

# Public health and economic implications of hypertension in the context of Indonesia's double burden of malnutrition

Implicaciones económicas y de salud pública de la hipertensión en el contexto de la doble carga de desnutrición en Indonesia

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## Abstract

**T**his study analyzes trends and projects future trajectories of key maternal and child nutrition indicators in Indonesia toward the 2030 Global Nutrition Targets, explicitly examining their implications for the nation's growing hypertension burden. Using time-series data (2000-2023) from the World Bank, Autoregressive Integrated Moving Average (ARIMA) models were employed to forecast the prevalence of stunting, anemia in women, low birth weight, and childhood overweight through 2030. Projections indicate Indonesia is on track to meet the stunting target (18.0% by 2030) and control childhood overweight (3.4%). However, targets for anemia in women (25.2%) and low birth weight (9.5%) are projected to be missed. Strong positive correlations were found among stunting, anemia, and low birth weight, while childhood overweight correlated inversely with these indicators. The analysis reveals a critical public health insight: the off-track maternal and birth nutrition indicators represent a significant, modifiable risk factor for future hypertension at the population level. Deficits in early life nutrition are strongly linked, through developmental origins pathways, to an increased risk of adult cardiometabolic disease. Therefore, accelerating progress on these overlooked indicators is not only a nutritional imperative but a foundational strategy for primary prevention of hypertension. Achieving sustainable health gains requires life-course policies that integrate maternal-child nutrition with non-communicable disease prevention agendas.

**Keywords:** Nutrition Transition, Double Burden of Malnutrition, Stunting, Low Birth Weight, Hypertension, Developmental Origins of Health and Disease (DOHaD), Indonesia.

## Resumen

**E**ste estudio analiza las tendencias y proyecta las trayectorias futuras de los principales indicadores de nutrición materno-infantil en Indonesia hacia las Metas Mundiales de Nutrición para 2030, examinando explícitamente sus implicaciones para la creciente carga de hipertensión en el país. Utilizando datos de series temporales (2000-2023) del Banco Mundial, se emplearon modelos ARIMA (Autorregresivo Integrado de Promedio Móvil) para pronosticar la prevalencia del retraso del crecimiento, la anemia en mujeres, el bajo peso al nacer y el sobrepeso infantil hasta 2030. Las proyecciones indican que Indonesia está bien encaminada para alcanzar la meta de retraso del crecimiento (18,0 % para 2030) y controlar el sobrepeso infantil (3,4 %). Sin embargo, se prevé que no se alcancen las metas de anemia en mujeres (25,2 %) y bajo peso al nacer (9,5 %). Se encontraron fuertes correlaciones positivas entre el retraso del crecimiento, la anemia y el bajo peso al nacer, mientras que el sobrepeso infantil mostró una correlación inversa con estos indicadores. El análisis revela una perspectiva crucial para la salud pública: los indicadores nutricionales desfavorables de la madre y el nacimiento representan un factor de riesgo significativo y modificable para la hipertensión futura a nivel poblacional. Las deficiencias en la nutrición en la primera infancia están estrechamente vinculadas, a través de las vías de origen del desarrollo, a un mayor riesgo de enfermedad cardiometabólica en la edad adulta. Por lo tanto, acelerar el progreso en estos indicadores desatendidos no solo es un imperativo nutricional, sino también una estrategia fundamental para la prevención primaria de la hipertensión. Lograr mejoras sostenibles en la salud requiere políticas a lo largo de la vida que

integren la nutrición materno-infantil con las agendas de prevención de enfermedades no transmisibles.

**Palabras clave:** Transición nutricional, Doble carga de malnutrición, Retraso del crecimiento, Bajo peso al nacer, Hipertensión, Orígenes del desarrollo de la salud y la enfermedad (DOHaD), Indonesia.

Indonesia's public health landscape is characterized by a complex and persistent double burden of malnutrition, where the challenges of undernutrition—such as stunting, wasting, and micronutrient deficiencies—coexist with a rising prevalence of overnutrition, including overweight, obesity, and related non-communicable diseases (NCDs)<sup>1</sup>. This nutritional transition poses a significant threat to human capital development and the nation's progress toward the Sustainable Development Goals (SDGs). Within this framework, the escalating burden of hypertension emerges as a critical, yet often underexplored, nexus between maternal-child nutrition and long-term cardiometabolic health<sup>2</sup>.

The State of the World's Children report highlights that globally, one-third of children under five experience malnutrition, while nearly two-thirds are at risk due to poor diet quality<sup>3</sup>. In Indonesia, this is reflected in high rates of childhood stunting alongside growing concerns about childhood overweight. Beyond their immediate health impacts, these early-life nutritional insults have profound developmental consequences. Crucially, emerging evidence suggests that both undernutrition and overnutrition in early life can program an individual for an increased risk of hypertension and other cardiovascular diseases in adulthood, creating a lifelong trajectory of health inequity<sup>4</sup>. Hypertension, a major modifiable risk factor for heart disease and stroke, is thus not merely an adult health issue but one deeply rooted in the nutritional environment of the first 1,000 days of life and beyond.

In response, global and national agendas have set ambitious targets. The World Health Assembly and the SDGs established the Global Nutrition Targets (GNTs) for 2030, which include indicators like stunting, anemia, and childhood overweight<sup>5</sup>. Concurrently, Indonesia's Presidential Regulation No. 72 of 2021 prioritizes stunting reduction through multisectoral action<sup>6</sup>. However, integrated analyses that connect these maternal and child nutrition indicators with the rising tide of NCDs, particularly hypertension, remain limited. Monitoring progress is further challenged by gaps in annual data availability from periodic national surveys<sup>7</sup>.

Therefore, a comprehensive assessment is urgently needed. This study aims to analyze historical trends and project future trajectories of key nutrition indicators in Indonesia toward the 2030 GNTs. More importantly, it situates this analysis within the broader public health discourse by examining the potential implications of these nutritional trends for the nation's growing hypertension burden. Such an integrated perspective is essential for designing life-course interventions that not only address the double burden of malnutrition but also proactively mitigate its long-term cardiometabolic consequences, thereby fostering a healthier trajectory for Indonesia's future generations.

## 1. Study Design and Data Source

This observational study was conducted to analyze national-level trends and project future trajectories of key maternal and child nutrition indicators in Indonesia. A secondary data analysis was performed using longitudinal, country-level data extracted from the World Bank's World Development Indicators (WDI) database for Indonesia, covering the period from 2000 to 2023.

## 2. Selection of Nutrition Indicators and Variables

The analysis focused on four primary indicators aligned with the 2030 Global Nutrition Targets (GNTs)<sup>8</sup>: the prevalence of stunting in children under five, defined as a height-for-age measurement more than two standard deviations below the World Health Organization (WHO) Child Growth Standards median; the prevalence of anemia among women of reproductive age (15-49 years); the prevalence of low birth weight (newborns weighing less than 2,500 grams); and the prevalence of overweight in children under five, defined as a weight-for-height measurement more than two standard deviations above the WHO median. Indicators with extensive data gaps exceeding 50% of the time-series, such as exclusive breastfeeding and wasting, were excluded from the analysis as reliable imputation and trend modeling were deemed unfeasible<sup>9</sup>.

## 3. Statistical Analysis and Projection Modeling

Future projections for each indicator through to the year 2030 were generated using Autoregressive Integrated Moving Average (ARIMA) modeling. The ARIMA (p, d, q) model, where p represents the autoregressive order, d the degree of differencing, and q the moving average order, was employed to forecast time series data after ensuring stationarity. Model parameters were specifically selected for each indicator based on its historical data pattern. The projected values for 2030 were then compared against the established SDG targets, which

include a 40% reduction in stunting, a 50% reduction in anemia among women, a 30% reduction in low birth weight (all from a 2012 baseline), and a target to reduce childhood overweight to below 5%.

the dynamics of the double burden of malnutrition. The resulting matrix was visualized using a heatmap to aid interpretation.

#### 4. Assessment of Inter-Indicator Relationships

To examine the interrelationships between the maternal and child nutrition indicators, a correlation analysis was performed. A correlation matrix was constructed using Spearman's rank correlation coefficient to quantify the strength and direction of monotonic associations between the variables over the observed period. This analysis helps elucidate how different forms of undernutrition and overnutrition co-occur, providing insight into



### Results



he observed and projected prevalence of key nutrition indicators from 2000 to 2030 are summarized in **Table 1**.

**Table 1. Observed and projected prevalence of stunting, anemia among women, LBW babies, and overweight in Indonesia from 2000 to 2030.**

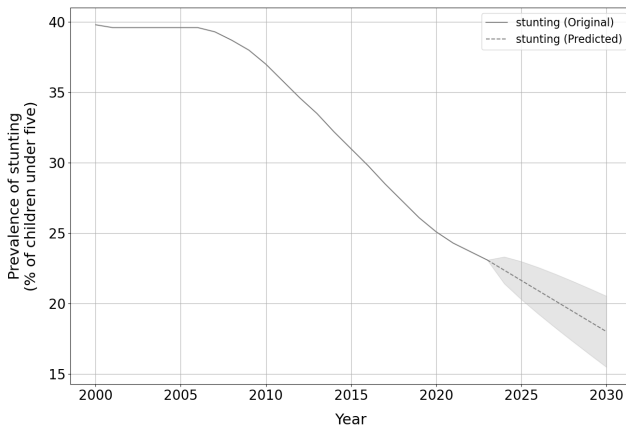
Year	Prevalence of stunting (% of children under 5)	Prevalence of anemia among women of reproductive age (% of women ages 15-49)	Prevalence of low birth weight babies (% of births)	Prevalence of overweight (% of children under 5)
2000	39.80	31.70	10.85	3.00
2001	39.60	31.50	10.82	3.40
2002	39.60	31.40	10.79	3.80
2003	39.60	31.20	10.77	4.20
2004	39.60	31.10	10.75	4.60
2005	39.60	30.90	10.73	5.10
2006	39.60	30.70	10.70	5.60
2007	39.30	30.50	10.68	6.20
2008	38.70	30.20	10.65	6.70
2009	38.00	29.90	10.63	7.20
2010	37.00	29.60	10.60	7.60
2011	35.80	29.30	10.56	8.00
2012	34.60	29.10	10.50	8.30
2013	33.50	28.90	10.43	8.50
2014	32.20	28.70	10.36	8.50
2015	31.00	28.50	10.28	8.40
2016	29.80	28.20	10.19	8.20
2017	28.50	27.90	10.11	7.70
2018	27.30	27.50	10.03	7.20
2019	26.10	27.20	9.97	6.50
2020	25.10	26.90	9.93	5.70
2021	24.30	26.70	9.88	4.90
2022	23.70	26.60	9.84	4.10
2023	23.10	26.70	9.79	3.30
2024	22.37	26.48	9.75	3.31
2025	21.65	26.27	9.70	3.33
2026	20.92	26.05	9.65	3.34
2027	20.20	25.83	9.61	3.35
2028	19.47	25.61	9.56	3.37
2029	18.74	25.40	9.52	3.38
2030	18.02	25.18	9.47	3.39

 ARIMA-based projections prevalence  
 Actual prevalence

Over the observed period (2000-2023), the prevalence of stunting among children under five demonstrated a substantial and consistent decline, falling from 39.8% to 23.1%. A more gradual decreasing trend was observed for anemia among women of reproductive age, which reduced from 31.7% to 26.7%. The prevalence of low birth weight showed a modest but steady reduction from 10.85% to 9.79%. In contrast, the trend for childhood overweight was non-linear, characterized by a steady increase from 3.0% to a peak of approximately 8.5% around 2013-2014, followed by a pronounced decline to 3.3% by 2023. The ARIMA-based projections for the period 2024-2030 indicate a continued downward trajectory for stunting, anemia, and low birth weight. Conversely, the prevalence of childhood overweight is projected to stabilize at a low level, showing a very slight upward tendency.

The detailed trend for each indicator is visualized in the accompanying figures. **Figure 1** illustrates the observed and projected decline in stunting prevalence, which is expected to reach 18.02% by 2030.

**Figure 1. Observed and projected trends in the prevalence of stunting in Indonesia from 2000 to 2030.**



**Figure 2 depicts the gradual reduction in anemia among women, with a projected prevalence of 25.18% in 2030.**

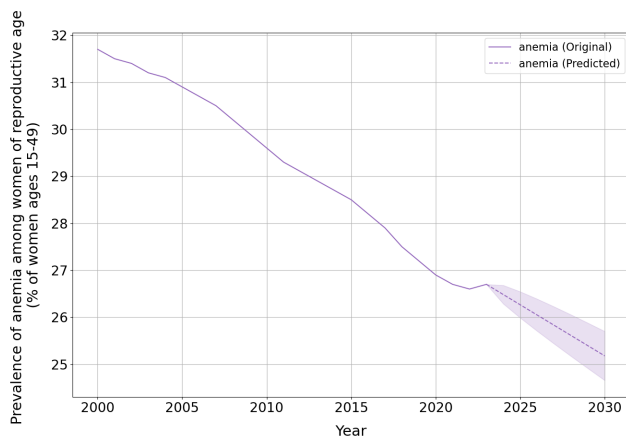


Figure 2. Observed and projected trends in the prevalence of anemia among women of reproductive age in Indonesia from 2000 to 2030.

**Figure 3 shows the trend for low birth weight, projected to decline to 9.47% by the end of the decade.**

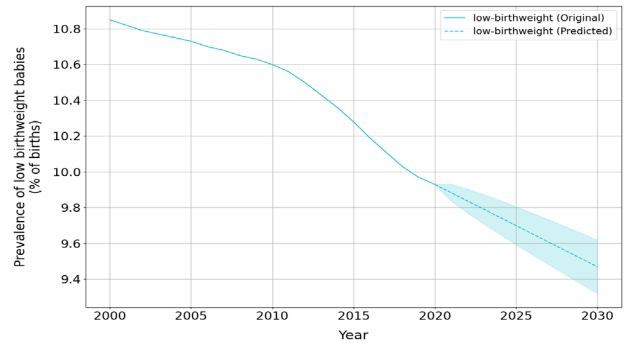
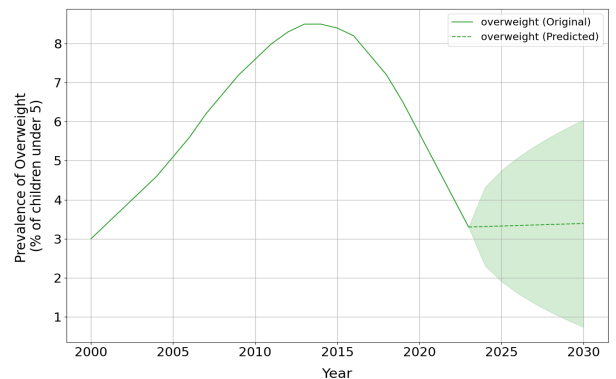


Figure 3. Observed and projected trends in the prevalence of LBW babies in Indonesia from 2000 to 2030.

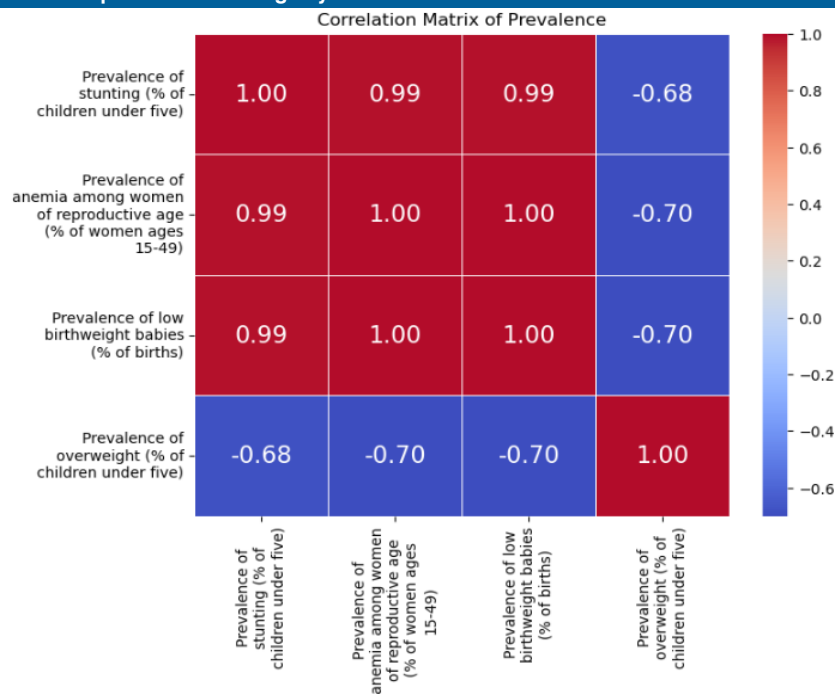
Finally, **Figure 4** presents the distinctive trajectory of childhood overweight, highlighting its peak and subsequent decline, with projections suggesting a stable prevalence around 3.39% by 2030.

**Figure 4. Observed and projected trends in the prevalence of overweight in Indonesia from 2000 to 2030.**



The correlation analysis revealed significant associations between the key maternal and child nutrition indicators over the study period, as visualized in the **Figure 5** correlation matrix heatmap. A very strong positive correlation was observed among the three indicators of undernutrition: stunting, anemia in women, and low birth weight (correlation coefficients ranging from  $r = 0.97$  to  $0.99$ ). This indicates that periods or populations with higher stunting prevalence were also very likely to experience higher rates of maternal anemia and low birth weight.

Figure 5. Correlation matrix of prevalence among key variables



In contrast, childhood overweight demonstrated moderate to strong negative correlations with the undernutrition indicators (coefficients ranging from  $r = -0.54$  to  $-0.70$ ). This inverse relationship suggests that improvements in undernutrition have coincided with a shifting burden toward overnutrition, underscoring the concurrent presence of both conditions within Indonesia’s nutritional landscape.

The projected nutritional trends for 2030 have direct and concerning implications for Indonesia’s future hypertension burden, as synthesized in **Table 2**. While the stunting target may be met, a prevalence of 18% still represents a significant population exposed to a well-established life-course risk factor for adult hypertension. More critically, the off-track projections for maternal anemia and low birth weight signal persistent deficits in foundational maternal and neonatal health. These conditions are strongly linked to developmental programming that predisposes individuals to cardiometabolic disease, including hypertension, later in life. Consequently, these trends suggest that without intensified intervention, the early-life nutritional environment will continue to fuel a pipeline for hypertension and related non-communicable diseases in the adult population for decades to come, even as indicators of undernutrition improve.

Table 2. Projected Nutritional Status in 2030 and Associated Long-Term Risks for Hypertension and Cardiometabolic Health

Nutrition Indicator	Projected 2030 Prevalence	Projection vs. 2030 Target	Implication for Hypertension / Cardiometabolic Risk
Stunting in Children <5	18.02%	On track to meet target (Target: 20.76%)	<b>Moderate-High Risk.</b> Early-life stunting is a well-established risk factor for later-life hypertension and metabolic syndrome, even after catch-up growth.
Anemia in Women (15-49)	25.18%	Off track (Target: 14.55%)	<b>High Risk.</b> Maternal anemia reflects poor iron status and is linked to low birth weight, which itself is a risk factor for adult hypertension. It also indicates broader micronutrient deficiencies affecting vascular health.
Low Birth Weight (LBW)	9.47%	Off track (Target: 7.35%)	<b>High Risk.</b> LBW is a strong predictor of increased risk for hypertension, insulin resistance, and cardiovascular disease in adulthood (Developmental Origins of Health and Disease - DOHaD hypothesis).
Overweight in Children <5	3.39%	On track (Target: <5%)	<b>Emerging Risk.</b> While currently low and stable, early childhood overweight is a direct risk factor for sustained obesity, insulin resistance, and early-onset hypertension. The stable trend requires vigilance.

Discussion

This study provides an integrated analysis of trends and future trajectories for key maternal and child nutrition indicators in Indonesia, explicitly framing them within the context of long-term cardiometabolic risk, with a focus on hypertension. Our projections indicate a high likelihood of achieving the 2030 target for childhood stunting, which aligns with national survey data and reflects the impact of concentrated policy efforts, such as those mandated by Presidential Regulation No. 72 of 2021<sup>10</sup>. However, the projected prevalence of 18.02% remains a public health concern. Extensive evidence from the developmental origins of health and disease (DOHaD) framework es-

establishes that early-life stunting and undernutrition are not merely childhood conditions but are powerful predictors of increased susceptibility to hypertension, insulin resistance, and metabolic syndrome in adulthood<sup>11,12</sup>. Therefore, meeting the numerical target does not negate the enduring cardiometabolic risk carried by a generation exposed to early growth faltering.

The off-track projections for anemia among women of reproductive age (25.18%) and low birth weight (9.47%) are particularly alarming from a life-course perspective. These indicators reflect persistent gaps in maternal nutrition and health, which have intergenerational consequences. Maternal anemia and low birth weight are intricately linked; poor maternal iron status and nutritional health contribute to restricted fetal growth<sup>13</sup>. Low birth weight, in turn, is one of the most robust risk factors associated with the development of essential hypertension and cardiovascular disease later in life, as the fetus adapts to a suboptimal nutritional environment in ways that permanently alter metabolic and vascular function<sup>14,15</sup>. The stagnation in reducing these indicators suggests that future cohorts may continue to enter life with a biologically programmed higher risk for hypertension.

The trajectory for childhood overweight, projected to remain stable but below the 5% target, presents a complex picture of Indonesia's nutritional transition. The initial rise and subsequent decline may reflect the early effects of national policies like the guidelines for sugar, salt, and fat labeling<sup>16</sup> and Balanced Nutrition guidelines<sup>17</sup>. However, the stabilization at a low level requires vigilant monitoring. Childhood overweight is a direct precursor to sustained obesity, a primary driver of insulin resistance and early-onset hypertension<sup>18</sup>. The co-occurrence of improving but still significant stunting with stable childhood overweight, as evidenced by their inverse correlation in our analysis, epitomizes the double burden of malnutrition. This coexistence creates a scenario where populations face compounded risks: the long-term cardiometabolic penalties of early undernutrition layered with the more immediate risks associated with excess weight<sup>19</sup>.

The strong positive correlations between stunting, anemia, and low birth weight underscore their common roots in interrelated factors such as household food insecurity, suboptimal maternal diets, and access to healthcare<sup>20</sup>. This synergy necessitates integrated, multi-sectoral interventions that simultaneously address maternal, infant, and young child nutrition. Our findings strongly argue that nutrition policies must evolve beyond siloed targets. Strategies aimed solely at reducing stunting, while crucial, may be insufficient to mitigate the future burden of non-communicable diseases like hypertension. A life-course prevention framework is essential—one that recognizes improving maternal nutrition and birth outcomes as foundational not only for child survival and growth but also as a critical primary prevention strategy against the national epidemic of hypertension<sup>21,22</sup>. This requires strengthening antenatal care, scaling up proven inter-

ventions like iron-folic acid supplementation, and ensuring continuity of care from pregnancy through early childhood.

## Conclusions

**T**his analysis of trends and projections toward the 2030 Global Nutrition Targets reveals a nuanced outlook for Indonesia. While progress in reducing childhood stunting is commendable and on track, the persistently high projected rates of maternal anemia and low birth weight indicate unresolved challenges in the foundational health of mothers and newborns. Most significantly, this study connects these early-life nutritional indicators to their profound implications for long-term cardiometabolic health, particularly hypertension. The off-track targets for maternal and birth outcomes suggest that Indonesia may inadvertently be sustaining a pipeline of physiological risk for hypertension in future adult populations.

Therefore, accelerating progress requires a strategic shift. Policymakers must champion integrated nutrition interventions that explicitly bridge maternal, child, and adolescent health with non-communicable disease prevention agendas. The goal must expand from merely achieving numerical targets to fostering a healthier life-course trajectory. Future research should prioritize longitudinal studies that track the direct links between early nutritional status and adolescent/adult hypertension risk within the Indonesian context. Ultimately, safeguarding the cardiovascular health of the next generation depends on the nutrition and care provided today, making the reduction of maternal anemia and low birth weight not only a nutrition imperative but a cornerstone of national hypertension prevention.

## References

1. Rachmi CN, Li M, Baur LA. The double burden of malnutrition in Association of Southeast Asian Nations (ASEAN) countries: a comprehensive review of the literature. *Asia Pac J Clin Nutr*. 2018;27(4):736-55.
2. Wells JC, Sawaya AL, Wibaek R, Mwangome M, Poullas MS, Yajnik CS, et al. The double burden of malnutrition: aetiological pathways and consequences for health. *Lancet*. 2020;395(10217):75-88. doi:10.1016/S0140-6736(19)32472-9.
3. United Nations Children's Fund (UNICEF). The state of the world's children 2019: children, food and nutrition. New York: UNICEF; 2019.

4. Fall CH. Fetal malnutrition and long-term outcomes. In: Bhatia J, Bhutta ZA, Kalhan SC, editors. Nestle Nutrition Institute workshop series. Philadelphia: Nestec Ltd., Vevey/S. Karger AG; 2013. p. 11-25.
5. World Health Organization. Global nutrition targets 2025: policy brief series. Geneva: World Health Organization; 2014.
6. President of the Republic of Indonesia. Presidential Regulation No. 72 of 2021 on the Acceleration of Stunting Reduction. Jakarta: State Secretariat of the Republic of Indonesia; 2021.
7. Buckland AJ, Thorne-Lyman AL, Aung T, King SE, Manarat R, Becker L, et al. Nutrition data use and needs: findings from an online survey of global nutrition stakeholders. *J Glob Health*. 2020;10(2):020403. doi:10.7189/jogh.10.020403.
8. World Health Organization. Global targets 2030: to improve maternal, infant and young child nutrition [Internet]. Geneva: WHO; 2025 [cited 2026 Jan 12]. Available from: <https://www.who.int/teams/nutrition-and-food-safety/global-targets-2030>
9. Junaid KP, Kiran T, Gupta M, Kishore K, Siwatch S. How much missing data is too much to impute for longitudinal health indicators? A preliminary guideline for the choice of the extent of missing proportion to impute with multiple imputation by chained equations. *Popul Health Metr*. 2025;23(2):8. doi:10.1186/s12963-025-00364-2.
10. Fall CH. Fetal malnutrition and long-term outcomes. In: Bhatia J, Bhutta ZA, Kalhan SC, editors. Nestle Nutrition Institute workshop series. Philadelphia: Nestec Ltd., Vevey/S. Karger AG; 2013. p. 11-25.
11. Sanatkanuly, M., & Baigabylov, N. Intersectoral collaboration among NGOs addressing complex public health issues: a comprehensive study. *Economic Annals-XXI*, 2024; 207(1-2), 59-70. doi: <https://doi.org/10.21003/ea.V207-09>
12. Rahman MM, Abe SK, Rahman MS, Kanda M, Narita S, Bilano V, et al. Maternal anemia and risk of adverse birth and health outcomes in low- and middle-income countries: systematic review and meta-analysis. *Am J Clin Nutr*. 2016;103(2):495-504. doi:10.3945/ajcn.115.107896.
13. Huxley RR, Shiell AW, Law CM. The role of size at birth and post-natal catch-up growth in determining systolic blood pressure: a systematic review of the literature. *J Hypertens*. 2000;18(7):815-31. doi:10.1097/00004872-200018070-00002.
14. Sharopova, N., Turgunov, J., Eshbekov, M., Abdullayev, D., Sherov, A., & Ashurov, F. The effect of green supply chain management on workplace safety and healthiness for employees. *Economic Annals-XXI*, 2024; 211(9-10), 52-57. doi: <https://doi.org/10.21003/ea.V211-08>
15. Minister of Health of the Republic of Indonesia. Regulation of the Minister of Health of the Republic of Indonesia Number 30 of 2013 concerning the inclusion of sugar, salt and fat content information and health messages for processed food and fast food. Jakarta: Ministry of Health of the Republic of Indonesia; 2013.
16. Minister of Health of the Republic of Indonesia. Regulation of the Minister of Health of the Republic of Indonesia Number 41 of 2014 concerning guidelines for balanced nutrition. Jakarta: Ministry of Health of the Republic of Indonesia; 2014.
17. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev*. 2008;9(5):474-88. doi:10.1111/j.1467-789X.2008.00475.x.
18. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. *Paediatr Int Child Health*. 2014;34(4):250-65. doi:10.1179/2046905514Y.0000000158.
19. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*. 2008;371(9609):340-57. doi:10.1016/S0140-6736(07)61692-4.
20. Ministry of Health of the Republic of Indonesia, Health Research and Development Agency. National report on Indonesian nutritional status survey (SSGI) 2022. Jakarta: Ministry of Health of the Republic of Indonesia; 2022.
21. Makaba, S., Mardianto, U., Jumintono, K., & Nugrohowati, N. Genetic algorithm optimization with machine learning to check the primary health of hospital visitors. *Procedia Environ. Sci. Eng. Manag*, 2025; 12(1), 7-15.
22. Alem AZ, Efendi F, Mckenna L, Dimog-Felipe EB, Chilot D, Tonapa SI, et al. Prevalence and factors associated with anemia in women of reproductive age across low- and middle-income countries based on national data. *Sci Rep*. 2023;13(1):17746. doi:10.1038/s41598-023-46739-z.