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Cardiovascular complications in arterial hypertension: Prevention strategies and literature review

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Abstract

Introduction: Arterial hypertension remains one of the leading threats to global public health. Despite the availability of multiple therapeutic options, hypertension control remains inadequate in many regions. Barriers include poor treatment adherence and delayed diagnosis, highlighting the need to assess the effectiveness of current interventions in diverse contexts.

Objective: To evaluate the most effective strategies for preventing cardiovascular complications in patients with arterial hypertension, based on scientific evidence published over the past ten years.

Methodology: A systematic literature review was conducted. Studies assessing preventive strategies in adult patients with chronic hypertension aimed at reducing cardiovascular complications were included. The search was limited to articles published between 2013 and 2023 in English and Spanish.

Results: Evidence indicates that intensive blood pressure management, pharmacological optimization, novel therapies, dietary interventions, physical activity, weight loss, educational programs, telemonitoring, and collaborative care models significantly improve blood pressure control. The literature consistently highlights cardiovascular preventive benefits, although their magnitude varies depending on population, clinical context, and adherence levels.

Conclusions: Effective management of hypertension requires a multimodal and integrated approach that combines lifestyle modifications, pharmacological optimization, educational strategies, community-based interventions, and the use of emerging technologies.

Keywords: Arterial Hypertension; Cardiovascular Complications; Prevention; Adherence; Cardiovascular Risk

1. Introduction

Arterial hypertension (AH) represents one of the main threats to global public health in the 21st century. It is a chronic disease, generally of silent progression, that affects more than 1.28 billion adults worldwide, according to data from the World Health Organization (WHO)(1). Of this total, approximately 46% are unaware of their diagnosis, and an even larger proportion do not maintain effective blood pressure control, substantially increasing their risk of developing severe cardiovascular complications. This issue is particularly evident in regions such as Latin America and the Caribbean, where hypertension control rates barely exceed 35%, despite the availability of multiple pharmacological and non-pharmacological therapeutic alternatives validated by the scientific community(2).

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The clinical relevance of hypertension is not limited to its high prevalence but is heightened by the severe consequences it can cause if not treated in a timely and adequate manner(3). The most frequent complications include acute myocardial infarction, stroke, heart failure, peripheral arterial disease, and chronic kidney disease(4). These conditions not only significantly reduce patients' quality of life but also contribute to increased premature mortality and generate a considerable economic burden on health systems. High hospitalization costs, loss of productivity, the need for complex treatments, and functional decline in hypertensive patients are among the most significant adverse outcomes of inadequate disease control(5). Despite advances in medical knowledge and the availability of evidence-based clinical guidelines, a persistent gap remains between recommendations and real-world clinical practice(6). Factors such as poor treatment adherence, lack of timely diagnosis, limited public awareness of risk factors, unequal access to healthcare services, and insufficient health education continue to hinder the effectiveness of hypertension control and prevention strategies(7). This situation has prompted researchers and healthcare professionals to explore and develop more comprehensive and sustainable strategies that can be implemented in various contexts and address the real needs of the population(8).

In recent years, the scientific literature has documented a wide range of strategies aimed at preventing cardiovascular complications in hypertensive patients These include the optimized use of pharmacological combinations and the promotion of lifestyle changes such as reduced salt intake, increased physical activity, weight loss, smoking cessation, and the adoption of healthy dietary patterns(10). Additionally, patient-centered educational interventions, self-care programs, home blood pressure monitoring, and the use of technological tools to facilitate clinical follow-up and reinforce therapeutic adherence have been promoted(11). However, despite the growing volume of research, there remains a need to integrate, compare, and critically evaluate the findings to determine which strategies are the most effective, feasible, and adaptable to different settings particularly those with structural and social limitations(12).

In this regard, conducting a systematic review of recent scientific literature is essential to identify, classify, and analyze the most effective strategies for preventing cardiovascular complications in hypertensive patients(13). This review is especially relevant in contexts such as Colombia, where hypertension is one of the leading causes of medical consultations and hospitalizations and where strengthening the problem-solving capacity of the primary healthcare level remains necessary. A critical appraisal of the evidence will not only help identify best practices but also provide valuable input for designing public policies, prevention programs, and evidence-based clinical care protocols that contribute to reducing disease burden and improving the quality of life of affected populations(14). Moreover, from an academic and educational perspective, this work seeks to contribute to the development of students' critical thinking and research competence, while also providing a substantive contribution to national scientific literature(15). A rigorous analysis of the available strategies will make it possible to identify their strengths and limitations and open opportunities to propose innovative, comprehensive, and context-specific approaches capable of bridging the gap between theory and clinical practice(16). Finally, from a public health perspective, the findings of this review could facilitate informed clinical decision-making, promote the rational use of healthcare resources, and encourage more equitable, humane, and patient-centered care(17).

2. Methodology

The present research was conducted following a literature review design. From the outset, strict adherence to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was ensured. Accordingly, the research question, inclusion and exclusion criteria, search strategy, study selection process, quality assessment methods, and result presentation format were clearly defined. This structured approach guaranteed methodological rigor throughout each stage of the study. The formulation of the research question followed the PICOT framework, which allowed for an adequate structuring of the key elements of the review. The target population consisted of adult patients diagnosed with arterial hypertension (P), on whom different strategies for the prevention of cardiovascular complications were analyzed (I). These strategies were compared with standard management approaches or alternative preventive interventions (C), with the primary outcome being the reduction of cardiovascular events (O). The temporal scope was limited to studies published over the last ten years (T), from 2013 to 2023, to ensure the relevance and currency of the evidence collected..

In the subsequent phase, search equations were designed using Boolean operators and both controlled and free terms. The databases selected were PubMed, Scopus, and Google Scholar, chosen for their comprehensive coverage of biomedical scientific literature. The search included combinations such as: ("arterial hypertension" OR "high blood pressure") AND ("prevention strategies" OR "preventive interventions") AND ("cardiovascular complications" OR "heart diseases") AND ("last 10 years" OR "2013–2023"). The searches were independently performed by the researchers, and the results were integrated using the Zotero reference manager, which also facilitated the automated removal of duplicates.

Subsequently, inclusion and exclusion criteria were applied. Studies published between 2013 and 2023, written in English or Spanish, addressing preventive strategies in adult patients with arterial hypertension and reporting clinical outcomes related to cardiovascular complications, were included. Conversely, non–peer-reviewed articles, studies lacking relevant quantitative or qualitative data, reviews without primary data, and studies including pediatric or adolescent populations were excluded.

The selection of articles was carried out in two stages. First, titles and abstracts of the identified studies were screened; second, potentially eligible full texts were reviewed in detail. At each stage, two independent reviewers conducted the process, and discrepancies were resolved through discussion until consensus was reached. To ensure the quality of the selected studies, a critical appraisal strategy based on a checklist derived from the PRISMA guidelines was implemented. This checklist included criteria such as clarity of the research question, appropriate justification of inclusion and exclusion criteria, detailed description of methodological design, and structured presentation of results. A narrative synthesis was performed, allowing the findings to be grouped according to the strategies employed, context of application, outcomes obtained, and methodological quality of the studies. This synthesis made it possible to identify trends, innovative approaches, and gaps in the existing literature. It should be noted that, as this study was based exclusively on secondary data sources and involved no direct intervention with human participants, institutional ethical approval was not required. Nevertheless, academic integrity, methodological transparency, and ethical use of scientific information were guaranteed through proper citation practices, respect for intellectual property rights, and full traceability of the research process.

3. Results

The initial search identified 452 records, of which 84 were removed due to duplication. Subsequently, 368 titles and abstracts were screened, and 340 were excluded for not meeting the inclusion criteria. Finally, 28 articles met all eligibility criteria and were included in the qualitative analysis. The selection process is presented in the PRISMA flow diagram **(Figure 1).**

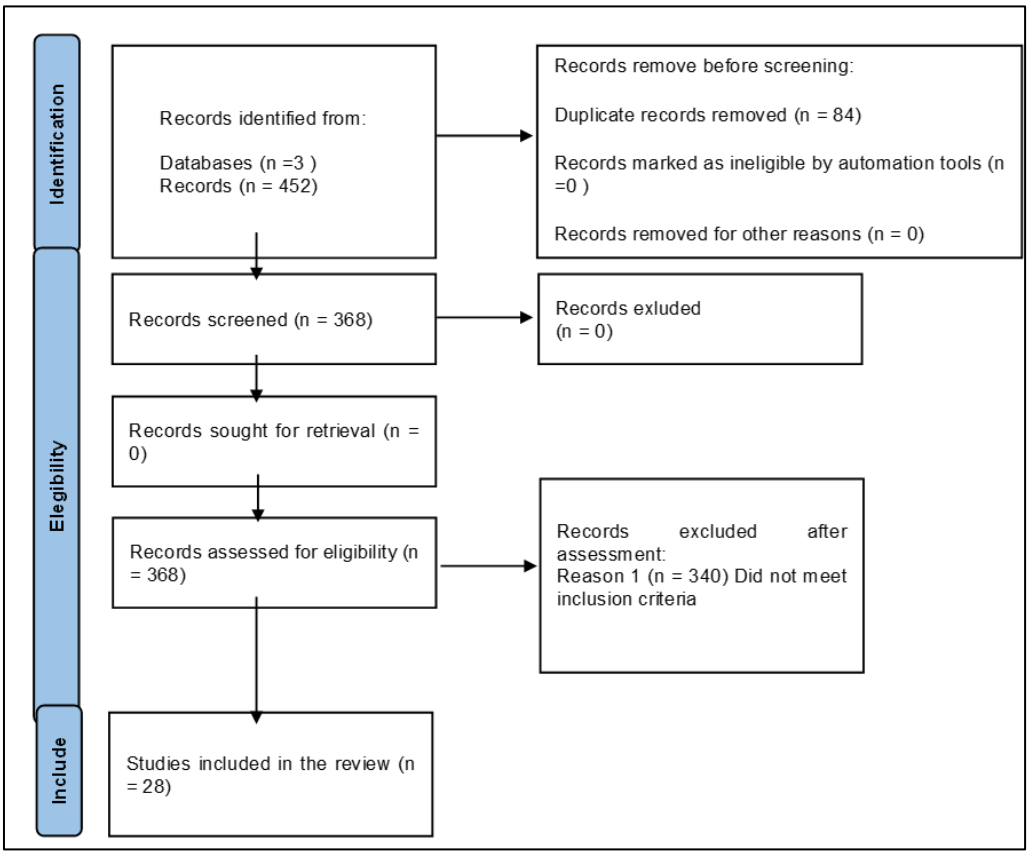

Figure 1 PRISMA (Autoship elaboration)

3.1. Intensification of Pharmacological Treatment and Blood Pressure Targets

Clinical trials and sub-analyses (e.g., STEP, SPRINT, and subsequent studies) show that intensive management of systolic blood pressure with lower targets in selected patients reduces cardiovascular events compared with standard control. However, benefits in cognitive outcomes and certain subgroups are less consistent and require evaluation according to age, comorbidities, and risk of adverse effects. Evidence suggests that treatment goals should be individualized and that the benefit–risk balance should be carefully considered in elderly and polymedicated patients(18).

3.2. Optimization of Treatment Regimens (Smart Polypharmacy and Protocol-Based Approaches)

The literature indicates that, beyond selecting effective pharmacological classes, protocolized intensification or adjustment (for example, guideline-tuned protocols and titration based on home blood pressure metrics) frequently outperforms the passive approach of "waiting" until the next visit to escalate treatment(19). Therapeutic inertia remains a major barrier, and models that delegate treatment adjustments to protocols or multidisciplinary teams (e.g., pharmacists under collaborative practice agreements) demonstrate higher intensification and blood pressure control rates(20).

3.3. New Therapies with Indirect Cardiovascular Impact

Drugs originally developed for other purposes (e.g., GLP-1 receptor agonists such as Semaglutide) have shown reductions in cardiovascular events in selected populations with obesity or diabetes(21); Their role in secondary prevention associated with hypertension deserves further investigation, particularly because of their pleiotropic effects (weight loss, metabolic improvement, mild reductions in blood pressure) that may contribute to a lower cardiovascular risk in the medium to long term. However, specific evidence in hypertensive patients without diabetes remains limited(22).

3.4. Safety and Applicability Considerations.

Intensive pharmacological management requires close monitoring of adverse effects, drug interactions, and adherence(23). In populations with a high prevalence of comorbidities (e.g., diabetes mellitus, chronic kidney disease, older adults), treatment protocols should include renal function monitoring, electrolyte control, and polypharmacy review to prevent iatrogenic harm. Moreover, the evidence for treatment efficacy may vary across healthcare systems and ethnic groups(24).

3.5. Lifestyle Changes: Evidence and Implementation Challenges

3.5.1. Dietary Interventions and Exercise

Structured dietary modifications (e.g., DASH pattern, sustained sodium reduction, increased intake of fruits and vegetables) and supervised physical activity programs remain fundamental strategies to reduce blood pressure and cardiovascular risk factors(25). The expected magnitude of blood pressure reduction varies by individual intervention for instance, the DASH diet may lower systolic blood pressure by approximately 6–11 mmHg, depending on adherence but the population-level impact is significant if dissemination and maintenance are achieved(26).

3.5.2. Weight Loss and Metabolic Control

Sustained weight reduction (≥5–10%) is associated with clinically meaningful decreases in blood pressure and improvements in lipid and glycemic profiles. Multimodal interventions (diet + exercise + behavioral support) increase the likelihood of medium-term success. Recent studies on weight management drugs (e.g., Semaglutide) demonstrate substantial potential for weight loss and reduction of certain cardiovascular events in specific populations, providing complementary pathways to behavioral interventions when these are insufficient(27).

3.5.3. Educational Programs and Self-Management

Health education and training in self-monitoring and self-management (including action plans and periodic review) improve knowledge, self-efficacy, and adherence to lifestyle modifications(28). However, long-term adherence remains a major challenge: multiple studies show that adherence to dietary and physical activity recommendations declines over time in the absence of continuous follow-up and community-based support structures.

3.5.4. Community Interventions and Social Determinants.

Structural factors condition the real-world effectiveness of any individual intervention. In settings with low healthcare coverage or fragmented systems, patient-centered interventions alone, without addressing social determinants, have

limited impact. Local evidence (e.g., Colombian studies) highlights issues such as lack of medication supply by insurers as a frequent cause of non-adherence(29).

Table 1 Prevention strategies

Thematic axis	Main findings	Clinical and public health implications
Dietary interventions and exercise	The DASH diet, sodium reduction, and increased intake of fruits and vegetables, combined with supervised physical activity programs, reduce blood pressure.	Promote structured diet and exercise programs; design long-term adherence strategies.
Weight loss and metabolic control	A ≥5–10% reduction in body weight leads to clinically relevant decreases in blood pressure and metabolic improvement.	Integrate weight control as part of routine hypertension management; consider anti-obesity pharmacologic therapies in selected cases.
Educational programs and self-management	Health education, blood pressure self-monitoring, and action plans improve adherence and self-efficacy.	Implement continuous education and self-management programs; foster community networks and periodic follow-up.
Community interventions and social determinants	Limited access to healthy foods, unsafe environments for physical activity, and economic or administrative barriers reduce the effectiveness of individual interventions.	Strengthen health systems to ensure continuous access to medications and preventive programs.

3.6. Adherence: Measurement, Barriers, and Effective Strategies.

3.6.1. Importance and Measurement.

Adherence to antihypertensive medication (initiation, implementation, and persistence) is a critical determinant of blood pressure control. Its assessment requires multiple methods (self-report, validated scales such as MMAS-8, pill counts, pharmacy dispensing data, electronic sensors, and serum drug levels), since each approach has limitations in sensitivity and specificity. The American Heart Association's scientific statement summarizes the available evidence on assessment methods and recommends integrating multiple measures for a robust evaluation(30).

3.6.2. Barriers (Intentional and Unintentional)

Barriers include economic factors (e.g., lack of medication supply from insurance providers), regimen complexity, adverse effects, low health literacy, beliefs and perceptions, psychiatric comorbidities, and lack of access to follow-up services. Local studies report low adherence rates (e.g., 14% adherence in a Colombian cohort) due to systemic causes such as drug delivery failures(31).

3.6.3. Effectiveness Assessment in Real-World Practice.

Although many strategies show benefit in controlled trials, real-world implementation faces effectiveness loss due to issues of scale, cost, and inequitable access. Therefore, improvements in adherence must be addressed through combined systemic and individual approaches. Critical reviews emphasize the need to include adherence measurement in any study on preventive strategies(32).

3.7. Emerging Technologies and Team-Based Models: Telemedicine, HBPM, and Cost-Effectiveness.

3.7.1. Effectiveness of Telemonitoring and HBPM.

Recent trials and systematic reviews demonstrate that home blood pressure monitoring (HBPM) combined with support (telemonitoring, pharmaceutical counseling, or team-based care) significantly reduces blood pressure compared to office-based care alone. Studies published between 2023–2024 show clinically meaningful reductions in systolic/diastolic BP when HBPM is accompanied by treatment adjustment guidance(33). In the United States, telemedicine guided by self-measured blood pressure (SMBP) with pharmacist support produces average systolic BP reductions of −7 to −8 mmHg in meta-analyses.

3.7.2. Pharmacist and Non-Physician Team Models.

Controlled delegation of certain management tasks (e.g., pharmacists authorized to recommend or initiate protocol-based adjustments) improves treatment intensification and blood pressure control. Meta-analyses of pharmacist-led telemonitoring models show sustained improvement in BP values, although evidence regarding hard cardiovascular outcomes remains limited due to short follow-up duration(34). These models reduce the burden on primary care physicians and can be cost-effective when designed for selected populations.

3.7.3. Cost-Effectiveness of HBPM and Combined Modalities.

Recent economic reviews on HBPM(35), particularly when combined with team support (telemonitoring or team-based care), indicate it is likely cost-effective over long-term horizons (≥10 years) compared with office-based monitoring. Additionally, ambulatory blood pressure monitoring (ABPM) or HBPM plus support show better cost–utility ratios than HBPM alone. However, generalizability depends on the health system structure and reimbursement models.

3.8. Equity and Outcome Gaps.

Emerging evidence indicates that the benefits of telemedicine and HBPM are not uniform; studies report smaller gains in trials involving predominantly non-White populations and in settings with digital access barriers(36). Technological interventions, if not implemented with an equity-centered approach (device access, digital literacy, multilingual support), may unintentionally widen existing health disparities(37).

3.8.1. Determinant Factors.

Adherence to preventive interventions among hypertensive patients is a critical determinant of the real-world impact of any strategy on reducing cardiovascular events(38). Over the past decade, the literature has consistently shown that non-adherence explains a large portion of the poor population-level BP control and that addressing it requires going beyond prescription it is essential to include social, cultural, psychological, and healthcare system variables in both analyses and proposed solutions(39).

3.8.2. Socioeconomic Factors.

Socioeconomic factors are strongly associated with both adherence and blood pressure control(40). Recent studies and reviews show that lower economic capacity and lack of insurance coverage or subsidies increase the likelihood of treatment interruption or non-purchase of medications. Educational level and health literacy mediate understanding of the disease and the ability to follow complex recommendations. These relationships imply that isolated clinical interventions (e.g., dose adjustment) are less effective unless accompanied by policies or support systems that reduce economic barriers and facilitate access.

3.8.3. Cultural Factors.

Cultural factors and health literacy influence beliefs about hypertension, perceived risk, and treatment acceptance. Qualitative and quantitative evidence from the past decade shows that traditional beliefs about the causes of "high blood pressure," the use of complementary remedies, family and linguistic norms, and educational materials not adapted to patient literacy levels are significant barriers to adherence(18). Low health literacy is associated not only with poorer adherence but also with worse BP control, suggesting that interventions must be culturally adapted and communicated using accessible health frameworks for patients.

3.8.4. Psychological Factors.

Psychological factors (depression, anxiety, chronic stress, low self-efficacy) are consistently linked to lower adherence to medication and lifestyle changes. Systematic reviews and longitudinal studies indicate that depressive symptoms reduce the likelihood of regular medication use and maintaining preventive behaviors. Furthermore, psychiatric comorbidity may mediate the relationship between socioeconomic adversity and non-adherence. Therefore, integrating screening and treatment of affective disorders into hypertension programs could improve adherence and cardiovascular outcomes(41).

Table 2 Socioeconomic Factors.

Socioeconomic factor	Impact on adherence
Educational level	Greater understanding of preventive recommendations and better adherence among individuals with higher education.
Economic income	Low-income limits access to healthcare services, medications, and follow-up visits; strongly associated with treatment discontinuation.
Access to healthcare services	Limited in rural areas and fragmented systems; affects continuity of preventive care.
Health insurance coverage	Populations without insurance or with partial coverage show lower adherence.

The characteristics of the therapeutic regimen and healthcare system (dosage complexity, polypharmacy, adverse effects, continuity of care, and quality of clinician–patient communication) also play a significant role. Clinical trials and systematic reviews indicate that simplifying treatment regimens (e.g., single-dose combinations), providing structured education, and ensuring continuity of care (same provider or team-based management) increase adherence(42). Moreover, technological interventions such as home telemonitoring, mHealth reminders, and pharmacist follow up have shown benefits in adherence and blood pressure control in several recent trials and meta-analyses, although the magnitude of effect varies depending on study design and population characteristics.

Table 3 Cultural factors

Cultural factors	Impact on adherence
Beliefs about the disease	Some perceptions minimize the need for prevention, while others generate resistance to behavioral change.
Family and community influence	Social approval and family support improve adherence.
Language and health literacy	Language barriers and low health literacy hinder understanding of medical instructions.
Traditional practices	Some alternative practices replace or delay preventive strategies.

Qualitative studies and reviews of barriers and facilitators help explain why interventions that succeed under controlled trial conditions often fail in real-world practice: the interaction among factors (e.g., poverty, depression, and low literacy) creates “synergies” that amplify the risk of non-adherence(32). his implies that the most promising solutions are multifactorial and staged, combining subsidies or direct medication delivery, culturally and literacy-adapted education, integration of mental health care, pharmacological simplification, and remote or community health worker–based follow-up models to sustain support within the patient’s environment.

Table 4 Psychological factors

Psychological factor	Impact on adherence
Depression and anxiety	Emotional disorders reduce motivation and adherence to preventive measures.
Risk perception	Lower perceived risk is associated with poorer preventive adherence.
Self-efficacy	Positively associated with greater engagement in healthy behaviors.
Chronic stress	Limits decision-making and reduces adherence to medical recommendations.

From a practical perspective for clinical implementation, the evidence suggests prioritizing (1) ystematic assessment of social and psychological determinants during clinical visits (brief screenings to identify economic insecurity and depression), (2) tailored interventions, including culturally sensitive education, social support, and therapy simplification; and (3) strategic use of technologies and multidisciplinary teams (telemonitoring involving

pharmacists/nurses and community health workers) in populations with limited access(40). Taken together, these actions increase adherence and improve blood pressure control, thereby contributing to the prevention of cardiovascular complications(43).

Table 5 Summary of evidence and GRADE recommendations

Axis	Findings	Level of evidence	Strength of recommendation	Ref.
Intensification of pharmacological treatment	Trials (SPRINT, STEP) show that lower blood pressure targets reduce cardiovascular events, but goals must be individualized according to age, comorbidities, and risk of adverse effects.	High (A)	Strong (1)	(44)
Optimization of regimens (protocols and smart polypharmacy)	Protocolized titration and involvement of teams/pharmacists improve intensification and control rates compared with passive management.	Moderate (B)	Strong (1)	(19,20)
New therapies with indirect cardiovascular impact (GLP-1, Semaglutide)	In patients with obesity or type 2 diabetes, these therapies reduce cardiovascular events and body weight; evidence remains limited in hypertensive patients without diabetes.	Low (C)	Weak (2)	(21)
Safety and applicability considerations	Monitoring of adverse effects, renal function, and electrolytes is necessary, especially in elderly, polymedicated, and CKD patients.	Moderate (B)	Strong (1)	(23,24)
Dietary and exercise interventions (DASH)	The DASH diet, sodium reduction, and supervised exercise reduce systolic BP by 6–11 mmHg depending on adherence.	High (A)	Strong (1)	(25,26)
Weight loss and metabolic control	A ≥5–10% weight reduction leads to lower BP and metabolic improvement; multimodal interventions increase success rates	High (A)	Strong (1)	(27)
Educational and self-management programs	Education and self-monitoring improve adherence and self-efficacy, but effects decline without continuous follow-up.	Moderate (B)	Strong (1)	(25)
Community interventions and social determinants	Structural barriers (poverty, lack of medication, insecurity) limit the effectiveness of individual interventions.	Moderate (B)	Strong (1)	(45)
Telemedicine, HBPM, and team-based models	HBPM with support reduces BP; pharmacist-led teams improve treatment intensification; cost-effective in the long term.	High (A)	Strong (1)	(36,37)
Socioeconomic, cultural, and psychological factors	Key determinants of adherence; poverty, low education, depression, and low self-efficacy reduce preventive compliance.	High (A)	Strong (1)	(38,39)

4. Discussion

Evidence from trials such as SPRINT and STEP supports intensive management of systolic blood pressure in selected patients(44). In the SPRINT trial, achieving a systolic blood pressure (SBP) target of <120 mmHg (vs <140 mmHg) reduced major cardiovascular events by 25% and all-cause mortality by 27%. However, a slight increase in adverse events such as hypotension, renal injury, and syncope was observed, underscoring the need for careful patient selection,

particularly among the elderly and frail(46). The STEP trial, which included Chinese adults aged 60–80 years, compared intensive (110–<130 mmHg) versus standard (<150 mmHg) targets and showed a significant reduction in cardiovascular events (HR 0.74), including stroke, coronary syndrome, and cardiovascular death. A secondary analysis found that participants who maintained SBP below 130 mmHg "in-target" had a lower cardiovascular risk (HR 0.61), with the optimal benefit threshold around 126.9 mmHg(47).

However, regarding cognitive outcomes, the results are less conclusive. A subanalysis of SPRINT-MIND found no differences in memory scores (p=0.33), although it reported a smaller decline in processing speed in the intensive-treatment group (p=0.02)(45). Other studies indicated that intensive blood pressure lowering did not increase the risk of cerebral hypoperfusion or adverse changes in Alzheimer's biomarkers, except for a slight reduction in hippocampal volume. More recently, a trend toward lower incidence of mild cognitive impairment (MCI) or probable dementia was observed in the intensive group at seven years, although the hazard ratio was marginally non-significant (HR 0.86; 95% CI 0.72–1.02)(48).

In summary, current evidence supports intensive treatment of SBP (ideally 120–130 mmHg) in selected adult patients, with close monitoring for potential adverse effects and without expecting clear cognitive benefits, at least in the medium term. Non-pharmacological measures—such as the DASH diet, sodium reduction, increased fruit and vegetable intake, and supervised physical activity—have a moderate but significant effect, lowering SBP by approximately 6–11 mmHg, depending on adherence level. Recent meta-analyses confirm these findings, particularly when ongoing behavioral support is included(49). Sustained weight loss (≥5–10%) also results in clinically meaningful blood pressure reductions and improves lipid and glycemic profiles. Combined interventions (diet, exercise, behavioral support) maximize medium-term success, although sustainability remains a challenge, as adherence tends to decline without structured follow-up or community support, limiting long-term effectiveness(47).

Adherence is a cornerstone of blood pressure control, encompassing initiation, implementation, and persistence. Its assessment requires a combination of methods self-report (e.g., MMAS-8), pill count, dispensing data, electronic sensors, and biomarkers given the limitations of each. The AHA promotes a multimethod approach to enhance measurement validity(50). Barriers to adherence are multiple: economic (lack of medication supply), treatment complexity, adverse effects, low health literacy, cultural beliefs, psychiatric comorbidities, and limited follow-up access. In a Colombian cohort, only 14% showed adequate adherence, reflecting a serious problem with systemic and social roots(51).

The most effective interventions include team-based models (clinical pharmacists, nurses), behavioral support (reminders, personalized education, motivational strategies), and digital tools (apps, electronic dispensers, SMS reminders). However, real-world effectiveness depends on usability, digital literacy, and user acceptance, requiring context-sensitive implementation(52). In practice, the efficacy observed in controlled trials often diminishes due to issues of scale, cost, and access inequality. Therefore, strategies should be combined, integrating individual and structural approaches to improve adherence and sustainability.

Home blood pressure monitoring (HBPM) combined with telemonitoring and professional support has demonstrated significant SBP reductions (−7 to −8 mmHg) compared with office-based care alone. Delegation of responsibilities to pharmacists or non-physician teams under established protocols enhances treatment intensification and blood pressure control, while reducing the workload of primary care physicians. Although data on hard outcomes (mortality, major cardiovascular events) remain limited due to short follow-up periods, initial results suggest sustained clinical benefit. The findings of this study confirm that adherence to preventive strategies in patients with hypertension depends not only on medical prescription but also on a network of socioeconomic, cultural, and psychological factors influencing patient behavior(41). This result aligns with recent reviews identifying non-adherence as the main barrier to achieving blood pressure control and reducing cardiovascular complications, despite the availability of effective pharmacologic therapies(21).

Regarding socioeconomic determinants, patients with lower income, lower education, and difficulty affording medications exhibited higher non-adherence rates. This finding is consistent with international studies showing that medication cost, lack of subsidies, and logistical barriers (distance to care, waiting times) limit therapeutic continuity(40). herefore, adherence should not be viewed solely as an individual responsibility, but also as a phenomenon shaped by the structure and equity of the healthcare system. The results also highlight the importance of cultural factors and health literacy. Patients with traditional beliefs about the causes of hypertension or with low disease understanding showed less willingness to follow medical recommendations and adopt lifestyle changes. These findings are consistent with reviews showing that the lack of culturally and linguistically adapted educational materials constitutes a significant barrier to cardiovascular prevention. Hence, there is a reinforced need to develop culturally

sensitive educational programs that involve families and communities, rather than unidirectional physician-centered strategies(53).

In the psychological domain, depression, anxiety, and low self-efficacy were significantly associated with poorer adherence to both pharmacologic and non-pharmacologic measures. This finding aligns with studies showing that untreated depression reduces the likelihood of regular antihypertensive medication use by up to 30%. Moreover, psychiatric comorbidity may mediate the relationship between socioeconomic adversity and adherence, suggesting that a comprehensive approach should include early detection and management of mental health conditions in hypertensive patients(54). Additionally, factors related to the therapeutic regimen (polypharmacy, dosing complexity, adverse effects) and healthcare organization (continuity of care, physician–patient communication) emerged as modulators of adherence(55). These results align with clinical trials showing that simplifying regimens through fixed-dose combinations and the use of telemonitoring technologies and pharmacist-led follow-up programs improve adherence and blood pressure control(56).

From a clinical perspective, these findings emphasize that improving adherence requires multilevel interventions: medication subsidies or free distribution, culturally adapted education, integration of mental health services, therapeutic simplification, and digital follow-up tools. Thus, adherence should no longer be viewed as the patient's sole responsibility but rather as a shared goal among the individual, the healthcare team, and public policy. A key limitation of this analysis is the methodological heterogeneity of the included studies, which may introduce bias in estimating the relative weight of each factor. Moreover, psychological and cultural factors are often underassessed in clinical practice and may therefore be underestimated in the available data. Nevertheless, the consistency of findings across diverse populations supports the validity of these conclusions and provides a solid foundation for guiding future interventions in clinical practice.

5. Conclusions

This study identified that the effective management of hypertension requires a multimodal and integrated approach, combining lifestyle modification, pharmacological optimization, educational strategies, community-based interventions, and the use of emerging technologies. One of the main conclusions is that no single strategy is sufficient to achieve a sustained impact on blood pressure levels and cardiovascular risk reduction; rather, strategic combinations tailored to patients' individual and contextual characteristics are necessary.

Regarding dietary and physical activity modifications, the evidence supports their role as first-line measures in both prevention and treatment of hypertension. However, one of the most consistent findings is that the magnitude of benefit depends on adherence and the presence of long-term support structures, as spontaneous compliance with lifestyle recommendations tends to decline over time. Similarly, supervised exercise programs not only contribute to blood pressure reduction but also improve cardiorespiratory fitness and reduce other metabolic risk factors.

A crucial aspect that emerges is weight loss and metabolic control. Sustained weight reduction of 5–10% of body weight is associated with clinically significant decreases in blood pressure and parallel improvements in glycemic and lipid parameters. These results reinforce the importance of multimodal programs combining diet, exercise, and behavioral support. The introduction of weight-control pharmacotherapies, such as GLP-1 receptor agonists (e.g., Semaglutide), has opened new avenues by demonstrating substantial weight reduction and a potential impact on cardiovascular outcomes. However, the scalability of these therapies faces challenges related to cost, access, and sustainability—particularly in middle- and low-income health systems, such as Colombia's.

Another key focus is adherence to antihypertensive pharmacotherapy, recognized as a critical determinant of therapeutic success. Consequently, hypertension control programs should incorporate systematic measurement of adherence, using validated tools such as the MMAS-8 scale, complemented by behavioral support interventions, electronic reminders, and multidisciplinary follow-up. In the field of educational and self-management interventions, the findings clearly show that health education, self-measurement of blood pressure, and self-management strategies enhance self-efficacy and adherence to both lifestyle changes and pharmacological treatment. However, the sustainability of these effects remains a major challenge. Without ongoing follow-up and support mechanisms, benefits tend to wane over time. Therefore, self-management programs must be designed with a continuity-oriented approach, integrated into routine medical care and supported by community or digital infrastructures that help sustain patient motivation.

Telemonitoring and home blood pressure monitoring (HBPM) stand out as strategies with significant potential in contemporary practice. However, their implementation faces equity challenges, as populations with limited digital

literacy or restricted access to technology tend to benefit less, potentially perpetuating inequalities if inclusive approaches are not designed. Regarding cost-effectiveness, current evidence suggests that both HBPM and shared-care models involving pharmacists are likely cost-effective over long-term horizons (≥10 years), particularly when considering savings derived from the prevention of major cardiovascular complications. In resource-limited countries such as Colombia, the adoption of these strategies should be accompanied by local economic evaluations to determine their feasibility and sustainability.

Ultimately, the effectiveness of any individual intervention is limited unless structural barriers faced by patients are addressed. Lack of access to healthy foods, medication costs, unsafe environments for physical activity, and fragmented health systems significantly reduce the impact of preventive and therapeutic strategies. Another overarching element is the need for combined and synergistic approaches. Evidence demonstrates that the most effective strategies are those integrating educational, technological, pharmacological, and community components. For instance, the combination of HBPM with pharmacist counseling and behavioral support not only improves blood pressure control but also strengthens adherence and patient engagement. These findings highlight the importance of designing adaptive interventions that do not focus on a single dimension but instead respond to the multifaceted nature of hypertension management.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

Statement of ethical approval

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