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# Key Factors of Stunting Prevalence: Configurational Analysis of Sub-Districts in Sleman, Indonesia

## Abstract

This study employs crisp-set Qualitative Comparative Analysis (csQCA) to examine the determinants of stunting prevalence in 17 sub-districts of Sleman Regency. Addressing the critical issue of stunting, the research aims to identify factors contributing to high and low stunting prevalence. Methodologically, this study advances the application of csQCA in public health research by uncovering the complex interplay of conditions affecting stunting rates, demonstrating its utility in identifying precise causal configurations. Findings reveal that high stunting prevalence is uniquely caused by poor stunting management performance, making it both necessary and sufficient. Moreover, the study elucidates the concept of asymmetric causality by demonstrating that low stunting prevalence results from diverse combinations of high stunting management performance and advanced village development, thereby contributing to a nuanced understanding of causality in public health research. This study not only underscores the need for multi-dimensional strategies but also enriches the WHO framework by methodologically enhancing the identification of necessary and sufficient conditions for effective stunting management, offering a refined approach to tackling complex public health challenges. The research provides valuable insights for policymakers to develop comprehensive stunting reduction strategies, focusing on improving stunting management and fostering village infrastructure development.

**Keywords:**
stunting prevalence; policy intervention; asymmetric causality; csQCA

## Introduction

Stunting prevalence is a key indicator of child health, reflecting poor nutrition and adverse health conditions during critical growth periods. This study aims to address the factors influencing stunting prevalence and underscores the importance of effective interventions. A joint publication by UNICEF, WHO, and the World Bank reports that global stunting rates decreased from 26.3% in 2012 to 22.3% in 2022. Despite these improvements, stunting rates

still fall short of the SDG target of reducing stunting prevalence to below 15% by 2030 (UNICEF et al., 2023). Asia and Africa have the highest numbers of stunted children, accounting for 52% and 43% of the global total, respectively. According to the same report, the estimated stunting prevalence in Indonesia for 2022 remains higher compared to neighboring countries like Thailand and Malaysia. Further data from the 2023 Indonesian Health Survey (Ministry of Health, 2023, p. 875) shows that the stunting prevalence among children under five in Indonesia is 21.6%. This highlights the urgent need for Indonesia to intensify efforts to achieve the global SDG target of ending all forms of malnutrition by 2030.

Reflecting on global efforts and integrating findings from a spectrum of studies, it becomes evident that policy effectiveness significantly influences nutritional outcomes. Research such as that by Salazar-Morales (2022) and Djani and Therikh (2024) illustrates how nuanced public policy and administration mechanisms can directly impact stunting rates. Their analyses, along with insights from Namirembe et al. (2022) on governance indices and Nisbett and Barnett (2017) on multi-sectoral cooperation in Maharashtra, suggest that strategic, well-coordinated policies, underpinned by accurate data and inclusive governance, are fundamental to stunting reduction. Such comprehensive approaches underscore the necessity of aligning policies not only with national objectives but also with local realities and challenges.

Building on this discussion of broad policy frameworks, it is essential to delve into the specific factors that directly and indirectly affect stunting prevalence. Various factors such as low birth weight, short birth intervals (Idrus et al., 2023; Nazli et al., 2018), and poor maternal nutrition (Scott et al., 2020; Thahir et al., 2023) play pivotal roles. Additionally, the environment's role, highlighted through inadequate water and sanitation infrastructure (Dorsey et al., 2018; Kwami et al., 2019; Saxton et al., 2016; Torlesse et al., 2016), along with socioeconomic determinants like maternal education and household income (Cetthakrikul et al., 2018; Reyes et al., 2004; Roy et al., 2023; Sarma et al., 2017; Wake et al., 2023), significantly impacts stunting outcomes. Musheiguza et al. (2023) and Saleem et al. (2024) further demonstrate that higher socioeconomic status, effective breastfeeding practices, and comprehensive immunization schedules are instrumental in mitigating stunting, underscoring the multifactorial nature of this global challenge. Complementing these findings, research by Saif and Anwar (2023) across Pakistan, India, and Bangladesh identifies additional critical factors including political stability, maternal education, undernutrition prevalence, household size, dependency ratio, air pollution, and poor sanitation, emphasizing the extensive range of influences on child malnutrition.

Stunting is a complex public health issue with multiple determinants. According to the WHO framework by Stewart et al. (2013), these include inadequate complementary feeding, household and family factors, poor sanitation and water supply, and broader contextual factors like poverty and infrastructure. This framework highlights that stunting is influenced by not only child and maternal nutrition but also socioeconomic and environmental factors. While the WHO framework provides a holistic view at the individual level, a regional-level framework for addressing stunting is still needed.

Although research on stunting has identified various individual and contextual factors influencing its prevalence, there is insufficient knowledge about the combinations of conditions that are necessary and sufficient for regions with high and low stunting prevalence. Most studies focus on single factors such as low birth weight, maternal education, sanitation, and socioeconomic status in isolation, which limits their ability to capture the complex and

multifaceted nature of stunting that results from interdependent variables. For instance, Idrus et al. (2023), Roy et al. (2023), and Thahir et al. (2023) examine individual factors separately, without exploring their interactions. This singular focus restricts our understanding of how interrelated conditions affect stunting prevalence, overlooking potential synergistic or mitigating effects between variables. Consequently, a significant gap remains in comprehending how interconnected socioeconomic, health, environmental, and policy factors collectively determine stunting prevalence. Addressing this gap, this article employs crisp-set Qualitative Comparative Analysis (csQCA), a novel methodological approach that allows for the examination of how combinations of factors interact, providing deeper insights into the causal mechanisms driving stunting prevalence. Understanding these combinations is crucial for policymakers and practitioners to design more effective, targeted interventions that address the root causes of stunting holistically. This, in turn, can contribute to better health outcomes and help achieve global health goals.

Considering the knowledge gap and the problem statement above, the research question is formulated as follows: "What configurations of conditions related to public health, socioeconomic factors, environmental or infrastructure development, and stunting reduction policies can be considered necessary and sufficient in determining high and low stunting prevalence?" Addressing this, the study focuses on Indonesia, a country with a relatively high global ranking in stunting prevalence, which underscores the urgency and relevance of exploring effective stunting reduction strategies within this context. The research employs the csQCA method to delve into the intricate dynamics of stunting across various regions, pinpointing 17 *kapanewon* (sub-districts) of Sleman Regency as the specific study locale. Sleman, with its dynamic stunting prevalence of 12.4%—lower than the 18% average in the Yogyakarta Special Region (DIY) Province—was chosen for its higher variation in socioeconomic conditions compared to Yogyakarta city and other regencies in DIY. This variation offers deeper insights into the combinations of conditions affecting stunting prevalence. Moreover, Sleman's diverse range of urban and rural communities makes it an invaluable case study for understanding stunting across different developmental contexts. The regency's unique demographic and economic diversity provides a comprehensive overview of the challenges and successes in regional health and infrastructure policies, enhancing the applicability and relevance of the study's findings to similar contexts.

Additionally, the broader selection of Daerah Istimewa Yogyakarta (DIY) for this study is underscored by its balanced mix of urban and rural settings, with Sleman district offering the most complete variation of these environments, which provides varied insights into stunting dynamics. Despite having one of the lowest stunting rates in 2022, DIY experienced an increase to 18% in 2023, similar to increases seen in other low-stunting regions (i.e., DKI and Kepulauan Riau); however, DIY was specifically chosen for its unique mix of urban and rural variations and the highest economic disparities in Indonesia, which provide a distinctive context influencing stunting management outcomes. This variance makes DIY a valuable case for comparative research into effective stunting management strategies. The province's diverse demographics and geography are ideal for exploring and implementing strategies that could serve as models both nationally and globally, making the findings from DIY crucial for advancing global health strategies and stunting reduction initiatives.

The csQCA method identifies configurations of conditions that are necessary and sufficient for high or low stunting prevalence, aiming to fill the knowledge gap regarding how various condition combinations determine these outcomes. By

considering these configurations, this study aims to offer insights that may assist in developing targeted and context-specific strategies to reduce stunting prevalence, contributing to the broader goal of enhancing child health and development.

As part of the introduction, the following subsection briefly overviews the determinants of stunting prevalence based on existing research. The paper then details the QCA method used, including data utilization, stages, and analysis techniques. The data analysis, adhering to the csQCA procedure, is presented transparently, followed by the result and discussion section, which highlights the theoretical and practical contributions of the study. The final section presents the conclusion, limitations, and recommendations for future research and policy based on the csQCA findings.

**Theoretical Review of Stunting Determinants**

This subsection of the introduction explores four key conditions critical in determining stunting levels: participation in family planning programs, socioeconomic vulnerability, village infrastructure development, and stunting management performance. These factors were selected based on their frequent identification in the literature as primary determinants of child growth and health outcomes (e.g., Idrus et al., 2023; Saif & Anwar, 2023; Saleem et al., 2024; Wake et al., 2023). Reviewing these factors, along with insights from the WHO framework developed by Stewart et al. (2013), provides a comprehensive view of the various determinants of child nutrition and health in different regional contexts. The WHO framework identifies key causes of stunting such as poverty, inadequate complementary feeding, short birth spaces, insufficient breastfeeding practices, inadequate sanitation and water supply, infections, and health care management, which interact to hinder child growth. These align closely with the factors discussed, illustrating the intricate web of causes at both the household and broader contextual levels including political economy, healthcare systems, and environmental conditions. This synthesis sets the stage for further analysis using Qualitative Comparative Analysis (QCA) to identify causal patterns and underscores the importance of a transdisciplinary approach in addressing the multifaceted nature of stunting.

**Family planning program participation**

Several studies highlight the significant role of family planning programs in reducing stunting prevalence by increasing birth intervals and improving maternal nutritional status, directly impacting child health and growth. A comprehensive analysis of 129 countries found that targeted nutritional interventions for women of reproductive age can enhance long-term health outcomes in children, including reduced stunting (Scott et al., 2020). Additionally, data from 193 Demographic and Health Surveys across 69 countries revealed that maternal attendance in antenatal care programs is associated with improved long-term child survival and reduced prevalence of low birth weight and stunting, emphasizing the importance of quality antenatal services (Kuhnt & Vollmer, 2017). Addressing unmet needs in family planning, another study found that many women in developing countries who wish to delay or stop childbearing are not using contraceptive methods. Improving access to and the variety of contraceptive methods can effectively reduce stunting by giving women greater control over birth intervals (Nazli et al., 2018). In conclusion, effective family planning programs and better access to antenatal services are crucial components of a multisectoral strategy to reduce stunting, underscoring the importance of integrating reproductive health and nutrition services within family planning programs to achieve optimal child health outcomes.

**Household socioeconomic vulnerability**

Household socioeconomic vulnerability significantly impacts stunting prevalence across

various countries. In Thailand, children breastfed for more than 12 months in impoverished families have a higher risk of stunting, underscoring the need for adequate nutritional support alongside breastfeeding (Cetthakrikul et al., 2018). In Mexico, factors such as the father's unstable employment and limited social networks contribute to high stunting prevalence in urban poor areas, highlighting the complex challenges in urban contexts (Reyes et al., 2004). In Bangladesh, limited access to healthcare and education, combined with poor living conditions, exacerbates nutritional problems in children, emphasizing the urgent need for targeted interventions addressing socioeconomic factors (Sarma et al., 2017). These studies collectively stress the importance of multisectoral interventions that consider social, economic, and health conditions to effectively combat the global stunting issue.

**Village Infrastructure Development**

Adequate infrastructure in clean water, sanitation, and healthcare is crucial for reducing stunting prevalence. In Indonesia, poor sanitation and untreated drinking water triple the risk of stunting in children (Torlesse et al., 2016), while the village fund program has reduced stunting by improving health infrastructure, especially outside Java (Indra & Khoirunurrofik, 2022). WASH interventions in Ethiopia, focusing on handwashing and clean water access, have significantly decreased stunting (Kwami et al., 2019). Studies in India highlight the importance of improved health and sanitation infrastructure in reducing stunting (Saxton et al., 2016). In Nepal, community infrastructure like paved roads, markets, and hospitals plays a significant role, with underdeveloped areas facing higher stunting risks (Dorsey et al., 2018). Collectively, these studies demonstrate that enhancing access to sanitation, clean water, and robust infrastructure is essential for reducing stunting, requiring a cross-sectoral collaborative approach.

**Effectiveness of stunting management policies**

Global efforts to address stunting involve integrated strategies across sectors and countries. In sub-Saharan Africa, a multisectoral approach combining agriculture, nutrition, and health has significantly reduced stunting (Remans et al., 2011). In the Philippines, the Pantawid conditional cash transfer program has improved child nutrition by incentivizing health service utilization and better dietary practices (Kandpal et al., 2016). In China, the Rural Dibao program reduced stunting by 11.9 percentage points through increased protein intake (Chen et al., 2024). In Ghana, free maternal healthcare reduced stunting by 12.3%, emphasizing the importance of maternal health investments (Bigool, 2024). Tanzania's conditional cash transfer program showed significant long-term stunting reduction using the Regression Discontinuity Design (RDD) method (Rukiko et al., 2023). In Indonesia, national convergence action policies have achieved success through cross-sectoral collaboration, with significant stunting reductions in regions like Palembang (Erlyn et al., 2021) and Ende (Daniel et al., 2023). However, challenges such as poor communication, inadequate resources, and lack of local government support remain barriers to effective policy implementation (Sunarya, 2023). These studies highlight the critical importance of cross-sectoral collaboration and sustained support to effectively eliminate stunting.

In addressing the complexities of stunting, prior research has often focused on isolated determinants within limited contexts, which may not capture the multifaceted and interconnected factors contributing to stunting across different environments. While these studies have provided valuable insights, they frequently utilize linear models that fail to account for the interaction between determinants at various levels—household, community, and policy—thereby oversimplifying the pathways leading to stunting.

This study seeks to fill these gaps by employing a QCA approach, which is particularly suited to understanding complex issues by examining how different conditions combine to produce an outcome. Unlike traditional methods, QCA allows for the identification of multiple pathways to stunting, recognizing that different combinations of factors can lead to similar outcomes. As explained further in the following section, this method acknowledges the heterogeneity across different regions and the potential for varying determinants to interact in unique ways, providing a more nuanced understanding of stunting that can inform targeted and effective interventions.

Furthermore, by focusing on Sleman Regency with its diverse socio-economic landscape, this study provides a context-sensitive analysis that integrates both micro-level (household and individual) and macro-level (policy and infrastructure) determinants. This comprehensive approach enables a deeper exploration of how specific local conditions might influence the effectiveness of stunting reduction strategies, offering insights that are crucial for crafting nuanced health policies tailored to the specific needs of different communities.

**Methods**

This study adopts a case study approach, focusing on the Sleman Regency to explore regional stunting prevalence by identifying the necessary and sufficient conditions, as well as combinations of conditions, that lead to areas of high and low stunting prevalence. Employing the crisp-set Qualitative Comparative Analysis (csQCA) method, this research meticulously analyzes the complex interactions between various determinants influencing stunting. The csQCA method was selected over other qualitative or quantitative methods due to its unique capability to handle the diversity and complexity of data, providing clear delineations of how different combinations of variables contribute to specific outcomes. The csQCA approach is particularly suited for this study as it allows for the exploration of how different conditions combine to produce specific outcomes, recognizing that similar outcomes can arise from different combinations of factors. This methodological choice enhances our understanding of the complex policy dynamics within Sleman, making a significant contribution to the development of a nuanced regional framework for stunting management. The investigation of this single region not only highlights specific local challenges and successes but also offers broader insights applicable to similar contexts, thereby supporting the formulation of targeted and effective regional stunting management strategies.

**Data and measurement**

This study is a multiple-case analysis of 17 sub-districts (*kapanewon*) in Sleman Regency. It aims to identify combinations of conditions that are necessary and sufficient for explaining variations in stunting prevalence, both above and below the average rate for the entire regency. Four potential determinants are examined: family planning participation rate, the proportion of vulnerable families, the level of village infrastructure development, and stunting management performance.

The selection of sub-districts as the unit of analysis is strategically focused on enhancing the understanding of governmental roles in stunting management at a regional level. Sub-districts in Sleman are critical nodes in the administrative hierarchy, tasked with the crucial responsibilities of coordinating, facilitating, and supervising the implementation of health and developmental policies at the village level, as is also the case in other regencies across Indonesia. They act as essential intermediaries, bridging the gap between village administrations and district-level government offices (e.g., *dinas, kantor,* and *badan*),

thereby playing a pivotal role in the dissemination and oversight of public health initiatives. This strategic positioning of sub-districts makes them ideal focal points for assessing the effectiveness of stunting management strategies across varied urban and rural contexts within Sleman. Given their significant responsibilities in public issue mitigation and policy implementation across the villages they oversee, understanding their effectiveness provides crucial insights into the systemic strengths and areas for improvement within regional stunting initiatives. This approach not only aligns with the study's objectives to assess policy impacts comprehensively but also highlights the potential for sub-districts to serve as catalysts in the broader fight against stunting.

**The studied outcome**

The outcome of interest in this study, assessed using QCA, is the stunting prevalence in each sub-district in Sleman for 2023, labeled as 'S'. The threshold used to determine high and low stunting prevalence is 4.81%, which is the average stunting prevalence across all sub-districts in Sleman. A sub-district is categorized as having high stunting prevalence if its rate exceeds 4.81%, and low if it is below this average. As shown in Table 1, nine sub-districts have high stunting prevalence (above the average), while eight sub-districts have low stunting prevalence (below the average).

**The four conditions**

Four conditions were examined in this study, following the QCA guideline that the number of conditions should be proportional to the number of cases analyzed. Since there are 17 sub-districts (*kapanewon*) being studied, the appropriate number of conditions is the value 'n' from $2^n$ which is closest to 17, which is 4 ($2^4$=16). If more than four conditions are analyzed, the resulting solutions would be too numerous, making it difficult to identify necessary and sufficient combinations.

The four conditions selected for analysis are all potential determinants of stunting prevalence, which include:

a. **Family Planning Participation Rates:** This condition is indicated by a composite score considering new family planning participants in 2022 and 2023 (each weighted at 40%) and the percentage of family planning participants in those same years (each weighted at 10%). The cut-off point for this condition is 64.5, the average score for all sub-districts. Sub-districts with scores above 64.5 are categorized as having high family planning participation (8 sub-districts), while those below are categorized as low (9 sub-districts).
b. **Proportion of Vulnerable Families:** This condition considers the average percentage of poor families in 2022 and 2023 (weighted at 50%) and the average percentage of infants with low birth weight and malnutrition in the same years (weighted at 50%). The cut-off point for this condition is 8.3, the average percentage for all sub-districts. Sub-districts with percentages above 8.3 are categorized as having a high proportion of vulnerable families (8 sub-districts), while those below are categorized as low (9 sub-districts).
c. **Level of Village Infrastructure Development:** This is assessed using the Village Development Index (IDM) from the Ministry of Villages, PDT, and Transmigration, integrating three components: IDM score for 2023, three-year average IDM (2021-2023), and five-year IDM improvement (2019-2023), with weights of 50%, 30%, and 20%, respectively. The cut-off point for this condition is 0.69, the average IDM score for all sub-districts. Sub-districts with scores above 0.69 are categorized as having a high level of village infrastructure development (8 sub-districts), while those below are categorized as low (9 sub-districts).
d. **Stunting Management Performance:** This composite variable reflects the change in

stunting prevalence over the last two years, showing whether stunting prevalence is lower or higher compared to the previous year. It is calculated using the average change in stunting prevalence between 2022 and 2023 and between 2021 and 2022, with each period weighted equally. The resulting values are then converted into scores on a 100-point scale. This approach ensures that the condition reflects both significant improvements and the overall stunting prevalence levels. Sub-districts that show a sharp decline in stunting prevalence might still have high prevalence rates compared to others, while some sub-districts might have lower stunting prevalence despite smaller declines. The cut-off point for this condition is 76.2, the average score for all sub-districts. Sub-districts with scores above 76.2 are categorized as having high stunting management performance (9 sub-districts), while those below are categorized as low (8 sub-districts).

The weights for each factor and sub-factor were carefully determined to emphasize certain sub-indicators that are critical in reflecting specific conditions affecting stunting. This targeted weighting, guided by insights from relevant literature and validated through expert consultations, ensures that the composite scores accurately represent the nuanced conditions contributing to stunting. This approach allows for a precise assessment of each determinant's impact, reflecting their varying degrees of influence on the overall stunting prevalence, thereby facilitating a more effective analysis of complex interactions within the data.

The study exclusively utilized secondary data, meticulously collected from authoritative sources to ensure comprehensiveness and reliability. Data sources included 'Sleman Regency in Figures 2022 and 2023' published by BPS Sleman, the 'Village Development Index 2019-2023' from the Ministry of Village, Development of Disadvantaged Regions, and Transmigration, along with the 'Recapitulation Data of Infant Nutrition Status Monitoring for 2022 and 2023', and historical data from 2021 provided by the Sleman Health Office. This secondary data provided a robust foundation for analyzing stunting determinants within the region, allowing for a comprehensive exploration of how socioeconomic, environmental, and policy factors interact to influence stunting rates.

In applying csQCA, it is crucial to systematically categorize and evaluate the conditions across all cases to identify patterns and combinations that lead to different outcomes. Table 1 summarizes the data for each condition and their categorizations, providing a clear foundation for the csQCA analysis. This step is essential for understanding the necessary and sufficient conditions influencing stunting prevalence, enabling a rigorous comparative analysis that reveals the complex interplay of factors at the sub-district level.

**Analysis Technique**

This study employs the Qualitative Comparative Analysis (QCA) method, developed by Charles Ragin in the 1970s, to explore conditions or combinations of conditions that are necessary and sufficient for outcomes like varying stunting prevalence in different regions. QCA facilitates a systematic and transparent analysis of the relevant conditions and contexts influencing specific outcomes (Greckhamer et al., 2018). As noted by Thomann and Maggetti (2020), QCA is useful for creating typologies, conducting comparative analyses, testing theories, and generating new hypotheses inductively. It provides tools to unravel complex causal relationships through structured comparative and configurational analysis (Fischer, 2015; Fiss et al., 2013; Thomann et al., 2018).

In this study, crisp-set QCA (csQCA) is utilized, following the recommendations of Rihoux and Mour (2009). The data is analyzed using

**Table 1**
**Summary of Conditions and Stunting Prevalence in Each Sub-District**

| No. | Sub-district/ *Kapanewon* (Cases) | The four conditions* | | | | The outcomes: Stunting Prevalence (SP) |
|---|---|---|---|---|---|---|
| | | Family Planning Participation (FP) | Proportion of Vulnerable Families (VF) | Village Infrastructure Development Level (VID) | Stunting Management Performance (SMP) | |
| 1 | Gamping | 64,8[a] | 7,0[a] | 0,76[a] | 84,2[a] | 4,56[a] |
| 2 | Godean | 59,8[b] | 9,5[b] | 0,71[a] | 77,0[a] | 3,63[a] |
| 3 | Mlati | 72,7[a] | 7,1[a] | 0,71[a] | 80,2[a] | 3,93[a] |
| 4 | Depok | 95,2[a] | 4,3[a] | 0,78[a] | 83,7[a] | 4,15[a] |
| 5 | Kalasan | 79,7[a] | 6,4[a] | 0,76[a] | 71,7[b] | 5,19[b] |
| 6 | Sleman | 80,9[a] | 7,7[b] | 0,70[a] | 83,9[a] | 3,52[a] |
| 7 | Ngaglik | 60,3[b] | 5,8[a] | 0,70[a] | 87,8[a] | 2,69[a] |
| 8 | Moyudan | 50,0[b] | 8,5[b] | 0,66[b] | 73,3[b] | 5,09[b] |
| 9 | Minggir | 52,5[b] | 10,3[b] | 0,61[b] | 63,3[b] | 6,07[b] |
| 10 | Seyegan | 58,7[b] | 11,6[b] | 0,63[b] | 68,3[b] | 7,21[b] |
| 11 | Berbah | 51,7[b] | 8,7[b] | 0,65[b] | 84,1[a] | 2,37[a] |
| 12 | Prambanan | 77,8[a] | 7,9[b] | 0,65[b] | 76,2[a] | 5,49[b] |
| 13 | Ngemplak | 66,2[a] | 7,4[a] | 0,70[a] | 70,4[b] | 4,94[b] |
| 14 | Tempel | 53,6[b] | 10,8[b] | 0,65[b] | 82,0[a] | 2,94[a] |
| 15 | Turi | 52,3[b] | 11,5[b] | 0,66[b] | 67,0[b] | 5,92[b] |
| 16 | Pakem | 46,6[b] | 6,9[a] | 0,67[b] | 70,0[b] | 8,69[b] |
| 17 | Cangkringan | 73,3[a] | 9,5[b] | 0,68[b] | 72,7[b] | 5,3[b] |
| | *The average as cut-off points* | 64,5 | 8,3 | 0,69 | 76,2 | 4,81 |

*Source: Processed by the researcher using various sources of basic data, including Sleman Regency in Figures 2022 and 2023 (BPS Sleman), Village Development Index 2019-2023 (Ministry of Village, Development of Disadvantaged Regions, and Transmigration), Recapitulation Data of Infant Nutrition Status Monitoring 2022 and 2023 (Sleman P3AP2KB Office), and Recapitulation Data of Infant Nutrition Status Monitoring Sleman 2021 (Sleman Health Office).*

*Notes:*

**) Each condition reflects composite variables formed through specific mechanisms, including composition and weighting, as previously explained;*
*a) the value is above the average or the cut-off point;*
*b) the value is below the average or the cut-off point*

Tosmana software version 1.6.1, developed by Cronqvist (2019). Instead of testing predefined hypotheses, this study aims to uncover partial relationships between conditions and outcomes, which can then be considered as hypotheses. The analysis proceeds through four steps, briefly outlined below.

***Step 1: Data preparation***

To use csQCA, data on each sub-district (*kapanewon*) was converted into binary format (0/1) by determining cut-off points for each condition and outcome. Cases with stunting prevalence above the average were assigned a "0" (high stunting prevalence), while those below were assigned a "1" (low stunting prevalence). This binary conversion was applied to all conditions. The binary data were then input into Tosmana software, which produced a truth table listing all condition configurations and their empirical outcomes, as well as potential configurations not represented by the existing cases. Tosmana also generated Boolean expressions describing the configurations associated with high or low stunting prevalence.

**Step 2: Necessity analysis**

Following csQCA guidelines, the researcher conducted necessity and sufficiency analyses using the truth table to identify condition combinations related to the outcome (Rihoux & Ragin, 2009). Necessity analysis, performed first as recommended by Ragin (2006), identifies conditions essential for a specific outcome. A condition ($X_1$) is necessary for an outcome ($Y_1$) if $Y_1$ cannot occur without $X_1$, even if $X_1$ alone does not guarantee $Y_1$. A condition is deemed necessary if it appears in most cases, with a consistency value above 0.9 and a coverage value over 0.5 (Ragin, 2006; Schneider & Wagemann, 2012; Thomann et al., 2018). Consistency values (0 to 1) indicate the proportion of cases where a specific condition leads to the outcome, while coverage values (0 to 1) show the proportion of all cases with the outcome explained by the condition. High consistency means the outcome consistently occurs when the condition is present, and high coverage indicates the condition's significance in explaining the outcome.

**Step 3: Sufficiency analysis**

QCA emphasizes causal asymmetry, meaning opposite conditions do not always produce opposite outcomes. For instance, high-poverty regions may have high stunting rates, but low poverty does not necessarily mean low stunting rates. Therefore, sufficiency analysis is conducted separately to identify conditions correlated with high or low stunting prevalence. Tosmana generates paths showing relationships between specific conditions or combinations and outcomes, including empirical case configurations and logical remainders (hypothetical cases) as recommended by Rihoux and Ragin (2009). Ignoring logical remainders usually results in descriptive formulas that only reflect empirical cases. To achieve simpler Boolean expressions, the analysis must include potential cases or logical remainders. As Rihoux and Ragin (2009) state, "The simpler the Boolean expression, the more configurations it can cover." This approach produces a concise formula describing the relationships between conditions and outcomes. A set relationship implies that a condition or combination of conditions can reliably predict an outcome. For example, condition $X_1$ is sufficient for outcome $Y_1$ if $X_1$ always accompanies $Y_1$, though other conditions like $X_2$ or a combination like $X_2$*$X_3$ can also produce $Y_1$. In a sufficiency analysis, a consistency level of at least 0.80 is used to determine the reliability of each identified relationship (Greckhamer et al., 2018).

**Step 4: Evaluating the results**

The evaluation aims to verify how well the set-theoretical relationships produced by the software align with empirical data, using consistency and coverage as key indicators of fit (Ragin, 2006). Consistency measures the reliability of the relationship between conditions (or combinations) and the outcome, reflecting the ratio of instances where a condition (e.g., $X_1$) or combination (e.g., $X_1$*$X_2$) leads to an outcome (e.g., $Y_1$) compared to all cases where $X_1$ (or $X_1$*$X_2$) occurs. A higher consistency value indicates a more reliable and sufficient condition, with a value of "1" indicating conclusive sufficiency for $Y_1$. Coverage values provide empirical evidence of the importance of these relationships. Raw coverage measures the number of cases where a condition leads to an outcome, including those covered by multiple configurations, while unique coverage measures the percentage of cases covered by a particular path without overlap (Andrews et al., 2016).

Researchers assess the combined consistency and coverage of paths (solutions) for each outcome, whether high or low stunting prevalence. Solution consistency reflects the integrated fit of causal conditions or combinations, while solution coverage indicates the percentage of cases covered by all paths

(Andrews et al., 2016). A high consistency score (>0.75; Ragin, 2006) suggests that the causal conditions or combinations are crucial for the outcome, whereas low consistency or coverage values (<0.75) indicate that the set-theoretical relationship is not specific or accurate.

## Results and Discussion

### The truth table

The truth table generated by Tosmana, supplemented by the researcher, shows 16 combinations of the four conditions studied. Of these, 10 rows represent empirical cases from Sleman sub-district data, while the remaining 6 rows are logical remainders indicating potential but unobserved combinations. These logical remainders are crucial for broadening our understanding of possible condition combinations that may be significant in a wider comparative analysis. The truth table shows an even distribution between low (1) and high (0) stunting prevalence outcomes, with each outcome represented by different condition combinations, indicating diverse correlations with stunting levels.

The proportion of empirical cases (10 rows) versus logical remainders (6 rows), along with the distribution of high and low stunting outcomes, provides valuable insights into the socioeconomic configurations in Sleman that influence stunting. Each condition combination recorded in empirical cases confirms key determinants of stunting prevalence, while logical remainders highlight

**Table 2**
***Truth Table***

| Rows | Conditions | | | | Outcome | n | Cases |
|---|---|---|---|---|---|---|---|
| | FP | VF | VID | SMP | SP | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 4 | Moyudan, Minggir, Seyegan, Turi |
| 2 | 0 | 1 | 0 | 0 | 0 | 1 | Pakem |
| 3 | 1 | 0 | 0 | 0 | 0 | 1 | Cangkringan |
| 4 | 1 | 0 | 0 | 1 | 0 | 1 | Prambanan |
| 5 | 1 | 1 | 1 | 0 | 0 | 2 | Kalasan, Ngemplak |
| 6 | 0 | 0 | 0 | 1 | 1 | 2 | Berbah, Tempel |
| 7 | 0 | 0 | 1 | 1 | 1 | 1 | Godean |
| 8 | 0 | 1 | 1 | 1 | 1 | 1 | Ngaglik |
| 9 | 1 | 0 | 1 | 1 | 1 | 1 | Sleman |
| 10 | 1 | 1 | 1 | 1 | 1 | 3 | Gamping, Mlati, Depok |
| 11 | 0 | 0 | 1 | 0 | R | - | - |
| 12 | 0 | 1 | 1 | 0 | R | - | - |
| 13 | 0 | 1 | 0 | 1 | R | - | - |
| 14 | 1 | 0 | 1 | 0 | R | - | - |
| 15 | 1 | 1 | 0 | 1 | R | - | - |
| 16 | 1 | 1 | 0 | 0 | R | - | - |

| Legend: | |
|---|---|
| $SP_1$ | Stunting prevalence equal to or below 4.81% |
| $SP_0$ | Stunting prevalence above 4.81% |
| $FP_1$ | Family Planning participation rate equal to or above 64.5 |
| $FP_0$ | Family Planning participation rate below 64.5 |
| $VF_1$ | The proportion of vulnerable families equal to or below 8.3 |
| $VF_0$ | The proportion of vulnerable families above 8.3 |
| $VID_1$ | Village Infrastructure Development Index equal to or above 0.69 |
| $VID_0$ | Village Infrastructure Development Index below 0.69 |
| $SMP_1$ | Stunting Management Performance equal to or above 76.2 |
| $SMP_0$ | Stunting Management Performance below 76.2 |
| R | Logical remainders (combinations of conditions that do not appear in the dataset of empirical cases but are theoretically possible) |

*Source: Generated by Tosmana Software and further processed by the researcher (2024).*

potential areas yet to be fully explored in the context of stunting prevalence. Overall, this comparative analysis deeply illustrates how different conditions interact and contribute to varying stunting levels. The absence of contradictions in the truth table indicates consistent data with no differing outcomes for similar condition combinations, reinforcing the validity of the condition analysis and demonstrating accuracy in selecting and defining the conditions.

**Necessity analysis**

The necessity analysis reveals that low stunting management performance ($SMP_0$) is the only condition that meets the high threshold with a perfect consistency score of 1.000 for the outcome of high stunting prevalence (outcome '0'). This indicates that $SMP_0$ is consistently necessary for high stunting prevalence, showing a critical and reliable relationship between poor stunting management and increased stunting rates across the sub-districts.

The coverage value for $SMP_0$ in the context of high stunting prevalence is 0.889, indicating that this condition explains a significant proportion of the cases with high stunting prevalence. This high coverage score further emphasizes the substantial role of inadequate stunting management in contributing to higher stunting rates. It highlights that most cases of high stunting prevalence can be attributed to poor performance in stunting management.

These findings underscore the importance of addressing stunting management performance to reduce high stunting rates. The perfect consistency of $SMP_0$ indicates that improving stunting management is a critical and necessary step in combating high stunting prevalence. However, while necessary, improving stunting management alone may not be sufficient to achieve low stunting prevalence, suggesting that other factors, such as village infrastructure development and family planning participation, must also be considered.

**Sufficiency analysis**

The purpose of sufficiency analysis is to understand how various conditions interact to influence stunting levels. Unlike necessity analysis, which identifies single conditions

**Table 3.**
**Consistency and Coverage Analysis**

| Conditions | Outcomes | Subset cases | Total subset cases | Total outcome cases | Consistency | Coverage |
|---|---|---|---|---|---|---|
| $FP_0$ | 0 | 5 | 9 | 9 | 5/9= 0.556 | 5/9= 0.556 |
| $FP_0$ | 1 | 4 | 9 | 8 | 4/9= 0.444 | 4/8= 0.500 |
| $FP_1$ | 0 | 4 | 8 | 9 | 4/8= 0.500 | 4/9= 0.444 |
| $FP_1$ | 1 | 4 | 8 | 8 | 4/8= 0.500 | 4/8= 0.500 |
| $VF_0$ | 0 | 6 | 10 | 9 | 6/10= 0.600 | 6/9= 0.667 |
| $VF_0$ | 1 | 4 | 10 | 8 | 4/10= 0.400 | 4/8= 0.500 |
| $VF_1$ | 0 | 3 | 7 | 9 | 3/7= 0.429 | 3/9= 0.333 |
| $VF_1$ | 1 | 4 | 7 | 8 | 4/7= 0.571 | 4/8= 0.500 |
| $VID_0$ | 0 | 7 | 9 | 9 | 7/9= 0.778 | 7/9= 0.778 |
| $VID_0$ | 1 | 2 | 9 | 8 | 2/9= 0.222 | 2/8= 0.250 |
| $VID_1$ | 0 | 2 | 8 | 9 | 2/8= 0.250 | 2/9= 0.222 |
| $VID_1$ | 1 | 6 | 8 | 8 | 6/8= 0.750 | 6/8= 0.750 |
| **$SMP_0$** | **0** | **8** | **8** | **9** | **8/8= 1.000*** | **8/9= 0.889*** |
| $SMP_0$ | 1 | 0 | 8 | 8 | 0/8= 0.000 | 0/8= 0.000 |
| $SMP_1$ | 0 | 1 | 9 | 9 | 1/9= 0.111 | 1/9= 0.111 |
| $SMP_1$ | 1 | 8 | 9 | 8 | 8/9= 0.889 | 8/8= 1.000 |

*Source: processed by the researcher (2024) based on the Truth Table (Table 2)*
**) The minimum threshold for consistency is 0.9, while the lowest acceptable score for coverage is 0.5.*

necessary for high or low stunting prevalence, sufficiency analysis examines combinations of conditions that are necessary and sufficient for these outcomes. Tosmana provides solutions for each outcome ('high stunting' and 'low stunting'), each consisting of multiple paths (condition combinations). As shown in Tables 4 and 5, there are two paths for high stunting prevalence and two for low stunting prevalence. The data in the truth table confirms each path by calculating consistency and coverage. Consistency indicates how often the condition combination accurately predicts the outcome, while coverage shows how many cases with a specific outcome are explained by the combination. These metrics provide insights into the significance and reliability of each condition combination in the context of stunting in Sleman.

As shown in Table 4, there are two paths leading to high stunting prevalence. The first path, involving low stunting management performance ($SMP_0$), shows perfect consistency (1.00) and high coverage (0.88), indicating its critical and consistent association with high stunting prevalence. The second path, combining high family planning participation with low village development ($FP_1$*$VID_0$), also has perfect consistency (1.00) but lower coverage (0.22), indicating it covers fewer cases but remains necessary.

Based on Table 5, the analysis of conditions leading to low stunting prevalence reveals two key combinations: low family planning participation with high stunting management performance ($FP_0$*$SMP_1$) and high village infrastructure development with high stunting management performance ($VID_1$*$SMP_1$). Both combinations exhibit perfect consistency (1.00), but the second path has higher coverage. This indicates that the latter combination is more commonly found in cases with low stunting prevalence.

Based on these results, it can be concluded that effective and swift stunting management is crucial in reducing or preventing high stunting rates. Additionally, village infrastructure development, particularly related to stunting prevention such as clean water, sanitation, and welfare support facilities, plays a vital role in achieving the desired outcomes. It is important to note that the analysis uses averaged data to represent the general conditions of village infrastructure within each sub-district. While this method allows for a broad overview of regional trends and supports generalized policy formulation, we recognize that infrastructure quality can vary significantly between villages in the same sub-district. This averaging approach is intended to highlight common trends and areas for

**Table 4.**
**Configurations of conditions for high stunting prevalence**

| | **Path 1** | **Path 2** |
|---|---|---|
| Condition or configuration of conditions identified by Tosmana | $SMP_0$ | $FP_1$*$VID_0$ |
| Empirical cases explained | 8 cases: Kalasan, Ngemplak, Moyudan, Minggir, Seyegan, Turi, Pakem, Cangkringan | 2 cases: Prambanan, Cangkringan |
| Empirical cases explained uniquely (by each path) | 7 cases: Kalasan, Ngemplak, Moyudan, Minggir, Seyegan, Turi, Pakem | 1 case: Prambanan |
| Consistency | 8/8= 1.00 | 2/2= 1.00 |
| Raw coverage | 8/9= 0.88 | 2/9= 0.22 |
| Unique coverage | 7/9= 0.77 | 1/9= 0.11 |
| Consistency of solution | 10/10= 1.00 | |
| Coverage of solution | 8/9= 0.88 | |

*Source: processed by the researcher (2024).*

**Table 5.**
**Configurations of conditions for low stunting prevalence**

| | Path 1 | Path 2 |
|---|---|---|
| Condition or configuration of conditions identified by Tosmana | $FP_0$*$SMP_1$ | $VID_1$*$SMP_1$ |
| Empirical cases explained | 4 cases: Godean, Ngaglik, Berbah, Tempel | 6 cases: Gamping, Mlati, Depok, Godean, Sleman, Ngaglik |
| Empirical cases explained uniquely (by each path) | 2 cases: Berbah, Tempel | 4 cases: Gamping, Mlati, Depok, Sleman |
| Consistency | 4/4= 1.00 | 6/6= 1.00 |
| Raw coverage | 4/8= 0.5 | 6/8= 0.75 |
| Unique coverage | 2/8= 0.25 | 4/8= 0.5 |
| Consistency of solution | 10/10= 1.00 | |
| Coverage of solution | 6/8= 0.75 | |

*Source: processed by the researcher (2024).*

improvement but does not discount the variability within each region. The implications of these findings are significant for policy formulation, suggesting that interventions should focus not only on strengthening stunting management systems but also on village infrastructure development in each sub-district.

These findings underscore the importance of understanding causal asymmetry in the interactions affecting stunting prevalence. While poor stunting management is consistently associated with high stunting prevalence, effective management alone does not automatically result in low stunting prevalence. High stunting management performance must be supported or combined with advanced village development to achieve low stunting rates. Interestingly, even with low family planning participation, high stunting management performance can still effectively reduce stunting prevalence, indicating that targeted stunting interventions can have a significant impact even when other conditions are not ideal.

Moreover, the concept of equifinality in this analysis shows that multiple different paths can lead to low stunting prevalence. This emphasizes that there is no single condition or combination of conditions for addressing stunting issues; various condition combinations, such as high village development or effective stunting management interventions, can be equally effective. A multifaceted and adaptive approach is necessary when designing intervention strategies, taking into account the unique local contexts of each sub-district to determine the most effective combination of strategies for reducing stunting.

The results of the csQCA analysis reveal that the combination of factors influences stunting prevalence in Sleman Regency, leading us into a discussion on how these findings contrast with previous studies. These findings contrast with previous studies that tend to focus on the impact of individual factors in isolation. For instance, studies by Idrus et al. (2023) and Thahir et al. (2023) in Indonesia identified low birth weight and maternal nutrition as key factors of stunting, but they did not explore how these factors interact to affect child health outcomes. This research study reveals that the configuration of conditions determines the outcome more than the influence of individual factors.

This study finds that poor stunting management performance is a single necessary and sufficient condition for high stunting prevalence in Sleman Regency. However, unlike previous studies by Roy et al. (2023) and Wake et al. (2023), which emphasize the importance of individual factors such as maternal education and sanitation, this research shows that no single condition is sufficient for regions with

low stunting prevalence. Instead, a combination of high stunting management performance and advanced village development is a necessary and sufficient configuration for achieving low stunting prevalence. These findings highlight that successful stunting reduction interventions must consider the complex interaction between these two conditions.

As previously mentioned, a key contribution of the csQCA analysis in this study is its emphasis on equifinality, where multiple configurations of conditions can lead to the same outcome. The sufficiency analysis reveals two configurations sufficient for low stunting prevalence: low family planning participation combined with high stunting management performance (path 1) and advanced village development combined with high stunting management performance (path 2). This contrasts with previous research that primarily highlights single-condition interventions, such as access to clean water or effective stunting management. This study underscores the need for a holistic and coordinated approach involving various sectors, particularly health and infrastructure development.

Additionally, this study also highlights the importance of asymmetric causality, which posits that conditions causing a particular outcome are not necessarily the same conditions that can prevent it when changed or improved. Asymmetric causality suggests that causal relationships are not always bidirectional or symmetrical. For example, while poor stunting management can lead to high stunting prevalence, merely improving stunting management is insufficient to reduce stunting without support from other factors, such as village infrastructure development. Thus, the conditions causing high stunting do not automatically have the opposite effect when reversed. Efforts to reduce stunting require a holistic and integrated approach, underscoring the complexity of causal interactions that cannot be captured by single-factor analyses.

Findings from the csQCA analysis indicate that family planning participation is not a necessary condition for reducing stunting prevalence, contrasting with previous studies (Kuhnt & Vollmer, 2017; Nazli et al., 2018; Scott et al., 2020). The results reveal that high stunting management performance combined with advanced village infrastructure development is necessary and sufficient for low stunting prevalence, while family planning participation alone is not essential. Even with high family planning participation, stunting remains high without adequate village development ($FP_1$*$VID_0$). Conversely, high stunting management performance can compensate for low family planning participation, reducing stunting prevalence ($FP_0$*$SMP_1$). Thus, effective stunting management and village development significantly impact stunting reduction in Sleman Regency. Additionally, the proportion of vulnerable families is neither necessary nor sufficient for determining stunting prevalence, as it shows low consistency and coverage. This suggests that while socioeconomic status influences stunting, it is not a primary determinant without other significant factors. Therefore, stunting reduction efforts should focus on improving stunting management and village infrastructure, while family planning and support for vulnerable families remain important but not independently significant.

Overall, this study makes significant theoretical and practical contributions. Theoretically, it demonstrates how csQCA can be used to identify combinations of conditions that are necessary and sufficient for achieving the desired outcome of low stunting prevalence. This approach offers a new way to understand the complexity of interactions among various determinants of stunting that have not been explored in previous research. It enriches the literature by introducing an analytical method capable of uncovering deeper configurations of conditions compared to single-factor analyses.

This study highlights both similarities and differences with the WHO framework in identifying

stunting determinants. Both approaches agree that multifaceted factors, including complementary feeding, health, poverty, and water and sanitation infrastructure, are critical. However, while the WHO framework focuses on individual child-level causes (Stewart et al., 2013), this study emphasizes stunting prevalence and its regional determinants. The csQCA findings reveal that high stunting management performance and significant village development are necessary and sufficient for reducing stunting prevalence. This underscores the need for the WHO to develop a framework that emphasizes regional-level stunting management. By demonstrating the importance of complex interactions among various factors and the need for a holistic, integrated approach, this study contributes theoretically by identifying the necessary and sufficient conditions for achieving low stunting prevalence, which should be incorporated into a regional-based stunting management framework.

**Conclusion**

This study identifies the necessary and sufficient conditions affecting stunting prevalence in Sleman Regency using the csQCA approach. It found that low effectiveness in stunting management is necessary and sufficient for high stunting prevalence. Conversely, while high effectiveness in stunting management is necessary, it is not sufficient for low stunting prevalence. The necessary and sufficient combination for low stunting prevalence is high village development combined with high effectiveness in stunting management. This indicates that high stunting management performance alone cannot ensure low stunting prevalence; it must be accompanied by adequate rural development, particularly in clean water and sanitation infrastructure. These findings highlight the importance of a holistic and coordinated approach involving both the health sector and rural infrastructure development to effectively reduce stunting prevalence.

Practically, this study reveals that effective stunting management performance combined with accelerated rural infrastructure development, particularly clean water and sanitation, are necessary and sufficient conditions for reducing stunting prevalence. These findings have significant implications for policymakers, indicating that interventions must prioritize enhancing stunting management programs and accelerating basic rural infrastructure development, i.e., sanitation and clean water infrastructure. This study emphasizes that adaptive strategies focusing on the combination of these two conditions are crucial for achieving optimal outcomes in stunting management.

This study has several limitations. First, the geographic scope is limited to Sleman Regency, so the results may not be generalizable to other areas with different characteristics. Second, the data used are secondary data, which may have limitations in terms of completeness and accuracy. Third, while the csQCA approach is effective in identifying combinations of conditions, it does not capture temporal dynamics or changes in conditions over time. Future studies should expand the geographic scope to include national-level analysis across all provinces to test the configuration of conditions in regions with different characteristics. Using longitudinal data can help understand changes over time and their impact on stunting prevalence. Additionally, combining csQCA with qualitative methods can provide deeper insights into causal mechanisms. Future research should also consider using fuzzy-set QCA (fsQCA) to capture more nuances in the data.

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