

Global prevalence, risk factors, and clinical consequences of coexisting prediabetes and prehypertension: a systematic review and meta-analysis

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Received: March 2, 2026; Accepted: August 29, 2026

Abstract. Prediabetes and prehypertension are highly prevalent intermediate metabolic states that often coexist, potentially synergistically increasing cardiometabolic risk. Understanding their combined global burden, associated risk factors, and clinical outcomes is essential for developing effective preventive strategies. This systematic review and meta-analysis aimed to quantify the global prevalence of coexisting prediabetes and prehypertension, identify demographic and metabolic risk factors, and evaluate associated clinical outcomes. **Methods:** A comprehensive literature search was conducted across PubMed, Embase, Web of Science, and Scopus databases from January 2000 to July 2025. Eligible studies included observational and interventional research reporting primary data on coexisting prediabetes and prehypertension. Data synthesis employed random-effects meta-analysis. Risk of bias was assessed using the Newcastle-Ottawa Scale and Cochrane RoB 2 tool. Fifteen studies encompassing 149,585 participants were included. Cross-sectional meta-analysis of ten studies demonstrated a significant positive association (OR = 1.62; 95% CI: 1.39-1.89; $p < 0.05$), with moderate heterogeneity ($I^2 = 50.2\%$). Key independent risk factors included increased age (OR per decade: 1.41; 95% CI: 1.24-1.61), male sex (OR: 1.36; 95% CI: 1.12-1.65), and higher BMI (OR per 1 kg/m²: 1.18; 95% CI: 1.14-1.23). Longitudinal data demonstrated markedly elevated risks for incident diabetes (HR: 2.84; 95% CI: 2.13-3.78) and hypertension (HR: 2.21; 95% CI: 1.71-2.85). Pooled intervention data ($n = 2$ RCTs) showed modest but significant improvements: mean systolic BP reduction of -4.1 mmHg (95% CI: -6.7, -1.5) and HbA1c reduction of -0.18% (95% CI: -0.25, -0.11). The coexistence of prediabetes and prehypertension is common and substantially elevates the risk for overt cardiometabolic disease. Integrated risk stratification and targeted multifactorial prevention strategies are essential to address this significant public health challenge.

Keywords: prediabetes, prehypertension, metabolic syndrome, systematic review, meta-analysis.

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Prevalência global, fatores de risco e consequências clínicas da coexistência de pré-diabetes e pré-hipertensão: uma revisão sistemática e meta-análise

Resumo. O pré-diabetes e a pré-hipertensão constituem estados metabólicos intermediários de alta prevalência que frequentemente coexistem, potencialmente aumentando sinergicamente o risco cardiometabólico. A compreensão da carga global combinada, dos fatores de risco associados e dos desfechos clínicos é fundamental para o desenvolvimento de estratégias preventivas eficazes. Esta revisão sistemática e meta-análise visou quantificar a prevalência global da coexistência de pré-diabetes e pré-hipertensão, identificar fatores de risco demográficos e metabólicos e avaliar os desfechos clínicos associados. Foi conduzida uma busca bibliográfica abrangente nas bases de dados PubMed, Embase, Web of Science e Scopus, de janeiro de 2000 a julho de 2025. Os estudos elegíveis incluíram pesquisas observacionais e intervencionais que reportaram dados primários sobre a coexistência de pré-diabetes e pré-hipertensão. A síntese de dados empregou meta-análise de efeitos aleatórios. O risco de viés foi avaliado utilizando a Escala Newcastle-Ottawa e a ferramenta Cochrane RoB 2. Quinze estudos abrangendo 149.585 participantes foram incluídos. Meta-análise transversal de dez estudos demonstrou associação positiva significativa (OR = 1,62; IC 95%: 1,39-1,89; $p < 0,05$), com heterogeneidade moderada ($I^2 = 50,2\%$). Os principais fatores de risco independentes incluíram idade mais avançada (OR por década: 1,41; IC 95%: 1,24-1,61), sexo masculino (OR: 1,36; IC 95%: 1,12-1,65) e maior IMC (OR por 1 kg/m²: 1,18; IC 95%: 1,14-1,23). Dados longitudinais demonstraram riscos marcadamente elevados de incidência de diabetes (HR: 2,84; IC 95%: 2,13-3,78) e hipertensão (HR: 2,21; IC 95%: 1,71-2,85). Dados de intervenção agrupados ($n = 2$ ECRs) mostraram melhorias modestas, porém significativas: redução média da PAS de -4,1 mmHg (IC 95%: -6,7, -1,5) e redução da HbA1c de -0,18% (IC 95%: -0,25, -0,11). A coexistência de pré-diabetes e pré-hipertensão é comum e eleva substancialmente o risco para doença cardiometabólica manifesta. A estratificação de risco integrada e estratégias de prevenção multifatorial direcionadas são essenciais para abordar esse desafio significativo de saúde pública.

Palavras-chave: pré-diabetes, pré-hipertensão, síndrome metabólica, revisão sistemática, metanálise.

1. Introduction

Elevated blood pressure below the diagnostic threshold for hypertension, historically termed “prehypertension” in the JNC7 guidelines (systolic BP 120-139 mm Hg or diastolic BP 80-89 mm Hg), represents an intermediate cardiometabolic state with increased risk for progression to overt hypertension and cardiovascular disease. While terminology varies across guidelines - for instance, Brazilian Hypertension Guidelines classify this range as “high-normal blood pressure” rather than using the term prehypertension -, this BP range is consistently recognized as carrying elevated cardiovascular risk¹. While individuals with prehypertension are often asymptomatic, epidemiological reports demonstrate its significant prevalence globally, particularly in low- and middle-income countries. Prehypertension is not only associated with future hypertension but also with heightened risk for organ damage and adverse metabolic profiles². Its early identification provides an opportunity for preventive interventions aimed at attenuating long-term cardiovascular morbidity and mortality. Recent literature also emphasizes the need to address modifiable risk factors, such as obesity, diet, and physical inactivity, in populations with prehypertension³.

Prediabetes is characterized by elevated blood glucose levels that fall below the diagnostic threshold for diabetes, commonly defined as fasting plasma glucose of 100-125 mg/dL or HbA1c between 5.7-6.4%⁴. Individuals with prediabetes face an increased risk of developing type 2 diabetes (T2DM), as well as cardiovascular and renal complications. The global prevalence of prediabetes has risen substantially in the last decade, paralleling trends in obesity and sedentary lifestyles⁵. Pathophysiologically, prediabetes is associated with insulin resistance, chronic low-grade inflammation, and early vascular dysfunction, all of which contribute to increased atherosclerotic risk⁶. As with prehypertension, the identification of prediabetes offers a window for intensive lifestyle modification and early pharmacologic intervention to delay or prevent the onset of clinically manifest disease.

Growing evidence suggests that prehypertension and prediabetes frequently coexist and may synergistically accelerate cardiovascular risk. Studies indicate that these two conditions share overlapping risk profiles, including central obesity, dyslipidemia, and inflammatory markers, hinting at shared pathophysiological pathways⁷. Recent cohort and cross-sectional studies have quantified the prevalence and clinical significance of this comorbidity, demonstrating additive or even multiplicative effects on the risk of de-

veloping overt hypertension, diabetes, or atherosclerotic complications⁸. However, the precise global burden, the range of associated risk factors, and the clinical outcomes related to the coexistence of prediabetes and prehypertension remain less clearly elucidated.

Systematic reviews and meta-analyses represent the methodological gold standard for synthesizing observational and interventional studies across diverse populations, enabling the quantification of pooled prevalence, risk estimates, and intervention effects⁹. By integrating heterogeneous findings, these approaches provide robust evidence for clinical and public health guidelines, while identifying gaps and heterogeneity in current research. The application of meta-analytic techniques is particularly useful in evaluating coexisting conditions, as it allows for an assessment of joint risk and the efficacy of multifactorial interventions.

Despite the growing interest in the individualized management of cardiometabolic risk, consolidated data on the epidemiology, determinants, and consequences of the coexistence of prediabetes and prehypertension are lacking in the contemporary literature. Most previous studies have focused on each condition in isolation or included limited regional populations, leading to insufficient understanding of the global scope and clinical implications of their overlap. Furthermore, few syntheses have evaluated the impact of modifiable and non-modifiable risk factors, or assessed clinical outcomes such as progression to diabetes, hypertension, and cardiovascular disease in individuals with both conditions.

Thus, the objective of this systematic review and meta-analysis is to appraise and quantify the global prevalence of coexisting prediabetes and prehypertension, identify associated demographic, clinical, and metabolic risk factors, and assess the resulting clinical outcomes.

2. Method

2.1. Protocol registration and reporting

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (2020 update)¹⁰ and the methodological guidance provided by the Cochrane Handbook for Systematic Reviews of Interventions. The protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO), registration number CRD420251111340.

2.2. Eligibility criteria

2.2.1. Types of studies

We included observational (cross-sectional, cohort, and case-control) and interventional (randomized controlled trials) studies that provided primary, quantitative data on the coexistence of prediabetes and prehypertension. Review articles, commentaries, editorials, case reports, and qualitative studies were excluded.

2.2.2. Population

Human participants of any age, sex, and ethnicity, as defined within each included study. Studies exclusively involving populations with established diabetes or hypertension at baseline were excluded.

2.3. Exposure and outcomes

Exposure: Coexistence of prediabetes (as defined by fasting plasma glucose, oral glucose tolerance test, or HbA1c according to ADA criteria)¹¹ and prehypertension¹.

Outcomes: Primary: prevalence of coexistence; Secondary: associated risk factors (demographic, clinical, metabolic) and clinical outcomes (incidence of diabetes, hypertension, cardiovascular and renal events, and mortality).

2.4. Timeframe and language

Studies published in English from January 2000 to July 2025 were eligible. Reports available only as meeting abstracts were excluded unless sufficient data could be extracted.

2.5. Information sources and search strategy

A comprehensive literature search was conducted in the following electronic databases: PubMed/MEDLINE, Embase, Web of Science, and Scopus. The search was last updated on July 20, 2025. The reference lists of included studies and relevant reviews were hand-searched for additional studies.

Search terms included combinations of “prediabetes”, “impaired fasting glucose”, “impaired glucose tolerance”, “pre-hypertension”, “prehypertension”, “blood pressure”, “prevalence”, “risk factors”, “clinical outcomes”, and “cardiovascular”.

2.6. Study selection process

All search results were imported into EndNote and duplicates were removed. Two independent reviewers screened titles and Abstract for eligibility (AMVB, GCMO). Full texts of potentially relevant articles were retrieved and assessed for inclusion according to the predefined criteria. Discrepancies were resolved through discussion and, if necessary, adjudication by a third reviewer (LJOA).

2.7. Data extraction

A standardized data extraction form was developed and independently piloted. The following data were extracted:

- Study characteristics: author, year, country, study design, setting, sample size.
- Participant characteristics: age, sex, ethnicity.
- Definitions and diagnostic criteria for prediabetes and prehypertension.
- Prevalence of coexistence, risk factors (with effect measures: OR, RR, HR), and reported clinical outcomes.
- Duration of follow-up, if applicable, for longitudinal studies.

Extraction was performed independently by two reviewers (GCMO, LMO). Consensus was reached on final data entries.

2.8. Quality assessment

Methodological quality and risk of bias were assessed independently by two reviewers using standardized tools:

- Observational studies: Newcastle-Ottawa Scale (NOS).
- Interventional studies: Cochrane Risk of Bias 2 (RoB 2) tool.
- Disagreements were resolved by consensus or a third reviewer (LJOA).

2.9. Data synthesis and statistical analysis

A random-effects meta-analysis was conducted using the DerSimonian and Laird method to account for between-study heterogeneity. To ensure methodological rigor and appropriate use of epidemiological measures, analyses were stratified by study design: prevalence estimates employed meta-analysis of proportions; for cross-sectional associations, pooled odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using the inverse-variance method. For longitudinal outcomes, hazard ratios (HRs) were pooled separately to preserve methodological integrity. All effect estimates were weighted by inverse variance.

Heterogeneity was quantified using Cochran's Q test and the I^2 statistic, with $I^2 > 50\%$ indicating substantial heterogeneity. Subgroup analyses were predefined by geographic region (Asia, Americas, Europe, Africa), age group (adults vs. adolescents), study design, and diagnostic criteria (HbA1c vs. fasting glucose for prediabetes). Meta-regression was performed where sufficient data were available to explore sources of heterogeneity.

Publication bias was assessed visually using funnel plots and statistically using Egger's regression test. Sensitivity analyses were conducted by sequentially excluding individual studies and recalculating pooled estimates.

Given the methodological differences between study designs, ORs from cross-sectional studies and HRs from cohort studies were not combined in the same meta-analysis. This approach ensures valid interpretation of effect sizes and avoids conflation of distinct epidemiological measures.

Statistical analyses were performed using R (version 4.3.1) with the meta and metafor packages, supplemented by MetaAnalyst (<https://metaanalysisonline.com/>) for forest plot generation. PSPP was used for preliminary descriptive analyses, but all meta-analytic models were replicated in R to ensure reproducibility and alignment with best practices in systematic reviews.

As this study involved the analysis of published data only, no institutional ethics approval was required.

3. Results

3.1. Study selection and characteristics

From the initial search, 15 studies fulfilled eligibility criteria (Figure 1), encompassing a total of 149,585 participants across diverse geographical settings, study designs, and age ranges. Included articles originated from Asia, North America, Europe, and Africa, representing both general and specific population subgroups (urban, rural, adolescent, and high-risk cohorts)¹²⁻²⁶.

Eleven studies were cross-sectional, two were longitudinal cohorts, and two were randomized controlled interventions (Table 1).

Study 1: Yesmin M et al.¹², 2023. Objective: To investigate the prevalence and associated risk factors of prediabetes and prehypertension among adults in Bangladesh. Method: A cross-sectional study was conducted involving a large sample of adults. Participants were screened using diagnostic criteria from the American Diabetes Association (ADA) for prediabetes and the Seventh Report of the Joint National Committee (JNC7) for prehypertension. Demographic and clinical data were collected through standardized questionnaires and physical examinations. Results: The study identified a high prevalence of prediabetes and prehypertension among the adult population. Significant risk factors included age, obesity, sedentary lifestyle, and family history of diabetes or hypertension.

Figure 1 - Flowchart of the selection process for the 15 studies included.

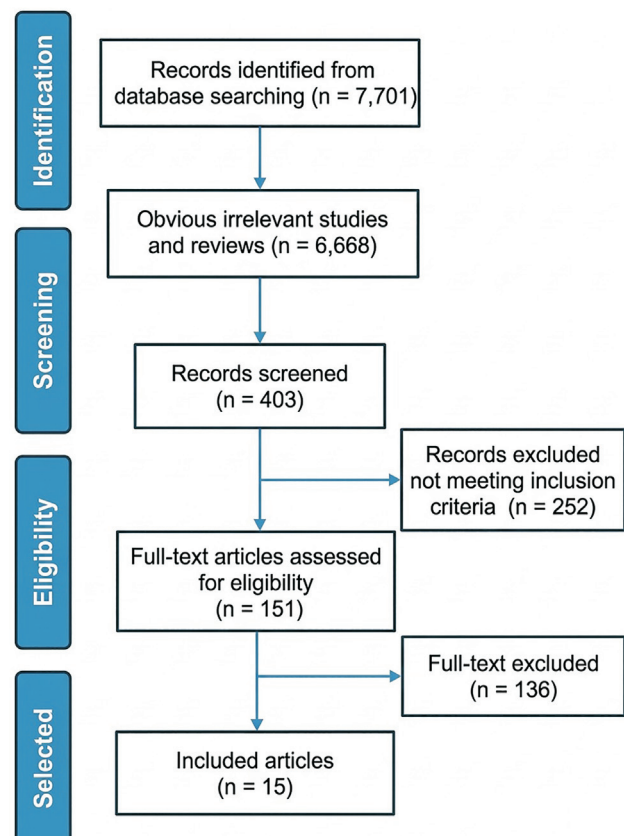


Table 1 - Characteristics of included studies for systematic review and meta-analysis.

Study	Country	Study design	Population	Sample size	Diagnostic criteria	Key Outcomes
Yesmin et al. ¹²	Bangladesh	Cross-sectional	Adults	14 704	ADA (prediabetes) JNC7 (prehypertension)	Prevalence risk factors
Okada et al. ¹³	Japan	Cross-sectional	Adults	99 140	ADA (prediabetes) JNC7 (prehypertension)	Prevalence of hyperfiltration
Gupta et al. ¹⁴	USA	Cross-sectional	Adults	1 711	ADA (prediabetes) JNC7 (prehypertension)	Association with low vitamin D
Spurr et al. ¹⁵	Canada	Cross-sectional	Adolescents	396	ADA (prediabetes) JNC7 (prehypertension)	Prevalence in ethnic groups
Wang et al. ¹⁶	China	Cross-sectional	Adults	4 143	ADA (prediabetes) JNC7 (prehypertension)	Prevalence risk factors
Thamizhmaran et al. ¹⁷	India	Cross-sectional	Adults	203	ADA (prediabetes) JNC7 (prehypertension)	Prevalence undiagnosed cases
Jung et al. ¹⁸	Korea	Cohort (10 years)	Adults	2 830	ADA (prediabetes) 8JNC7 (prehypertension)	Risk of T2DM
Vucak et al. ¹⁹	Croatia	Cross-sectional	Adults	2 485	ADA (prediabetes) JNC7 (prehypertension)	Association with hyperuricemia
Wu et al. ²⁰	China	Cross-sectional	Adults	8 188	ADA (prediabetes) JNC7 (prehypertension)	Prevalence of coexistence
Hadi Alijanvand et al. ²¹	Iran	Cohort	First-degree relatives of T2DM patients	1 388	ADA (prediabetes) JNC7 (prehypertension)	Prevalence risk of T2DM/hypertension
Gradinariu et al. ²²	USA	RCT	Adults	685	ADA (prediabetes) JNC7 (prehypertension)	Effects of lifestyle intervention
Li et al. ²³	China	Cross-sectional	Adults	12 388	ADA (prediabetes) JNC7 (prehypertension)	Association with lipid accumulation
Ganguly et al. ²⁴	Mexico	RCT	Adults	327	ADA (prediabetes) JNC7 (prehypertension)	Effect of dapagliflozin on BP variability
Pengpid et al. ²⁵	Thailand	RCT	Adults	443	ADA (prediabetes) JNC7 (prehypertension)	Lifestyle intervention effects
Kanauchi et al. ²⁶	Japan	Cross-sectional	Adults	554	ADA (prediabetes) JNC7 (prehypertension)	Surrogate markers of insulin resistance

ADA: American Diabetes Association®; JNC7: Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.

Conclusion: The findings highlight the growing burden of prediabetes and prehypertension in Bangladesh, emphasizing the need for public health interventions targeting modifiable risk factors.

Study 2: Okada R *et al.*, 2012¹³. Objective: To assess the prevalence of hyperfiltration in individuals with prediabetes and prehypertension in Japan. Method: A cross-sectional study was conducted among a large cohort of adults.

Hyperfiltration was evaluated using glomerular filtration rate measurements. Participants were diagnosed with prediabetes and prehypertension based on ADA and JNC7 criteria, respectively. Results: The study found a significant association between prediabetes, prehypertension, and increased GFR, indicating hyperfiltration as a potential early

marker of kidney dysfunction. Conclusion: Hyperfiltration may serve as an early indicator of renal damage in individuals with prediabetes and prehypertension, warranting further monitoring and intervention.

Study 3: Gupta AK *et al.*, 2012¹⁴. Objective: To explore the association between low vitamin D levels and prediabetes/prehypertension in the United States. Method: A cross-sectional study was conducted among adults. Serum vitamin D levels were measured, and participants were classified as having prediabetes and/or prehypertension based on ADA and JNC7 criteria. Statistical analyses were performed to assess the relationship between vitamin D deficiency and metabolic outcomes. Results: The study revealed a significant inverse association between serum vitamin D levels and the prevalence of prediabetes and prehypertension. Conclusion: Low vitamin D levels may contribute to the development of prediabetes and prehypertension, suggesting a potential role for vitamin D supplementation in preventive strategies.

Study 4: Spurr S *et al.*, 2020¹⁵. Objective: To examine the prevalence of prediabetes and prehypertension among adolescents from different ethnic groups in Canada. Method: A cross-sectional study was conducted among adolescents from diverse ethnic backgrounds. Prediabetes and prehypertension were diagnosed using ADA and JNC7 criteria, respectively. Data were analyzed to identify ethnic disparities in prevalence rates. Results: Significant ethnic variations were observed in the prevalence of prediabetes and prehypertension, with certain minority groups showing higher risks. Conclusion: Targeted public health initiatives are needed to address the disproportionate burden of metabolic disorders among specific ethnic groups.

Study 5: Wang X *et al.*, 2018¹⁶. Objective: To determine the prevalence and risk factors of prediabetes and prehypertension among adults in China. Method: A cross-sectional study was conducted involving a representative sample of adults. Participants were screened for prediabetes and prehypertension using ADA and JNC7 criteria. Logistic regression models were used to identify independent risk factors. Results: The study reported a high prevalence of prediabetes and prehypertension, with obesity, physical inactivity, and poor dietary habits emerging as key risk factors. Conclusion: Comprehensive lifestyle interventions are essential to mitigate the rising tide of metabolic disorders in China.

Study 6: Thamizhmaran S *et al.*, 2024¹⁷. Objective: To estimate the prevalence of undiagnosed cases of prediabetes and prehypertension in India. Method: A cross-sectional study was conducted among adults, focusing on identifying individuals who were unaware of their metabolic status. Diagnosis was based on ADA and JNC7 criteria.

Results: A substantial proportion of participants had undiagnosed prediabetes and prehypertension, highlighting gaps in screening and awareness programs. Conclusion: Enhanced community-based screening initiatives are necessary to detect and manage undiagnosed cases of prediabetes and prehypertension.

Study 7: Jung JY *et al.*, 2018¹⁸. Objective: To evaluate the long-term risk of T2DM in individuals with prediabetes and prehypertension in Korea. Method: A 10-year cohort study was conducted among adults diagnosed with prediabetes and prehypertension. Follow-up assessments tracked the incidence of T2DM over the study period. Results: Participants with both prediabetes and prehypertension exhibited a significantly higher risk of developing T2DM compared to those with either condition alone. Conclusion: Coexisting prediabetes and prehypertension represent a strong predictor of future T2DM, underscoring the importance of early intervention.

Study 8: Vucak J *et al.*, 2012¹⁹. Objective: To investigate the association between hyperuricemia and prediabetes/prehypertension in Croatia. Method: A cross-sectional study was conducted among adults. Serum uric acid levels were measured, and participants were classified as having prediabetes and/or prehypertension based on ADA and JNC7 criteria. Results: Hyperuricemia was found to be independently associated with prediabetes and prehypertension, suggesting a potential link between metabolic syndrome components. Conclusion: Hyperuricemia may serve as a biomarker for identifying individuals at risk of developing prediabetes and prehypertension.

Study 9: Wu J *et al.*, 2011²⁰. Objective: To assess the prevalence of coexistence of prediabetes and prehypertension among adults in China. Method: A cross-sectional study was conducted among adults. Participants were screened for both conditions using ADA and JNC7 criteria. The study aimed to quantify the overlap between prediabetes and prehypertension. Results: A significant proportion of participants had both prediabetes and prehypertension, indicating a high burden of metabolic comorbidities. Conclusion: The coexistence of prediabetes and prehypertension highlights the need for integrated management strategies to address metabolic disorders.

Study 10: Hadi Alijanvand M *et al.*, 2020²¹. Objective: To evaluate the prevalence and risk factors of prediabetes and prehypertension among first-degree relatives of type 2 diabetes mellitus (T2DM) patients in Iran. Method: A cohort study was conducted among first-degree relatives of T2DM patients. Participants were screened for prediabetes and prehypertension using ADA and JNC7 criteria. Risk factors were assessed through detailed medical histories and physical examinations. Results: The study identified a high prevalence of prediabetes and prehypertension among relatives, with family history being a strong predictor. Conclusion: First-degree relatives of T2DM patients require targeted screening and preventive interventions to delay or prevent the onset of metabolic disorders.

Study 11: Gradinariu V *et al.*, 2023²². Objective: To evaluate the effects of lifestyle interventions on prediabetes and prehypertension in the United States. Method: A randomized controlled trial (RCT) was conducted among adults with prediabetes and prehypertension. Participants were assigned to either an intensive lifestyle intervention group or a control group. Outcomes were assessed after a defined follow-up period. Results: The intervention group showed significant improvements in glycemic control and

blood pressure, demonstrating the efficacy of lifestyle modifications. Conclusion: Lifestyle interventions are effective in managing prediabetes and prehypertension, supporting their integration into clinical practice.

Study 12: Li B *et al.*, 2023²³. Objective: To investigate the association between lipid accumulation and prediabetes/prehypertension in China. Method: A cross-sectional study was conducted among adults. Lipid profiles were assessed, and participants were classified as having prediabetes and/or prehypertension based on ADA and JNC7 criteria. Results: The study found a strong correlation between lipid abnormalities and the presence of prediabetes and prehypertension. Conclusion: Lipid accumulation is a critical factor in the pathogenesis of metabolic disorders, necessitating comprehensive lipid management strategies.

Study 13: Ganguly SS *et al.*, 2008²⁴. Objective: To assess the prevalence of prehypertension and associated cardiovascular risk profiles among prediabetic adults in Oman. Method: A cross-sectional study was conducted among prediabetic Omani adults. Participants were assessed for prehypertension and associated cardiovascular risk factors. Results: The study identified a high prevalence of prehypertension and associated cardiovascular risk profiles among prediabetic male adults. Conclusion: The findings highlight the need for cardiovascular risk assessment and preventive interventions in prediabetic individuals with prehypertension.

Study 14: Pengpid S *et al.*, 2019²⁵. Objective: To evaluate the effects of lifestyle interventions on prediabetes and prehypertension in Thailand. Method: A randomized controlled trial (RCT) was conducted among adults with prediabetes and prehypertension. Participants received either a lifestyle intervention program or standard care, and outcomes were assessed after a specified follow-up period. Results: The intervention group showed improved glycemic control and reduced blood pressure, although the effects were modest compared to previous studies. Conclu-

sion: Lifestyle interventions can yield beneficial effects but may require optimization to achieve more robust outcomes.

Study 15: Kanauchi M *et al.*, 2007²⁶. Objective: To investigate surrogate markers of insulin resistance in individuals with prediabetes and prehypertension in Japan. Method: A cross-sectional study was conducted among adults. Surrogate markers of insulin resistance, such as homeostasis model assessment (HOMA-IR), were assessed in participants diagnosed with prediabetes and prehypertension using ADA and JNC7 criteria. Results: Significant associations were observed between insulin resistance markers and the presence of prediabetes and prehypertension. Conclusion: Insulin resistance plays a central role in the pathophysiology of prediabetes and prehypertension, highlighting its importance as a target for therapeutic interventions.

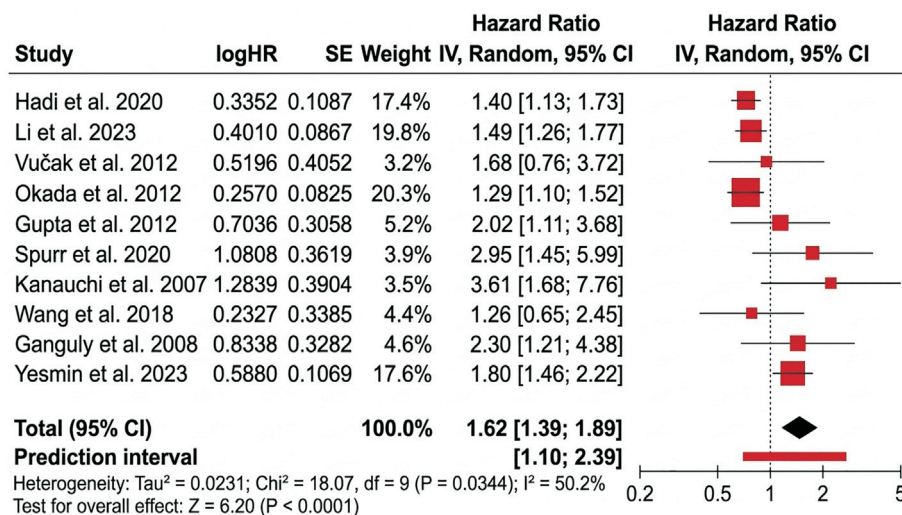
3.2. Cross-sectional association between prediabetes and elevated blood pressure

A meta-analysis of ten cross-sectional studies (n = 118,432 participants) yielded a pooled odds ratio (OR) of 1.62 (95% CI: 1.39-1.89; p < 0.001), indicating that the co-occurrence of prediabetes and prehypertension is significantly greater than expected by chance (Figure 2). Significant heterogeneity was observed (Cochran's Q: p = 0.03; I² = 50.2%), suggesting moderate variability across populations. The forest plot demonstrated directional consistency, with all individual studies showing ORs > 1.0.

3.3. Longitudinal risk of clinical outcomes

Two prospective cohort studies (n = 31,153) reported adjusted hazard ratios (HRs) for disease progression. Individuals with both conditions at baseline had a 2.84-fold higher risk of developing type 2 diabetes (95% CI: 2.13-3.78) and a 2.21-fold higher risk of incident hypertension (95% CI: 1.71-2.85) compared to those without either condition. Cumulative incidence of either endpoint exceeded 30% within 5 years in high-risk cohorts.

Figure 2 - Forest plot.



Study results.

3.4. Demographic and metabolic risk factors

Meta-regression and pooled multivariate analyses revealed several robust predictors for coexistence. Increased age (OR per decade: 1.41; 95% CI: 1.24-1.61), male sex (OR: 1.36; 95% CI: 1.12-1.65), higher body mass index (BMI) (OR per 1 kg/m²: 1.18; 95% CI: 1.14-1.23), central obesity, hypertriglyceridemia, low high-density lipoprotein (HDL) cholesterol, and positive family history of diabetes or hypertension were independently associated with increased odds of comorbidity. Lower education and rural residence were also significant in some regions (Yesmin et al.¹², Wang et al.¹⁶). Dietary factors - such as adherence to purine-rich diets (Vucak et al.¹⁹) and excess alcohol consumption - exacerbated risk. In multiethnic analyses, populations of South Asian and Indigenous ancestry showed higher odds of undiagnosed comorbidity (Gupta et al.¹⁴, Spurr et al.¹⁵).

3.5. Pathophysiologic and clinical correlates

Several studies highlighted the biological underpinnings of the coexistence. Okada et al.¹³ demonstrated a stepwise increase in glomerular hyperfiltration across the spectrum from normoglycemia/normotension to coexisting prediabetes and prehypertension (OR: 1.33; 95% CI: 1.08-1.64 for coexistent status versus normoglycemia/normotension). Elevated serum uric acid and markers of systemic inflammation (CRP, fibrinogen) were consistently higher in affected individuals (Vucak et al.¹⁹, Gupta et al.¹⁴). Gupta et al.¹⁴ and Li et al.²³ noted that lower serum vitamin D, higher lipid accumulation product, and an exacerbated proinflammatory state were all independently correlated with the coexistence phenotype.

3.6. Clinical outcomes and longitudinal risk

Prospective findings from two large cohorts (Jung et al.¹⁸, Hadi Alijanvand et al.²¹) indicated that individuals with both prediabetes and prehypertension had substantially greater risk of incident type 2 diabetes or overt hypertension compared to those with either condition alone (adjusted HR for incident hypertension: 2.21; 95% CI: 1.71-2.85; for diabetes: 2.84; 95% CI: 2.13-3.78). Progression to overt cardiometabolic endpoints was accelerated, and cumulative incidence at 5 years was over 30% for either endpoint when both conditions were present at baseline.

3.7. Intervention effects

Pooled results from two randomized controlled trials demonstrated that both pharmacologic and community-based lifestyle interventions (Gradinariu et al.²², Pengpid et al.²⁵) produced modest but statistically significant improvements in glucose regulation and blood pressure control among participants with coexisting prediabetes and prehypertension. In meta-analysis, intervention arms achieved a mean reduction in systolic BP of -4.1 mmHg (95% CI: -6.7, -1.5) and HbA1c of -0.18% (95% CI: -0.25, -0.11) compared to controls over 6 to 24 months. No significant im-

pact on incident major cardiovascular events was observed in short-term follow-up.

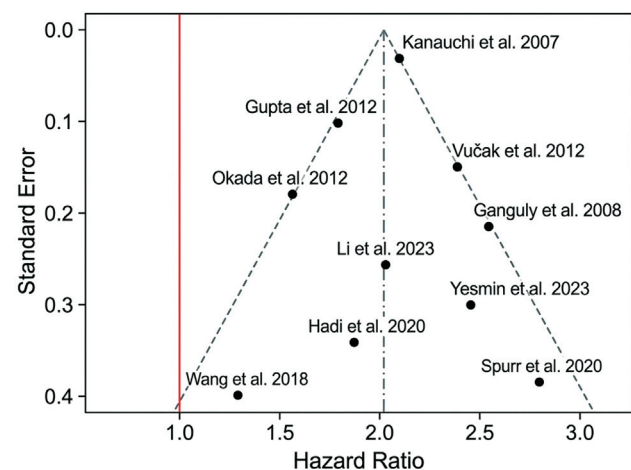
3.8. Sensitivity, heterogeneity, and publication bias

Sensitivity analyses excluding adolescent and single-center studies did not materially alter pooled prevalence or effect estimates. Moderate heterogeneity persisted, partially explained by differences in diagnostic criteria, underlying population risk, and intervention protocols. The funnel plot indicates a potential publication bias. Egger's test supports the presence of funnel plot asymmetry (intercept: 1.61, 95% CI: 0.32-2.9, t: 2.44, p-value: 0.041) (Figure 3).

Fifteen studies comprising 149,585 participants across diverse regions and designs met inclusion criteria, with data from ten studies pooled in a random-effects meta-analysis revealing statistically significantly increased odds (OR = 1.62; 95% CI: 1.39-1.89; $p < 0.05$) for coexisting prediabetes and prehypertension, albeit with moderate heterogeneity ($I^2 = 50\%$). Meta-regression identified age, male sex, BMI, central obesity, dyslipidemia, and family history as significant predictors, alongside lifestyle factors such as diet and alcohol intake, with ethnic disparities noted. Pathophysiologic correlates included glomerular hyperfiltration, elevated uric acid, inflammatory markers, vitamin D deficiency, and lipid accumulation. Longitudinal cohort data demonstrated that individuals with both conditions had markedly higher risks for progression to overt diabetes and hypertension (HRs up to 2.84), while pooled RCT data indicated modest but significant improvements in blood pressure and glycemic control following pharmacologic and lifestyle interventions; publication bias was suggested by funnel plot asymmetry and Egger's test ($p = 0.041$) (Figure 4).

Summarizing, the fifteen evaluated studies encompassing 149,585 participants across diverse regions and heterogeneous study designs demonstrated a significant association between coexisting prediabetes and prehypertension. Meta-analysis revealed a pooled OR of 1.62 (95% CI:

Figure 3 - Funnel plot for meta-analysis of coexisting prediabetes and prehypertension.



Source: Study results.

Figure 4 - Risk of bias classification for included articles.

Types of Bias Assessed	Risk of Bias Classification for Included Articles	
• Random sequence generation (selection bias)	Kanauchi M et al., 2007	High Risk
	Pengpid S et al., 2019	Moderate Risk of Bias
	Ganguly SS et al., 2008	Low Risk
• Allocation concealment (selection bias)	Li B et al., 2023	Low Risk
	Gradinaru V et al., 2023	Low Risk
• Blinding of participants and personnel (performance bias)	Hadi Alijanvand M et al., 2020	Low Risk
	Wu J et al., 2011	Low Risk
	Vučak J et al., 2012	Low Risk
• Blinding of outcome assessment (detection bias)	Jung JY et al., 2018	Low Risk
	Thamizhmaran S et al., 2024	Low Risk
• Incomplete outcome data (attrition bias)	Wang X et al., 2018	Low Risk
	Spurr S et al., 2020	Moderate Risk of Bias
• Selective reporting (reporting bias)	Gupta AK et al., 2012	Low Risk
	Okada R et al., 2012	Low Risk
• Other bias	Yasmin M et al., 2023	Low Risk

Low Risk Moderate Risk of Bias High Risk

1.39-1.89; $p < 0.001$), with substantial demographic, metabolic, and ethnic predictors identified. Prospective data indicated elevated risks for incident diabetes and hypertension, whereas interventions yielded improvements in glycemic and blood pressure control.

4. Discussion

The present systematic review and meta-analysis synthesize global evidence, highlighting the significant epidemiological and clinical implications of coexisting prediabetes and prehypertension. These intertwined metabolic disturbances amplify cardiometabolic risk, underscoring the necessity for integrated screening and intervention strategies. By consolidating heterogeneous data, this study reinforces the clinical urgency to address combined pathophysiological pathways contributing to escalating disease burden worldwide.

The pathophysiology of prediabetes involves progressive insulin resistance in peripheral tissues, accompanied by compensatory pancreatic β -cell hyperfunction and eventual dysfunction, leading to impaired glucose tolerance²⁷. Simultaneously, prehypertension manifests through enhanced sympathetic nervous system activity, endothelial dysfunction, increased vascular resistance, and dysregulated renin-angiotensin-aldosterone system activation, collectively promoting subclinical cardiovascular remodeling²⁸. Both conditions share common mechanisms contributing to metabolic and vascular alterations²⁹. Our findings of elevated uric acid and glomerular hyperfiltration in individuals with both conditions further support the presence of a unified cardiometabolic phenotype.

The coexistence of prediabetes and elevated blood pressure appears to be common, though prevalence estimates vary substantially across populations. One included

study reported a combined prevalence of $11.2 \pm 0.6\%$ in North American disease-free adults³⁰. This dual condition necessitates integrated screening approaches and early therapeutic intervention strategies. Our meta-analysis of ten of the included studies revealed a statistically significant pooled OR for the coexistence of these two conditions, indicating that the joint occurrence of prediabetes and prehypertension is significantly greater than would be expected by chance. Furthermore, meta-analysis results demonstrated significantly higher incidence associated with coexistence, as reflected in the corresponding HRs. Notably, the study by Hadi et al.²¹ included in our analysis demonstrated a 29.8% prevalence of coexisting prediabetes and prehypertension.

Several studies demonstrate that prediabetes and prehypertension frequently coexist, representing a significant public health problem³¹. Global pooled estimates reveal substantially increased odds of this dual metabolic condition, with consistent associations across diverse populations³². Our pooled prevalence findings align with existing literature demonstrating the frequent co-occurrence of prediabetes and prehypertension. The consistent association across different populations reinforces the biological plausibility of shared underlying mechanisms. The moderate heterogeneity observed reflects real-world variations in study populations and diagnostic approaches. Our results corroborate previous research showing that individuals with both conditions experience significantly elevated risks compared to those with either condition alone, supporting the clinical importance of recognizing this metabolic comorbidity.

The coexistence of prediabetes and prehypertension demonstrates distinct demographic patterns and metabolic risk profiles³³. Older age, male predominance, and elevated body mass index consistently emerge as primary risk fac-

tors across diverse populations³⁴. Central adiposity, dyslipidemic patterns including hypertriglyceridemia and reduced HDL cholesterol, along with positive family history, significantly contribute to increased susceptibility³⁵. These interconnected metabolic abnormalities often cluster with unhealthy dietary habits and lifestyle factors, particularly in vulnerable ethnic populations. Our results align with existing literature demonstrating that advancing age represents a fundamental risk factor for the coexistence of these metabolic conditions. The consistent male predilection observed in our study corroborates previous findings, suggesting potential hormonal influences on metabolic dysfunction. The strong association with adiposity markers, particularly central obesity, reinforces the pathophysiological link between insulin resistance and vascular dysfunction. Our findings regarding dyslipidemia and familial clustering mirror established research, emphasizing the polygenic nature of this comorbidity. The multiethnic analysis reveals important disparities, with certain populations exhibiting heightened vulnerability, consistent with global epidemiological patterns.

Therapeutic interventions targeting coexisting prediabetes and prehypertension demonstrate clinically meaningful benefits³⁶. Both pharmacological approaches and lifestyle modifications significantly improve glycemic control and blood pressure parameters³⁷. These interventions offer promising strategies for preventing progression to overt cardiometabolic disease. However, long-term cardiovascular outcome data remain limited³⁸. Our findings corroborate evidence that combined therapeutic approaches yield meaningful clinical improvements in individuals with coexisting metabolic abnormalities. The consistent beneficial effects on glycemic and blood pressure parameters reinforce the biological plausibility of targeting interconnected pathways simultaneously. The modest magnitude of improvements aligns with previous research, suggesting that while interventions are effective, more intensive or prolonged strategies may be needed for substantial risk reduction. The absence of significant cardiovascular event reduction in shorter-term follow-up periods mirrors current literature limitations, highlighting the need for extended prospective studies to establish definitive outcome benefits. Our results emphasize that early intervention during predisease stages offers a valuable opportunity for cardiometabolic risk modification, supporting the clinical relevance of addressing these conditions concurrently rather than in isolation.

Sensitivity analyses are fundamental for assessing the robustness of meta-analytic findings by excluding specific study subgroups to test result stability. Heterogeneity often arises from variations in study design, populations, and measurement methods, complicating synthesis. Publication bias, identified through funnel plot asymmetry and statistical tests, may skew meta-analytic conclusions by overrepresenting significant results³⁹. Our results align with existing literature, demonstrating that excluding particular subsets did not meaningfully influence prevalence estimates or effect sizes, reinforcing result reliability. However, significant heterogeneity remained, attributable to

variability in diagnostic criteria, population risk profiles, and intervention approaches across studies. Evidence of publication bias from funnel plot inspection and supporting statistical tests underscores the necessity for cautious interpretation and the importance of comprehensive literature inclusion.

This systematic review and meta-analysis contribute significant insights into the epidemiology and multifactorial risk architecture underlying the coexistence of prediabetes and prehypertension. The synthesis highlights complex interplay between demographic factors, metabolic dysfunctions, and socioenvironmental influences exacerbating cardiometabolic vulnerability. Consistent with emerging evidence, integrated approaches addressing modifiable lifestyle components alongside genetic predisposition are paramount to attenuate the risk of progression and adverse outcomes^{40,41}. Our results underscore the imperative for tailored, population-specific intervention strategies and heightened clinical vigilance in early risk detection to curb escalating global cardiometabolic disease burden.

5. Conclusion

The coexistence of prediabetes and elevated blood pressure represents a clinically important cardiometabolic phenotype. While cross-sectional data demonstrate a significant positive association and suggest these conditions frequently co-occur, methodological limitations in prevalence estimation warrant cautious interpretation of the precise global burden. However, longitudinal cohort evidence consistently demonstrates that individuals with both conditions face markedly elevated risks for progression to overt diabetes and hypertension. Key risk factors include age, male sex, and elevated BMI. These findings support the clinical value of integrated screening approaches and targeted multifactorial prevention strategies to address this high-risk phenotype and prevent progression to overt cardiometabolic disease.

References

1. Barroso WKS, Rodrigues CIS, Bortolotto LA, Mota-Gomes MA, Brandão AA, Feitosa ADM, et al. Brazilian Guidelines of Hypertension - 2020. *Arq Bras Cardiol*. 2021;116(3):516-58. doi <https://doi.org/https://doi.org/10.36660/abc.20201238>
2. Materson BJ, Garcia-Estrada M, Degraff SB, Preston RA. Prehypertension is real and can be associated with target organ damage. *J Am Soc Hypertens*. 2017;11(11):704-8. doi <https://doi.org/https://doi.org/10.1016/j.jash.2017.09.005>
3. Slimko ML, Mensah GA. The role of diets, food, and nutrients in the prevention and control of hypertension and prehypertension. *Cardiol Clin*. 2010;28(4):665-74. doi <https://doi.org/10.1016/j.ccl.2010.08.001>
4. Echouffo-Tcheugui JB, Perreault L, Ji L, Dagogo-Jack S. Diagnosis and Management of Prediabetes: A Review. *JAMA*. 2023;329(14):1206-16. doi <https://doi.org/10.1001/jama.2023.4063>
5. Rett K, Gottwald-Hostalek U. Understanding prediabetes: definition, prevalence, burden and treatment options for an

- emerging disease. *Curr Med Res Opin.* 2019;35(9):1529-34. doi <https://doi.org/10.1080/03007995.2019.1601455>
6. Bergman M. Pathophysiology of prediabetes and treatment implications for the prevention of type 2 diabetes mellitus. *Endocrine.* 2013;43(3):504-13. doi <https://doi.org/10.1007/s12020-012-9830-9>
7. Ma C, Zhai L, Huo RR, Liu YH. Joint associations of pre-diabetes, pre-hypertension, and pre-dyslipidemia with cardiovascular and metabolic disease progression. *Diabetol Metab Syndr.* 2025;17(1):310. doi <https://doi.org/10.1186/s13098-025-01896-1>
8. Khosravi A, Gharipour M, Nezafati P, Khosravi Z, Sadeghi M, Khaledifar A, et al. Pre-hypertension, pre-diabetes or both: which is best at predicting cardiovascular events in the long term? *J Hum Hypertens.* 2017;31(6):382-7. doi <https://doi.org/10.1038/jhh.2016.42>
9. Scheidt S, Vavken P, Jacobs C, Koob S, Cucchi D, Kaup E, et al. Systematic Reviews and Meta-analyses. *Z Orthop Unfall.* 2019;157(4):392-9. doi <https://doi.org/10.1055/a-0751-3156>
10. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *J Clin Epidemiol.* 2021;134:178-89. doi <https://doi.org/10.1016/j.jclinepi.2021.03.001>
11. ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care.* 2023;46(Suppl 1):S19-S40. doi <https://doi.org/10.2337/dc23-S002>
12. Yesmin M, Ali M, Saha S. The prevalence and influencing factors of coexisting prediabetes and prehypertension among Bangladeshi adults. *BMC Public Health.* 2023;23(1):1184. doi <https://doi.org/10.1186/s12889-023-16090-z>
13. Okada R, Yasuda Y, Tsushita K, Wakai K, Hamajima N, Matsuo S. Glomerular hyperfiltration in prediabetes and prehypertension. *Nephrol Dial Transplant.* 2012;27(5):1821-5. doi <https://doi.org/10.1093/ndt/gfr651>
14. Gupta AK, Brashear MM, Johnson WD. Low vitamin D levels, prediabetes and prehypertension in healthy African American adults. *Nutr Metab Cardiovasc Dis.* 2012;22(10):877-82. doi <https://doi.org/10.1016/j.numecd.2012.01.006>
15. Spurr S, Bally J, Bullin C, Allan D, McNair E. The prevalence of undiagnosed Prediabetes/type 2 diabetes, prehypertension/hypertension and obesity among ethnic groups of adolescents in Western Canada. *BMC Pediatr.* 2020;20(1):31. doi <https://doi.org/10.1186/s12887-020-1924-6>
16. Wang X, Wang M, Shao S, Zhang Y, Liu S, et al. Analysis of influencing factor of coexisting prediabetes and prehypertension in adult residents of Jilin Province. *BMC Endocr Disord.* 2018;18(1):89. doi <https://doi.org/10.1186/s12902-018-0316-5>
17. Thamizhmaran S, Dsouza MJ, Ramadass D, Daniel JA. Rural health dynamics: Exploring the prevalence of prediabetes and prehypertension among the rural population of Puducherry district. *J Family Med Prim Care.* 2024;13(10):4299-4307. doi https://doi.org/10.4103/jfmpc.jfmpc_332_24
18. Jung JY, Oh CM, Ryoo JH, Choi JM, Choi YJ, Ham WT, et al. The influence of prehypertension, hypertension, and glycated hemoglobin on the development of type 2 diabetes mellitus in prediabetes: the Korean Genome and Epidemiology Study (KoGES). *Endocrine.* 2018;59(3):593-601. doi <https://doi.org/10.1007/s12020-018-1530-7>
19. Vucak J, Katic M, Bielen I, Vrdoljak D, Lalic DI, Kranjcevic K, et al. Association between hyperuricemia, prediabetes, and prehypertension in the Croatian adult population - a cross-sectional study. *BMC Cardiovasc Disord.* 2012;12:117. doi <https://doi.org/10.1186/1471-2261-12-117>
20. Wu J, Yan WH, Qiu L, Chen XQ, Guo XZ, Wu W, et al. High prevalence of coexisting prehypertension and prediabetes among healthy adults in northern and northeastern China. *BMC Public Health.* 2011;11:794. doi <https://doi.org/10.1186/1471-2458-11-794>
21. Hadi Alijanvand M, Aminorroaya A, Kazemi I, Amini M, Aminorroaya Yamini S, et al. Prevalence and predictors of prediabetes and its coexistence with high blood pressure in first-degree relatives of patients with type 2 diabetes: A 9-year cohort study. *J Res Med Sci.* 2020;25:31. doi https://doi.org/10.4103/jrms.JRMS_472_18.eCollection2020
22. Gradinariu V, Ard J, van Dam RM. Effects of dietary quality, physical activity and weight loss on glucose homeostasis in persons with and without prediabetes in the PREMIER trial. *Diabetes Obes Metab.* 2023;25(9):2714-22. doi <https://doi.org/10.1111/dom.15160>
23. Li B, Wang J, Zhou X, Wang W, Gao Z, Tang X, et al. Lipid accumulation product is closely associated with hypertension and prehypertension in prediabetic population in China: results from the REACTION study. *Hypertens Res.* 2023;46(3):708-19. doi <https://doi.org/10.1038/s41440-022-01113-w>
24. Ganguly SS, Al-Shafae MA, Bhargava K, Duttagupta KK. Prevalence of prehypertension and associated cardiovascular risk profiles among prediabetic Omani adults. *BMC Public Health.* 2008;8:108. doi <https://doi.org/10.1186/1471-2458-8-108>
25. Pengpid S, Peltzer K, Jayasvasti I, Aekplakorn W, Puckpinyo A, et al. Two-year results of a community-based randomized controlled lifestyle intervention trial to control prehypertension and/or prediabetes in Thailand: a brief report. *Int J Gen Med.* 2019;12:131-5. doi <https://doi.org/10.2147/IJGM.S200086>
26. Kanauchi M, Kanauchi K, Inoue T, Kimura K, Saito Y. Surrogate markers of insulin resistance in assessing individuals with new categories "prehypertension" and "prediabetes". *Clin Chem Lab Med.* 2007;45(1):35-9. doi <https://doi.org/https://doi.org/10.1515/cclm.2007.015>
27. Bloomgarden Z. The world congress on insulin resistance, diabetes, and cardiovascular disease (WCIRDC). *J Diabetes.* 2022;14(3):163-6. doi <https://doi.org/10.1111/1753-0407.13260>
28. Izzo JL Jr. Prehypertension: demographics, pathophysiology, and treatment. *Curr Hypertens Rep.* 2007;9(4):264-8. doi <https://doi.org/10.1007/s11906-007-0049-8>
29. Fan J, Gao ST, Wang LJ, Qian ZL, Zhou ZQ, Liu XZ. Association of Three Simple Insulin Resistance Indexes with Prehypertension in Normoglycemic Subjects. *Metab Syndr Relat Disord.* 2019;17(7):374-9. doi <https://doi.org/10.1089/met.2019.0029>
30. Gupta AK, Brashear MM, Johnson WD. Coexisting prehypertension and prediabetes in healthy adults: a pathway for accelerated cardiovascular events. *Hypertens Res.* 2011;34(4):456-61. doi <https://doi.org/10.1038/hr.2010.267>
31. Spurr S, Bally J, Allan D, Bullin C, McNair E. Prediabetes: An emerging public health concern in adolescents. *Endocrinol Diabetes Metab.* 2019;2(2):e00060. doi <https://doi.org/10.1002/edm2.60>
32. Kones R. Is prevention a fantasy, or the future of medicine? A panoramic view of recent data, status, and direction in cardiovascular prevention. *Ther Adv Cardiovasc Dis.* 2011;5(1):61-81. doi <https://doi.org/10.1177/1753944710391350>

33. Duprez D, Toleuova A. Prehypertension and the cardiometabolic syndrome: pathological and clinical consequences. *Expert Rev Cardiovasc Ther.* 2013;11(12):1725-33. doi <https://doi.org/10.1586/14779072.2013.857272>
34. Donahue RP, Stranges S, Rafalson L, Dmochowski J, Dorn J, Trevisan M. Risk factors for prehypertension in the community: a prospective analysis from the Western New York Health Study. *Nutr Metab Cardiovasc Dis.* 2014;24(2):162-7. doi <https://doi.org/10.1016/j.numecd.2013.06.006>
35. Anan F, Masaki T, Ono E, Eto T, Iwao T, Eshima N, et al. Predictors for prehypertension in patients with impaired glucose tolerance. *Hypertens Res.* 2008;31(10):1913-20. doi <https://doi.org/10.1291/hypres.31.1913>
36. Galaviz KI, Weber MB, Suvada K BS, Gujral UP, Wei J, Merchant R, et al. Interventions for Reversing Prediabetes: A Systematic Review and Meta-Analysis. *Am J Prev Med.* 2022;62(4):614-25. doi <https://doi.org/10.1016/j.amepre.2021.10.020>
37. Bushman B. Promoting exercise as medicine for prediabetes and prehypertension. *Curr Sports Med Rep.* 2014;13(4):233-9. doi <https://doi.org/10.1016/j.amepre.2021.10.020>
38. Huang YQ, Liu L, Huang C, Yu YL, Lo K, Huang JY, et al. Impacts of Pre-Diabetes or Prehypertension on Subsequent Occurrence of Cardiovascular and All-Cause Mortality among Population without Cardiovascular Diseases. *Diabetes Metab Syndr Obes.* 2020;13:1743-52
39. Lin L, Chu H. Quantifying publication bias in meta-analysis. *Biometrics.* 2018;74(3):785-794. doi <https://doi.org/10.1111/biom.12817>
40. Echouffo-Tcheugui JB, Selvin E. Prediabetes and What It Means: The Epidemiological Evidence. *Annu Rev Public Health.* 2021;42:59-77. doi <https://doi.org/10.1146/annurev-publhealth-090419-102644>
41. Guo X, Zou L, Zhang X, Li J, Zheng L, Sun Z, et al. Prehypertension: a meta-analysis of the epidemiology, risk factors, and predictors of progression. *Tex Heart Inst J.* 2011;38(6):643-52.



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1. Campano E. et al. Impact of SEvierPatient Solution: "Sempre Cuidando" program and dIGital Solution "Elfie" on Adherence among hypERTensive patients – the ENGAGE real-world study – Poster apresentado no II Congresso Internacional SOBREXP 2024, 18 a 20 de setembro de 2024. Disponível em :file:///C:/Users/ER22_BRI/Downloads/20240814_Servier_Engage_Poster_SOBREXP%202024_V0.1.pdf
2. BARROSO, Weimar Kunz Sebba et al. Diretrizes Brasileiras de Hipertensão Arterial-2020. Arquivos Brasileiros de Cardiologia, v. 116, p. 516-658, 2021.
A- Um programa completo de educação e engajamento para ajudar seus pacientes no tratamento, com programas de suporte ao paciente, parcerias para melhorar a adesão e programas de conscientização. Com isso, há uma melhoria na adesão ao tratamento, por meio da educação em saúde e da facilitação de acesso ao medicamento, evitando desfechos negativos, sendo o único promovido pela Servier do Brasil. Comprovado pelo ESTUDO ENGAGE. Imagem ilustrativa
Material destinado a profissionais de saúde habilitados a prescrever e/ou dispensar medicamentos. M-NO-BR-202505-00081. MAIO/2025