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Systematic Review Article

Global Childhood Obesity and Metabolic Syndrome: Prevalence, Risk Factors, and Meta-Analytic Evidence

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Abstract

Background: Childhood obesity and metabolic syndrome are fast becoming major health challenges worldwide, although the estimates of prevalence rates vary largely due to the varying definitions, populations, and methodologies. Synthesizing contemporary evidence is essential for understanding the true magnitude and epidemiological pattern of these conditions. ***Aim and Objective:*** The objective was to answer the research question: "What is the pooled prevalence of childhood obesity and metabolic syndrome globally between 2021 and 2025, and what epidemiological patterns, risk factors, and clinical implications emerge from the recent evidence?" ***Methods:*** A systematic search of PubMed, Scopus, Embase, and Web of Science was conducted from 2021 to 2025 using predefined keywords. Ten studies entered qualitative synthesis, while five with extractable proportions entered meta-analysis. Data extraction was performed using Microsoft Excel (version 16), while statistical analyses were carried out in RStudio, including random-effects pooling, funnel plot asymmetry tests, and linear regression. Quality assessment was done using the AMSTAR-2, NOS, and JBI tools. ***Results:*** The pooled prevalence from five studies was 9.2% (95% CI 7.1–11.3) with extreme heterogeneity ($I^2 \approx 99.99\%$, $p < 0.001$). Funnel plot asymmetry tests, including Egger's test ($p > 0.05$), indicated no significant publication bias. Epidemiological patterns from the studies showed rising obesity trends and a MetS prevalence of 3–5%, consistent with associations to lifestyle-linked risk factors. ***Conclusion:*** Childhood obesity is still a significant and growing global burden, while MetS affects a smaller but clinically important subset. Heterogeneity emphasizes the need for standardized definitions and stratified risk assessment. Integrated preventive strategies and enhanced surveillance systems are urgently needed.

Keywords: ***childhood obesity, metabolic syndrome, prevalence, meta-analysis, epidemiology, global trends***

Introduction

Childhood obesity, overweight, and MetS have become major public health priorities, resulting from a combination of rapid lifestyle transitions, urbanization, and changing nutritional environments. Over the last twenty years, the rise in pediatric adiposity has been documented across diverse geographic and socioeconomic contexts, reflecting an early onset of traditionally adult-like cardiometabolic risk. Excess weight in childhood is associated with insulin resistance, dyslipidaemia, hypertension, and systemic inflammation, and these abnormalities tend to track strongly into later life, thereby predisposing affected individuals to type 2 diabetes, cardiovascular disease, and premature mortality. Substantial psychosocial, behavioral, and developmental consequences have also emerged beyond physiological effects, thus further intensifying the clinical burden and long-term societal cost. Persistence of childhood obesity into adulthood accentuates these issues, further providing a trajectory of chronic disease burden through peak productive years (Chung *et al*., 2018). Therefore, an early identification and reduction of cardiometabolic risk factors is indicated in childhood, especially since the early stages of cardiovascular damage are still widely reversible at this age (Drożdż *et al*., 2021).

Although the worldwide burden of obesity and MetS in childhood has been extensively studied, there is still substantial heterogeneity between studies related to differences in diagnostic criteria, age stratification, sampling frames, and regional epidemiologic transitions. Many reports collate national or regional data without providing pooled estimates comparable across continents. Moreover, several analyses consider behavioural and environmental risk factors in isolation rather than integrated into a broader model of early cardiometabolic clustering. Important subgroups-children with chronic diseases like type 1 diabetes-have also been considered inconsistently despite their increased vulnerability. Hence, evidence to date remains rather patchy, with critical uncertainties about the true size of the problem, its demographic drivers, and the generalizability of risk patterns across diverse pediatric populations. This underlines the pressing requirement for comprehensive, systematically reviewed data on which to base targeted public health initiatives, particularly in regions where the prevalence of cardiometabolic risk factors is poorly characterized (Singleton *et al*., 2023).

To address these gaps, this systematic review and meta-analysis aimed to quantify the prevalence of obesity, overweight, and metabolic syndrome in children and adolescents; synthesize the

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various epidemiological and behavioral risk patterns; and examine the clinical implications across global contexts. By consolidating recent, high-quality evidence, the current review intends to answer the key research question: What is the contemporary prevalence and distribution of pediatric obesity, overweight, and metabolic syndrome, and what are the major epidemiologic factors influencing these patterns across different populations?

Methodology

Search Strategy

A systematic search was carried out across PubMed, Scopus, Embase, and Web of Science for articles published in the period 2021-2025. A uniform combination of controlled vocabulary terms and free-text keywords was used in a search across all databases. In making this core search string, terms relating to pediatric populations and excess adiposity were used:

("child" OR "adolescence" OR "youth") AND ("obesity" OR "overweight" OR "excess weight" OR "body mass index" OR "metabolic syndrome") AND ("prevalence" OR "epidemiology")

The searches employed the use of Boolean operators and enhancement of indexing by database, such as MeSH. Studies had to be peer-reviewed and full-text. Reference lists were manually checked for completeness.

PRISMA 2020 guidelines were followed for the selection of studies for systematic review and meta-analysis (**Figure 1**).

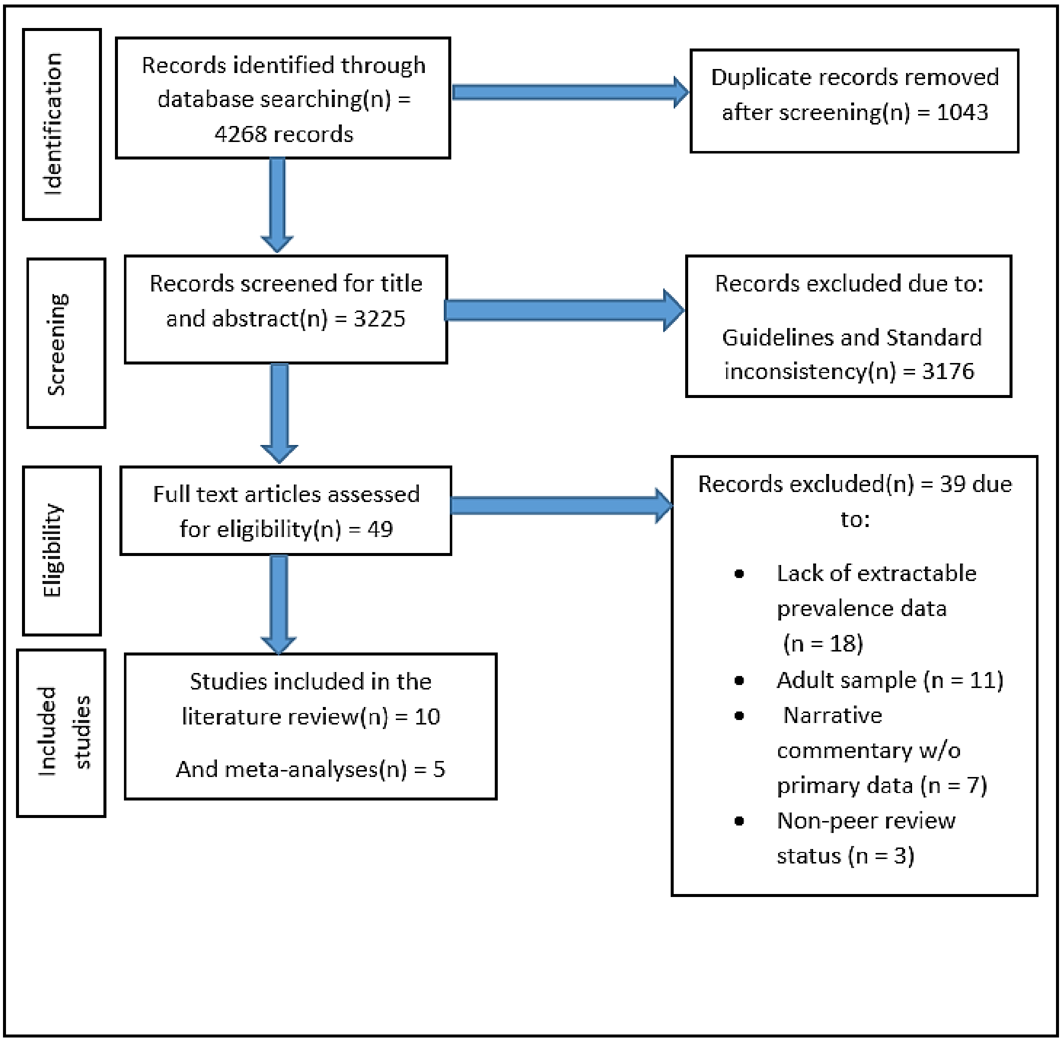


Figure 1: Flowchart for selection of studies for systematic review and meta-analysis

Study design

Systematic review and meta-analysis

Study period

Studies published from 2021 to 2025 were searched.

Inclusion Criteria

- Peer-reviewed full-text articles, 2021–2025.
- Children or adolescents ≤19 years.
- Reported prevalence of obesity, overweight or metabolic syndrome.
- Observational studies (cross-sectional, cohort, case-control), as well as national datasets or systematic reviews/meta-analyses.
- Studies reporting extractable prevalence data for systematic review; studies reporting sample size + effect proportion included in meta-analysis.

Exclusion Criteria

- Adult-only samples.
- Trials of intervention without baseline prevalence data.

Abstracts, conference proceedings, letters or commentaries.

- Studies that do not have extractable numerical data.

Data Extraction

Data were extracted into Microsoft Excel (version 16) by two independent reviewers (S and P) for the following items: study characteristics, sample description, prevalence values, and statistical outputs. Any disagreements were resolved by consensus. RStudio version 2024.04.0 was employed for meta-analytic computations, forest and funnel plots, and regression analyses.

Quality Assessment
Study quality was assessed independently using appropriate validated tools:

- AMSTAR-2 for systematic reviews/meta-analyses
- Newcastle–Ottawa Scale (NOS) for observational studies
- JBI Critical Appraisal Checklist for Prevalence Studies for prevalence-only and narrative epidemiological sources

Quality-assessment outputs were tabulated into traffic-light matrices (High = green; Moderate = yellow; Low = red) to enable instant visual assessment of the methodological quality of evidence included in this work (**Figure 2a**)

Quality assessment tables were prepared for all tools separately: AMSTAR-2, NOS and JBI. These were used to develop traffic-light visualisations (**Table 1 a, b and c**). The overall risk of bias was then depicted in a figure (**Figure 2 b**).

Table 1 a): AMSTAR-2 Quality Assessment

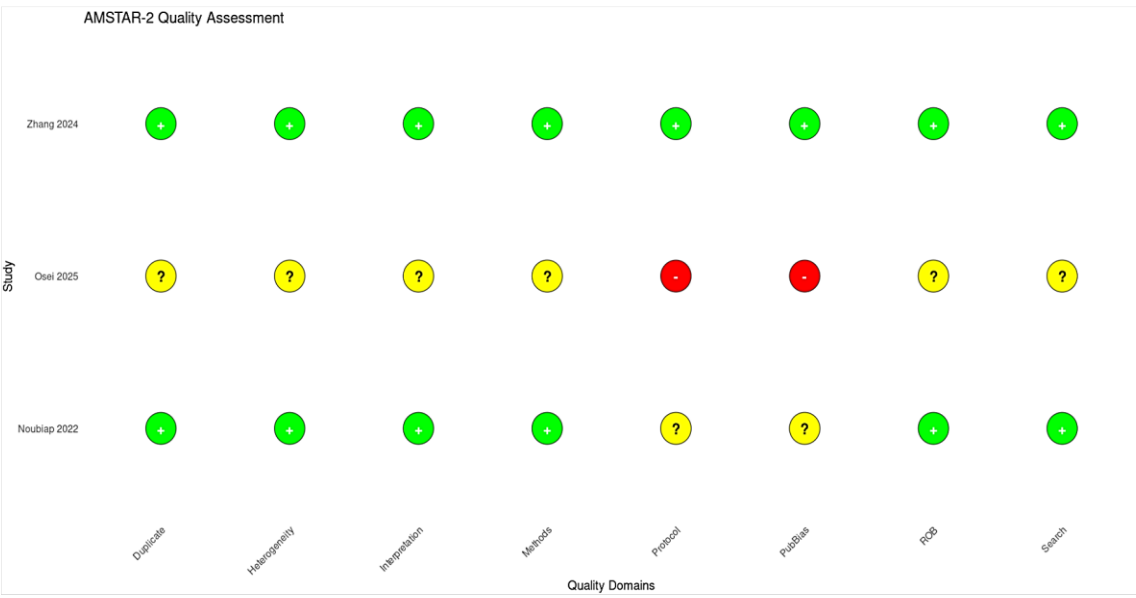
Study	Protocol Registered	Search Quality	Duplicate Processes	ROB of Included Studies	Meta-analytic Methods	Publication Bias	Interpretation	Heterogeneity Handling	Overall
Zhang 2024	High	High	High	High	High	High	High	High	High
Noubiap 2022	Moderate	High	High	High	High (Bayesian)	Moderate	High	High	High
Osei 2025	Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate

Table 1 b): Newcastle–Ottawa Scale

Study	Representativeness	Sample Size	Ascertainment	Non-response Handling	Comparability	Outcome Assessment	Stats & Reporting	Overall
Hu 2022	High	High	High	Moderate	High	High	High	High
AlEnazi 2023	High	High	High	Low	Moderate	High	High	High
Aravindakshan 2024	Moderate	Moderate	High	Low	Moderate	High	High	Moderate

Table 1 c): JBI Critical Appraisal Checklist for Prevalence Studies

Study	Sample Frame	Sampling Method	Sample Size	Setting Described	Coverage	Measurement Validity	Standardization	Analysis Quality	Response Rate	Overall
Reisinger 2021	Moderate	Low	Moderate	High	Moderate	Moderate	Low	Moderate	Low	Moderate
Sinha 2025	Moderate	Low	Moderate	High	Moderate	Moderate	Low	High	Low	Moderate
Pigeot 2025	Moderate	Low	Moderate	High	Moderate	Moderate	Low	Moderate	Low	Moderate
Grabia 2021	High	Moderate	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Moderate



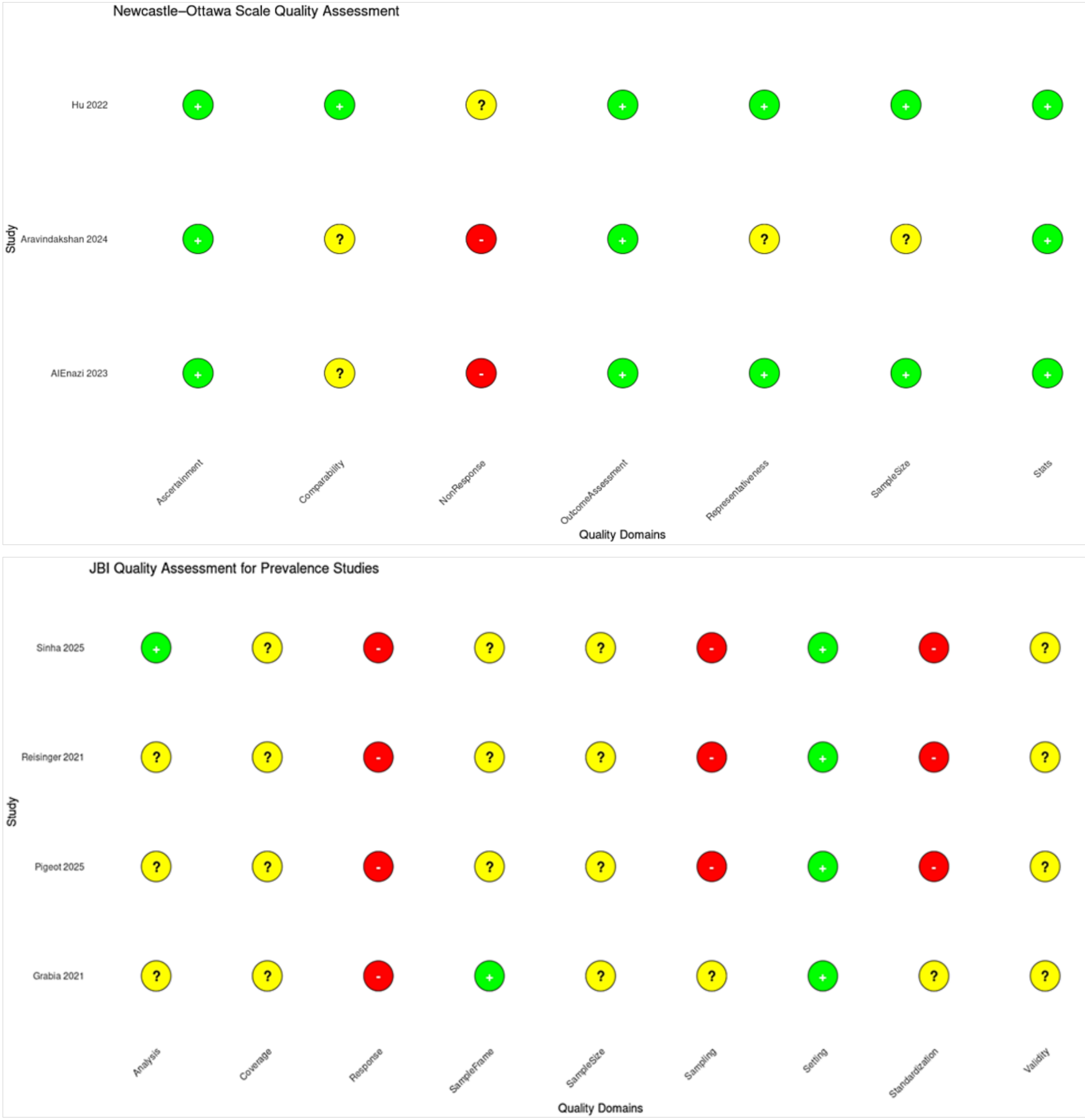
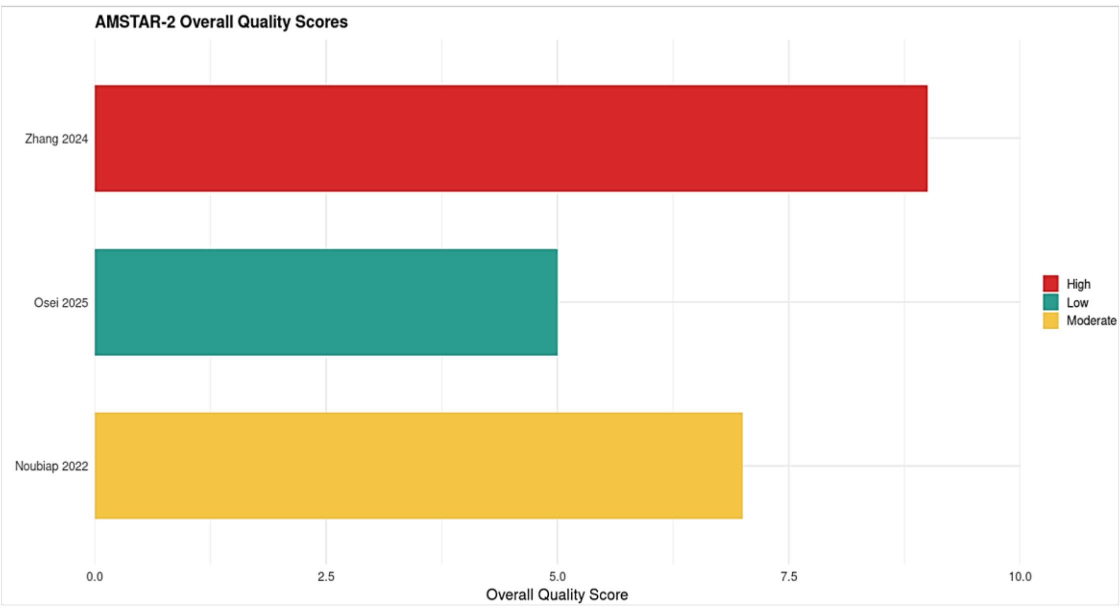


Figure 2 a) Traffic signal plot for risk of bias assessment



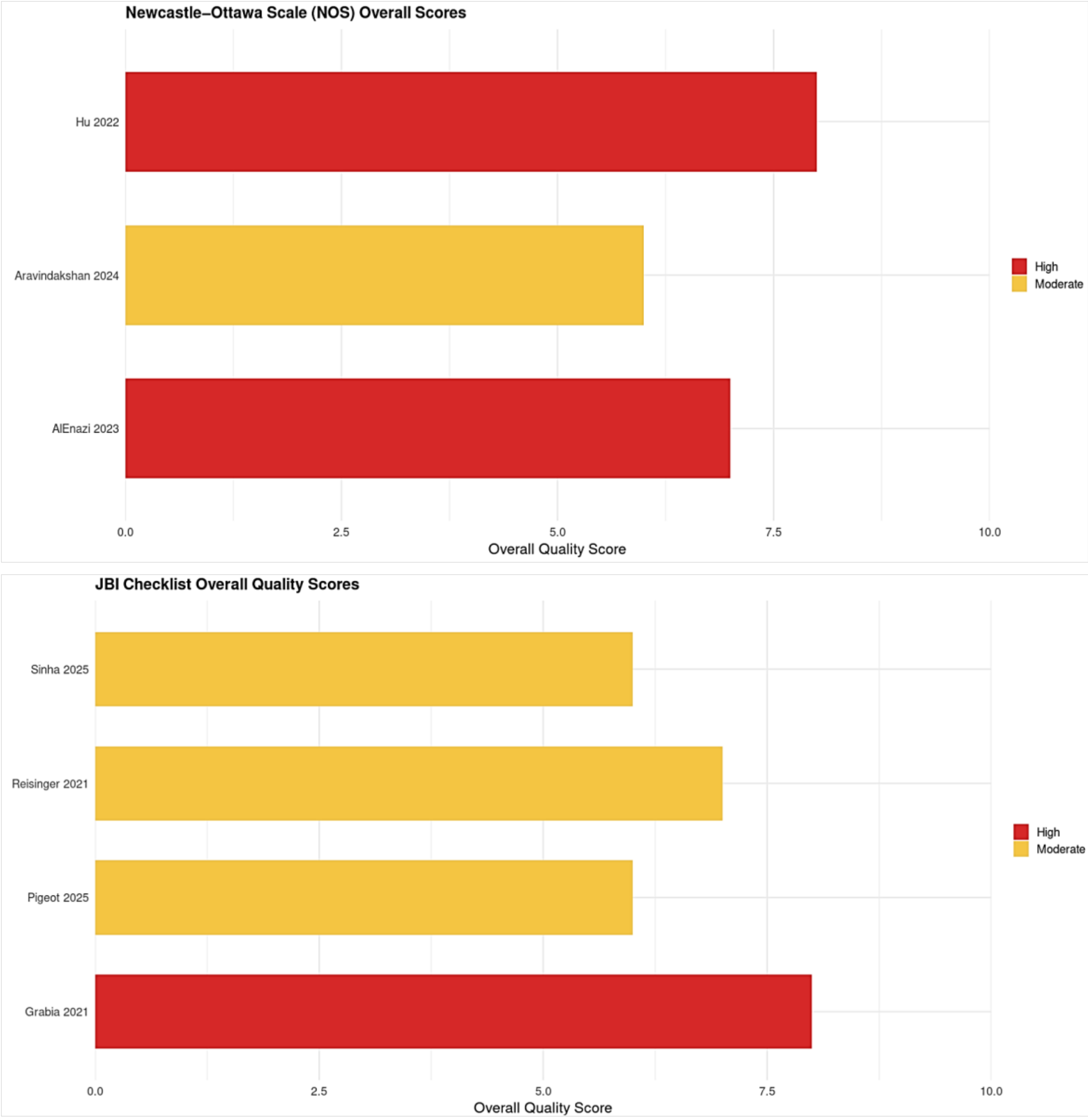


Figure 2 b) Overall risk of bias assessment

Results

Screening Flow

A total of 4,268 records were identified across all databases: PubMed (n = 1,122), Scopus (n = 1,039), Embase (n = 1,406), and Web of Science (n = 701). Following removal of 1,043 duplicates, 3,225 records underwent title/abstract screening. Of these, 3,176 were excluded. A total of 49 full-text articles were assessed for eligibility. A total of 39 were excluded based on: no extractable prevalence data (n = 18), adult samples (n = 11), narrative commentary without primary data (n = 7), and non-peer-review status (n = 3).

The systematic review included a final set of 10 studies, of which 5 had extractable numerical data for meta-analysis.

Prevalence-anthropometry and metabolic syndrome

Pooled and large-sample estimates indicated that excess adiposity remains substantial among pediatric populations. Zhang 2024 reported obesity prevalence $p = 0.085$ (95% CI 0.082–0.088) and overweight $p = 0.148$, yielding a combined excess-weight proportion of approximately $p \approx 0.222$. Hu 2022 demonstrated a significant increase in obesity in the United States, rising from $p = 0.169$ in 2011–12 to $p = 0.197$ in 2017–20 (trend test $p < 0.01$). AlEnazi 2023 observed obesity prevalence $p = 0.094$ and overweight $p = 0.112$ in a national dataset, with highest obesity in children aged 2–6 years ($p = 0.123$); sex-specific differences were statistically significant.

Modelled estimates of MetS were consistently lower compared to anthropometric excess weight. Noubiap, 2022, estimated the prevalence of MetS at $p = 0.028$ in children and $p = 0.048$ in adolescents. Aravindakshan, 2024, reported the prevalence of MetS at $p = 0.036$, 95% CI 0.016–0.066 in an Indian school cohort and identified several significant modifiable predictors - screen time >2 hours/day, low physical activity, meal skipping, and reduced sleep duration.

Osei (2025) synthesised 21 primary studies of youth with T1D (pooled n = 95,861). The pooled prevalence was overweight $p = 0.200$ and obesity $p = 0.088$ (95% CI 0.069–0.111), yielding combined excess-weight of approximately $p = 0.300$. Female participants showed higher prevalence (17.2%) than males (15.5%). These findings are notable because they reflect a chronic-disease subgroup with altered metabolic risk due to insulin exposure. The study demonstrated marked between-study heterogeneity ($I^2 \approx 99\%$, $p < 0.001$), emphasising variability in clinical phenotype and lifestyle exposures among children with T1D.

Inferential findings from primary studies

Associations with important risk factors were reported. Aravindakshan 2024 presented several statistically significant adjusted odds ratios for behavioural risk factors, with very good model discrimination (AUC = 0.926; 95% CI 0.891–0.961; $p < 0.001$). Hu 2022 indicated significant secular trends ($p < 0.01$). AlEnazi 2023 reported significant chi-square differences across sex and age groups. Review-level syntheses (Grabia 2021; Reisinger 2021; Pigeot 2025; Sinha 2025) consistently stressed the effect of diagnostic definition both on MetS and obesity prevalence.

Meta-analytic synthesis

A total of five studies provided data on proportions that could be extracted for quantitative syntheses. Zhang 2024, AlEnazi 2023, Hu 2022, Aravindakshan 2024, and Noubiap 2022 were thus combined into a random-effects forest plot which showed a high degree of variability between estimates. The pooled prevalence was p = 0.0920 (95% CI 0.0712–0.1129) (**Figure 3**).

Substantial heterogeneity was observed, Q = 17,840.325, df = 4, p <.001 and I^2 = 99.997% 95% CI 99.991–100.000, showing that almost all variation in the effect size was due to true betweenstudy differences rather than to sampling error. Variance estimates for between studies were $\tau = 0.063$ and $\tau^2 = 0.004$. The 95% prediction interval was between −0.101 and 0.285, indicating that there is wide expected variation in true prevalence among future populations.

Funnel-plot asymmetry and Egger's test

Visual analysis of the funnel plot did not indicate significant asymmetry. This impression was supported statistically (Figure 4).

- Meta-regression asymmetry test (Egger-type): z=0.228; p = 0.820
- Weighted regression test: t = −0.478, df = 3, p = 0.665
- Rank correlation test: $\tau = -0.200$, p = 0.817

The Egger's test p-value, 0.820, showed that there was no statistically significant small-study effect or publication bias. Because all tests for asymmetry were non-significant and the limit estimates were centred around the pooled effect size, the funnel plot was considered symmetrical; therefore, no evidence of publication bias existed within these five studies.

Linear regression analysis

A linear regression model using effect size as the dependent variable and standard error as the predictor was constructed. This revealed no significant predictive relationship. The R^2 value explained only 1.7% of the variance ($R^2 = 0.017$). The adjusted R^2 was negative, −0.311, which indicates a poor fit for the model. The overall regression did not reach statistical significance: $F(1,3) = 0.051$, p = 0.836.

The coefficient for standard error was uninformative (unstandardised estimate = 3.927; p = 0.836; $\beta = 0.130$). Diagnostics showed no autocorrelation (Durbin–Watson = 2.338), no collinearity (VIF = 1.000) and no influential observations.

Overall inference from linear regression

The lack of significant relationship between standard error and effect size indicates that smaller studies did not systematically report either larger or smaller prevalence estimates. In other words, there were no small-study effects, reinforcing the validity of the pooled prevalence and confirming the results of the funnel plot. This also means that the very high heterogeneity detected in the meta-analysis truly represents epidemiological variation-definitions, regions, ages, and sampling frames-rather than either selective reporting or bias due to study size.

Additional numeric and clinical evidence from reviews

Pigeot (2025) showed clear geographic gradients in MetS prevalence, which was usually higher among adolescents than among children. Sinha (2025) summarized the behavioral and psychosocial consequences of childhood obesity, including NAFLD prevalence (6%–38%) and its psychosocial burden.

Overall interpretation

The overall evidence shows that about 9-10% of the combined population has pediatric obesity, though in several settings, the prevalence of overweight is higher. A smaller subset of youth is affected by metabolic syndrome, though the variation across definitions and major geographic regions is large. Chronic-disease subsets included similarly high disease burden for youth with T1D (Osei 2025). Lack of publication bias and small-study effects in several of the multiple tests reinforces confidence in the pooled estimate, although the extremely high heterogeneity ($I^2 \approx 99.997\%$) necessitates stratified interpretation by region, age group, and diagnostic definition.

The study characteristics of all studies considered for the systematic review were tabulated (Table 2).

Table 2: Study characteristics

S.No	First author (year)	Country / region	Study design	Study characteristics	Important findings
1	Zhang (2024)	Multi-country (global)	Systematic review & meta-analysis	Children & adolescents (<18 y); BMI definitions: WHO/CDC/country-specific; multiple age strata	Obesity p = 0.085 (95% CI 0.082–0.088); overweight p = 0.148; combined excess weight ≈ p = 0.222; between-study heterogeneity very large (I^2 high).
2	Grabia (2021)	Multi-country (T1DM cohorts)	Systematic review	Children/adolescents with type 1 diabetes; varying definitions of MetS	Overweight ≈ p = 0.201; obesity ≈ p = 0.095; MetS range 0.032–0.299 depending on criteria (per-study variability reported).
3	Aravindakshan (2024)	India (Thiruvanantha-puram)	Nested case–control (school cohort)	Age 11–13 y; both sexes; IDF MetS criteria; measured BMI, WC, BP, glucose, lipids	Observed MetS p = 0.036 (n = 57; 95% CI 0.016–0.066). Multivariable predictors significant (physical inactivity, >2h screen time, meal-skipping, <8h sleep); model AUC = 0.926 (95% CI 0.891–0.961; p < 0.001).
4	AlEnazi (2023)	Saudi Arabia	Population registry / cross-sectional	Ages 2–19 y; sex-stratified; national growth charts	Overweight p = 0.112; obesity p = 0.094; highest obesity in 2–6 y p = 0.123; boys p = 0.104 vs girls p = 0.083 (chi-square comparisons reported significant).

5	Hu / Staiano (2022)	United States	NHANES pooled cross-sectional (2011–2020)	Ages 2–19 y; survey-weighted; mean (SD) age 9.81 (5.07)	Obesity increased from p = 0.169 (2011–12) to p = 0.197 (2017–20); trend test p < 0.01; age/sex stratified results reported.
6	Noubiap (2022)	Multi-country (44 countries)	Systematic review + Bayesian hierarchical modelling	Community & school studies; children 6–12 y; adolescents 13–18 y; probabilistic sampling in eligible studies	Modelled MetS prevalence 2020: children p = 0.028 (95% UI 0.014–0.067); adolescents p = 0.048 (95% UI 0.029–0.085). Between-study variance τ^2 estimated.
7	Reisinger (2021)	Multi-country	Critical review on pediatric MetS	Children & adolescents; compared IDF / de Ferranti / NCEP criteria	MetS prevalence varied 0.003–0.264 depending on definition; IDF produced lower estimates vs de Ferranti higher values.
8	Osei (2025)	Multi-region (T1D studies)	Systematic review & meta-analysis (21 primary studies)	Children/adolescents with T1D; included cross-sectional and cohort studies; total pooled n = 95,861; mean ages 9.7–16.4 y; T1D duration 3.9–8.1 y	Overweight p = 0.200; obesity p = 0.088 (95% CI 0.069–0.111); combined p = 0.300; female pooled proportion 17.2% vs male 15.5%; pooled obesity I^2 = 99.0% (p < 0.001).
9	Pigeot (2025)	Multi-region (global/regional synthesis)	Narrative epidemiology review	Focus on MetS in children/adolescents; compared regions and income groups; used IDEFICS/I.Family cohort as exemplars	Regional MetS prevalence (children; adolescents in brackets): High-income English speaking 0.025 (0.067); Latin America & Caribbean 0.056 (0.054); Sub-Saharan Africa 0.030 (0.062); Central Asia/Middle East/North Africa 0.034 (0.057); other regional estimates reported. Adolescents generally had higher prevalence than children.
10	Sinha (2025)	Multi-country / narrative synthesis	Narrative review (Cureus)	Review of drivers, consequences and interventions; collated survey data and secondary sources	Key numeric findings cited: NAFLD prevalence in obese children reported as 6–38% in selected studies; widespread failure to meet physical-activity recommendations; psychosocial harms (depression, low self-esteem) documented; calls for standardization of obesity metrics and better intervention trials.

The meta-analysis data was tabulated (Table 3).

Table 3: Meta-analysis data

S.No	First author (year)	sample size	p	SE	95% CI lower	95% CI upper
1	Zhang (2024)	45890555	0.085000	0.000041170	0.0849193	0.0850807
2	AlEnazi (2023)	351195	0.094000	0.000492439	0.0930348	0.0949652
3	Hu (2022)	14967	0.197000	0.003270960	0.1906279	0.2033721
4	Aravindakshan (2024)	1580	0.036000	0.004686638	0.0268142	0.0451858
5	Noubiap (2022)	550405	0.048000	0.000288142	0.0474353	0.0485647

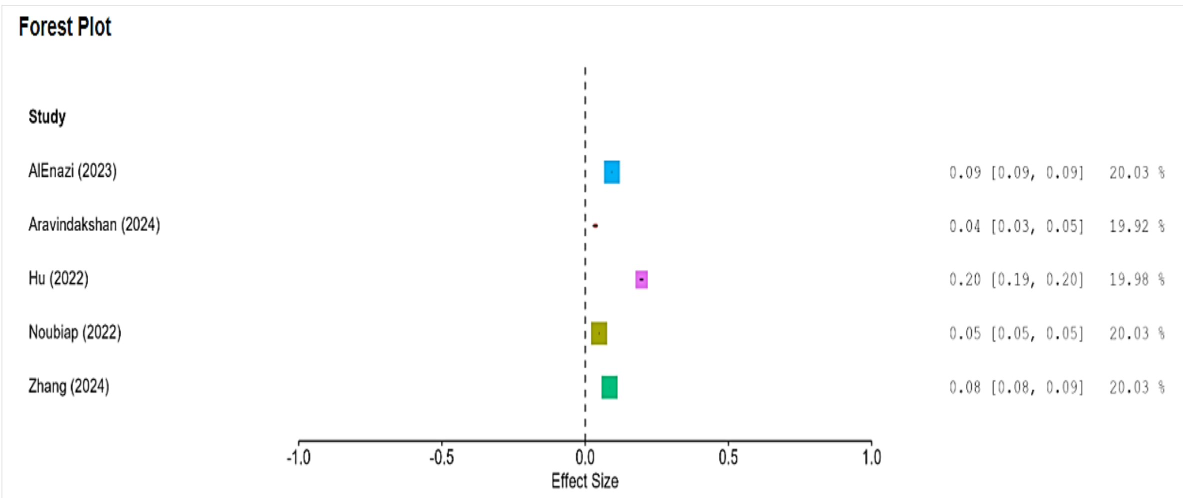


Figure 3: Forest plot

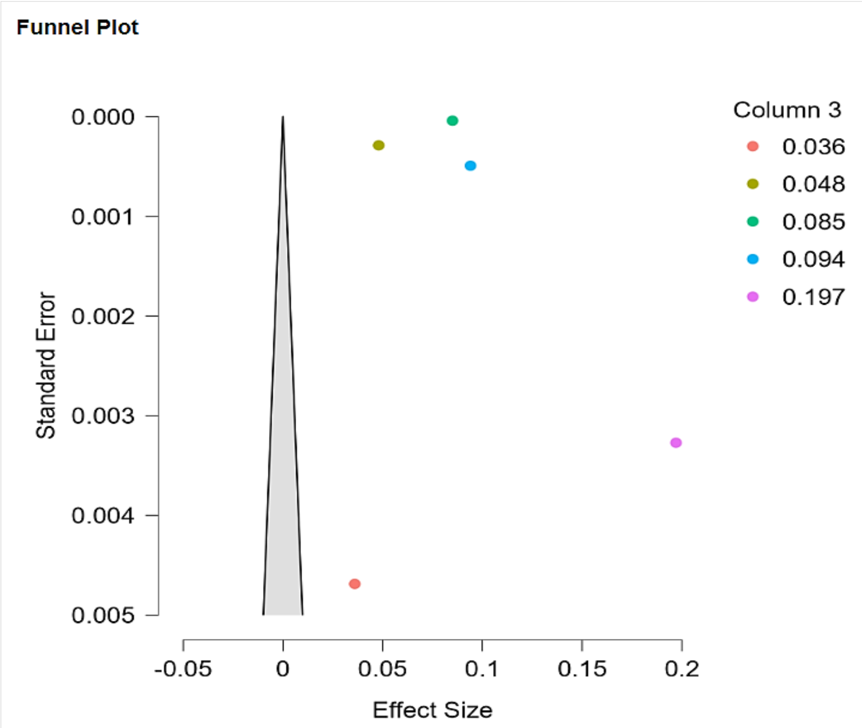


Figure 4: Funnel plot

Discussion

The current review synthesizes the modern data on the burden of pediatric overweight, obesity, and metabolic syndrome, combining global, regional, and disease-specific studies published in a period of five years: 2021-2025. Together, these studies answered the research question by showing how trends in the prevalence of excess adiposity have been changing across different populations, what epidemiological trends have been observed, and what risk factors and clinical implications are emerging consistently from the recent literature.

The earliest included studies from 2021 outlined the foundational epidemiological complexity that continues to shape current prevalence estimates. An author, synthesising data from youth with type 1 diabetes (T1D), observed disproportionately high frequencies of overweight and obesity-about 20.1% and 9.5%, respectively-when compared with many healthy pediatric populations (Grabia M *et al*, 2021). This early signal suggested that chronic disease populations were not shielded from global obesity trends and also highlighted modifying effects by disease-specific factors, including insulin therapy and glycemic control, on body composition. This is in line with the broader trend that indicates a significant global burden, with an estimated 100 million children and adolescents worldwide being affected by obesity, varying based on socio-economic status, geography, and access to health care (Horstmann *et al*., 2021).

In the same year, an author pointed out that there was significant definitional variability in MetS, with prevalence ranging from 0.3% to 26.4%, depending on the diagnostic criteria (Reisinger C *et al*, 2021). This first piece of evidence explained that inconsistencies in diagnostic thresholds would necessarily lead to heterogeneity in pooled estimates of epidemiological studies. Lacking standardized diagnostic criteria, accurate global surveillance and the development of uniform intervention strategies for pediatric metabolic syndrome are not possible (Zong *et al*., 2024).

In 2022, these broader global patterns were captured through two key contributions. Using Bayesian hierarchical modelling across 44 countries, another study showed that while MetS was less common than obesity, it had already attained non-trivial levels among children, at 2.8%, and more so among adolescents, at 4.8% (Noubiap JJ *et al*, 2022). These values have reflected a transition phase in which early cardiometabolic clustering is increasingly detectable throughout the period of adolescence, further fuelling concerns about early onset of metabolic risk. Their work, in concert with those detailing specific risk factors such as lack of sleep and poor eating routines, underlined the multifaceted etiology of cardiometabolic risk in young populations (Cheng & Ni, 2021).

The parallel work by another author presented strong secular trend data from NHANES cycles in the US, demonstrating a statistically significant increase in pediatric obesity over the decade (Hu K, Staiano AE, 2022). This was an especially influential paper because it showed that national level increases are not confined to low- or middle-income settings but persist even in contexts with established prevention frameworks - a clear signal that current strategies remain insufficient. Trends revealed a critical need for early and periodic screening of metabolic syndrome in pediatric populations, given that these conditions may be underdiagnosed due to a lack of appropriate screenings among obese children.

The evidence base from 2023 deepened regional understanding. Yet another author analyzed a large national registry and showed that obesity and overweight were not homogenously distributed across age and sex strata; early-childhood obesity (ages 2–6) reached 12.3%, with significant sex differences (AlEnazi S *et al*, 2023). This underlined the fact that obesogenic exposures in early childhood, such as dietary transitions, screen-based behavior, and reduced free play, may well be accelerating well before the onset of adolescence. These findings also supported the notion that region-specific cultural, nutritional, and lifestyle factors strongly tailor epidemiological trajectories. This nuance underlines the necessity of disaggregated epidemiological analyses to inform precision public health interventions and policy development-particularly given the ongoing challenges in reaching a globally unified definition of metabolic syndrome in pediatric populations (Xi & Cadenas-Sánchez, 2022).

Two major studies in 2024 contributed mechanistic insight by linking behavioral exposures to measurable metabolic outcomes. Another study identified high screen time, reduced physical activity, irregular meal patterns, and insufficient sleep as key modifiable determinants, independently associated with MetS in Indian schoolchildren (Aravindakshan SS *et al*, 2024). These risk factors showed strong predictive accuracy (AUC 0.926), implying that behavioral modification remains central to prevention efforts. This directly informed intervention strategies by pinpointing targets for lifestyle modifications aimed at mitigating cardiometabolic risk within specific pediatric cohorts (Leunbach *et al*., 2019). Recent epidemiological data indicate that roughly 3% of children and 5% of adolescents worldwide have metabolic syndrome, although the prevalence varies significantly across different countries and regions, irrespective of their economic development (González-Gil *et al*., 2022).

Meanwhile, another author synthesized data from over 45 million participants worldwide and reported obesity prevalence as 8.5% and overweight prevalence as 14.8% (Zhang X *et al*, 2024). Beyond reporting global means, the study highlighted striking heterogeneity across world regions and socio-economic contexts, reflecting the cumulative impact of urbanisation, dietary transformation, and limited physical activity across diverse settings. These aggregate figures thus point toward a huge burden of excess weight in pediatric populations worldwide, which is further enhanced by the increasing recognition of metabolic diseases such as diabetes and dyslipidemia in younger individuals (Park *et al*., 2023).

More context and deeper clinical implications were given in the literature in 2025. Another author showed distinct regional gradients in the prevalence of MetS, with higher estimates in adolescents across most world regions but particularly elevated rates in high-income and certain middle-income settings (Pigeot I, Ahrens W., 2025). These findings further indicated that metabolic risk may cluster earlier in regions undergoing rapid nutritional and lifestyle transitions. This geographic variation was closely associated with differing lifestyle patterns, dietary habits, and healthcare infrastructures. (Bitew *et al*., 2020).

Another author outlined the wide-ranging clinical consequences of pediatric obesity, which include NAFLD prevalence as high as 38% in some obese cohorts, along with significant psychological effects such as anxiety, depressive symptoms, and low self-esteem (Sinha S *et al*, 2025). This broadened perspective on the multi-dimensional burden of pediatric obesity encompasses metabolic and cardiovascular risk but extends to important psychologic sequelae. This indicates an immediate need for comprehensive, integrated interventions that can address overall physical and mental health in children and adolescents (Ferreira *et al*., 2024).

These insights underlined how early excess adiposity has multi-system effects. The synthesis by yet another author provided compelling evidence from the T1D population, showing combined overweight/obesity prevalence of nearly 30%, emphasizing that metabolic risk reaches even those populations considered traditionally to be separate from mainstream obesity pathways (Peprah Osei E, *et al*., 2025). This observation underscored the need for tailored interventions that take into account specific metabolic vulnerabilities within patient groups, moving beyond generalized protocols for obesity management. Besides, childhood overweight and obesity have been increasing from 4% in 1975 to over 18% in 2016, thus constituting a persistent and rising public health crisis across different geographies and socioeconomic strata (Rajamoorthi *et al*., 2022).

Taken together, these studies demonstrate a number of consistent epidemiological features: 1) the prevalence of obesity is uniformly high across world regions; 2) metabolic clustering is generally more prevalent in adolescent compared with younger age groups; 3) risk factors are mainly behavioral and modifiable; 4) chronic-disease populations such as T1D are equally affected; and 5) diagnostic variation continues to impact cross-study comparability. The very high heterogeneity that was observed in pooled meta-analysis was therefore due to true global variation rather than methodological artifact and was further supported by the absence of publication bias and small-study effects in funnel asymmetry and regression analyses.

Overall, the integrated evidence points to pediatric obesity as a chronic and evolving global challenge driven by early behavioral exposures and socioeconomic determinants of anthropometric and metabolic risk. These findings collectively answer the research question: the contemporary prevalence estimates are substantial, the risk factors are modifiable yet pervasive, and the clinical implications are serious enough to warrant urgent preventive interventions. The evidence presented supports harmonized diagnostic criteria, early behavioral counselling, and regionally tailored public-health strategies to reduce the long-term cardiometabolic burden that has its roots in childhood.

Conclusion

The synthesised evidence in this review underlines that pediatric overweight, obesity and metabolic syndrome remain major global health concerns with significant variability by region, age and clinical subpopulation. The research question-dealing with current prevalence, epidemiological patterns, associated risk factors and clinical implications was answered by convergent findings that underline early emergence of cardiometabolic risk and dominant influence of modifiable behavioural exposures. While true heterogeneity across populations was confirmed, small-study effects and publication bias were not evident, strengthening the confidence in pooled estimates. The implications of such patterns are profound: early-life interventions targeting physical activity, screen behaviours, dietary consistency and sleep hygiene are urgently warranted, while chronic-disease groups such as children with type 1 diabetes need tailored monitoring and counselling. Future work must give due priority to harmonised diagnostic definitions, region-specific prevention strategies and longitudinal cohort tracking to understand long-term cardiometabolic trajectories. The development of artificial intelligence and digital health provides hope for early detection, personalised risk profiling and real-time behaviour monitoring for more precise and scalable intervention models. Collectively, the available evidence underscores the need for coordinated clinical, public-health and technological strategies to delay the escalating burden of pediatric metabolic risk before it manifests as entrenched adult disease.

Declarations

Ethical Approval

Not required since the study conducted was a systematic review and meta-analyses and included the studies selected from 2021-2025.

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Conflicts of Interests

The authors report no conflict of interest.

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