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REVIEW

Prevalence of Metabolic Syndrome in Iran: An Umbrella Review Across Diagnostic Criteria and Population Subgroups

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Background: Metabolic Syndrome (MetS) is a significant public health concern globally, driven by factors like obesity and sedentary lifestyles. In Iran, numerous meta-analyses have estimated its prevalence, but results vary. This umbrella review aims to synthesize these findings to provide a definitive summary of MetS prevalence across both general and high-risk populations in Iran.

Methods: We systematically searched international (PubMed/Medline, Scopus, Web of Science) and Persian databases (SID, Magiran) for meta-analyses published between January 2014 and August 2025 reporting pooled MetS prevalence in Iranian populations. Data extraction covered overall prevalence, subgroup analyses (gender, diagnostic criteria, population risk strata), and study characteristics. Methodological quality was assessed using AMSTAR 2, and evidence quality was evaluated using GRADE framework. Meta-analysis of pooled estimates was performed using random-effects models.

Results: Nineteen meta-analyses comprising 119 prevalence estimates and 1,954,049 participants were included. The overall pooled prevalence of MetS in Iran was 30.4% (95% CI: 28.44–32.33). Prevalence was higher in females (33.05%) than in males (27.57%). The prevalence varied by diagnostic criteria, with the Joint Interim Statement (JIS) criteria yielding the highest estimate (36.47%), followed by the International Diabetes Federation (IDF) criteria (32.03%), and the NCEP-ATP III criteria (26.86%). High heterogeneity ($I^2 > 99\%$) was observed. The methodological quality of included studies was predominantly moderate, and the GRADE evidence quality for most outcomes was moderate.

Conclusion: Approximately one in three Iranian adults is affected by MetS, with disproportionately higher burden among women and specific high-risk populations. The choice of diagnostic criteria significantly influences prevalence estimates, and considerable heterogeneity across studies highlights the context-dependent nature of these findings. These results underscore the urgent need for targeted public health interventions and systematic screening strategies tailored to different population risk profiles.

Registration Information: The study protocol was registered in the Prospero with ID, CRD420251182425.

Keywords: metabolic syndrome, Iran, meta-analysis, umbrella review, prevalence

Background

Metabolic Syndrome (MetS) is a clustering of interrelated cardiometabolic risk factors, including abdominal obesity, dyslipidemia (elevated triglycerides and low high-density lipoprotein cholesterol), hypertension, and impaired fasting glucose.[1] This constellation of abnormalities significantly increases the risk of developing type 2 diabetes mellitus, cardiovascular diseases (CVD), stroke, and all-cause mortality, posing a substantial public health concern worldwide.[2] The underlying pathophysiology of MetS is complex, often rooted in insulin resistance and abdominal adiposity, and is heavily influenced by modifiable lifestyle factors such as physical inactivity, unhealthy diet, and genetic predisposition.[1,3]

Globally, the prevalence of MetS is rising, mirroring the epidemic of obesity and diabetes. According to the International Diabetes Federation (IDF), approximately 20–25% of the world's adult population is affected.[4,5] This high prevalence places a significant economic burden on healthcare systems due to the costs associated with managing its long-term complications.[6] Notably, significant and consistent gender differences in MetS prevalence have been observed

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across diverse populations, with a generally higher prevalence reported in females compared to males. These disparities are attributed to a complex interplay of biological and hormonal factors (such as the protective role of estrogen in premenopausal women), as well as sociocultural and behavioral determinants. Investigating these differences is crucial, as being male is itself considered a non-modifiable risk factor for cardiovascular disease, while the risk profile in females shifts significantly after menopause.[7–9] The diagnosis of MetS is not uniform, with several criteria established by leading organizations, including the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), the International Diabetes Federation (IDF), and the Joint Interim Societies (JIS).[10,11] While these definitions share common components, differences in cut-off points, particularly for waist circumference, and the mandatory inclusion of central obesity lead to variations in prevalence estimates across populations and studies.

In Iran, as a low income country in Persian Gulf Region which has over 90 million population,[12] rapid urbanization, nutritional transition towards high-calorie diets, and increasingly sedentary lifestyles have contributed to a growing burden of non-communicable diseases.[13] Over the past two decades, a substantial body of primary research has emerged documenting the prevalence of MetS in various Iranian populations, including general adults, specific demographic groups (eg, postmenopausal women), and clinical populations (eg, those with polycystic ovary syndrome or cardiovascular disease). To synthesize this extensive and heterogeneous body of evidence, numerous systematic reviews and meta-analyses have been conducted. These studies have provided valuable insights into the pooled prevalence of MetS at a national level and have explored variations by sex, age, and region.[14] However, the existence of multiple meta-analyses, sometimes with overlapping primary studies and yielding conflicting conclusions, has created a clear evidence gap. This gap arises from the inability of the existing body of synthesized literature to provide a consistent and definitive estimate of the MetS burden for Iran. Consequently, this presents a significant challenge for policymakers and clinicians who require a single, reliable, and high-level evidence summary to inform decision-making.

The existing meta-analyses exhibit notable inconsistencies including significant variations in pooled prevalence estimates, even for similar populations, often due to differing inclusion criteria, geographic focus, or the application of different MetS diagnostic definitions. Furthermore, some meta-analyses have focused narrowly on specific subpopulations, while others have attempted broader national estimates but with conflicting results. This has resulted in a fragmented evidence base, leaving a clear gap for a comprehensive, higher-order synthesis that can reconcile these discrepancies and provide a unified, national-level estimate while systematically evaluating the impact of key moderators like diagnostic criteria and gender. Therefore, an umbrella review, which synthesizes findings from multiple meta-analyses, is needed to provide a more comprehensive and stable estimate of the MetS burden in Iran. This approach allows for the consolidation of existing evidence, helps to resolve inconsistencies, and offers a broader perspective on the determinants and distribution of the syndrome.

The primary objective of this review is to derive a unified national prevalence estimate of Metabolic Syndrome in the Iranian adult population by synthesizing all available meta-analytical evidence. Secondary objectives include conducting stratified analyses to determine the precise influence of gender, and diagnostic criteria on prevalence estimates. This umbrella review aimed to provide the most comprehensive and up-to-date synthesis of evidence on the prevalence of MetS in Iran by integrating data from all available meta-analyses. Specifically, it sought to determine the overall pooled prevalence, examine variations according to diagnostic criteria, gender, and discuss the critical public health implications for the Iranian healthcare system.

Methods

Study Design and Protocol

This study was an umbrella review of meta-analyses examining the prevalence of metabolic syndrome (MetS) in Iran. The review was conducted in accordance with the preferred reporting items for umbrella reviews.

Eligibility Criteria

The inclusion criteria for this umbrella review were defined using the PICO (Population, Intervention/Exposure, Comparison, and Outcome) framework. The study population included adults residing in Iran. We considered both

general population samples and specific sub-populations (eg, postmenopausal women, patients with polycystic ovary syndrome (PCOS), cardiovascular patients, etc). Intervention/Exposure: Not applicable, as this review focuses on prevalence. Comparison: Not applicable. Outcomes: The primary outcome was the prevalence of metabolic syndrome, reported as a proportion with a 95% confidence interval (CI). The diagnosis of MetS could be based on any established international or national criteria, including but not limited to the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), International Diabetes Federation (IDF), Joint Interim Statement (JIS), and World Health Organization (WHO) definitions. We included published systematic reviews and meta-analyses that provided a quantitative synthesis (pooled estimate) of MetS prevalence in any Iranian population. Studies were excluded if they were narrative reviews, scoping reviews, primary research articles, conference abstracts, or meta-analyses that did not focus on the Iranian population or did not report a pooled prevalence estimate.

Search Strategy

A systematic and comprehensive search was performed across several international and Persian electronic for meta-analyses published between January 2014 and August 2025, reporting pooled MetS prevalence in Iranian populations. The databases included PubMed/MEDLINE, Scopus, Web of Science, Cochrane Database of Systematic Reviews, and Google Scholar for international literature. For Persian literature, we searched Scientific Information Database (SID), IranMedex, and Magiran. The search strategy utilized a combination of Medical Subject Headings (MeSH) terms and keywords related to three core concepts: "Metabolic Syndrome," "Iran," and "Meta-Analysis" or "Systematic Review." The search strategy was adapted for the syntax of each database. A sample search strategy for PubMed is provided in the Supplementary Materials. The reference lists of all included articles were also manually screened to identify any additional relevant studies.

Study Selection Process

The study selection process was conducted in two stages by two independent reviewers. First, all identified records were imported into EndNote X9, and duplicates were removed. The reviewers then screened the titles and abstracts of the remaining records against the eligibility criteria. In the second stage, the full texts of potentially relevant articles were retrieved and assessed in detail for final inclusion. Any disagreements between the reviewers at any stage were resolved through discussion or by consultation with a third senior reviewer. The study selection process was documented using a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

Data Extraction

Data from the included meta-analyses were extracted independently by two reviewers using a pre-piloted, standardized data extraction form. The following information was collected: First author, publication year, the number of primary studies included, Target population (eg, general population, specific patient groups), total pooled sample size, gender distribution, diagnostic criteria for MetS used in the meta-analysis, the pooled prevalence estimate for MetS for the overall population and for reported subgroups (eg, by gender and diagnostic criteria), along with their 95% confidence intervals. If a single meta-analysis reported multiple prevalence estimates for different subgroups (eg, by gender and by criteria), each estimate was extracted as a separate data point (record) for the umbrella review's quantitative synthesis.

Methodological Quality and Quality of Evidence Assessment

The methodological quality of each included meta-analysis was assessed independently by two reviewers using the AMSTAR 2 (A Measurement Tool to Assess systematic Reviews 2) checklist.[15] The AMSTAR 2 tool consists of 16 domains, and the overall confidence in the results of the meta-analysis was rated as High, Moderate, Low, or Critically Low based on critical and non-critical weaknesses. The quality of evidence for the main prevalence estimates was evaluated using the GRADE (Grading of Recommendations, Assessment, Development, and Evaluations) approach for prevalence studies.[16] The evidence started as high quality and was downgraded based on factors including risk of bias, inconsistency (heterogeneity), indirectness, imprecision, and publication bias. The overall quality was categorized as High, Moderate, Low, or Very *Low*. Furthermore, the credibility of the evidence for each pooled prevalence estimate

was classified into four pre-defined classes: Class I (Convincing evidence): >1000 cases; $P < 10^{-6}$; no evidence of bias; $I^2 < 50\%$, Class II (Highly suggestive evidence): >1000 cases; $P < 10^{-6}$; largest study significant, Class III (Suggestive evidence): >1000 cases; $P < 0.001$ and Class IV (Weak evidence): $P < 0.05$ but does not meet higher class criteria.

Data Synthesis and Statistical Analysis

Given that the included data were pooled prevalence estimates from independent meta-analyses, we conducted a meta-analysis of meta-analyses. The primary summary measure was the pooled prevalence with a 95% confidence interval (CI). All analyses were performed using the metaprop command in Stata software (version 11.0), employing a random-effects model with the DerSimonian and Laird method to account for the anticipated high heterogeneity between estimates. Statistical heterogeneity was assessed using the I^2 statistic, where values of 25%, 50%, and 75% were considered to represent low, moderate, and high heterogeneity, respectively. To explore potential sources of heterogeneity, we performed pre-specified subgroup analyses based on gender (male, female, both) and diagnostic criteria (ATP III, IDF, JIS, NECP-ATP III, Mixed, Others).

Publication bias was assessed visually using Begg's rank correlation test and Egger's linear regression test. The multiple meta-regression was used to identify effective factors on heterogeneity in prevalence. A p-value of less than 0.10 was considered indicative of statistically significant publication bias to increase the sensitivity for detecting potential publication bias, as these tests can have low power, particularly when the number of included studies is modest.

Results

Description of Included Meta-Analyses

The process of study identification, screening, and inclusion is detailed in the PRISMA flow diagram (Figure 1). A systematic search of electronic databases initially yielded 354 records. No additional records were identified through other sources. After removing duplicates, 224 unique records remained for screening. The title and abstract screening of these 224 records led to the exclusion of 196 records that did not meet the inclusion criteria. The full text of the remaining 28 articles was thoroughly assessed for eligibility. Of these 28 articles, 9 were excluded for specific reasons, with the most common reason being a lack of necessary information, such as a (1) wrong population; (2) wrong outcome; (3) wrong study design and (4) insufficient data. Consequently, a total of 19 studies were deemed eligible for inclusion. These 19 studies (or 119 records) were included in both the qualitative synthesis and the quantitative synthesis (meta-analysis). The included meta-analyses were published between 2014 and 2025, providing a broad temporal perspective on the condition's epidemiology. Table 1 shows included studies.

The primary studies aggregated within these meta-analyses collectively represented a vast and diverse sample of the Iranian population, totaling 1,954,049 participants. The study populations were heterogeneous, including representatives from the general adult population, specific demographic groups such as postmenopausal women, patients with polycystic ovary syndrome (PCOS), cardiovascular patients, professional drivers, and individuals with schizophrenia, allowing for a nuanced analysis across different segments of society.

The meta-analyses employed a variety of international and national diagnostic criteria to define MetS, ensuring a comprehensive assessment. The most frequently applied criteria were those of the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) and the International Diabetes Federation (IDF). Other utilized criteria included the Joint Interim Statement (JIS), American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI), World Health Organization (WHO), and Iranian-specific criteria (INCO), among others. The overall pooled prevalence was 30.4% (95% CI: 28.44–32.33). A high degree of heterogeneity was observed across the included studies ($I^2 = 99.4\%$, $p < 0.001$) (Table 2, Figure 2).

Subgroup Analysis by Gender

Analysis based on gender revealed a distinct pattern. The pooled prevalence was significantly higher in females (33.05%, 95% CI: 31.68–34.42) compared to males (27.57%, 95% CI: 24.70–30.45). Studies that reported combined data for both

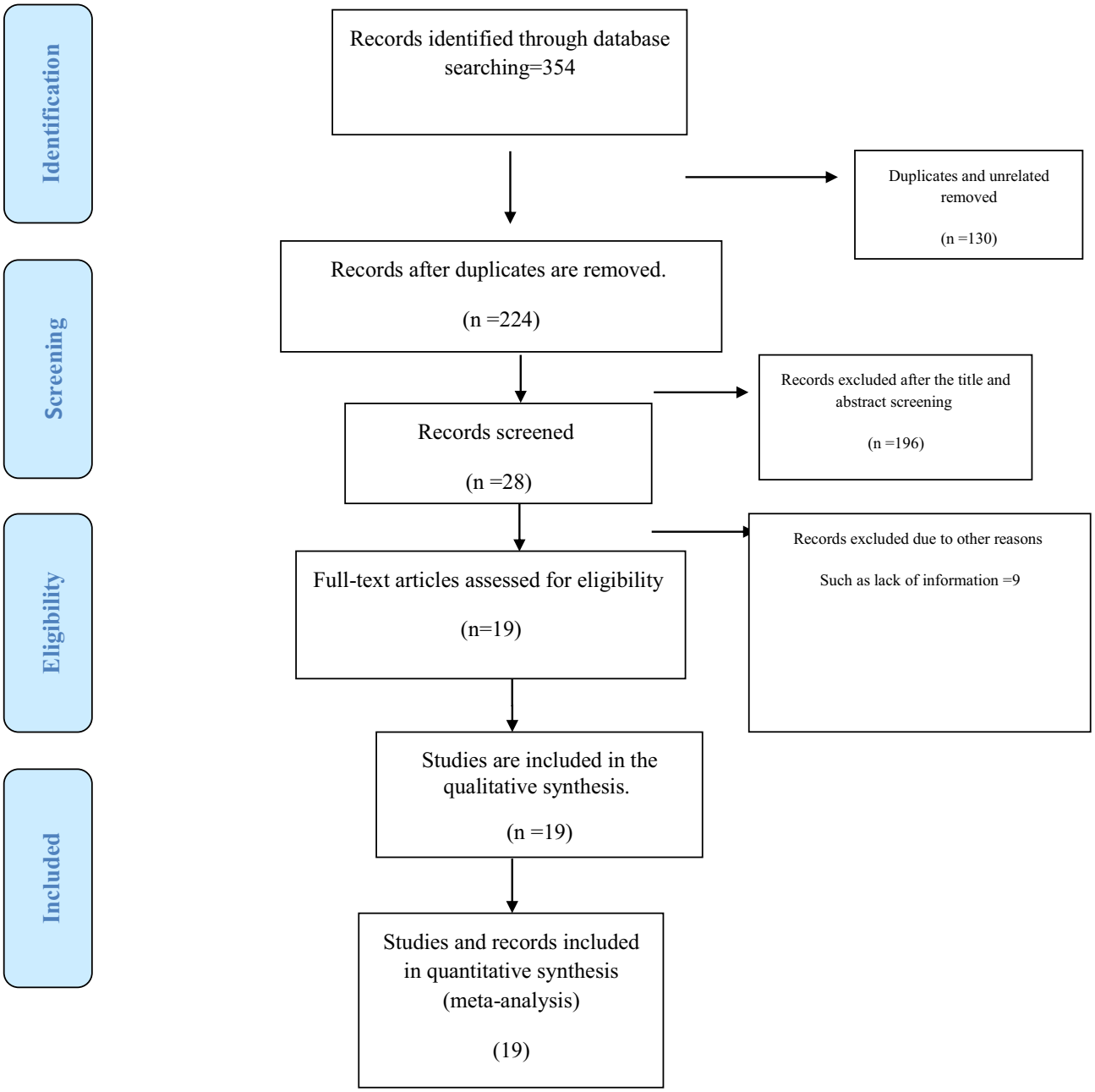

Figure 1 PRISMA Flow Diagram for included studies in the current meta-analysis.

genders yielded a prevalence of 29.47% (95% CI: 26.72–32.23). Heterogeneity remained significant within all gender subgroups ($I^2 > 93.5\%$, $p < 0.001$) (Table 2, Figure 3).

Subgroup Analysis by Diagnostic Criteria

The estimated prevalence of MetS varied considerably depending on the diagnostic criteria applied. The Joint Interim Statement (JIS) criteria yielded the highest pooled prevalence at 36.47% (95% CI: 27.55–45.38). This was followed by the International Diabetes Federation (IDF) criteria at 32.03% (95% CI: 28.35–35.71), and a group of Mixed Criteria at 30.33% (95% CI: 27.48–33.18). The prevalence estimates for other criteria were 29.61% for NECP-ATP III, 29.60% for Other Criteria (including Iranian, AHA/NHLBI, CDS, WHO, AACE, INCO), and 26.86% for ATP III. Significant heterogeneity was present across all criteria-based subgroups ($I^2 > 83.7\%$, $p < 0.001$) (Table 2, Figure 3).

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Table 1 Included Studies in Umbrella Systematic Review and Meta-Analysis of Metabolic Syndrome Prevalence in Iranian Population

First Author	Year	Study Population	Total Sample Size	Diagnostic Criteria Used (in the study)	Prevalence of Mets (%)
Amirkalali[5]	2015	Iranian adult population	54043	ATP III, IDF, JIS	37
Ansarimoghaddam[17]	2017	Middle East adult population (incl. Iran)	150168	Mixed (mainly ATP III & IDF)	27.5
Fatahi[18]	2020	Iranian general population	472401	Mixed (mainly ATP III), IDF, JIS, Iranian Definition	26
Ebtekar[19]	2018	Iranian postmenopausal women	5893	Mixed (mainly ATP III), ATP III, IDF	51.7
Farmanfarma[8]	2018	Iranian general population (≥20 years)	146644	Mixed (ATP III, IDF, etc).	30.4
Hallajzadeh[20]	2018	Iranian women with PCOS	20552	Mixed (NCEP-ATP III, IDF, etc)., NCEP-ATP III, IDF, AHA/NHLBI	26.3
Khorshidi[21]	2019	Patients with PCOS	8946	IDF, NECP-ATP III, AHA NHLBI, CDS, Not specified	30
Maleki[22]	2014	Iranian general population	60635	IDF, ATP III	36
Mazloomzadeh[23]	2018	Iranian general population	46464	ATP III	21.1
Mokhayeri[24]	2017	Iranian adult population	65049	ATP III, IDF	28
Moradkhani[14]	2025	General Population (Iran)	526562	NCEP ATP III, IDF, AHA/NHLBI, Iranian Criteria, WHO, JIS, AACE, De Ferranti, INCO	31
Salari[25]	2020	Iranian cardiovascular patients	44735	ATP III, WHO, IDF	34.2
Izadi[26]	2021	Professional drivers worldwide	19350	NCEP-ATP III/ IDF	32.8
Niksima[27]	2019	Iranian women with PCOS	1353	ATP III, JIS	26.6
Ostovar[4]	2017	Iranian adult population	145887	ATP III, IDF, JIS	25
Dalvand[28]	2017	Iranian population (General)	74440	NCEP/ATP III, IDF, JIS	32
Dalvand[9]	2017	Iranian population (General)	83227	ATP III, NCEP/ATP III, IDF, WHO	31
Shojaeimotlagh[29]	2018	Schizophrenia patients	1589	ATP III, IDF	24
Soltaninejad[30]	2020	Drivers	26156	ATP III	34

Assessment of Publication Bias

For the overall analysis, both Begg's test (p=0.96) and Egger's test (p=0.80) indicated no statistically significant evidence of publication bias. This absence of significant bias was consistent across most subgroups, with the notable exception of the IDF criteria subgroup, where both Begg's (p=0.039) and Egger's (p=0.04) tests suggested the presence of potential publication bias. Formal statistical tests (Begg's and Egger's) indicated no significant publication bias overall; however, the IDF-based subgroup exhibited marginal evidence of small-study effects. This may reflect preferential publication of studies reporting higher MetS prevalence when using the IDF definition. Nonetheless, the large aggregate sample and consistency of findings across subgroups mitigate concerns about systematic bias at the umbrella-analysis level.

Table 2 Overall and Subgroup Prevalence of Metabolic Syndrome Among the Iranian Population

Estimation	Number of Records	Prevalence (95% CI)	I^2	T^2	Heterogeneity chi-Squared	Beggs Test	Egger's Test
Overall	119	30.4 (28.44–32.33)	99.4	64.04	<0.001	0.96	0.80
Gender							
Females	39	33.05 (31.68–34.42)	93.5	9.34	<0.001	0.22	0.84
Males	27	27.57 (24.70–30.45)	99.3	51.10	<0.001	0.02	0.22
Both genders	53	29.47 (26.72–32.23)	98.9	91.63	<0.001	0.41	0.37
Criteria							
ATP III	33	26.86 (23.91–29.82)	99.3	65.15	<0.001	0.466	0.47
IDF	29	32.03 (28.35–35.71)	99.4	88.72	<0.001	0.039*	0.04*
JIS	12	36.47 (27.55–45.38)	99.2	225.61	<0.001	0.98	0097
NECP-ATP III	9	29.61 (26.68–32.53)	83.7	14.54	<0.001	0.40	0.46
Mixed	17	30.33 (27.48–33.18)	95.9	30.13	<0.001	0.45	0.48
Other (Iranian Definition,AHA/NHLBI,CDS,WHO,AACE,INCO)	19	29.60 (23.86–35.34)	98.2	141.77	<0.001	0.64	0.67

Notes: *Significant publication bias.
Abbreviations: NCEP ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Federation; JIS, Other utilized criteria included the Joint Interim Statement; AHA/NHLBI, American Heart Association/National Heart, Lung, and Blood Institute; WHO, World Health Organization; INCO, Iranian-specific criteria.

Methodological Quality of the Included Meta-Analyses

The methodological quality of the 19 included meta-analyses was assessed using the AMSTAR checklist. Four studies were rated as high quality, 14 were rated as moderate quality, and two studies were rated as low quality. Common strengths across the majority of studies included a comprehensive search strategy, duplicate study selection and data extraction, and the use of appropriate statistical methods. Frequent limitations contributing to the moderate or low ratings were the lack of an explicitly registered protocol, failure to provide a list of excluded studies, not reporting on the funding sources of primary studies, and not formally assessing the impact of risk of bias on the meta-analysis results. Table 3 shows the methodological quality assessment of all included Meta-analyses (AMSTAR II).

Quality of Evidence

The synthesized evidence from these meta-analyses provides estimates for the prevalence of MetS across Iranian population. According to the GRADE assessment, the quality of evidence for most outcomes was rated as Moderate. The primary reason for downgrading the evidence from high to moderate was serious inconsistency, attributable to substantial and largely unexplained statistical heterogeneity ($I^2 > 90\%$ in most analyses) across the primary studies included in the meta-analyses. For two outcomes, MetS prevalence in women with PCOS (from one meta-analysis) and prevalence using IDF criteria (from another)—the evidence was further downgraded to Low quality, due to serious imprecision and suspected publication bias, respectively.

The credibility of the evidence, assessed using a pre-defined classification system, was predominantly Class III (suggestive evidence). This classification indicates that the associations are supported by a large sample size (>1000 cases) and statistical significance ($P < 0.001$), but are limited by the high heterogeneity present. A few associations, namely the incidence rate of MetS, its prevalence in schizophrenia patients, and some estimates for PCOS and ATP III criteria, were classified as Class IV (weak evidence), reflecting more limited statistical strength or precision. No evidence met the criteria for Class I (convincing) or Class II (highly suggestive) (Table 4).

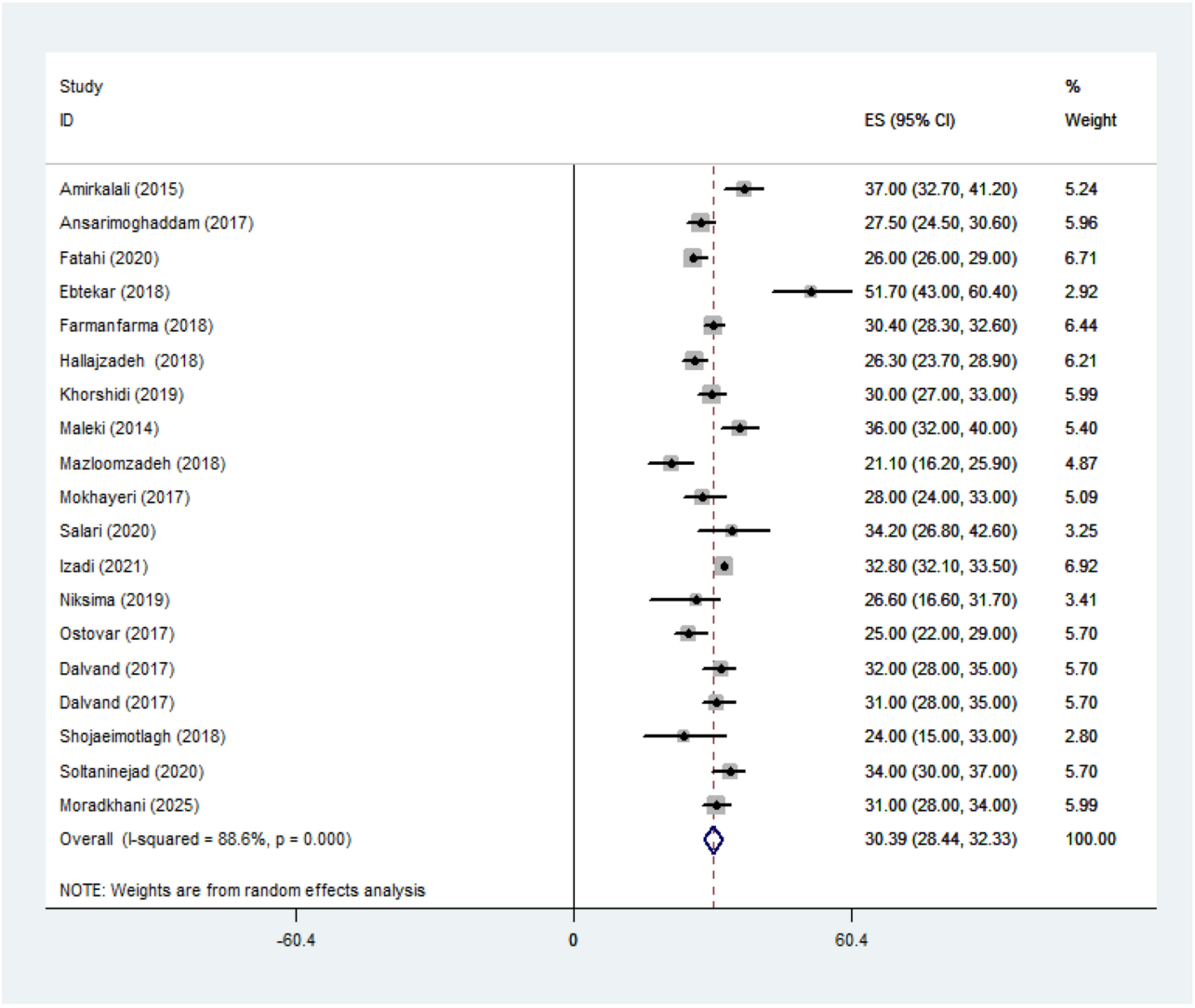

Figure 2 Forest plot of the overall prevalence of Metabolic Syndrome among the Iranian population.

Meta Regression

The meta-regression found that sample size, gender, and diagnostic criteria, do not significantly explain the heterogeneity in prevalence estimates across the studies (Table 5 and Figure 4).

Sensitivity Analysis

To assess the influence of studies with a high risk of bias on the overall results, a sensitivity analysis was done, and discovered that no study changed the results of the meta-analysis.

Discussion

This umbrella meta-analysis provides the most comprehensive synthesis to date of the prevalence of MetS in Iran, integrating evidence from 19 independent meta-analyses encompassing 119 prevalence estimates and nearly 2 million participants. The overall pooled prevalence of MetS was 30.4% (95% CI: 28.4–32.3), confirming that approximately one in three Iranian adults is affected by this multifactorial metabolic disorder.[8,9] This estimate is substantially higher than the global average of 20–25% reported by the International Diabetes Federation.[31] More importantly, a critical regional comparison reveals that Iran's burden is among the highest in the Middle East and North Africa (MENA) region. Our

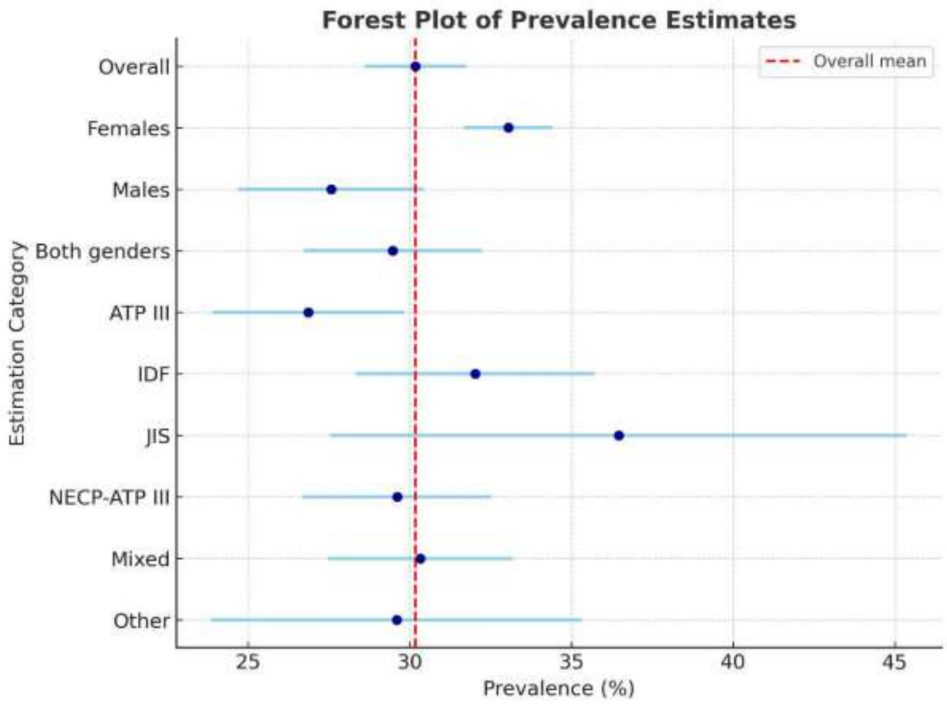

Figure 3 Overall and subgroup prevalence of Metabolic Syndrome among the Iranian population.

finding of 30.4% for Iran is therefore consistent with the elevated rates observed in Persian Gulf Region, which share similar drivers such as rapid urbanization, nutritional transition towards high-calorie diets, and increasingly sedentary lifestyles.[32,33] This regional context underscores that the high prevalence in Iran is not an isolated phenomenon but part of a broader, worrying public health trend affecting the Middle East. These findings highlight a substantial and continuing public-health challenge, consistent with the broader global epidemic of metabolic disorders. This estimate aligns with the pooled prevalence of 25% to 36.9% reported in prior national meta-analyses using ATP III and IDF criteria, respectively.[4,5] A large-scale national survey carried out in 2016 among adults over 25 years of age reported MetS prevalence rates ranging from 32.0% to 47.6%, depending on the diagnostic standard applied.[34] Likewise, a meta-analysis focusing on cardiovascular patients estimated a prevalence of 34.2%, with the highest figures observed in studies conducted between 2015 and 2020[21]. Such increases may stem from rapid urbanization, reduced physical activity, and changes in dietary habits.[13,35] The complications associated with MetS, such as atherosclerosis, myocardial infarction, cerebrovascular events, and type 2 diabetes, pose heavy financial and structural burdens on healthcare systems. As a result, this syndrome represents a critical public health challenge requiring effective prevention, policy reform, and optimized healthcare resource allocation.

Our pooled estimate aligns with prior national and sub-national studies in Iran. In Iranian studies, the reported prevalence of MetS differs between 25% and 41%.[14] In Iran, the situation is particularly concerning, as both hereditary and lifestyle-related factors contribute to its growing occurrence. These convergent estimates corroborate our findings, suggesting that the burden of MetS in Iran has remained persistently high over the past decade despite increasing public-health awareness. The burden of MetS in Iran is not uniform and exhibits significant demographic and geographic disparities.

Consistent with global trends, our analysis and previous studies confirm a significantly higher prevalence among females (33.05%) compared with males (27.57%).[7–9] This gender disparity is well-documented in the Iranian context; for instance, Farmanfarma et al reported a prevalence of 34.8% in women versus 25.7% in men,[8] while another large meta-analysis found rates of 37% in women and 24% in men using NCEP/ATP III criteria.[9] Fatahi et al documented prevalence rates of 34% in women versus 22% in men, and Ghorbani et al[36] found rates of 37.8% versus 17% using ATP III criteria

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Table 3 Methodological Quality Assessment of All Included Meta-Analyses (AMSTAR II)

Study (Author, Year)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Quality Assessment
Amirkalali et al, 2015[5]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	No	No	No	Moderate
Ansarimoghaddam et al, 2017[17]	Partial Yes	Partial Yes	Yes	Partial Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	Low
Fatahi et al, 2020[18]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	No	No	No	Moderate
Ebtekar et al, 2018[19]	Partial Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	No	No	No	Moderate
Farmanfarma et al, 2019[8]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	Yes	Yes	Moderate
Hallajzadeh et al, 2018[20]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	Yes	Yes	Moderate
Khorshidi et al, 2019[21]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	Yes	Yes	Moderate
Maleki et al, 2014[22]	Partial Yes	Partial Yes	Yes	Partial Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	No	No	Low
Mazloomzadeh et al, 2018[23]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	No	Yes	Moderate
Mokhayeri et al, 2017[24]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Partial Yes	No	Yes	No	Yes	Yes	No	Yes	Moderate
Moradkhani et al, 2025[14]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	High
Salari et al, 2020[25]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	High
Izadi et al, 2021[26]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	High
Niksima et al, 2019[27]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	High
Ostovar et al, 2017[4]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Partial Yes	Partial Yes	No	Yes	No	Yes	Yes	Yes	Yes	Moderate
Dalvand et al, 2017[28]	Yes	Partial Yes	Yes	Yes	Yes	Yes	No	Partial Yes	Partial Yes	No	Yes	No	Yes	Yes	Yes	Yes	Moderate
Dalvand et al, 2017[9]	Yes	Partial Yes	Yes	Yes	Yes	Yes	Partial Yes	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Moderate
Shojaeimotlagh et al, 2018[29]	Yes	Partial Yes	Yes	Yes	Yes	Yes	Partial Yes	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Moderate
Soltaninejad et al, 2020[30]	Yes	Partial Yes	Yes	Yes	Yes	Yes	Partial Yes	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Moderate

Notes: Q1 (PICO): Both studies clearly defined their research question and inclusion criteria. Q2 (Protocol): Both reports imply methods were established beforehand but lack an explicit statement or reference to a published protocol. Q3 (Study Design): Both explicitly included cross-sectional studies. Q4 (Search Strategy): Both used comprehensive searches in multiple databases. Q5 (Selection in Duplicate): Both stated that study selection was performed by two independent reviewers. Q6 (Data Extraction in Duplicate): Both stated that data extraction was performed by two independent reviewers. Q7 (List of Excluded Studies): Neither provided a full list of excluded studies, though they provided reasons for exclusion in a flow diagram. Q8 (Description of Included Studies): Both provided adequate details of included studies in tables. Q9 (Risk of Bias Assessment): Both used a tool (STROBE/JBI) to assess study quality, but the application and reporting were not highly detailed. Q10 (Funding of Included Studies): Neither reported on the funding sources of the primary studies they included. Q11 (Appropriate Statistical Methods): Both used random-effects models and appropriate transformations (like Freeman-Tukey) for meta-analysis of prevalences. Q12 (RoB impact on meta-analysis): Neither assessed the impact of individual study RoB on the meta-analysis results. Q13 (Account for RoB in discussion): Both discussed heterogeneity and its potential sources, which is indirectly related to RoB. Q14 (Heterogeneity): Both extensively investigated and discussed the high heterogeneity found (I^2 > 99%). Q15 (Publication Bias): Both mentioned publication bias as a consideration but did not perform formal tests (eg, funnel plots), arguing it is less relevant for prevalence studies. Q16 (Conflict of Interest): Both explicitly declared no conflict of interest.

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Table 4 Summary of Findings and Quality of Evidence (GRADE and Credibility Assessment)

Outcome Measure	Population/ Context	No. of Participants/ No. of Studies	Effect Size (95% CI)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of Evidence (GRADE)	Evidence Class
Overall Prevalence of Metabolic Syndrome	Iranian Adults	472,401/1 (125 studies)	0.26 (0.24 to 0.29)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Overall Prevalence of Metabolic Syndrome	Iranian Adults	526,562/194 studies	31% (28 to 34%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Overall Prevalence of Metabolic Syndrome	Iranian Adults	220,327/2	28.5% (25.0 to 32.0%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Overall Prevalence of Metabolic Syndrome	Iranian Adults	83,227/1	31% (28 to 35)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (ATP III Criteria)	Iranian Adults	54,043/1 (17 studies)	0.369 (0.327 to 0.412)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (ATP III Criteria)	Iranian Adults	46,464/14	21.1% (16.2 to 25.9)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	IV
Prevalence (ATP III Criteria)	Iranian Adults (≥20 years)	44,584/25	28% (24 to 32)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (ATP III Criteria)	Iranian Adults	145,887/2	27.5% (23.5 to 31.5%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (IDF Criteria)	Iranian Adults	23,774/1 (7 studies)	0.346 (0.317 to 0.376)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (IDF Criteria)	Iranian Adults	51,356/11	28% (24 to 33)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (IDF Criteria)	Iranian Adults	87,071/2	32.0% (27.5 to 36.5%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence (IDF Criteria)	Iranian Adults	60,635/1	36% (32 to 40)	Not serious	Serious	Not serious	Not serious	Serious	Low	IV
Prevalence (JIS Criteria)	Iranian Adults	11,081/2	41.3% (33.0 to 49.6%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Postmenopausal Women	Iranian Women	5,893/1 (16 studies)	0.516 (0.43 to 0.60)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Women with PCOS	Iranian Women	20,552/1	26.3% (23.7 to 28.9)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Women with PCOS	Iranian Women	8,946/1	30% (27 to 33)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III

(*Continued*)

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Table 4 (Continued).

Outcome Measure	Population/ Context	No. of Participants/ No. of Studies	Effect Size (95% CI)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of Evidence (GRADE)	Evidence Class
Prevalence in Women with PCOS	Iranian Women	1,353/10	24.15% (16.60 to 31.70%)	Not serious	Serious	Not serious	Serious	Not serious	Low	IV
Prevalence in Cardiovascular Patients	Iranian Patients	44,735/27 studies	34.2% (26.8 to 42.6%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Professional Drivers	Iranian Drivers	19,350/12 studies	32.8% (32.1 to 33.5%)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Drivers	Iranian Drivers	26,156/1	34% (30 to 37)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Schizophrenia Patients	Iranian Patients	1,589/1	24% (15 to 33)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	IV
Incidence Rate of Metabolic Syndrome	Iranian Population	138,182/1 (20 studies)	97.96 per 1000 (75.98 to 131.48)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	IV
Prevalence in Women (General)	Iranian Women	Not pooled/2	35.7% (Ostovar)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III
Prevalence in Men (General)	Iranian Men	Not pooled/2	26.9% (Ostovar)	Not serious	Serious	Not serious	Not serious	Not serious	Moderate	III

Notes: Inconsistency: Downgraded by one level due to substantial unexplained statistical heterogeneity ($I^2 > 90\%$ in all meta-analyses). Imprecision: Downgraded by one level for the PCOS meta-analysis due to the relatively small total sample size and a very wide confidence interval. Explanation of Evidence Classes (Credibility Assessment): Class I (Convincing evidence): >1000 cases; $P < 10^{-6}$; no evidence of small study effects or excess significance bias; 95% prediction interval excludes null; no large heterogeneity ($I^2 < 50\%$). Class II (Highly suggestive evidence): >1000 cases; $P < 10^{-6}$; largest study has a 95% CI excluding the null value. Class III (Suggestive evidence): >1000 cases and statistical significance at $P < 0.001$. Class IV (Weak evidence): Remaining significant associations with $P < 0.05$.

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Table 5 Meta-Regression Analysis of Effective Factors on Mets Prevalence Estimates

Variable	Coefficient	Se	*t*-value	*P*	95% Confidence Interval
Sample size	-2.11×10^{-6}	5.96×10^{-6}	−0.35	0.725	-0.000014 to 9.70×10^{-6}
Gender	−1.706	1.025	−1.66	0.099	−3.737 to 0.325
Diagnostic criteria	0.429	0.244	1.76	0.082	−0.055 to 0.913
Intercept	31.956	1.525	20.96	< 0.001	28.935 to 34.976

and 44.1% versus 25.4% using IDF criteria. In contrast, Esmailzadehha et al[37] reported 30.5% in men and 25.7% in women based on WHO criteria in a 2010–2011 study from Ghazvin. Biological factors, including hormonal changes during menopause, higher adiposity, and metabolic alterations in estrogen deficiency, contribute to this disparity.[19] Additionally, socio-cultural determinants such as lower levels of physical activity and traditional dietary habits may further exacerbate women's vulnerability. This pattern underscores the need for gender-sensitive preventive strategies emphasizing weight management and physical activity among Iranian women, particularly in midlife and postmenopausal groups.

Health status also affects MetS prevalence in Iran, as shown in several studies applying different diagnostic criteria. For instance, Jangrabani et al[38] reported a prevalence rate as high as 65%. Evidence indicates that insulin resistance serves as a potential link between PCOS and MetS.[39] Apridonidze et al[40] found that 43% of women with PCOS met the criteria for MetS, signifying an elevated metabolic risk in this group compared to the general population.

Impact of Diagnostic Criteria

The observed variability in prevalence across diagnostic definitions highlights the ongoing challenge of definitional heterogeneity in MetS research. Our analysis confirms that the choice of criteria significantly impacts the estimated burden. Studies using the JIS definition yielded the highest prevalence (36.47%), followed by IDF (32.03%) and NCEP-ATP III (29.61%).[8,9,24] These differences are largely attributable to variation in the required thresholds and mandatory

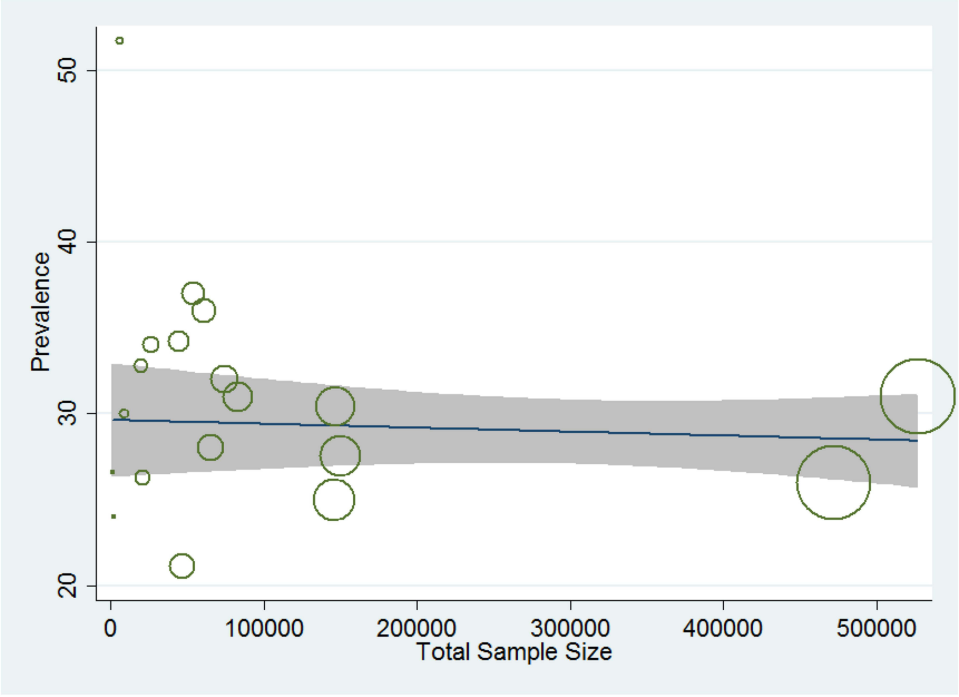

Figure 4 The trend of prevalence of Metabolic Syndrome among the Iranian population by study sample size.

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components. For example, the JIS harmonized definition applies population-specific waist-circumference cut-offs and does not mandate central obesity as a prerequisite, thereby identifying a broader at-risk population.[41] In contrast, IDF criteria historically required central obesity as an essential condition, which may underestimate prevalence in populations where abdominal obesity is less dominant. The highest prevalence ever reported in an Iranian sub-population was 65% among patients with PCOS,[20] a group with a well-established elevated metabolic risk driven by insulin resistance.[40] The use of Iranian-specific adaptations of waist-circumference thresholds further influences local estimates.[42] Our findings reinforce the importance of standardized, ethnically tailored criteria to enhance comparability across studies and facilitate targeted health policies.

MetS is a well-established precursor of type 2 diabetes and cardiovascular disease, both leading causes of morbidity and mortality. A meta-analysis on cardiovascular patients in Iran estimated a MetS prevalence of 34.2%, with the highest figures in recent studies (2015–2020),[25] suggesting a growing burden. The complications associated with MetS—such as myocardial infarction and stroke, pose heavy financial and structural burdens on healthcare systems. Given the strong association between MetS and modifiable lifestyle factors, comprehensive prevention programs are urgently required. These should include the promotion of healthy diets, community-based interventions to increase physical activity, and systematic screening for MetS components within primary-care settings.

The principal strength of this umbrella review is its extensive scope, aggregating high-quality evidence from numerous meta-analyses to provide a robust and generalizable national estimate. The methodological rigor of the included studies, as assessed by the AMSTAR 2 tool (Table 3), strengthens our confidence in the findings; the majority of the source meta-analyses were of moderate to high quality, employing comprehensive searches and duplicate procedures for study selection and data extraction. Furthermore, the pre-specified subgroup analyses by gender and diagnostic criteria add depth and clarity to the findings.

However, several limitations must be acknowledged. The most notable is the high statistical heterogeneity (I^2 = 99.4%), which, while expected in a synthesis of diverse populations and methodologies, limits the precision of the pooled estimate. This is reflected in the GRADE assessment (Table 4), where the quality of evidence for nearly all outcomes was downgraded to moderate primarily due to serious inconsistency. This heterogeneity reflects true population variability influenced by differences in demographic composition, urban–rural distribution, diagnostic definitions, and study settings. The inclusion of both general and high-risk populations (eg, postmenopausal women,[19] patients with PCOS,[20] cardiovascular disease,[25] schizophrenia,[29] and professional drivers[26,30]) adds further, expected variability.

The inclusion of both general and high-risk populations, while comprehensive, may inflate the overall estimate relative to a purely general population sample. Furthermore, our reliance on aggregated data precluded a more granular meta-regression to fully quantify all sources of heterogeneity. Although publication bias was not significant overall, it was detected in the subgroup using IDF criteria, which correspondingly led to a downgrade in the quality of evidence for that specific outcome in Table 4. Finally, the credibility assessment in Table 4 indicates that the evidence is predominantly Class III (suggestive), meaning that while the findings are supported by a large sample size and statistical significance, the high heterogeneity precludes a classification as convincing or highly suggestive. This provides a nuanced interpretation of the results, acknowledging their scale while cautioning against over-interpretation given the underlying variability. However, the findings should not be read as a precise estimate of national prevalence without considering the extreme heterogeneity, mixing of population types, and moderate underlying evidence quality require cautious interpretation of the pooled prevalence.

Conclusion

This umbrella review provides a definitive synthesis that resolves longstanding inconsistencies in the literature, establishing that Metabolic Syndrome (MetS) affects approximately one in three adults. This unified and robust prevalence estimate, derived from 19 prior meta-analyses, conclusively demonstrates that Iran faces a significantly higher MetS burden than the global average. A key finding critical for public health planning is the marked gender disparity, with a substantially higher prevalence in women than in men. These findings have profound and immediate implications. The high prevalence signals a looming epidemic of cardiovascular diseases and diabetes, placing a substantial and unsustainable burden on the Iranian healthcare system. This evidence mandates a strategic shift from documentation to action, specifically the development of

a national MetS prevention and control strategy that prioritizes gender-sensitive community-based lifestyle interventions, the standardized use of Iranian-adapted diagnostic criteria in primary care to ensure early and consistent identification of at-risk individuals and implementing longitudinal studies to track temporal trends, investigating underlying socioeconomic and regional determinants, and evaluating the cost-effectiveness of targeted interventions. By providing this comprehensive and authoritative estimate, this review delivers the critical evidence base required to guide effective policy, optimize clinical practice, and direct future research to mitigate the growing burden of MetS in Iran. The high and persistent prevalence of MetS in Iran has profound implications for national health policy.

Use of AI Statement

The author(s) utilized DeepSeek to assist with language editing and refinement of certain sections of the manuscript. This included improving sentence clarity, conciseness, and overall flow. The author(s) critically reviewed and revised the AI-generated suggestions and are solely responsible for the final intellectual content, accuracy, and conclusions presented in this work.

Data Sharing Statement

The original contributions of this study are contained within the article and the data supporting the findings are available upon reasonable request. For further inquiries, please contact the corresponding author.

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Author Contributions

Mojtaba Sepandi: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft. **Maryam Taghdir**: Conceptualization, Investigation, Resources, Validation, Writing – original draft. **Yousef Alimohamadi**: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Software, Supervision, Visualization, Writing – review & editing. Mojtaba Sepandi, Maryam Taghdir, and Yousef Alimohamadi contributed equally to this work. All authors gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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