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WEARABLE DEVICES IN HYPERTENSION SELF-MANAGEMENT: PATIENT ENGAGEMENT, CLINICAL OUTCOMES, AND BARRIERS TO LONG-TERM ADOPTION

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ABSTRACT

Background: Hypertension remains poorly controlled worldwide despite the availability of effective treatment. Wearable devices may support self-management by combining blood pressure monitoring, physical activity feedback, reminders, and digital communication outside clinic visits.
Objective: This review evaluates whether wearable and connected devices improve hypertension self-management, which components appear clinically useful, and why long-term adoption often fails.
Materials and Methods: A structured narrative review was conducted using English-language publications available through June 2026. Thirty sources were included, comprising randomized trials, systematic reviews, professional statements, validation studies, and qualitative research.
Results: Wearable or connected monitoring appears most useful when it is embedded in a care pathway that includes reliable measurement, feedback, education, medication titration, or professional support. Activity tracking or self-measurement alone produces small, inconsistent, or absent blood pressure effects. Cuffless blood pressure devices may reduce measurement burden and capture patterns across daily life, but calibration drift, position effects, proprietary algorithms, and incomplete validation currently limit their use for diagnosis or treatment decisions. Sustained engagement depends on usability, perceived value, trust, tailored feedback, social support, and integration with clinical workflows.
Conclusions: Wearables should be treated as components of an organized self-management system rather than stand-alone therapies. Future implementation should prioritize validated measurement, low-burden design, human support, interoperability, and equity-sensitive evaluation over device novelty.

KEYWORDS

Hypertension; Wearable Devices; Self-Management; Blood Pressure Monitoring; Patient Engagement; Digital Health

CITATION

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1. Introduction

Hypertension is both common and unusually amenable to treatment, yet control remains inadequate in most regions. An analysis of 1,201 population-representative studies estimated that the number of adults aged 30–79 years with hypertension increased from approximately 648 million in 1990 to 1.28 billion in 2019. In 2019, blood pressure was controlled in only 23% of women and 18% of men with hypertension, with large differences between countries and income settings (NCD Risk Factor Collaboration [NCD-RisC], 2021). These figures expose a gap that is not explained by drug efficacy alone. Diagnosis may be delayed, treatment is not always intensified, daily adherence is imperfect, and the behavioral changes recommended in clinical practice are difficult to sustain.

Contemporary guidelines place accurate out-of-office measurement, lifestyle modification, adherence, and shared decision-making at the center of hypertension care (McEvoy et al., 2024). However, conventional clinic visits capture only a small fraction of a patient's life. Home blood pressure monitoring provides a broader view, but it still depends on the patient remembering to measure, recording results correctly, and communicating them to a clinician who can act on the information. Wearable and connected technologies promise to shorten this chain. Smartwatches, wristbands, patches, activity trackers, and linked applications can collect data repeatedly, visualize trends, issue reminders, and transmit information to patients, families, or healthcare teams.

That promise requires careful qualification. The term *wearable* covers devices with very different purposes and levels of clinical maturity. Some devices measure steps, heart rate, sleep, or sedentary time and aim to influence lifestyle. Others estimate blood pressure from photoplethysmography, pulse transit time, tonometry, or combinations of sensors and algorithms. Still others function mainly as interfaces within a larger digital program that includes a validated cuff monitor, a smartphone application, educational content, or professional review. A consumer device that increases awareness is not automatically a medical device capable of guiding diagnosis or medication titration. Treating these categories as interchangeable obscures both benefit and risk (Bayoumy et al., 2021; Petek et al., 2023).

The central question is therefore not simply whether wearable devices "work." A more useful question is what work they perform within hypertension self-management. A device may reduce measurement burden, reveal behavioral patterns, strengthen self-efficacy, or support communication without independently lowering blood pressure. Conversely, frequent measurements may be clinically unhelpful when accuracy is uncertain, feedback is generic, or no one is responsible for acting on abnormal values. This review evaluates wearables as parts of a sociotechnical care system. It focuses on three connected domains: clinical outcomes, patient engagement, and the barriers that determine whether use can be sustained beyond a short study period.

2. Materials and Methods

This article is a structured narrative review. PubMed was searched, using combinations of the terms *hypertension*, *wearable*, *smartwatch*, *activity tracker*, *cuffless blood pressure*, *self-management*, *patient engagement*, *adherence*, *telemonitoring*, *digital health*, *barriers*, and *health equity*. Crossref was used to verify the current European Society of Cardiology guideline record and bibliographic metadata. The main publication window was January 2017 through June 2026.

Eligible publications were English-language peer-reviewed articles concerning adults with hypertension or elevated blood pressure and addressing at least one of the following: wearable or connected monitoring, blood pressure outcomes, self-management, engagement or adherence, device validation, clinical implementation, digital literacy, or equity. Randomized and non-randomized clinical studies, systematic reviews, qualitative studies, professional recommendations, and major guidelines were considered. Studies focused exclusively on arrhythmia detection, inpatient monitoring, engineering performance without a clinically relevant validation context, or conditions unrelated to hypertension self-management were excluded. Earlier evidence was retained only when it provided a necessary conceptual or clinical foundation.

Titles and abstracts were screened for relevance, after which 30 publications were selected for the final synthesis. The evidence was organized into four themes: the functions of wearable devices, clinical outcomes, mechanisms of engagement, and barriers to sustained adoption. Because the objective was interpretive synthesis rather than estimation of a pooled treatment effect, no new meta-analysis was performed. Conclusions were calibrated to study design: professional statements were used for measurement and safety recommendations, randomized trials for intervention effects, systematic reviews for consistency across settings, and qualitative studies for adoption and workflow factors.

For each included publication, the following information was extracted when available: study design, population, intervention or device type, comparator, duration of follow-up, blood pressure outcomes, engagement outcomes, implementation barriers, and the authors' main conclusions. Particular attention was given to whether the technology was a direct blood pressure measuring device, an activity or wellness wearable, or a connected component within a wider care pathway. This distinction was used throughout the synthesis because clinical claims, validation requirements, and patient responsibilities differ substantially across these categories.

3. Results

3.1. Profile of the included evidence

The final synthesis included 30 publications. The evidence base was mixed in both design and clinical purpose: randomized trials and meta-analyses informed the likely effect on blood pressure, validation studies and professional statements informed measurement safety, and qualitative or implementation studies clarified why adoption succeeds or fails in routine care. The main finding across these sources was not that one device type is universally effective. Rather, benefit depended on whether data collection was connected to interpretation, feedback, treatment adjustment, and human or organizational support.

3.2. Device categories and intended functions

Wearables used in hypertension care can be grouped by the task they are expected to perform. Activity trackers and general-purpose smartwatches record steps, movement, heart rate, sleep proxies, and periods of inactivity. Their therapeutic logic is indirect: continuous feedback is expected to make behavior visible and encourage physical activity, weight management, or more regular sleep. Blood pressure–enabled smartwatches and wristbands attempt a more direct role by estimating blood pressure intermittently or continuously. Chest straps and sensor patches may add high-frequency physiological signals, although their routine role in hypertension remains less established. Finally, wearables are frequently combined with a smartphone application and a validated upper-arm cuff. The cuff is not itself wearable, but it provides the measurements around which reminders, feedback, communication, and treatment decisions are organized.

Table 1. Main device categories relevant to hypertension self-management

Device category	Typical data	Potential self-management role	Principal limitation
Activity tracker or standard smartwatch	Steps, activity intensity, heart rate, sedentary time, sleep estimates	Goal setting, feedback, prompts, lifestyle awareness	Behavioral data do not directly establish blood pressure control
Cuffless blood pressure smartwatch or wristband	Estimated systolic and diastolic pressure, pulse, trends across daily life	Lower-burden monitoring, detection of patterns, possible nocturnal assessment	Calibration, position effects, algorithm opacity, and incomplete validation
Patch or chest-worn sensor	Heart rate, rhythm, activity, occasionally hemodynamic proxies	Continuous observation and contextualization of symptoms or activity	Comfort, skin irritation, charging, data volume, and limited hypertension-specific evidence
Wearable plus smartphone application	Sensor data, reminders, education, goals, messaging	Tailored feedback, self-efficacy, adherence support, communication	Engagement may decline; requires digital skills and reliable connectivity
Connected validated cuff within a wearable ecosystem	Standardized home blood pressure readings transmitted electronically	Treatment titration, safety alerts, clinician review	Not truly wearable; benefit depends on workflow and professional response

Note. Categories overlap because many commercial systems combine several sensors and a mobile application. The distinction between lifestyle tracking and clinically validated blood pressure measurement should be preserved (Bayoumy et al., 2021; Petek et al., 2023; Stergiou et al., 2022).

The available literature also shows how quickly the field changes. A systematic review of cardiometabolic wearables covering studies published through early 2021 found that smartwatches, patches, and chest straps were common, but none of the included real-world studies tracked blood pressure as the principal cardiometabolic signal (Lee et al., 2023). Within only a few years, dedicated cuffless blood pressure studies and commercial claims became much more prominent. This pace creates a mismatch between product cycles and clinical evidence. Devices can be updated, discontinued, or assigned a new algorithm before an independent trial is completed.

3.3. From data collection to a self-management pathway

Collecting a signal is only the first step. A clinically meaningful pathway requires at least four additional functions: the measurement must be interpretable, the user must understand what it means, an appropriate response must be available, and responsibility for that response must be clear. For physical activity, the response may be a realistic step goal or a prompt to interrupt prolonged sitting. For blood pressure, it may be repeat measurement, medication review, or urgent assessment. The higher the clinical consequence, the more important validation and escalation rules become.

This distinction helps reconcile apparently conflicting evidence. Home blood pressure self-monitoring is associated with a modest reduction in systolic pressure overall, but the effect is strongly modified by co-intervention. In an individual-patient-data meta-analysis, self-monitoring alone produced little or no benefit, whereas self-monitoring combined with medication titration, education, or lifestyle counseling achieved larger and clinically relevant reductions (Tucker et al., 2017). Wearables can make measurement easier or more frequent, but they cannot substitute for the clinical and behavioral processes that convert information into action.

3.4. Blood pressure monitoring and treatment adjustment

The strongest evidence for digital self-management does not come from a fully cuffless wearable. It comes from programs that connect reliable home measurements to structured treatment. In TASMINH4, 1,182 adults with poorly controlled hypertension were assigned to usual care, self-monitoring, or self-monitoring with telemonitoring. At 12 months, clinic systolic pressure was lower by 3.5 mm Hg with self-monitoring and by 4.7 mm Hg with telemonitoring compared with usual care. Telemonitoring did not clearly outperform self-monitoring, but both strategies enabled clinicians to titrate medication using out-of-office information (McManus et al., 2018).

The HOME BP trial extended this model by combining self-monitoring with digital feedback, optional lifestyle support, and communication between patients and professionals. Among 622 participants, the intervention reduced systolic pressure by an adjusted 3.4 mm Hg at one year compared with usual care, with low incremental cost per millimeter of mercury reduced. The authors nevertheless emphasized that implementation requires integration into primary-care workflows and attention to patients who may be excluded from digital services (McManus et al., 2021). For wearable programs, the practical implication is that automated collection may improve convenience, but clinical benefit still depends on a pathway that recognizes the data and allows treatment to change.

Evidence from consumer blood pressure devices leads to the same conclusion. A systematic review of 49 controlled studies found that monitors used without substantial co-intervention generally reduced systolic pressure by approximately 2–4 mm Hg and diastolic pressure by 1–3 mm Hg. Adherence varied widely, from 38% to 89%, while evidence for mortality, hospitalization, or quality-of-life outcomes remained unclear because studies were short and events were uncommon (Treadwell et al., 2022). These data support modest benefit but not the claim that purchasing a device, by itself, changes long-term cardiovascular risk.

3.5. Multicomponent wearable interventions

Some trials have evaluated a wearable as one element in a broader intervention. In a 12-week randomized study conducted in a low-resource rural setting in China, a monitoring device was combined with a smartphone application that provided reminders, adherence reports, medical guidance, and optional family support. The intervention group experienced a greater reduction in systolic pressure and reported improvements in adherence, self-efficacy, and quality of life. Interpretation should remain cautious because follow-up was short and the abstract contains an internal inconsistency between the reported blood pressure results and its concluding sentence (Yuting et al., 2023). Even so, the intervention illustrates why it is difficult to isolate a “wearable effect”: the active ingredients included reminders, professional information, and social support.

A larger study of 400 older adults compared usual management with a platform integrating wearable monitoring and personalized intervention. The technology-supported group showed better blood pressure

control, medication adherence, disease knowledge, self-management, and quality-of-life measures (Wang et al., 2025). This is encouraging for older patients, who may benefit from reduced measurement burden and timely support. However, a single regional platform evaluated over a limited period cannot establish durability, transferability to other health systems, or the independent contribution of the device.

In contrast, a pilot trial of commercial smartwatches enrolled 60 healthy young adults rather than patients with established hypertension. Participants using a watch with a blood pressure feature showed reductions in blood pressure and resting heart rate over 12 weeks, suggesting that feedback may promote awareness and healthier behavior (Yen et al., 2022). The small, young sample and prevention-oriented context limit clinical generalization. The study supports feasibility more than it supports medication decisions or hypertension control.

Personalization may strengthen the link between observation and action. Chiang et al. (2021) combined a home monitor, wearable activity data, and machine learning to identify individual associations between blood pressure, activity, and sleep. In a three-month study of 25 adults, personalized recommendations were associated with larger reductions in systolic and diastolic pressure than no recommendation. The sample was too small to establish effectiveness, but the work highlights a productive direction: a wearable may be most useful when it identifies which modifiable behavior matters for a particular person rather than delivering the same advice to everyone.

3.6. Physical activity promotion

Activity tracking is attractive because physical activity is a standard component of hypertension management and consumer devices already measure it reasonably well under many conditions. Yet the assumption that more feedback automatically produces lower blood pressure is not supported consistently. A 2025 systematic review and meta-analysis included 21 randomized trials lasting 12–48 weeks and found no statistically significant improvement in systolic or diastolic pressure at any intervention duration. Effects on body weight, fasting glucose, and glycated hemoglobin were also not significant (Koyama et al., 2025).

This finding is clinically useful because it separates measurement from behavior change. Step counts document activity, but they do not by themselves solve the practical reasons why activity is difficult to maintain. Users may increase activity briefly and then return to baseline; goals may be unrealistic; feedback may arrive without context; and illness, pain, work, neighborhood safety, or caregiving responsibilities may constrain behavior. Wearables used only as electronic pedometers therefore should not be presented as antihypertensive treatment. Their contribution is more plausible when activity data are combined with tailored goals, coaching, reinforcement, and attention to the user's environment.

3.7. Summary of clinical evidence

Table 2. Selected evidence on monitoring, engagement, and blood pressure outcomes

Source	Design and population	Intervention	Main finding	Interpretation
Tucker et al. (2017)	Individual-patient-data meta-analysis of randomized trials	Blood pressure self-monitoring with variable co-interventions	Approximately 3.2 mm Hg lower clinic systolic pressure overall; little effect from monitoring alone	Support and treatment action modify effectiveness
McManus et al. (2018)	Randomized trial; 1,182 adults with poorly controlled hypertension	Self-monitoring with or without telemonitoring	Both strategies lowered systolic pressure versus usual care at 12 months	Reliable measurements can support medication titration
McManus et al. (2021)	Randomized trial; 622 adults	Digital self-management plus home monitoring and feedback	Adjusted 3.4 mm Hg systolic reduction versus usual care at one year	Integration of patient and professional action is clinically useful
Yen et al. (2022)	Pilot randomized trial; 60 healthy young adults	Commercial smartwatch with or without blood pressure function	Feasible; reductions in blood pressure and resting heart rate in the BP-feature group	Preliminary prevention evidence; not a hypertension treatment trial

Source	Design and population	Intervention	Main finding	Interpretation
Yuting et al. (2023)	Randomized trial; rural, low-resource setting	Wearable, app, reminders, reports, guidance, and family support	Improved several clinical and self-management outcomes over 12 weeks	Multicomponent model is promising but durability is unknown
Katz et al. (2024)	Systematic review and meta-analysis; 28 studies, 8,257 participants experiencing disparities	Mainly remote monitoring with professional or culturally tailored support	Systolic reductions of about 4.2 mm Hg at six months and 4.3 mm Hg at 12 months	Tailored digital care can improve outcomes in underserved groups
Wang et al. (2025)	Randomized study; 400 older adults with hypertension	Wearable-based chronic disease platform	Better control, adherence, knowledge, self-management, and quality of life	Supports integrated management; external validity requires testing
Koyama et al. (2025)	Systematic review and meta-analysis; 21 randomized trials	Wearables promoting physical activity	No significant blood pressure reduction across 12–48 weeks	Activity tracking alone is insufficient

The table shows a consistent pattern across heterogeneous interventions. Monitoring tied to feedback and treatment action produces modest but meaningful reductions in blood pressure. Monitoring without such a pathway, particularly when limited to activity tracking, has far less reliable effects. This difference should guide both device evaluation and patient counseling.

3.8. Patient engagement and behavior change

Engagement is more than frequency of use

Digital studies often reduce engagement to the number of log-ins, days worn, or measurements submitted. These variables are easy to count, but they do not fully describe whether the user understands the data, trusts the system, or changes behavior. A systematic review of hypertension self-management interventions found that engagement was usually operationalized at this narrow, behavioral level. Only three included studies formally examined the association between engagement and outcomes, although all three reported better biomedical outcomes among more engaged participants (Cao et al., 2022). The small evidence base makes it unsafe to assume a simple dose-response relationship between screen time and health.

A person may wear a device every day yet ignore its feedback. Another may use it intermittently but learn enough to establish a sustainable walking routine or recognize when blood pressure is repeatedly elevated. Engagement therefore has behavioral, cognitive, and emotional dimensions. It includes attention to information, perceived relevance, confidence in acting, and willingness to return to the system after an interruption. Measures of long-term adoption should reflect these dimensions rather than treating uninterrupted device use as the only success criterion.

The wider cardiovascular literature similarly shows that greater application use is often associated with favorable weight, activity, or glycemic outcomes, but the relationship with blood pressure is less consistent (Spaulding et al., 2021). This may reflect reverse causality: people who are already motivated use digital tools more frequently. It also suggests that raw usage metrics can confuse intervention exposure with patient characteristics. Trials should report why use declined, whether key skills persisted after use declined, and whether the intervention remained available when the patient needed it.

Feedback, tailoring, and interactivity

Data become engaging when they answer a question the user recognizes. A daily step count may be useful when linked to an attainable goal, while a blood pressure trend may matter when it explains why medication is being adjusted. Generic messages repeated at fixed intervals quickly lose salience. Tailored content can account for baseline pressure, treatment regimen, confidence, preferences, cultural context, or the patient's prior experience of self-management.

Cao et al. (2022) found that tailoring in hypertension interventions ranged from personalized goals and reminders to feedback based on medication lists, blood pressure stage, adherence, and individual values. Interactivity was less developed. Only seven reviewed studies enabled two-way communication with a health professional, and many systems provided no more than one-way alerts when values were abnormal. This matters because feedback that identifies a problem without offering an understandable next step may increase anxiety rather than agency.

Human support is not necessarily the opposite of automation. The most credible models use automation for repetitive tasks—recording, visualization, reminders, and routine triage—while reserving human attention for interpretation, motivation, and treatment decisions. The HOME BP intervention illustrates this division of labor: the system organized measurements and feedback, but the pathway remained connected to clinical care (McManus et al., 2021). Social support can also come from family members or caregivers, particularly for older adults or users with limited digital confidence. The 2026 qualitative synthesis identified interpersonal support, trust, and cultural or linguistic relevance as central determinants of adoption rather than optional enhancements (Motta-Yanac et al., 2026).

Self-efficacy without transferring all responsibility to the patient

Wearables are frequently described as tools of "empowerment." The term is useful only if it refers to a real increase in capacity: understanding one's condition, recognizing patterns, discussing treatment, and making feasible changes. It becomes problematic when technology quietly transfers monitoring work, troubleshooting, and risk interpretation from the health system to the patient.

Healthcare professionals interviewed in Germany perceived that mobile tools could improve safety, autonomy, and clinical decision-making. At the same time, they identified data management, communication, system handling, reimbursement, and workflow redesign as obstacles (May et al., 2025). These findings expose a recurring tension. A patient can generate far more information than a clinic can safely review. If the application implies that transmitted data are being monitored when no accountable team or response time exists, reassurance may be false. Programs should state clearly which data are reviewed, by whom, how often, and what the patient should do when symptoms or extreme values occur.

3.9. Accuracy and clinical safety

Cuffless blood pressure measurement

Cuffless devices are attractive because inflation of an arm cuff is uncomfortable, disrupts sleep, and discourages repeated measurement. Most current wrist-worn systems use photoplethysmography, sometimes combined with an electrocardiographic signal, to estimate pressure from pulse-related features. Others use tonometry or different optical and mechanical approaches. Estimates are generated by algorithms and often require initial calibration against a cuff measurement (Islam et al., 2022).

Validation is difficult because good performance at rest does not guarantee accurate tracking during posture change, exercise, sleep, medication response, or the weeks following calibration. Hydrostatic differences between wrist and heart level can introduce error. Vascular properties vary with age and disease, while firmware or algorithms may change without being visible to users or clinicians. A systematic review of 16 validation studies involving 15 devices found high heterogeneity and inconsistent standards. Although several devices showed small mean bias, pooled comparisons were highly heterogeneous and did not establish interchangeable clinical performance (Islam et al., 2022).

Small validation studies demonstrate potential but also illustrate why caution is needed. A 24-hour comparison in 28 adults found close average agreement and less inconvenience with a cuffless wrist device than with standard ambulatory monitoring (Nachman et al., 2021). A later study compared a photoplethysmography wristband with intra-arterial pressure in 97 patients and reported low mean errors across a broad pressure range and different skin colors. The algorithm nevertheless required three cuff-based initialization measurements, and the authors called for further evaluation under the full European Society of Hypertension framework (van Vliet et al., 2024). Neither study, alone, establishes stable accuracy in diverse patients during months of unsupervised use.

Validation standards and clinical claims

The European Society of Hypertension has stated that cuffless devices should not yet be used for routine diagnosis or management unless their accuracy and intended use have been appropriately demonstrated. Its 2022 statement highlighted calibration stability, tracking of blood pressure changes, algorithm performance, and real-world implementation as unresolved issues (Stergiou et al., 2022). In 2023, the Society proposed six validation domains: static accuracy, device position, response to treatment, awake–asleep change, exercise

response, and recalibration stability. The required tests depend on how and when a device measures and whether individual calibration is required (Stergiou et al., 2023).

This caution is consistent with the Lancet Commission position that many marketed blood pressure devices lack independent validation according to accepted standards. The problem is regulatory as well as technical: market clearance may not require the kind of evidence needed for clinical decision-making. Mandatory independent validation, transparent device lists, and standards specific to new technologies were identified as priorities (Sharman et al., 2020).

The practical consequence is that relative trends and behavior prompts should not be confused with diagnostic measurements. A smartwatch may encourage a user to seek a validated assessment, but an unvalidated value should not independently trigger medication titration. Clinicians should determine whether the exact model—not merely the brand or sensor type—has been tested, for which population, under what calibration conditions, and for which intended use. Consumer-facing interfaces should communicate uncertainty rather than displaying algorithmic estimates with unwarranted precision.

3.10. Barriers to long-term adoption

Usability, burden, and habituation

Initial enthusiasm is easy to generate. Sustained use is harder. Charging, synchronization, software updates, sensor positioning, skin discomfort, and repeated alerts introduce small but cumulative demands. Interfaces designed for technically confident users may be difficult for people with impaired vision, reduced dexterity, cognitive limitations, or limited experience with smartphones. The most recent qualitative synthesis of hypertension tools identified usability and design, cultural and linguistic relevance, healthcare context, trust, and interpersonal relationships as interconnected determinants of adoption (Motta-Yanac et al., 2026).

Burden also increases when patients have several chronic conditions. A 2025 systematic review modeled the digital technologies that might be prescribed to a patient with five common conditions. Because most products addressed a single disease or function, the hypothetical patient could require as many as 13 applications and seven devices to receive all functions considered important by clinicians (Phi et al., 2025). This scenario captures an overlooked risk: digital care can reproduce the complexity of fragmented healthcare on the patient's wrist and phone.

Habituation creates a different problem. A notification that attracts attention during the first week may become background noise by the third month. Frequent low-value alerts encourage dismissal, while excessive measurement can create anxiety or compulsive checking. Designers should therefore optimize for meaningful interactions rather than maximal contact. Periods of lower-intensity maintenance, configurable reminders, and summaries that emphasize actionable trends may be more sustainable than constant prompts.

Data overload and clinical workflow

Continuous monitoring changes the scale of information. Traditional home monitoring may generate a few readings on selected days; a wearable can produce thousands of data points with activity, sleep, heart rate, and contextual variables. More data do not guarantee better decisions. Noise, missingness, calibration changes, and artifacts can generate false alerts or conceal a true trend. Proprietary formats may prevent data from entering the electronic record in a usable form.

Healthcare professionals have repeatedly identified unclear responsibility and poor interoperability as barriers. They need concise summaries, thresholds matched to clinical protocols, and a method to distinguish routine variation from a signal requiring action. They also need protected time and reimbursement for reviewing information. Without these arrangements, remote data become an additional inbox rather than a form of care (May et al., 2025). A safe implementation should specify data ownership, review frequency, escalation rules, documentation, and fallback procedures when transmission fails.

Trust, privacy, and algorithmic opacity

Wearables collect intimate information about routines, location, sleep, activity, and physiological state. Users may not know whether data are stored locally, uploaded to a commercial cloud, used for product development, or shared with third parties. Consent notices are often long and difficult to interpret. Trust may be weakened further when a device produces values that differ from a clinical monitor without explaining why.

Algorithmic opacity is especially consequential for cuffless blood pressure. A proprietary model may combine sensor signals with age, sex, body size, or other personal data. Performance can differ across skin tones, vascular conditions, motion states, or populations that were underrepresented during development. Independent evaluation should therefore report demographic composition and subgroup performance, while manufacturers should provide versioning and change-control information. Privacy and transparency are not

separate from engagement: people are less likely to use a system consistently when they do not understand what it measures or who can see the result (Bayoumy et al., 2021; Petek et al., 2023).

Digital literacy, affordability, and unequal access

Wearable programs can reduce geographic and scheduling barriers, but they can also create a new eligibility test based on device ownership, broadband access, language, and digital confidence. Digital health literacy requires more than the ability to operate a screen. Users must judge information quality, interpret risk, protect personal data, and communicate through digital systems. Populations already affected by limited health literacy are also more likely to face difficulty with these additional tasks (Smith et al., 2019).

Cost is not limited to purchasing the device. A compatible smartphone, data plan, replacement hardware, subscription, and technical support may be required. Neighborhood infrastructure and historical patterns of underinvestment can shape whether digital services are realistically available, a process described as digital redlining (Merid et al., 2021). Underrepresented communities may also be less visible in design, validation, and implementation studies. This can produce tools that are less relevant, less trusted, or less clearly validated for populations with the greatest burden of uncontrolled hypertension (Johnson et al., 2023).

The evidence does not support abandoning digital care in underserved populations. It supports designing it differently. A meta-analysis of 28 studies involving 8,257 participants experiencing health disparities found that digital hypertension interventions produced greater systolic reductions than standard care at six and 12 months. Most successful programs were multicomponent: remote monitoring was frequently paired with nurses or community health workers and with cultural or linguistic tailoring (Katz et al., 2024). Equity therefore depends on support, adaptation, and access rather than on distributing identical technology.

Global implementation adds another layer. Technologies developed in well-resourced health systems may assume reliable connectivity, dense clinical staffing, and individual smartphone ownership. Translation to lower-resource settings requires adaptation and reciprocal learning rather than one-way export. Locally developed workflows may offer simpler and more scalable solutions that are also useful in high-income settings (Ogungbe et al., 2024). The objective should be equivalent capacity to benefit, not merely equal availability of a device.

Table 3. Barriers, facilitators, and implementation responses

Domain	Common barrier	Facilitator	Practical implementation response
Measurement	Uncertain accuracy, calibration drift, position effects	Independent validation and clear intended use	Use validated devices; confirm important readings with a standard method
Patient experience	Charging, complex interfaces, alert fatigue	Low-burden design and configurable feedback	Co-design with users; offer training and non-digital alternatives
Behavior change	Generic goals and passive dashboards	Tailoring, timely feedback, achievable goals	Connect data to a specific action plan and periodic human support
Clinical workflow	Data overload and unclear responsibility	Interoperability, summaries, escalation protocols	Define who reviews data, when, and how treatment decisions are documented
Trust and privacy	Opaque algorithms and data sharing	Transparent governance and understandable consent	Explain data flow, uncertainty, retention, and algorithm updates
Equity	Cost, connectivity, language, and digital literacy	Cultural adaptation and community or caregiver support	Provide devices and connectivity where needed; preserve accessible alternatives
Multimorbidity	Multiple apps and devices for different conditions	Integrated platforms and shared goals	Minimize duplicated tasks and prioritize the patient's overall treatment burden

4. Discussion

4.1. Principal findings

This review supports a cautiously positive interpretation of wearable and connected digital devices in hypertension self-management. The most consistent benefits are not produced by passive monitoring alone. They appear when measurement is linked to feedback, education, medication adjustment, professional review, or practical support. This pattern is visible across trials of home blood pressure monitoring, digital self-management programs, and disparity-focused interventions. In other words, the effective intervention is usually not the device by itself, but the care process built around it.

A second finding is that wearable technologies should not be discussed as one category. A smartwatch that counts steps, a wristband estimating blood pressure from optical signals, and a validated upper-arm cuff connected to an application have different levels of evidence and different safety implications. Activity wearables may encourage awareness and goal setting, but current evidence does not justify presenting them as independent antihypertensive treatment. Connected cuff-based systems are more defensible for treatment adjustment because they rely on established measurement methods. Cuffless blood pressure devices are promising, especially for reducing burden and capturing measurements during daily life, but they remain limited by calibration, validation, and algorithm transparency.

The third finding is organizational. Long-term adoption depends on trust, usability, digital literacy, affordability, and the presence of a clear response pathway. A wearable that increases the volume of data without clarifying responsibility can increase workload for both patients and clinicians. Conversely, a modest technology can be useful if it is easy to use, clinically interpretable, culturally acceptable, and connected to a person or protocol that can respond. This is why equity, privacy, and workflow should be treated as central clinical design issues rather than as secondary implementation details.

4.2. Implications for clinical practice and policy

Wearables should be recommended according to a defined clinical purpose. For a patient who wants to become more active, a step counter may support goal setting. For someone with poorly controlled hypertension, a validated home monitor linked to structured review is currently more defensible than an unvalidated cuffless estimate. A cuffless device may be useful in research or as an adjunct for observing trends, but its values should not be treated as interchangeable with guideline-based office, home, or ambulatory measurements without appropriate validation.

Before introducing a device, clinicians and patients should agree on five questions: What will be measured? How accurate does it need to be? What action follows an abnormal result? Who reviews transmitted data? What happens if the patient stops using the system? These questions turn technology selection into care planning. They also prevent the common situation in which data are collected continuously but no person or process is prepared to respond.

A practical pathway can start with risk and need rather than device preference. Patients with newly diagnosed or poorly controlled hypertension may first need a validated home blood pressure monitor, education on measurement technique, and a simple plan for sending readings to the clinical team. Patients who are trying to increase activity may benefit from a wearable step counter if goals are realistic and reviewed periodically. Patients interested in cuffless monitoring should be informed that convenience does not remove the need for validation and confirmation with accepted methods. In all cases, the pathway should preserve a non-digital alternative for people who cannot or do not wish to use connected devices.

Health services should evaluate wearable programs as complete interventions. Procurement decisions should consider validation, accessibility, training, technical support, interoperability, data governance, clinician workload, and the availability of an equivalent non-digital pathway. Reimbursement should recognize professional review and coaching rather than rewarding device distribution alone. Public or insurer-funded programs should avoid requiring the patient to supply expensive hardware, because that design can selectively exclude lower-income users.

Regulators should distinguish wellness claims from clinical measurement claims and require evidence that matches the consequence of use. A device intended to motivate activity does not require the same validation pathway as one used to diagnose hypertension or adjust medication. For blood pressure–estimating wearables, standards should address calibration stability, posture, exercise, sleep, skin characteristics, vascular disease, and algorithm updates. Publicly accessible lists of validated models would help clinicians and consumers make decisions (Sharman et al., 2020; Stergiou et al., 2023).

4.3. Research priorities

Future studies should move beyond short feasibility trials. Follow-up of at least 12 months is needed to distinguish sustained self-management from novelty effects, and longer observation is required for cardiovascular events, healthcare utilization, and cost-effectiveness. Trials should report device wear, application use, reasons for discontinuation, technical failures, and the proportion of participants who remain engaged after active support ends. Clinical outcomes should include standardized office or ambulatory blood pressure measured independently of the intervention device.

Comparative designs should separate the contribution of the wearable from feedback, coaching, medication management, and social support. Factorial or adaptive trials could identify which combination is necessary for which patient. Research should also compare low-intensity, scalable support with more resource-intensive professional review. The aim is not to prove that every user needs continuous coaching, but to determine the minimum effective support and the circumstances in which escalation is useful.

Equity should be built into recruitment, analysis, and design. Studies need adequate representation across age, socioeconomic position, race and ethnicity, skin tone, language, disability, rurality, and digital experience. Reporting average accuracy or engagement can conceal poor performance in a subgroup. Researchers should evaluate the cost borne by users, the availability of non-digital options, and whether an intervention reduces or increases the work of self-management.

Finally, the field needs a clearer outcome hierarchy. Technical accuracy, usability, engagement, blood pressure reduction, medication adherence, quality of life, and cardiovascular events are related but not interchangeable. A device can succeed at one level and fail at another. Explicitly mapping this chain would make claims more honest and comparisons more meaningful.

4.4. Strengths and limitations

This review brings together clinical trials, systematic reviews, validation statements, and qualitative implementation research rather than treating wearable technology as a single intervention. This is a strength because activity trackers, connected cuff-based systems, and cuffless blood pressure devices raise different questions of effectiveness, safety, and responsibility. The review also separates patient engagement from simple device use, which is important for interpreting long-term self-management.

Several limitations should be acknowledged. The article is a structured narrative review rather than a new meta-analysis, and only English-language publications were included. The field is changing quickly, so commercial devices and algorithms may change faster than independent evaluations can be completed. Several newer studies are short-term or implementation-specific, and evidence remains limited for cardiovascular events, health-care utilization, cost-effectiveness, and durability beyond the first year of use.

5. Conclusions

Wearable devices can support hypertension self-management, but their value does not reside in continuous data collection alone. The most persuasive evidence comes from systems that combine reliable measurement with tailored feedback, education, professional review, or treatment adjustment. Such programs can achieve modest reductions in systolic blood pressure and may improve adherence, self-efficacy, and access. In contrast, activity tracking or self-monitoring without a response pathway produces inconsistent benefit.

Cuffless blood pressure wearables remain promising but clinically unsettled. Convenience and the possibility of measurements during daily life must be weighed against calibration, validation, position, algorithm, and regulatory problems. Until these issues are resolved for a specific device and intended use, cuffless values should complement rather than replace established measurement methods.

Long-term adoption is ultimately a human and organizational problem as much as a technical one. Usability, trust, relevance, social support, affordability, and clinical integration determine whether the device remains useful after initial enthusiasm fades. Programs that ignore digital literacy or require patients to assemble multiple disconnected tools may deepen inequity and treatment burden. Wearables should therefore be implemented as optional, validated, low-burden components of person-centered care, with clear responsibility for translating data into action.

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