

## Prevalence, Trends, and Projections of Overweight and Obesity Among Children and Adolescents in Indonesia, 1993–2050: A Meta-Analysis of Observational Studies

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### ABSTRACT

Overweight and obesity among children and adolescents are growing public-health challenges with long-term consequences for noncommunicable disease burden. This study primarily aimed to estimate the pooled prevalence of overweight and obesity among Indonesian school-aged children and adolescents; secondarily, we examined temporal trends and estimated number of cases through 2050. We conducted a meta-analysis of cross-sectional studies up to 10 September 2025. Pooled estimates used random-effects models with heterogeneity assessed by  $I^2$ . Publication bias was explored and adjusted using trim-and-fill when indicated. Subgroup analyses included sex, school level, and period. Temporal trends were modelled with Autoregressive Integrated Moving Average (ARIMA) and projected to 2050 using national demographic data. A total of 152 studies were included. The pooled prevalence of combined overweight and obesity was 18.13% (95% CI: 15.02–21.71%); obesity alone 7.49% (95% CI: 5.89–9.47%); overweight alone 11% (95% CI: 10–13%). Substantial between-study heterogeneity ( $I^2 = 77.5–99.9\%$ ) was observed. Higher prevalence was found in boys and primary-school children. ARIMA projections indicate an increase in combined prevalence to 23.02% by 2050. About one in five Indonesian children and adolescents are affected by overweight or obesity with projected increases, highlighting the urgent need for targeted, multisectoral prevention strategies, especially at primary-school age, to curb future noncommunicable-disease burden. However, given the high between-study heterogeneity consistently observed across all categories, these estimates and projections should be interpreted cautiously as indicative rather than definitive figures.

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### INTRODUCTION

Under the WHO guideline, a child or adolescent is considered overweight when the BMI sits more than one standard deviation above the mean, and obese when it surpasses two standard deviations (de Onis, 2007). In 2022, the global number of overweight or obese children and adolescents aged 5–19 years exceeded 390 million, with prevalence rising from 8% in 1990 to 20% in 2022 (Phelps et al., 2024). At its most basic, this trend reflects an energy imbalance in which surplus intake is stored as fat (Klos et al., 2023). In Indonesia, however, the drivers of this imbalance are structurally more complex than overeating alone.

Indonesia is undergoing a nutrition transition shaped by rapid urbanization, widening socioeconomic inequality, and the proliferation of ultra-processed foods, forces that together reshape dietary patterns across the income spectrum. Urbanization concentrates populations in food environments

where cheap, calorie-dense snacks, sugary drinks, and fried foods are widely available through street vendors and online platforms, while simultaneously reducing opportunities for physical activity in schools and communities (Afriza & Andrafikar, 2025). Socioeconomic inequality compounds this problem. Although higher-income households carry greater odds of overweight due to their purchasing power, lower-income families facing food insecurity are increasingly compelled to prioritize caloric satiety over nutritional quality (Anyanwu et al., 2022). This is the mechanism through which the nutrition transition disadvantages the poor: not simply by increasing caloric access, but by substituting micronutrient-rich foods with ultra-processed alternatives.

These dynamics are most pronounced within Indonesia's double burden of malnutrition, where stunting and overnutrition coexist within the same populations and households. Children who experience early-life undernutrition are metabolically primed toward rapid

adipose accumulation when subsequently exposed to energy-dense food environments (Maehara et al., 2019). The shift from stunted or underweight to overweight is therefore not a paradox but a predictable biological response to the nutrition transition; early deprivation sensitizes children to the excess that urbanization and cheap ultra-processed foods then deliver (Widyastuti et al., 2025). The double burden cannot be understood separately from the socioeconomic and food-environment forces that drive it; they form a reinforcing system that is reshaping the health trajectory of Indonesian children and adolescents.

The long-term consequences are substantial. Childhood and adolescent obesity substantially increases the likelihood of persisting into adulthood and precipitating non-communicable diseases, including type 2 diabetes mellitus, cardiovascular diseases, musculoskeletal disorders, and certain cancers, at progressively younger ages (Kerr et al., 2025; Sulistiadi et al., 2023).

Despite this urgency, to the best of our knowledge, comprehensive pooled prevalence data synthesizing this specific demographic over the extended 1993-2025 period remain limited. This makes it difficult to understand the changes that have taken place over the years and to project the future prevalence of obesity among children and adolescents.

The primary objective of this study is to estimate the pooled prevalence of combined overweight and obesity, obesity alone, and overweight alone among Indonesian school-aged children and adolescents. The secondary objectives are to examine temporal trends from 1993 to 2025 and to project future prevalence and estimated case numbers through 2050 using ARIMA modeling. Projecting these epidemiological trends to 2050 is crucial for policymakers to proactively prepare healthcare infrastructure and design targeted, long-term prevention strategies before Indonesia's demographic bonus window closes.

## METHODS

### Study Design

We conducted a prevalence meta-analysis that follows the guidelines of the Meta-analysis of Observational Studies in Epidemiology (MOOSE) to ensure its validity and transparency (Stroup, 2000). The predefined study protocol was followed throughout and has been made publicly available on the Open Science Framework (OSF) at DOI: 10.17605/OSF.IO/YWC8G.

### Search Strategy and Selection Criteria

A systematic literature search was carried out using Google Scholar and PubMed databases until September 10, 2025. In addition, nationally representative data from the Indonesian Basic Health Research(es) (Riset Kesehatan Dasar/Riskesdas), the Indonesian Family Life Survey(s) (IFLS), and the Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) were included (Frankenberg et al., 1993; Frankenberg & Thomas, 1997; Kementerian Kesehatan RI, 2007, 2010, 2013, 2018, 2023; Strauss et al., 2000, 2007, 2014). The search was conducted using English and Indonesian terms with the help of Boolean operators, MeSH terms, and relevant keywords. The English search strategy was: ("child" OR "adolescent" OR "primary school" OR "junior high school" OR "senior high school") AND

("overweight" OR "obesity" OR "BMI") AND "prevalence" AND "Indonesia". The Indonesian search strategy was: ("anak" OR "remaja" OR "SD" OR "SMP" OR "SMA") AND ("kelebihan berat badan" OR "obesitas" OR "IMT") AND "prevalensi" AND "Indonesia". PubMed and Google Scholar were selected to ensure broad coverage of both international peer-reviewed literature and local Indonesian journals/grey literature not indexed in major databases. Additionally, manual reference list screening (citation tracking) of included full-texts was performed to identify further eligible records.

Studies included for analysis met the following inclusion criteria: population-based cross-sectional studies, population-based samples, including both nationally representative surveys and local community or school-based samples from Indonesian children and/or adolescents, reported prevalence of overweight and/or obese using WHO, IOTF, CDC, or other standard verified references, and written in English or Indonesian. The exclusion criteria included studies on clinical populations, case-control studies, cohort studies, and outcomes that were not clearly defined.

### Data Extraction and Quality Assessment

Two authors used a standardized form to extract relevant data, which recorded the main study informations, sample characteristics, and diagnostic criteria. The quality of studies was assessed by the adapted Newcastle-Ottawa Scale (NOS) for cross-sectional studies, which was used to ascertain data reliability and minimize bias in findings (Carra et al., 2025). The quality of studies was defined as unsatisfactory, with a score less than 5 on the NOS, and satisfactory, with a score of 5 or more on the NOS (Lo et al., 2014). The cutoff score was utilized to define satisfactory quality, providing a balanced threshold for observational data.

### Statistical Analysis

The analyses were done using R software (The R Foundation for Statistical Computing, Vienna, Austria) utilizing the meta package (Guido Schwarzer, Institute of Medical Biometry and Statistics, Freiburg, Germany) (Schwarzer, 2007), and the metafor package (Wolfgang Viechtbauer, Maastricht University, Maastricht, The Netherlands) (Viechtbauer, 2010). All extracted data were pooled. For national surveys (Riskesdas, IFLS, SKI), each survey wave was treated as an independent cross-sectional observation. Prevalence data were extracted according to the specific school-level age strata reported in the respective national reports to match the analytical subgroups. Overall pooled estimates for the prevalence of overweight, obesity, and the combined condition were determined using a random-effects model based on Generalized Linear Mixed-Model (GLMM) to take into account between-study variation. Heterogeneity was quantitatively assessed using the  $I^2$  statistic where values above 50% reflected substantial heterogeneity (Higgins et al., 2003; Stijnen et al., 2010). To properly reflect the distribution of the data, 95% Prediction Intervals (PI) were estimated together with 95% Confidence Intervals (CI), as a way of estimating in which range future study values would most likely fall (Int'Hout et al., 2016; Riley et al., 2011). For the investigation of publication bias, funnel plots were visually inspected, and the biases were further tested for significance using the Peters' test (Egger et al., 1997; Peters, 2006). If significant publication bias was detected, a correction of the prevalence estimates was made using the trim-and-fill method (Duval & Tweedie, 2000). Trim-and-fill was utilized specifically to adjust for suspected

publication bias and small-study effects. Where statistically stable, the robust estimates (adjusted or not) were used as input for subgroup analysis by sex, school level, and survey period.

Moreover, time trends were modeled by plotting prevalence against the midpoint of each survey year and projecting future prevalence using an Autoregressive Integrated Moving Average (ARIMA) model through 2050 (Box et al., 2015). The ARIMA (1,1,0) model was used, which means that there is one autoregressive term ( $p=1$ ), first-order differencing ( $d=1$ ) to achieve stationarity, and that there is no moving average term ( $q=0$ ). This type of ARIMA model is particularly well-suited to non-stationary time series that display linear trend characteristics, which are common in epidemiological time series. This type of ARIMA model has been successfully used in other studies to project prostate cancer case volume in Australia and to predict daily COVID-19 infection figures in Turkey (Earnest et al., 2019; Toğa et al., 2021). The resulting prevalence projections were subsequently combined with national demographic

projections obtained from PopulationPyramid.net to estimate the future absolute burden of cases.

## RESULTS OF STUDY

### Study Selection and Characteristics

The initial database search yielded 1,075 records. After removing 11 duplicates and screening 1,064 titles and abstracts, 765 records were excluded as being irrelevant. Out of 299 full-text articles used to evaluate inclusion criteria, 61 were unavailable, and 86 were excluded as not meeting inclusion criteria in terms of study design, population, and outcome. In total, 152 studies were used in the quantitative synthesis (Figure 1). The three sets of data used in the analysis were 103 studies on combined overweight and obesity with 1,020,709 records, 117 studies on obesity with 1,093,936 records, and 72 studies on overweight with 1,010,260 records from surveys between 1993 and 2025.

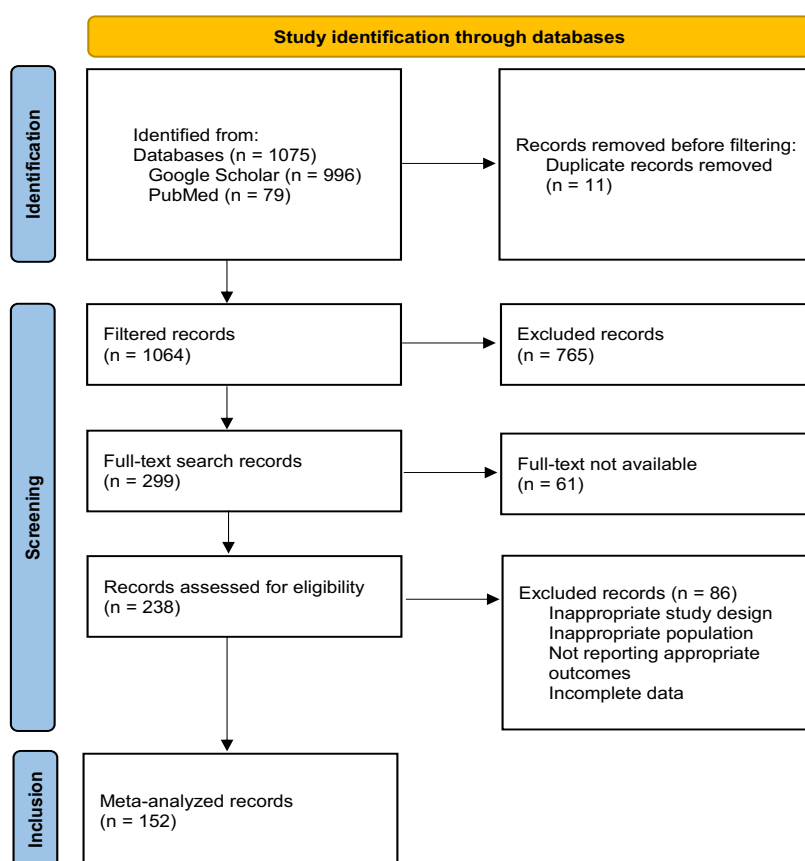


Figure 1. Search process flowchart.

It is important to emphasize that these studies were spread across various geographical regions of Indonesia with geographically concentrated primarily in the Java and Sumatra regions. The majority of studies were conducted after 2011. In terms of educational level/age group, the largest focus was on the elementary school student population. The majority of the studies analyzed were small-scale studies with fewer than 1,000 participants, and in terms of methodological quality, the number of studies assessed as satisfactory (NOS score  $\geq 5$ ) and unsatisfactory (NOS score  $< 5$ ) was almost evenly distributed (see Supplementary Material 1). The most frequently weak methodological domains were the lack of

description of non-responders and unclear or non-randomized sampling strategies.

### Pooled Prevalence, Heterogeneity, and Bias Adjustment

The initial analysis yielded a pooled prevalence for combined overweight and obesity of 23% (95% CI: 20%–27%). When analyzed separately, the prevalence for obesity alone was 11% (95% CI: 9%–13%), and overweight alone was 11% (95% CI: 10%–13%). Comprehensive details of these initial analyses are provided in Supplementary Materials 1, 2, and 3. Across all categories, substantial between-study

heterogeneity was observed, with  $I^2$  values ranging from 77.5% to 99.9% depending on the subgroup. Peters' test indicated significant publication bias for the combined group ( $p = 0.0498$ ) and the obesity-only group ( $p = 0.0006$ ),

suggesting the presence of small-study effects, whereas no significant bias was detected for the overweight-only group ( $p = 0.1233$ ), see Figure 2.

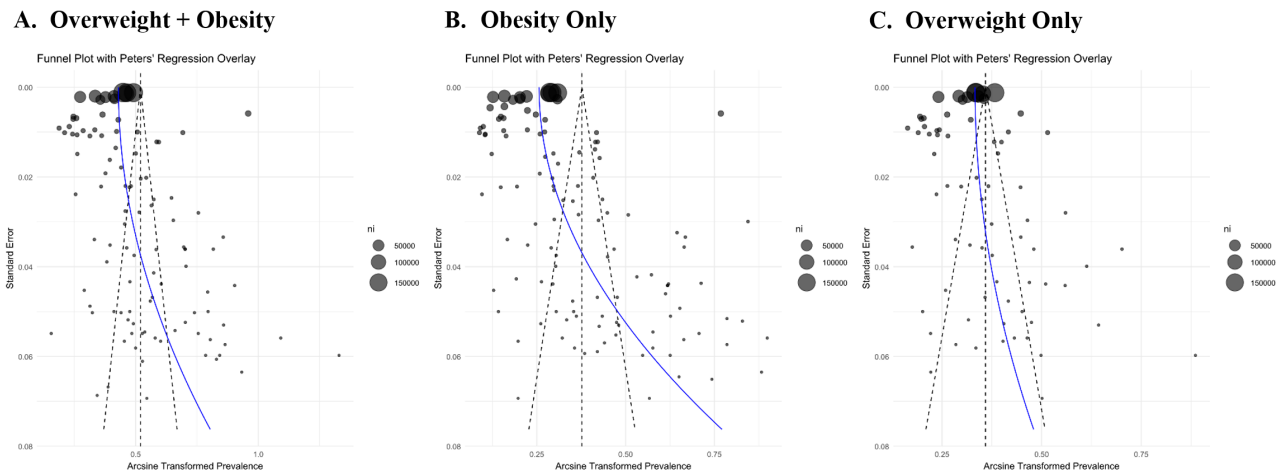


Figure 2. Funnel plot with peters regression line overlaid.

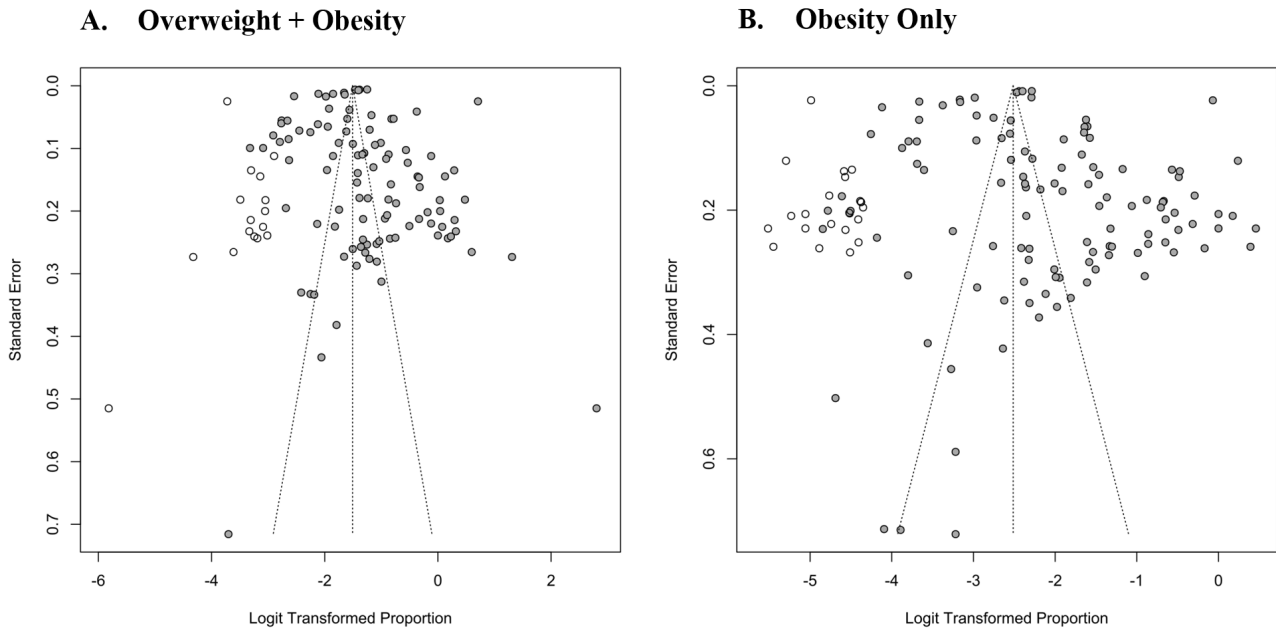


Figure 3. Trim-and-fill funnel plots for (A) Overweight + Obesity and (B) Obesity Only. Black circles represent the original studies, while white circles represent the imputed studies added using the trim-and-fill method.

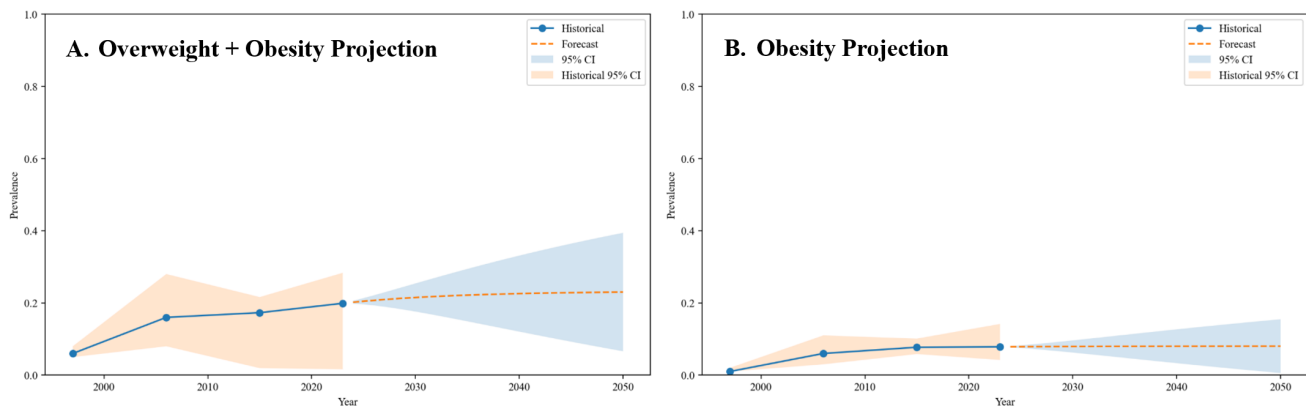


Figure 4. Trends and projections of overweight and obesity prevalence to 2050

To explore and adjust for this bias, trim-and-fill corrections were applied. These adjusted prevalence estimates represent sensitivity analyses accounting for potential missing small studies and should be interpreted cautiously rather than as definitive true values (Supplementary Material 4). After imputing 16 studies, the adjusted pooled prevalence for combined overweight and obesity was 18.13% (95% CI: 15.02%–21.71%). The prediction interval for this estimate was notably wide (PI: 1.96%–70.99%), reflecting the substantial variation inherent in the included studies. For the obesity-only category, the adjustment involved imputing 22 studies, resulting in a final prevalence of 7.49% (95% CI: 5.89%–9.47%), funnel plot after trim-and-fill can be seen in Figure 3. The prevalence for overweight alone remained at the unadjusted estimate of 11% (95% CI: 10%–13%).

### Subgroup Analysis, Temporal Trend, and Projections

Subgroup analyses based on the robust estimates revealed distinct demographic patterns. The combined prevalence was numerically higher in boys (19.89%) compared to girls (18.22%), though this difference was not statistically significant ( $p = 0.712$ ), a pattern that persisted for obesity alone (9.60% in boys vs. 7.06% in girls). Conversely, overweight prevalence was slightly higher in girls (9%) than in boys (7%). Regarding education level, the highest combined prevalence was observed among primary school students (18.97%), followed by junior high school students (14.44%), and was lowest among senior high school students (12.42%). A similar declining trend across educational levels was evident for obesity alone, decreasing from 9.03% in primary school to 4.50% in junior high school and 3.73% in senior high school. In contrast, overweight prevalence peaked at the junior high school level (13%), slightly exceeding that of primary (10%) and senior high school students (11%).

Table 1. Projection data details for 2030, 2040, and 2050 using ARIMA.

Category	Year	Estimated Population	Prevalence % (95% CI)	Estimated Cases
Combined Overweight and Obesity	2030	69,019,405	21.51	14,843,814
			(17.62–25.40)	
	2040	64,575,246	22.58	14,583,472
			(12.06–33.10)	
	2050	62,776,922	23.02	14,449,269
			(6.62–39.42)	
Obesity Only	2030	69,019,405	7.93 (6.26–9.61)	5,475,995
	2040	64,575,246	8.00 (3.32–12.67)	5,163,536
	2050	62,776,922	8.02 (0.58–15.47)	5,037,462

Notes. ARIMA = Autoregressive Integrated Moving Average.

To reconstruct historical trends and project future scenarios, we employed a hybrid adjustment strategy. We utilized unadjusted estimates for the 1993–2010 period to ensure model stability given limited early studies, while applying adjusted estimates for 2011–2025 to correct for publication bias. Under this approach, the combined prevalence of overweight and obesity rose from 6% (1993–2000) to 16% (2001–2010), plateaued near 17.30% (2011–2019), and increased to 19.90% (2020–2025). Specifically, overweight prevalence showed a steady increase from 4% to

16%. Meanwhile, obesity prevalence initially spiked from 1% to 6% in early periods, before stabilizing at 7.72% to 7.85% between 2011 and 2025.

Looking ahead, the ARIMA model projects the combined prevalence will gradually increase from 21.51% in 2030 to 23.02% by 2050. Conversely, obesity prevalence is expected to exhibit a slower rate of increase, rising only marginally from 7.93% to 8.02%. Despite these rising rates, demographic shifts are expected to cause a slight decline in the absolute burden of cases, dropping from approximately 14.8 million in 2030 to 14.4 million in 2050 (Figure 4 and Table 1). However, the remarkably wide prediction intervals (e.g., PI: 1.96%–70.99% for combined adjusted estimates) highlight the immense variance in the underlying data, limiting the precision of these long-term forecasts.

## DISCUSSION

### Main Findings and Interpretation

The bias-adjusted pooled prevalence of combined overweight and obesity among Indonesian school-aged children and adolescents was 18.13% (95% CI: 15.02%–21.71%), with obesity alone at 7.49% (95% CI: 5.89–9.47%) and overweight alone at 11% (95% CI: 10–13%). Approximately one in five Indonesian children and adolescents is therefore affected by excess weight. ARIMA projections indicate that combined prevalence will rise gradually to 23.02% by 2050, though the 95% CI for this estimate is wide (6.62–39.42%), which reflects the substantial uncertainty inherent in long-range projections derived from heterogeneous prevalence data. The absolute burden is projected to decline modestly from approximately 14.8 million cases in 2030 to 14.4 million in 2050, driven by expected demographic contraction in school-age cohorts rather than any reduction in prevalence rates.

Indonesia's bias-adjusted prevalence of 18.13% is broadly comparable to the regional estimate for Southeast Asia of 17% and remains below the current global estimate of 20% for children and adolescents aged 5–19 years (Kerr et al., 2025; Lobstein et al., 2024). Published national estimates from neighboring countries suggest a higher prevalence in Malaysia (24%) and a lower one in Thailand (13%), though these comparisons must be interpreted with caution. The studies from which these figures are drawn differ in their diagnostic criteria, the age ranges and school levels sampled, the observation periods covered, and the methodological quality of their constituent studies (Aekplakorn et al., 2023; Chua et al., 2025). Numerical differences between countries may therefore partly reflect variation in methodology rather than true differences in population burden.

The temporal trend observed here shows a marked rise in combined prevalence from 6% during 1993–2000 to 19.90% during 2020–2025, a trajectory that roughly parallels the global rise from 8% in 1990 to 20% in 2022 (Kerr et al., 2025). The slight plateau between 2011–2019 (17.30%) and 2020–2025 (19.90%) may reflect an approaching saturation in susceptible subpopulations, consistent with patterns observed in other countries that have entered a phase of endemic childhood obesity (Jebeile et al., 2022; Koliaki et al., 2023). Given that pre-2011 estimates relied on fewer studies and that a hybrid adjustment strategy was applied across periods, this apparent stabilization should be treated as suggestive rather than conclusive.

The 2020–2025 period coincides with the COVID-19 pandemic, and the modest increase in prevalence during this interval may partly reflect pandemic-related lifestyle changes, including reduced physical activity, increased screen time, altered dietary patterns, and family-level psychosocial stress. We speculate that these factors contributed to the observed rise, consistent with reports from other settings documenting weight gain during lockdown periods (Jebeile et al., 2022; Seda & Hasan, 2025; Alamri, 2021; Bennett et al., 2021; Cummins et al., 2024). This interpretation is tentative. The present analysis was not designed to isolate pandemic effects from underlying secular trends, and individual-level longitudinal data would be required to substantiate any causal attribution.

Subgroup analysis showed a modestly higher combined prevalence in boys (19.89%) than in girls (18.22%), with a wider gap for obesity alone (9.60% vs. 7.06%). This pattern is consistent with nationally representative data from Indonesia reporting overweight and obesity rates of 14% in adolescent boys versus 11% in girls (Niswah et al., 2021). Differences in physical activity patterns and dietary behaviors, shaped by gender norms, have been proposed as contributing factors (Fatchiya et al., 2024; Roshita et al., 2021), and secular trend analysis shows a 26.1% decline in physical activity among Indonesian youth over the past two decades (Rahmawati & Hastuti, 2021). Girls, conversely, may face societal pressure toward thinness that is associated with food-restriction behaviors, which could partially suppress measured overweight prevalence (Niswah et al., 2021; Garbett et al., 2023). These explanations are drawn from external literature and were not directly tested in this meta-analysis; they are offered as contextual interpretations rather than as findings of the present study.

Combined prevalence was highest among primary school students (18.97%) and declined consistently through junior (14.44%) and senior high school levels (12.42%), a pattern that was replicated for obesity alone. The higher prevalence in younger children may reflect early-life risk factors, including maternal obesity, excessive gestational weight gain, and infant feeding practices, which predispose children to adiposity before school entry (Jebeile et al., 2022). The lower prevalence in older adolescents may partly reflect increased body image awareness and health consciousness during puberty (Ballarin et al., 2024; Dobosz & Suligowska, 2025; Yu et al., 2023), as well as physiological changes in body composition (particularly greater adipose tissue accrual in girls and musculoskeletal mass in boys) that alter the relationship between BMI and adiposity (Rahmawati & Hastuti, 2021; Chun et al., 2024). These school-level subgroup estimates were also subject to substantial heterogeneity, which limits confident interpretation of the gradient.

### Heterogeneity, Definitions, and Validity of Pooled Estimates

Between-study heterogeneity was very high across all analytical categories, with  $I^2$  values exceeding 99% (Supplementary Materials 1–3). While conventional thresholds flag  $I^2$  values above 50–75% as problematic, this benchmark is poorly calibrated for prevalence meta-analyses. A systematic review of 134 published prevalence meta-analyses found a median  $I^2$  of 96.9% (IQR 90.5–98.7), and 76.1% of such analyses reported  $I^2$  above 90% (Migliavaca et al., 2020; Migliavaca et al., 2022). The heterogeneity observed here is therefore an expected feature of aggregating large-scale epidemiological data across diverse settings, rather than an indicator of individual study unreliability.

Three sources contribute most to this heterogeneity and have direct implications for the validity of the pooled estimates. First, studies applied different diagnostic criteria. The WHO, IOTF, and CDC references use different cut-offs and reference populations, and published analyses document that estimated prevalence can vary by several percentage points depending on which standard is applied to the same dataset. Second, study quality varied considerably: approximately half of included studies received an NOS score below 5 (unsatisfactory), and analysis by quality stratum showed that unsatisfactory-quality studies reported a combined prevalence of 29% compared to 18% in satisfactory-quality studies (Supplementary Material 1). This systematic difference is a well-recognized phenomenon in prevalence meta-analyses, attributable to convenience sampling, recruitment from higher-risk settings, and inadequate sampling frames (Migliavaca et al., 2020). Third, sample size was inversely associated with reported prevalence: small studies with fewer than 1,000 participants reported a pooled prevalence of 29%, compared to 13–15% in moderate-to-large studies. This pattern is consistent with the small-study effects detected by Peters' test and with the literature showing that smaller studies more often sample locally accessible, higher-prevalence populations. Together, these factors mean that the pooled estimate should be understood as a central tendency within a distribution, and the prediction interval of 1.96%–70.99% for the combined category quantifies this uncertainty explicitly. Taken alongside the national survey data, which indicate a lower overall prevalence of 13%, the pooled estimate of 18.13% likely reflects the overrepresentation of regional high-prevalence studies in the pool.

### Policy Implications and Future Research

The current rate of approximately one in five affected children and the projected rise to 23% by 2050 suggest a persistent pediatric obesity burden that warrants sustained public health attention. Primary school children, who showed the highest prevalence in this analysis, are a priority target group for early intervention, given that childhood obesity is associated with tracking into adulthood and with higher long-term risk of type 2 diabetes and cardiovascular disease (Jebeile et al., 2022; Sulistiadi et al., 2023). Multisectoral approaches are warranted, including the regulation of ultra-processed food marketing to children, integration of structured physical activity into school curricula, and the use of the school health clinic (Usaha Kesehatan Sekolah/UKS) as a platform for nutritional screening and early intervention. The modestly higher prevalence among boys suggests that intervention programs should attend to sex-specific behavioral patterns, though the magnitude of the difference does not support an exclusively targeted approach.

Several research priorities follow from these findings. Region-specific surveillance is needed for areas underrepresented in this analysis, particularly Kalimantan, Maluku, and Papua, where the small number of available studies precluded reliable regional estimates. Longitudinal studies tracking individual children from early school age through adolescence would allow more precise characterization of obesity persistence and its determinants. Future prevalence surveys should adopt a uniform anthropometric protocol and a single reference standard to improve comparability over time and reduce the definitional heterogeneity that currently limits interpretation. Intervention studies evaluating school-based and family-based programs under Indonesian conditions are also

required to move from characterizing the problem to testing solutions for it.

### Strengths and Limitations of the Study

This analysis drew on 152 studies spanning over three decades (1993–2025) and more than one million records across the three analytical categories. The inclusion of nationally representative surveys (Riskesdas, IFLS, SKI) alongside regional studies provided coverage that no single data source could supply. Reporting of prediction intervals alongside confidence intervals makes the uncertainty in pooled estimates explicit, which is a methodological step that is absent from many published prevalence meta-analyses. The use of ARIMA modeling combined with national demographic projections to estimate future absolute burden provides a quantitative basis for long-term policy discussions.

Several limitations must be acknowledged. The most consequential is the very high between-study heterogeneity ( $I^2 >99\%$ ), which cannot be fully resolved by statistical adjustment and which substantially widens the prediction intervals for all estimates. Variation in diagnostic criteria across studies introduces definitional inconsistency that cannot be corrected post hoc. The pool was heavily skewed toward small, local samples: 71 of 103 studies in the combined-overweight-and-obesity category had fewer than 1,000 participants, and these studies consistently reported higher prevalence estimates than larger studies, which may inflate the pooled estimate even after bias correction. Geographic representation was uneven, with the majority of studies conducted in Java and Sumatra, which means estimates for other archipelagic regions carry greater uncertainty. Finally, the ARIMA projections were built on prevalence data that are non-uniform in quality and coverage across time, and the widening confidence intervals at 2050 (6.62–39.42% for combined prevalence) reflect the compounding uncertainty of extrapolating from this base.

### CONCLUSIONS AND RECOMMENDATION

As a conclusion, this study demonstrates that nearly one in five children and adolescents in Indonesia are overweight or obese, with projections indicating a gradual increase to approximately 23% by 2050. The higher prevalence among primary school children compared to older age groups underscores the importance of early prevention efforts, while the relatively small differences by sex suggest the need for intervention approaches that are sensitive to social and behavioral contexts. The high heterogeneity across studies indicates that national estimates should be interpreted alongside substantial regional variations. If current trends continue, the rising prevalence of overweight among the younger population may increase the risk of metabolic and cardiovascular diseases in adulthood, with long-term implications for the healthcare system and productivity. Therefore, strengthened and multisectoral prevention strategies are required, particularly those focusing on early life stages and school environments. Future research should be directed toward strengthening region-based surveillance systems and evaluating sustainable and context-specific intervention models. Furthermore, addressing the immense uncertainty in current national estimates requires immediate investment in standardized longitudinal surveillance infrastructure and harmonized anthropometric reporting criteria for childhood obesity across all Indonesian regions.

### DECLARATION

#### Ethics approval and consent to participate

Not applicable. As a meta-analysis, it does not involve the use of animal or human data or tissue.

#### Consent for publication

Not applicable.

#### Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

#### Conflicts of interest Statement

The authors declare that they have no competing interests.

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#### Artificial Intelligence-Assisted Technology

During the preparation of this work, author used Google Gemini in order to assist with grammatical corrections and language refinement. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

#### Authors' contributions

The contributions of each author are as follows: AFA played a major role in designing the research, collecting data, analyzing data, and writing the manuscript. TADP contributed to data processing, performing statistical analysis, and assisting in the interpretation of results. PCDY reviewed the overall manuscript and supervised all processes from start to finish. All authors have read and approved the final version of this manuscript.

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**Azza Fithra Alhanifa** is a medical student at Universitas Udayana. His fields of study are public health and epidemiology, including the implementation of extensive meta-analyses, such as hypertension and scabies prevalence in Indonesia to participate in national-level competitions. By the time of this paper, he was developing educational health-promotion materials for his elective study, in addition to his community disease research.

**Tresna Ananda Dewi Purbasari** is a medical student at Universitas Udayana. She has a strong interest in public health, particularly in obesity research. This interest is reflected in her elective study focusing on trans-fat and obesity. Alongside her academic pursuits, she regularly volunteering for weekly health check-ups. She also bridges the gap in healthcare access by conducting community visits and medical missions in rural regions.

**Putu Cintya Denny Yuliyatni** is a lecturer and researcher in epidemiology and public health at Universitas Udayana. Her body of research focuses primarily on disease surveillance and control, with tuberculosis, HIV/AIDS, hepatitis, and COVID-19 being primary areas of research in collaboration with the Indonesian Ministry of Health and WHO country office in Indonesia. Her research expertise also includes preventive medicine, maternal-child health, immunization programs for Japanese Encephalitis and HPV, prevention of stunting in children, mental health screening, etc., in addition to health promotion activities in communities.

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## **ADDITIONAL INFORMATION**

**Correspondence** All inquiries and requests for additional materials should be directed to the Corresponding Author.

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## APPENDICES

## Supplementary Material 1

## Study characteristics of combined overweight and obesity.

Characteristics	Study count	Cases sample / Total	Combined prevalence, decimal (95% CI)	Heterogeneity (I <sup>2</sup> )	Between-group <i>p</i>
<b>Overall Prevalence</b>	103	183,016 / 1,020,709	0.23 [0.20; 0.27]	99.6%	-
<b>By Gender</b>					
Male	47	50,547 / 273,333	0.16 [0.12; 0.20]	99.5%	0.712
Female	52	45,306 / 263,161	0.15 [0.12; 0.19]	99.2%	
<b>By School Level/Age Group</b>					
Primary	42	101,610 / 516,842	0.22 [0.18; 0.28]	99.6%	0.881
Middle/Junior	24	25,684 / 178,710	0.23 [0.15; 0.33]	99.2%	
High/Senior	36	17,454 / 154,458	0.24 [0.18; 0.30]	99%	
<b>Based on Geographical Region</b>					
National	28	176,263 / 991,348	0.13 [0.09; 0.17]	99.9%	< .001
West Java	16	1,411 / 4,905	0.31 [0.21; 0.44]	96.4%	
Central Java	16	2,481 / 13,910	0.21 [0.16; 0.29]	97.8%	
East Java and Lesser Sunda Islands	19	984 / 3,502	0.30 [0.20; 0.42]	93.9%	
Sumatra	12	590 / 1,761	0.34 [0.23; 0.46]	92%	
Eastern Indonesia Regions	12	1,049 / 5,283	0.27 [0.19; 0.37]	95.8%	
<b>Based on Conducted Year</b>					
1993 – 2000	11	1,976 / 32,231	0.06 [0.05; 0.08]	96.5%	< .001
2001 – 2010	9	39,520 / 188,029	0.16 [0.08; 0.28]	99.1%	
2011 – 2019	60	104,962 / 604,681	0.25 [0.21; 0.29]	99.7%	
2020 – 2025	23	35,490 / 195,768	0.36 [0.29; 0.44]	98.9%	
<b>Based on Sample Size</b>					
Small (<1000)	71	3,939 / 14,788	0.29 [0.25; 0.34]	94.6%	< .001
Moderate (1000–9999)	22	12,572 / 70,190	0.13 [0.08; 0.18]	99.8%	
Big (≥10000)	10	166,261 / 935,731	0.15 [0.12; 0.19]	99.9%	
<b>Based on Study Quality</b>					
Unsatisfactory (NOS < 5)	51	3,415 / 13,749	0.29 [0.24; 0.35]	95.3%	< .001
Satisfactory (NOS ≥ 5)	52	179,333 / 1,006,960	0.18 [0.14; 0.22]	99.8%	

Notes. CI = Confidence Interval; NOS = Newcastle-Ottawa Scale. The *p*-value indicates the significance of the difference between subgroups (Q test).

**Supplementary Material 2****Study characteristics of obesity only.**

Characteristics	Study count	Cases / Total sample	Combined prevalence, decimal (95% CI)	Heterogeneity (I <sup>2</sup> )	Between-group <i>p</i>
<b>Overall Prevalence</b>	117	77,076 / 1,093,936	0.11 [0.09; 0.13]	99.6%	-
<b>By Gender</b>					
Male	47	26,725 / 275,959	0.09 [0.06; 0.13]	99.5%	0.171
Female	49	16,423 / 265,960	0.06 [0.04; 0.09]	99.4%	
<b>By School Level/Age Group</b>					
Primary	51	57,283 / 551,650	0.15 [0.11; 0.19]	99.6%	0.030
Middle/Junior	26	9,701 / 203,183	0.08 [0.05; 0.14]	99.2%	
High/Senior	38	5,186 / 168,404	0.09 [0.06; 0.12]	98.8%	
<b>Based on Conducted Year</b>					
1993 – 2000	10	504 / 30,864	0.01 [0.01; 0.02]	87.8%	< .001
2001 – 2010	13	19,407 / 257,987	0.06 [0.03; 0.11]	99.1%	
2011 – 2019	74	44,182 / 609,458	0.14 [0.11; 0.17]	99.6%	
2020 – 2025	20	12,922 / 195,627	0.18 [0.12; 0.27]	99.3%	
<b>Based on Sample Size</b>					
Small (<1000)	78	2,506 / 15,469	0.16 [0.13; 0.20]	95%	< .001
Moderate (1000–9999)	26	7,504 / 82,432	0.05 [0.03; 0.08]	99.7%	
Big (≥10000)	13	67,065 / 996,035	0.04 [0.03; 0.06]	99.9%	
<b>Based on Study Quality</b>					
Unsatisfactory (NOS < 5)	58	2,490 / 17,046	0.17 [0.14; 0.21]	96.1%	< .001
Satisfactory (NOS ≥ 5)	59	74,585 / 1,093,936	0.11 [0.09; 0.13]	99.7%	

Notes. CI = Confidence Interval; NOS = Newcastle-Ottawa Scale. The *p*-value indicates the significance of the difference between subgroups (Q test).

## Supplementary Material 3

## Study characteristics of overweight only.

Characteristics	Study count	Cases/Total sample	Combined prevalence, decimal (95% CI)	Heterogeneity (I <sup>2</sup> )	Between-group <i>p</i>
<b>Overall Prevalence</b>	72	109,774 / 1,010,260	0.11 [0.10; 0.13]	99.0%	-
<b>By Gender</b>					
Male	33	27,696 / 271,022	0.07 [0.05; 0.09]	98.3%	0.166
Female	36	28,873 / 260,246	0.09 [0.07; 0.11]	97.6%	
<b>By School Level/Age Group</b>					
Primary	28	55,798 / 511,430	0.10 [0.08; 0.14]	98.6%	0.551
Middle/Junior	19	18,322 / 177,416	0.13 [0.09; 0.18]	98.7%	
High/Senior	24	11,824 / 150,715	0.11 [0.08; 0.15]	98.2%	
<b>Based on Conducted Year</b>					
1993 – 2000	10	1,246 / 30,864	0.04 [0.04; 0.13]	77.5%	< .001
2001 – 2010	8	25,112 / 187,946	0.09 [0.07; 0.11]	98.7%	
2011 – 2019	38	60,893 / 596,196	0.14 [0.11; 0.17]	98.9%	
2020 – 2025	16	22,523 / 195,254	0.16 [0.12; 0.21]	97%	
<b>Based on Sample Size</b>					
Small (<1000)	42	1,248 / 8,279	0.15 [0.12; 0.18]	91%	< .001
Moderate (1000–9999)	20	5,635 / 66,250	0.07 [0.05; 0.10]	99.3%	
Big (≥10000)	10	102,891 / 935,731	0.10 [0.08; 0.12]	99.8%	
<b>Based on Study Quality</b>					
Unsatisfactory (NOS < 5)	27	1,332 / 9,903	0.15 [0.12; 0.20]	94.5%	0.003
Satisfactory (NOS ≥ 5)	45	108,442 / 1,000,357	0.09 [0.08; 0.11]	99.3%	

Notes. CI = Confidence Interval; NOS = Newcastle-Ottawa Scale. The *p*-value indicates the significance of the difference between subgroups (Q test).

## Supplementary Material 4

## Trim-and-fill results for combined overweight–obesity studies and obesity-only studies.

Characteristics	Number of studies, (+ imputation)	Pooled proportion, decimal (95% CI)	Prediction interval, decimal [95% PI]	Heterogeneity (I <sup>2</sup> )
<b>Overweight and Obesity</b>	120, (16)	0.1813 [0.1502; 0.2171]	[0.0196; 0.7099]	99.7%
<b>Gender</b>				
Male	56, (8)	0.1989 [0.1513; 0.2569]	[0.0219; 0.7332]	99.5%
Female	61, (8)	0.1822 [0.1470; 0.2237]	[0.0319; 0.6008]	99.2%
<b>Education Level/Age Group</b>				
Primary	47, (5)	0.1897 [0.1448; 0.2445]	[0.0260; 0.6722]	99.8%
Middle/Junior	31, (6)	0.1444 [0.0834; 0.2382]	[0.0059; 0.8268]	99.4%
High/Senior	51, (15)	0.1242 [0.0846; 0.1787]	[0.0068; 0.7455]	99.0%
<b>Conducted Year</b>				
1993 – 2000*	15, (4)	0.0726 [0.0569; 0.0923]	[0.0283; 0.1741]	96.7%
2001 – 2010*	11, (2)	0.2079 [0.0996; 0.3838]	[0.0188; 0.7822]	99.2%
2011 – 2019	78, (17)	0.1730 [0.1370; 0.2162]	[0.0194; 0.6893]	99.7%
2020 – 2025	35, (12)	0.1990 [0.1350; 0.2834]	[0.0162; 0.7890]	98.8%
<b>Obesity Only</b>	139, (22)	0.0749 [0.0589; 0.0947]	[0.0040; 0.6174]	99.7%
<b>Gender</b>				
Male	48, (2)	0.0960 [0.0637; 0.1420]	[0.0051; 0.6860]	99.5%
Female	51, (2)	0.0706 [0.0477; 0.1035]	[0.0044; 0.5680]	99.3%
<b>Education Level/Age Group</b>				
Primary	66, (15)	0.0903 [0.0644; 0.1254]	[0.0052; 0.6548]	99.7%
Middle/Junior	32, (6)	0.0450 [0.0233; 0.0851]	[0.0010; 0.6829]	99.4%
High/Senior	54, (15)	0.0373 [0.0229; 0.0601]	[0.0010; 0.5990]	99.0%
<b>Conducted Year</b>				
1993 – 2000*	15, (5)	0.0199 [0.0133; 0.0295]	[0.0046; 0.0815]	91.3%
2001 – 2010*	15, (2)	0.0793 [0.0421; 0.1443]	[0.0065; 0.5311]	99.4%
2011 – 2019	98, (24)	0.0772 [0.0585; 0.1011]	[0.0046; 0.6040]	99.7%
2020 – 2025	29, (9)	0.0785 [0.0421; 0.1417]	[0.0025; 0.7439]	99.2%

Notes. CI = Confidence Interval; NOS = Newcastle-Ottawa Scale. The *p*-value indicates the significance of the difference between subgroups (Q test).

\*Trim-and-fill results who were deemed inadequate due to the insufficient number of statistically unstable studies.

**Supplementary Material 5**  
**Individual characteristics study.**

Author	Year	Study Region	Study Design	Sample Size	Age Range	School Level	NOS
Frankenberg, E. & L. Karoly	1993	Indonesia (National)	Cross-sectional study	439	16-19 years	High/Senior	9
Frankenberg, E. & L. Karoly	1993	Indonesia (National)	Cross-sectional study	1,130	13-15 years	Middle/Junior	9
Frankenberg, E. & L. Karoly	1993	Indonesia (National)	Cross-sectional study	5,009	5-12 years	Primary	9
Frankenberg, E. & D. Thomas.	1997	Indonesia (National)	Cross-sectional study	2,286	13-15 years	Middle/Junior	9
Frankenberg, E. & D. Thomas.	1997	Indonesia (National)	Cross-sectional study	2,433	16-19 years	High/Senior	9
Frankenberg, E. & D. Thomas.	1997	Indonesia (National)	Cross-sectional study	5,269	5-12 years	Primary	9
Strauss, J. et al.	2000	Indonesia (National)	Cross-sectional study	2,218	13-15 years	Middle/Junior	9
Strauss, J. et al.	2000	Indonesia (National)	Cross-sectional study	3,251	16-19 years	High/Senior	9
Strauss, J. et al.	2000	Indonesia (National)	Cross-sectional study	5,819	5-12 years	Primary	9
Soekirman, et al.	2002	West Jakarta (Jakarta) and Bogor (West Java)	Cross-sectional study	1,367	8-10 years	Primary	8
Julia, et al.	2004	Yogyakarta City and Gunung Kidul, Yogyakarta	Cross-sectional study	3,010	6.0-8.9 years	Primary	7
Mahdiah, et al.	2004	Yogyakarta City and Bantul Regency, Yogyakarta	Cross-sectional study	9,349	10-15 years	Middle/Junior	7
Huriyati, E.	2006	Yogyakarta	Cross-sectional study	4,747	N/R	Middle/Junior	3
Ariani, et al.	2007	Medan, North Sumatra	Cross-sectional study	400	6-12 years	Primary	3
Ministry of Health, Republic of Indonesia	2007	Indonesia (National)	Cross-sectional study	170,699	5-15 years	Primary/Middle/Junior	7
Strauss, J. et al.	2007	Indonesia (National)	Cross-sectional study	2,116	13-15 years	Middle/Junior	9
Strauss, J. et al.	2007	Indonesia (National)	Cross-sectional study	2,666	16-19 years	High/Senior	9
Strauss, J. et al.	2007	Indonesia (National)	Cross-sectional study	6,732	5-12 years	Primary	9
Julia, et al.	2008	Yogyakarta	Cross-sectional study	510	6-8 years	Primary	8
Ministry of Health, Republic of Indonesia	2010	Indonesia (National)	Cross-sectional study	12,016	16-18 years	High/Senior	9
Ministry of Health, Republic of Indonesia	2010	Indonesia (National)	Cross-sectional study	13,657	13-15 years	Middle/Junior	9
Ministry of Health, Republic of Indonesia	2010	Indonesia (National)	Cross-sectional study	34,631	6-12 years	Primary	9
Aninditya, I. K.	2011	Semarang, Central Java	Cross-sectional study	143	9-12 years	Primary	4
Banowati, L., et al	2011	Cirebon, West Java	Cross-sectional study	76	N/R	High/Senior	6
Cintari, et al.	2011	Denpasar, Bali	Cross-sectional study	388	N/R	Primary	4
Cahyani & Sidiartha	2012	Bangli, Bali	Cross-sectional study	217	14-17 years	High/Senior	2
Fatta, L. A., et al	2012	Semarang, Central Java	Cross-sectional study	1,186	12-14 years	Middle/Junior	4
Febriyani	2013	Pontianak, West Kalimantan	Cross-sectional study	56	14-17 years	High/Senior	4
Hayuningtyas & Fitrianti	2013	Semarang, Central Java	Cross-sectional study	1,146	6-13 years	Primary	6
Khodijah, et al.	2013	South Jakarta, Jakarta	Cross-sectional study	202	~13.62 years	Middle/Junior	5
Ministry of Health, Republic of Indonesia	2013	Indonesia (National)	Cross-sectional study	53,195	16-18 years	High/Senior	9
Ministry of Health, Republic of Indonesia	2013	Indonesia (National)	Cross-sectional study	63,353	13-15 years	Middle/Junior	9
Ministry of Health, Republic of Indonesia	2013	Indonesia (National)	Cross-sectional study	178,924	5-12 years	Primary	9

Sandjaja, et al.	2013	Indonesia (National)	Cross-sectional study	2,772	5-12 years	Primary	9
Saputri, R.	2013	Yogyakarta	Cross-sectional study	79	12-15 years	Middle/Junior	3
Widyaningtyas & Kartini	2013	Semarang, Central Java	Cross-sectional study	71	15-17 years	High/Senior	4
Agusanty, et al.	2014	Pontianak, West Kalimantan	Cross-sectional study	2,573	16-18 years	High/Senior	7
Bidjuni, et al.	2014	Manado, North Sulawesi	Cross-sectional study	394	8-10 years	Primary	4
Chandra, et al.	2014	Manado, North Sulawesi	Cross-sectional study	100	13-18 years	High/Senior	3
Hartini, K., et al.	2014	Denpasar, Bali	Cross-sectional study	1,305	6-13 years	Primary	5
Indartanti & Kartini	2014	Semarang, Central Java	Cross-sectional study	90	12-14 years	Middle/Junior	5
Octari, et al.	2014	Padang, West Sumatra	Cross-sectional study	195	6-11 years	Primary	2
Pramono, et al.	2014	Semarang, Central Java	Cross-sectional study	1,040	12-15 years	Middle/Junior	5
Puspita, et al.	2014	Pontianak, West Kalimantan	Cross-sectional study	474	6-12 years	Primary	3
Putri, et al.	2014	Surabaya, East Java	Cross-sectional study	80	N/R	High/Senior	3
Strauss, J. et al.	2014	Indonesia (National)	Cross-sectional study	2,444	13-15 years	Middle/Junior	9
Strauss, J. et al.	2014	Indonesia (National)	Cross-sectional study	2,517	16-19 years	High/Senior	9
Strauss, J. et al.	2014	Indonesia (National)	Cross-sectional study	7,325	5-12 years	Primary	9
Tolombot, et al.	2014	Manado, North Sulawesi	Cross-sectional study	100	13-18 years	Middle/Junior	3
Tuerah, et al.	2014	Bitung, North Sulawesi	Cross-sectional study	137	13-18 years	High/Senior	3
Yaqin, et al.	2014	Surabaya, East Java	Cross-sectional study	503	N/R	Primary	3
Hadi, et al.	2015	Padang, West Sumatra	Cross-sectional study	93	6-12 years	Primary	3
Loliana, et al.	2015	Surabaya, East Java	Cross-sectional study	674	~16 years	High/Senior	4
Rafiony, et al.	2015	Pontianak, West Kalimantan	Cross-sectional study	861	15-18 years	High/Senior	6
Seprianty, et al.	2015	Musi Banyuasin, South Sumatra	Cross-sectional study	122	7-10 years	Primary	2
Setyoadi, et al.	2015	Tulungagung, East Java	Cross-sectional study	114	9-11 years	Primary	3
Wijaya & Sidiartha	2015	Denpasar, Bali	Cross-sectional study	128	6-8 years	Primary	6
Akhriani, et al.	2016	Bandung, West Java	Cross-sectional study	100	12-14 years	Middle/Junior	2
Lisnawati, et al.	2016	Palu, Central Sulawesi	Cross-sectional study	77	15-18 years	High/Senior	4
Mokolensang, et al.	2016	Bitung, North Sulawesi	Cross-sectional study	83	14-17 years	High/Senior	7
Susanti, et al.	2016	Yogyakarta	Cross-sectional study	96	15-18 years	High/Senior	2
Utami & Dieny	2016	Semarang, Central Java	Cross-sectional study	516	15-18 years	High/Senior	3
Zamzani, et al.	2016	Bantul, Yogyakarta	Cross-sectional study	96	9-14 years	Primary	4
Ambariyati, Y. L., Kristianingsih, Y. Ardiana	2017	Surabaya, East Java	Cross-sectional study	70	14-16 years	Middle/Junior	3
Astuti	2017	Sleman, Yogyakarta	Cross-sectional study	74	6-7 years	Primary	2
Astuti	2017	Yogyakarta	Cross-sectional study	78	13-14 years	Middle/Junior	3
Mandriyarini, et al.	2017	Semarang, Central Java	Cross-sectional study	2,299	14-18 years	High/Senior	5
Nisak, et al.	2017	Surabaya, East Java	Cross-sectional study	322	8-12 years	Primary	3
Pratiwi, N. A.	2017	Makassar, South Sulawesi	Cross-sectional study	679	12-15 years	Middle/Junior	3
Puspasari, et al.	2017	Semarang, Central Java	Cross-sectional study	602	9-12 years	Primary	3
Putra, W. N.	2017	Surabaya, East Java	Repeated cross-sectional study	157	N/R	High/Senior	3
Saidah, F., et al.	2017	Semarang, Central Java	Cross-sectional study	99	15-17 years	High/Senior	3
Sari, et al.	2017	Pekanbaru, Riau	Cross-sectional study	279	11-13 years	Middle/Junior	3
Sekiyama, et al.	2017	Sukajadi, West Java	Repeated cross-sectional study	83	9-10 years	Primary	3
Sekiyama, et al.	2017	Sukajadi, West Java	Cross-sectional study	165	9-10 years	Primary	3
Septiani, et al.	2017	Brebes Regency, Central Java	Cross-sectional study	284	9-11 years	Primary	2

Suryani, et al.	2017	Mataram, West Nusa Tenggara	Cross-sectional study	105	10-12 years	Primary	2
Suto, P. K.	2017	Padang, West Sumatra	Cross-sectional study	110	9-12 years	Primary	3
Adriyanto, et al.	2018	Denpasar, Bali	Cross-sectional study	614	N/R	Primary	3
Agita, et al.	2018	Semarang, Central Java	Cross-sectional study	288	15-18 years	High/Senior	4
Aprilliana, et al.	2018	Yogyakarta	Cross-sectional study	360	5-12 years	Primary	5
Armi, M. W. P., & Dwipayana, I. M. P.	2018	Gianyar, Bali	Cross-sectional study	269	14-18 years	High/Senior	5
Astuti, G. A. K. R. W.	2018	Denpasar, Bali	Cross-sectional study	59	12-17 years	Middle/Junior	3
Estiani, K., & Nindya, T. S.	2018	Surabaya, East Java	Cross-sectional study	99	N/R	High/Senior	4
Ferinawati, et al.	2018	Bireuen Regency, Aceh	Cross-sectional study	608	15-18 years	High/Senior	5
Hambali & Karjadidjaja	2018	West Jakarta, Jakarta	Cross-sectional study	89	8-10 years	Primary	4
Kurniawati, P., & Fayasari, A.	2018	Depok, West Java	Cross-sectional study	140	9-12 years	Primary	3
Lestari, M., & Nurhayati, F.	2018	Surabaya, East Java	Cross-sectional study	83	16-18 years	High/Senior	2
Ministry of Health, Republic of Indonesia	2018	Indonesia (National)	Cross-sectional study	51,826	16-18 years	High/Senior	9
Ministry of Health, Republic of Indonesia	2018	Indonesia (National)	Cross-sectional study	60,020	13-15 years	Middle/Junior	9
Ministry of Health, Republic of Indonesia	2018	Indonesia (National)	Cross-sectional study	165,682	5-12 years	Primary	9
Mukhlisa, et al.	2018	Jakarta	Cross-sectional study	120	16-18 years	High/Senior	4
Prima, et al.	2018	Banda Aceh, Aceh	Cross-sectional study	175	15-18 years	High/Senior	3
Rahmani, N. Y., et al	2018	Semarang, Central Java	Cross-sectional study	1,686	6-11 years	Primary	5
Sugiatmi, & Handayani, D. R.	2018	Tangerang Selatan, Banten	Cross-sectional study	131	15-18 years	High/Senior	5
Yulianti, et al.	2018	Mojokerto Regency, East Java	Cross-sectional study	53	12-15 years	Middle/Junior	3
Indrapermana & Pratiwi	2019	Denpasar, Bali	Cross-sectional study	130	N/R	Primary	6
Ishak, et al.	2019	Makassar, South Sulawesi	Cross-sectional study	146	N/R	Primary	3
Maesarah, et al.	2019	Gorontalo	Cross-sectional study	238	9-12 years	Primary	4
Maritasari & Resmiati	2019	Central Jakarta, Jakarta	Cross-sectional study	128	N/R	High/Senior	7
Novalina, R., et al.	2019	Kampar, Riau	Cross-sectional study	191	6-12 years	Primary	5
Nugrahaini, et al.	2019	Kediri, East Java	Cross-sectional study	178	15-18 years	High/Senior	6
Oktavia, S. N.	2019	Padang, West Sumatra	Cross-sectional study	82	15-18 years	High/Senior	5
Pradnyandari, et al.	2019	Denpasar, Bali	Cross-sectional study	319	8-12 years	Primary	4
Pratiwi, N. W. R.	2019	Tabanan, Bali	Cross-sectional study	67	9-12 years	Primary	3
Saputri, et al.	2019	Salatiga, Central Java	Cross-sectional study	60	N/R	Primary	3
Setiawati, et al.	2019	Surabaya, East Java	Cross-sectional study	133	15-17 years	High/Senior	4
Suryamulyawan & Arimbawa	2019	Denpasar, Bali	Cross-sectional study	1,003	N/R	Primary	2
Wijayanto, et al.	2019	Semarang, Central Java	Cross-sectional study	310	13-14 years	Middle/Junior	7
Wintariasih, et al.	2019	Gianyar, Bali	Cross-sectional study	94	9-12 years	Primary	3
Adinda, et al.	2020	Medan, North Sumatra	Cross-sectional study	309	N/R	Primary	3
Ekawaty, et al.	2020	Jambi, Jambi	Cross-sectional study	62	N/R	Primary	2
Firdaus, A., Mantu, M. R.	2020	Central Jakarta, Jakarta	Cross-sectional study	103	6-12 years	Primary	4
Santoso, et al.	2020	Semarang, Central Java	Cross-sectional study	514	12-15 years	Middle/Junior	7
Telisa, et al.	2020	Palembang, South Sumatra	Cross-sectional study	118	14-17 years	High/Senior	5
Triana, et al.	2020	Badung Regency, Bali	Cross-sectional study	96	10-12 years	Primary	3

Wulansari, et al.	2020	Gianyar, Bali	Cross-sectional study	83	13-15 years	Middle/Junior	3
Luwito, J., & Santoso, A. H.	2021	West Jakarta, Jakarta	Cross-sectional study	224	15-19 years	High/Senior	3
Niswah, et al.	2021	Indonesia (National)	Cross-sectional study	2,144	12-18 years	Middle/Junior & High/Senior	9
Wahyuni, et al.	2021	Makassar, South Sulawesi	Cross-sectional study	954	9.34 years	Primary	8
Amrynia, S. U., & Prameswari, G. N.	2022	Demak, Central Java	Cross-sectional study	99	16-18 years	High/Senior	7
Ariansyah, N. A.	2022	Makassar, South Sulawesi	Cross-sectional study	192	N/R	Middle/Junior	5
Aryandi, R.	2022	Jambi City, Jambi	Cross-sectional study	197	6-12 years	Primary	4
Aurora, H.P.	2022	Jambi, Jambi	Cross-sectional study	92	9-12 years	Primary	4
Langi, J. R.	2022	Makassar, South Sulawesi	Cross-sectional study	192	13-15 years	Middle/Junior	3
Nurazizah, Y. I., et al.	2022	West Lampung, Lampung	Cross-sectional study	132	15-18 years	High/Senior	8
Octoviani & Aprilla	2022	Bangkinang, Kampar, Riau	Cross-sectional study	192	N/R	Primary	4
Pusparani, N.E.	2022	Surakarta, Central Java	Cross-sectional study	85	15-17 years	High/Senior	3
Rahmadani, et al.	2022	Bengkulu, Bengkulu	Cross-sectional study	52	N/R	Primary	3
Saragi, M. C. S.	2022	Makassar, South Sulawesi	Cross-sectional study	78	N/R	Primary	3
Sarintohe, et al.	2022	Indonesia (National)	Cross-sectional study	411	11.0-14.1 years	Middle/Junior	5
Sucipto & Santoso	2022	North Jakarta, Jakarta	Cross-sectional study	74	16-18 years	High/Senior	5
Syah, M. N. H.	2022	Bekasi, West Java	Cross-sectional study	328	15-17 years	High/Senior	4
Andrini, et al.	2023	Jambi City, Jambi	Cross-sectional study	79	N/R	High/Senior	3
Apinda, N., et al.	2023	Jambi City, Jambi	Cross-sectional study	68	12-14 years	Middle/Junior	3
Bokau, M. S., et al.	2023	Minahasa, North Sulawesi	Cross-sectional study	84	8-11 years	Primary	2
Dewi, et al.	2023	Kampar, Riau	Cross-sectional study	52	16-18 years	High/Senior	5
Djalilah, et al.	2023	Gresik, East Java	Cross-sectional study	70	10-12 years	Primary	5
Irianti, D. & Navisa, Z.	2023	Banjar, South Kalimantan	Cross-sectional study	72	9-12 years	Primary	4
Mecheva, et al.	2023	Central Jakarta, Jakarta	Cross-sectional study	1,674	6-13 years	Primary	7
Ministry of Health, Republic of Indonesia	2023	Indonesia (National)	Cross-sectional study	31,825	16-18 years	High/Senior	9
Ministry of Health, Republic of Indonesia	2023	Indonesia (National)	Cross-sectional study	37,484	13-15 years	Middle/Junior	9
Ministry of Health, Republic of Indonesia	2023	Indonesia (National)	Cross-sectional study	122,723	5-12 years	Primary	9
Paramitha, K. S. D.	2023	South Denpasar, Bali	Cross-sectional study	80	13-15 years	Middle/Junior	4
Adimuntja, N. P.	2024	Jayapura, Papua	Cross-sectional study	100	15-19 years	High/Senior	3
Nugraha, et al.	2024	Jakarta	Cross-sectional study	70	15-18 years	High/Senior	3
Wirawan, et al.	2024	Negara, Bali	Cross-sectional study	88	15-17 years	High/Senior	4
Arroyyan, et al.	2025	Central Jakarta, Jakarta	Cross-sectional study	91	9-13 years	Primary	3
Kekalih, et al.	2025	Indonesia (National)	Cross-sectional study	780	7-12.9 years	Primary	9
Maulidina, et al.	2025	Makassar, South Sulawesi	Cross-sectional study	130	15-18 years	High/Senior	4
Mentemas, I. S., et al.	2025	Yogyakarta	Cross-sectional study	84	15-18 years	High/Senior	3
Siraz, N. A., et al.	2025	Bogor, West Java	Cross-sectional study	114	16-18 years	High/Senior	5

Notes. NOS = Newcastle-Ottawa Scale. N/R = Not Reported.