutrition

services. Such a design would allow multivariable modeling and would avoid ecological inference from subdistrict averages.

Before interpreting determinant pathways, the routine E-PPGBM distribution needs to be described by subdistrict and sex because aggregate city prevalence can conceal differences in the number of children measured and the proportion classified as stunted. Table 1 therefore summarizes the complete routine figures used in this article and provides the empirical basis for the local descriptive comparison (Tanjungpinang City Government, 2025).

Table 1 shows that Tanjungpinang Kota had the highest routine prevalence in 2024, whereas Tanjungpinang Timur contributed the largest measurement denominator and the largest absolute number of stunted children. The table also shows higher recorded prevalence among boys than girls at the city level and in each subdistrict. These values should be interpreted as routine surveillance indicators rather than as representative causal estimates because the denominator depends on children reached and recorded by the monitoring system (Tanjungpinang City Government, 2025).

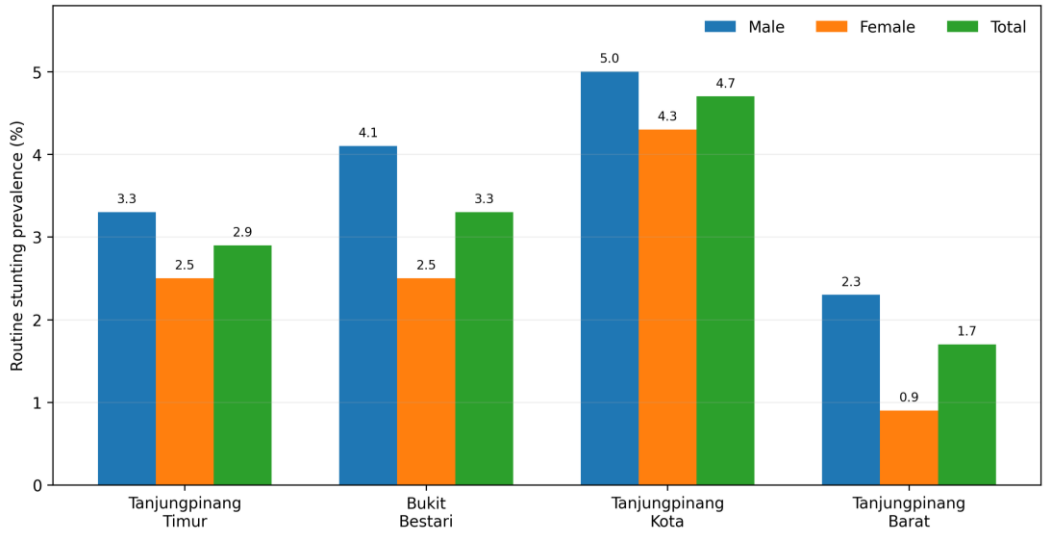

Figure 2. Subdistrict variation in routine stunting prevalence by sex, Tanjungpinang City, 2024
Source: Tanjungpinang City Government, 2025.

To make the sex- and subdistrict-specific pattern easier to compare visually, the same routine percentages are presented in Figure 2. The chart is descriptive and is intended to reveal the direction and relative magnitude of recorded differences across locations and sex groups, not to estimate causal effects between subdistricts or between boys and girls (Tanjungpinang City Government, 2025). Figure 2 highlights the consistently higher routine prevalence recorded among boys and the comparatively higher overall prevalence in Tanjungpinang Kota. Because the sex-specific denominators and service coverage can differ across locations, the visual pattern should guide sampling, data-quality assessment, and hypothesis formation for future primary research rather than support a biological or geographic causal conclusion on its own (Tanjungpinang City Government, 2025).

2. Maternal, Prenatal, and Birth-Related Determinants

The strongest recurring evidence concerns conditions that begin before the child's postnatal diet can exert its full influence. Low birth weight and prematurity

are repeatedly associated with later stunting because they indicate restricted fetal growth, shorter gestation, or both. Low birth weight and preterm birth have been identified among the most consistent determinants of childhood stunting in Indonesia (Gusnedi et al., 2023). National and multilevel studies similarly associate birth weight and maternal nutritional status with stunting (Sartika et al., 2021; Siramaneerat et al., 2024). These findings support a life-course perspective in which stunting prevention begins with adolescent and maternal nutrition, reproductive health, antenatal care, and prevention of adverse birth outcomes.

Maternal anemia is relevant within this pathway. Observational evidence indicates that maternal anemia may be associated with child stunting or impaired linear growth, particularly in developing-country settings (Nadhiroh et al., 2023). The pathway can operate through fetal nutrient constraints, low birth weight, prematurity, and reduced maternal reserves. In Indonesia, micronutrient deficiencies and stunting also cluster in lower socioeconomic groups, indicating that maternal anemia should not be studied as an isolated biomedical exposure (Ernawati et al., 2021). Its risk is shaped by diet, infection, poverty, health-service contact, and adherence to antenatal supplementation.

Maternal education is another consistent predictor, but its mechanism is multidimensional rather than purely educational. Lower maternal education may influence health literacy, access to resources, care-seeking, feeding decisions, sanitation practices, and the ability to act on nutrition information. A large Indonesian dataset found a marked education gradient in stunting among children under two (Laksono et al., 2022). Socioeconomic and rural-urban inequalities have likewise been shown to contribute to differences in stunting risk (Widyaningsih et al., 2022). In Tanjungpinang, maternal education should therefore be measured alongside household income or expenditure, food security, maternal employment, paternal education, and service access to avoid treating education as a stand-alone cause.

A future local model should distinguish prenatal determinants from postnatal mediators. For example, low birth weight may partly mediate maternal nutritional disadvantage, while feeding quality and infection after birth can either compound or mitigate growth risk. Modeling all variables at a single level without considering temporal ordering may obscure this pathway. A prospective birth cohort would be ideal, but a carefully designed cross-sectional or retrospective study can still improve inference if birth records, maternal characteristics, and current child exposures are measured reliably and interpreted cautiously.

3. Feeding Practices, Dietary Diversity, and Micronutrient Adequacy

The second major determinant cluster concerns the quality of infant and young-child feeding. Complementary feeding is a critical transition because children must obtain sufficient energy, high-quality protein, essential fatty acids, and micronutrients from an increasingly diverse diet while continuing appropriate breastfeeding. Systematic reviews in low- and middle-income countries suggest that complementary-feeding education and food supplementation can improve linear growth, although average effects are modest and depend on food security and intervention quality (Panjwani & Heidkamp, 2017; Heidkamp, 2017). This reinforces the view that feeding interventions are necessary but may be insufficient when infection, sanitation, poverty, or prenatal growth restriction remain unresolved.

Indonesian studies provide specific support for dietary diversity. Greater household dietary diversity in East Java has been associated with a lower likelihood of child stunting (Mahmudiono et al., 2017). National Riskesdas data for

children aged 6–23 months indicate that children who did not meet minimum dietary diversity were more likely to be stunted (Samosir et al., 2023). Relationships between dietary diversity, dietary patterns, inadequate energy and fat intake, and stunting have also been observed in Jeneponto (Basri et al., 2021). These findings are consistent with a broader systematic review in which low dietary diversity was repeatedly associated with stunting among infants and children under five (Molani Gol et al., 2022).

Diet quality is not reducible to the number of food groups. A child may consume several food groups yet still have inadequate iron, zinc, calcium, folate, vitamin B12, vitamin C, or other growth-relevant nutrients. Age-specific 'problem nutrients' have been documented across 37 Indonesian stunting-priority districts, with dietary inadequacy persisting even in some food-secure settings (Fahmida et al., 2024). This finding is important for Tanjungpinang because local food availability in an urban-coastal economy does not automatically guarantee nutritionally adequate consumption. Household purchasing power, caregiver knowledge, food preferences, feeding frequency, texture, and access to animal-source foods can shape actual intake.

Breastfeeding remains part of this feeding architecture. Evidence from Eastern Indonesia suggests that exclusive breastfeeding can protect against early stunting in low-income settings (Hadi et al., 2021). Indonesian reviews have also identified nonexclusive breastfeeding during the first six months as a recurrent determinant of stunting (Beal et al., 2018). However, breastfeeding variables must be measured precisely. Whether a child was ever breastfed, exclusively breastfed to six months, breastfed on demand, or continued breastfeeding at 12–23 months are different exposures. Future Tanjungpinang research should therefore use WHO-consistent infant and young-child feeding indicators rather than a single yes/no breastfeeding item.

The policy implication is that nutrition counseling should be linked to household constraints. Advice that recommends diverse, nutrient-dense foods has limited value when families face food insecurity, unstable income, or limited access to affordable foods. Conversely, food assistance without behavior-sensitive counseling may fail to improve age-appropriate feeding practices. An integrated intervention should therefore connect growth monitoring, maternal counseling, locally feasible food-based recommendations, micronutrient strategies where indicated, and social protection for food-insecure households.

4. Infection, WASH, and Household Environmental Exposure

Stunting can also emerge from a repeated infection-nutrition cycle. Diarrheal disease and enteric pathogen exposure may reduce appetite, increase nutrient losses, and impair absorption, while chronic intestinal inflammation can interfere with nutrient utilization and linear growth. Indonesian evidence supports a relationship between sanitation and child growth. Improved household sanitation has been associated with reduced odds of stunting among Indonesian children under three (Rah et al., 2020). Household and community sanitation conditions have also been related to stunting and cognitive outcomes (Cameron et al., 2021). These studies strengthen the rationale for considering sanitation as a nutrition intervention rather than as a separate infrastructure issue.

The WASH pathway is especially relevant because exposure occurs at multiple levels. A household can have an improved toilet while children remain exposed through unsafe water handling, contaminated play environments, inadequate handwashing, or community open defecation. Indonesian WASH research has expanded but still shows gaps in hygiene, implementation studies,

behavioral interventions, and financing (Satriani et al., 2022). For a city-level stunting study, WASH measurement should include drinking-water source and treatment, toilet type, feces disposal, handwashing facilities, drainage and waste conditions, and recent diarrheal or febrile illness.

Tanjungpinang's coastal and urban character may create a specific mix of environmental exposures. Population density, drainage, water-storage practices, seasonal flooding or standing water in some locations, and service inequality across neighborhoods could influence infection risk even where formal urban services exist. These exposures should be measured empirically rather than assumed from city status. Geographic information linked to household data could help identify whether growth faltering clusters with sanitation infrastructure, service access, or socioeconomic disadvantage.

Household tobacco smoke is a further environmental exposure worth measuring. Cigarette smoke exposure has been associated with stunting among children in poor Indonesian families (Muchlis et al., 2023). The evidence base is less mature than for birth weight, diet, and WASH, and residual confounding is possible because smoking is also correlated with poverty and household spending patterns. Nevertheless, measuring household smoking is inexpensive and policy-relevant, particularly because tobacco expenditure can compete with household food expenditure and smoke exposure may affect respiratory morbidity.

The evidence reviewed in the preceding subsections can be consolidated into determinant domains that are measurable in a future Tanjungpinang study. Table 2 links each domain with representative local variables, the main evidence-supported pathway to linear growth restriction, and selected recent studies so that the conceptual discussion can be translated into an operational measurement framework (Gusnedi et al., 2023; Mulyaningsih et al., 2021).

Table 2. Evidence synthesis of major determinant domains relevant to stunting in Tanjungpinang

Determinant domain	Representative variables for local study	Evidence-supported pathway	Selected recent evidence
Maternal / prenatal	Maternal height/BMI; anemia; ANC; pregnancy nutrition; maternal age	Fetal growth restriction, preterm delivery, constrained maternal nutrient reserves	(Nadhiroh et al., 2023; Sartika et al., 2021; Siramaneerat et al., 2024).
Birth / child biology	Birth weight; gestational age; birth length; age; sex	Low fetal growth and prematurity increase vulnerability to postnatal growth faltering	(Gusnedi et al., 2023; Beal et al., 2018).
Feeding & diet	Exclusive breastfeeding; complementary-feeding timing; MDD; meal frequency; animal-source foods	Insufficient energy, protein and micronutrient intake limits tissue growth and immune function	(Mahmudiono et al., 2017; Samosir et al., 2023; Fahmida et al., 2024).
Infection & WASH	Diarrhea; ARI; water source / treatment; toilet; handwashing; waste / drainage	Repeated infection, nutrient loss and enteric inflammation impair nutrient utilization	(Rah et al., 2020; Cameron et al., 2021; Satriani et al., 2022).

Determinant domain	Representative variables for local study	Evidence-supported pathway	Selected recent evidence
Socioeconomic context	Maternal / paternal education; income / expenditure; food insecurity; employment; social protection	Shapes food access, health literacy, care-seeking, sanitation and exposure to cumulative disadvantage	(Mulyaningsih et al., 2021; Laksono et al., 2022; Widyaningsih et al., 2022).
Health services & convergence	Posyandu attendance; immunization; ANC; growth monitoring; referral; counseling; program coordination	Determines prevention coverage, early detection, continuity of care and response to growth faltering	(Herawati & Sunjaya, 2022; Siswati et al., 2022; Arief et al., 2025).
Household environment	Second-hand smoke; food expenditure trade-offs; crowding	May increase morbidity and reduce resources available for nutrition	(Muchlis et al., 2023).

Source: Authors' synthesis of peer-reviewed studies published primarily during 2017–2026.

Table 2 demonstrates that the determinant domains operate at different levels and time points, from maternal and prenatal conditions to household resources, feeding, WASH, infection, service delivery, and environmental exposure. The table is not a ranking of causal strength; instead, it shows why a local multivariable design should measure several domains simultaneously to reduce omitted-variable bias and preserve temporal ordering in the analysis (Mulyaningsih et al., 2021; Gusnedi et al., 2023).

5. Socioeconomic Conditions, Education, and Food Security

Socioeconomic disadvantage is a distal determinant that can generate multiple proximal risks simultaneously. Low household resources can limit access to diverse foods, safe housing, water treatment, transportation to health services, and the ability to absorb income shocks. Multilevel Indonesian evidence confirms that the probability of stunting varies not only by child characteristics but also by household, subdistrict, and provincial context (Mulyaningsih et al., 2021). Geographic and socioeconomic disparities are visible across Indonesia's districts, emphasizing that national progress can coexist with local pockets of elevated vulnerability (Ayuningtyas et al., 2022).

Food insecurity is an especially important bridge between socioeconomic and nutritional pathways. It can reduce dietary quantity, dietary diversity, and caregiver capacity to maintain appropriate feeding across the month. Indonesian meta-analytic evidence identifies food insecurity among significant household-level risk factors for stunting (Gusnedi et al., 2023). Urban Indonesian research has also documented a household phenotype in which stunted children can coexist with overweight or obese mothers under conditions of food insecurity (Mahmudiono et al., 2018). Such findings demonstrate that household nutrition problems cannot be inferred from adult body size alone and that poor diet quality can exist alongside sufficient or excessive calories.

For Tanjungpinang, socioeconomic measurement should move beyond a single income question. Household expenditure, food expenditure, asset ownership, housing conditions, parental occupation, social assistance, household

size, dependency ratio, and a validated food-insecurity scale would provide a more robust representation. Maternal education should be retained because of its consistent association with stunting, but paternal education and caregiving arrangements are also relevant in households where mothers work outside the home or care is shared across family members.

The urban setting does not eliminate inequality. Urban averages can conceal informal settlements, precarious employment, unequal service access, and food-price exposure. Determinants of stunting can differ between urban and rural Indonesian children, which argues against directly transferring rural risk profiles to Tanjungpinang (Siramaneerat et al., 2024). A city-specific model should therefore test interactions among socioeconomic status, service access, feeding practices, and environmental conditions rather than assuming that urban residence is uniformly protective.

6. Health Services, Convergence Policy, and Data Quality

Health-service performance influences stunting through prevention, detection, counseling, treatment of illness, supplementation, immunization, antenatal care, and referral. Indonesia's convergence strategy recognizes that stunting reduction requires coordinated nutrition-specific and nutrition-sensitive actions rather than a single sector. Implementation outcomes can vary across district, subdistrict, and village levels even when national policy and district-level structures are relatively strong (Herawati & Sunjaya, 2022). This suggests that policy presence should not be equated with effective household-level coverage.

Yogyakarta's experience illustrates the potential value of sustained multisectoral action. Long-term drivers of stunting reduction have included government commitment, health and nutrition programs, socioeconomic improvements, and community participation (Siswati et al., 2022). For Tanjungpinang, the key question is not whether programs exist but whether children and mothers who need them receive the full package at the right time. Indicators should therefore include antenatal coverage and quality, iron-folic acid adherence, birth and postnatal care, exclusive breastfeeding support, complementary-feeding counseling, immunization, Posyandu attendance, growth-measurement quality, referral completion, and follow-up of growth faltering.

Data quality is integral to the intervention itself. The difference between the SKI 2023 survey estimate and 2024 E-PPGBM routine prevalence indicates the need for data triangulation. A strong nutrition information system should document measurement coverage, age and sex distribution, equipment calibration, anthropometrist competence, duplicate records, missingness, and follow-up. Routine data are most useful when they support action on individual children and can be reconciled with periodic survey estimates without assuming that the two sources have identical inferential properties.

Future analysis should also avoid treating program participation as automatically protective. Children may attend Posyandu because they are already at higher risk, creating confounding by indication. Likewise, receipt of social protection can appear positively associated with stunting because benefits are targeted to vulnerable households, as suggested in national analyses. Program variables therefore require careful interpretation and, where possible, longitudinal data or quasi-experimental methods to distinguish targeting from program effect.

Because the reviewed literature supports several determinant domains simultaneously, a qualitative priority map was constructed to distinguish factors with strong evidence and high feasibility for local validation from factors that are better treated as secondary hypotheses. The priority levels are evidence-synthesis

judgments and not locally estimated effect sizes, probabilities, or causal coefficients (Gusnedi et al., 2023; Arief et al., 2025).

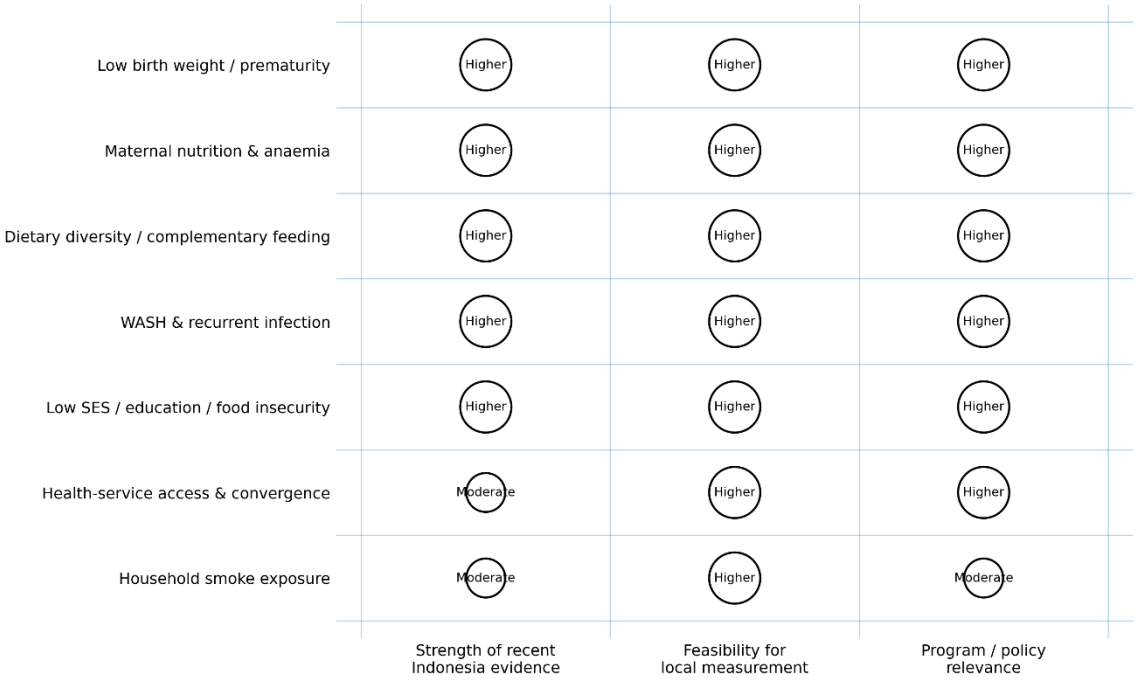

Figure 3. Evidence-informed determinant priorities for primary validation in Tanjungpinang City
Source: Authors' qualitative evidence mapping, 2026

Figure 3 places maternal and birth-related conditions, feeding and diet, WASH and infection, socioeconomic resources, and effective service delivery among the principal domains for primary validation in Tanjungpinang. Environmental exposures such as household smoking remain relevant but are better interpreted as additional hypotheses until their independent contribution is tested together with the stronger determinant domains. The matrix therefore prioritizes what should be measured first rather than claiming which factor has the largest local causal effect (Gusnedi et al., 2023; Arief et al., 2025).

7. Integrated Interpretation and Proposed Local Research Model

Taken together, the evidence supports a causal system rather than a single-factor explanation. Maternal disadvantage can influence fetal growth; low birth weight can increase vulnerability to postnatal growth faltering; poor diet can interact with recurrent infection; low household resources can simultaneously constrain diet, sanitation, and care-seeking; and weak service continuity can reduce the effectiveness of otherwise well-designed interventions. This interaction explains why a child-level analysis that enters only one or two variables may produce unstable or misleading conclusions.

The appropriate primary study for Tanjungpinang would therefore use a multivariable framework with temporally ordered domains. A cross-sectional design could recruit children aged 6–59 months from all four subdistricts using probability sampling and calculate height-for-age z scores using standardized anthropometry. The explanatory model could first enter immutable or background variables (age and sex), then maternal and birth variables, followed by feeding and morbidity variables, household socioeconomic and WASH variables, and finally

health-service indicators. A multilevel model could include clustering at Posyandu, kelurahan, or subdistrict level if the sampling structure supports it.

Such a study should pre-specify a limited set of core hypotheses to reduce indiscriminate testing. Based on the recent evidence, the highest-priority hypotheses are that low birth weight or prematurity, maternal nutritional constraints, inadequate dietary diversity or complementary feeding, poor sanitation or unsafe water, recurrent morbidity, lower household socioeconomic resources or food insecurity, and lower effective service coverage are associated with higher odds of stunting after adjustment for age and sex. Household smoke exposure can be included as a secondary environmental hypothesis. Interaction terms can be considered for food insecurity × dietary diversity and sanitation × recent diarrhea if sample size is sufficient.

The resulting model would be more useful for policy if statistical significance were not the only criterion. Effect size, confidence intervals, population exposure prevalence, modifiability, cost, feasibility, and equity should be considered together. A moderately strong association affecting a large proportion of children may have greater program importance than a strong association affecting very few children. Similarly, a determinant may be biologically important but difficult to modify after birth, which increases the value of prevention during pregnancy.

The present secondary analysis cannot provide these local effect estimates, but it establishes a defensible measurement architecture. It also prevents a common methodological error: assigning specific 'causes' to Tanjungpinang based solely on evidence from other regions. The evidence supports which factors should be tested and prioritized; it does not prove that the magnitude of those associations is identical in Tanjungpinang.

The integrated interpretation must ultimately be translated into variables and analytic decisions that can be implemented in a primary study. Table 3 therefore converts each determinant domain into a minimum measurement set, a suggested analytic strategy or indicator, and a corresponding program implication that should only be adopted if the association is confirmed using local child-level evidence (Mulyaningsih et al., 2021; Herawati & Sunjaya, 2022).

Table 3. Proposed Tanjungpinang primary-research and intervention matrix

Priority domain	Minimum variables to collect	Suggested analysis / indicator	Program implication if locally confirmed
Maternal & prenatal	Maternal height/BMI; Hb or anemia record; ANC visits/quality; pregnancy supplementation	Adjusted association with HAZ/stunting; pathway through birth weight	Strengthen preconception, antenatal nutrition and anemia prevention
Birth outcomes	Birth weight; gestational age; birth length; delivery place	Low birth weight/prematurity adjusted OR; mediation assessment where feasible	Early identification and intensified growth follow-up for high-risk newborns
Feeding & diet	Exclusive breastfeeding; MDD; meal frequency; food groups; animal-source foods	WHO IYCF indicators; dietary diversity-stunting association	Targeted counseling plus affordable nutrient-dense food strategies

Priority domain	Minimum variables to collect	Suggested analysis / indicator	Program implication if locally confirmed
WASH & morbidity	Water source/treatment; sanitation; handwashing; diarrhea/ARI episodes	Adjusted WASH and morbidity associations; interaction tests	Integrate sanitation, hygiene and infection prevention with nutrition services
Socioeconomic & food security	Education; expenditure/assets; food-security scale; employment; social protection	Wealth/food-security gradient; equity stratification	Link nutrition services with social protection and food-access measures
Service delivery	Posyandu attendance; growth monitoring; immunization; referral; counseling	Coverage, continuity and completion indicators; cluster-level variation	Improve targeted follow-up, measurement quality and convergence across sectors
Environmental exposure	Household smoking; crowding; drainage/waste exposure	Secondary adjusted environmental model	Integrate smoke-free household messages and broader healthy-home interventions
Data-system quality	Measurement coverage; missingness; equipment calibration; duplicate checks	Reconcile survey vs routine trends; completeness and validity indicators	Use surveillance for individual action while triangulating with representative surveys

Source: Developed by the authors, 2026.

Table 3 provides a bridge between the evidence synthesis and a future empirical research protocol for Tanjungpinang. It emphasizes confirmation through standardized anthropometry, temporally ordered exposure measurement, and adjusted analysis before translating associations into program priorities. This approach reduces the risk of importing effect sizes from other regions and is consistent with multilevel and convergence-oriented approaches in recent Indonesian research (Mulyaningsih et al., 2021; Herawati & Sunjaya, 2022).

CONCLUSION

Stunting among children under five in Tanjungpinang City should be understood as the result of interacting determinants rather than a single causal factor. The most recent evidence relevant to Indonesia consistently supports maternal and prenatal nutritional conditions, low birth weight and prematurity, feeding quality and dietary diversity, WASH and recurrent infection, socioeconomic resources and parental education, and effective access to health and nutrition services as central determinant domains. Household smoke exposure is a plausible additional factor that deserves local measurement. These domains converge through inadequate nutrient intake or utilization, infection and inflammation, and cumulative social disadvantage that restrict linear growth.

Local data provide an important but methodologically complex signal. SKI 2023 estimated stunting prevalence in Tanjungpinang at 15.2% (Ministry of Health of the Republic of Indonesia, 2024). Routine E-PPGBM monitoring in 2024 recorded 332 stunted children among 11,130 measured children, or 3.0%, with subdistrict prevalence ranging from 1.7% to 4.7% (Tanjungpinang City

Government, 2025). These figures should not be directly interpreted as a simple annual trend because they represent different data systems. The routine data nevertheless show meaningful geographic and sex-disaggregated patterns that can guide surveillance quality checks and sampling for future research.

The next scientific step is a probability-based child-level study across all Tanjungpinang subdistricts using standardized anthropometry and temporally ordered measurement of maternal, birth, feeding, morbidity, WASH, socioeconomic, environmental, and health-service variables. Multivariable or multilevel analysis should estimate locally specific effect sizes and distinguish determinants, mediators, confounders, and program-targeting effects. For policy, the evidence favors an integrated approach that combines maternal nutrition, appropriate infant and young-child feeding, food security, WASH, infection prevention, social protection, high-quality growth monitoring, and cross-sector program convergence. Such an approach is more consistent with the multidimensional evidence than isolated nutrition counseling or reliance on a single prevalence indicator.

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