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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии
საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

INNOVATIVE APPROACHES TO THE DIAGNOSIS AND TREATMENT OF HYPERTENSION: USE OF TECHNOLOGY AND PROSPECTS

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Abstract.

Introduction: Research in hypertension management highlights a significant gap in the effectiveness, accessibility, and patient-centricity of existing approaches. This study aims to examine the effectiveness of digital health, telemedicine, wearable devices, and hybrid approaches in hypertension management, addressing short-term and long-term outcomes and identifying implementation challenges.

Methods: This study retrieved data from studies indexed in the Scopus, WoS, PubMed, and IEEE Xplore databases, "published between 2020 and 2025." The search keywords included "hypertension diagnosis," "therapy technologies," namely "artificial intelligence" (AI), "telemedicine," and "wearables." Bias assessments followed the Cochrane Collaboration, STROBE, and NOS with high inter-observer reliability.

Results: This study included studies spanning multiple countries and revealed that digital health interventions, such as remote monitoring of blood pressure and artificial intelligence-supported apps, show significant short-term blood pressure reductions and improved patient adherence. Telemedicine and wearable technologies demonstrated positive outcomes in blood pressure control and patient engagement. Hybrid approaches, including artificial intelligence-driven decision support, exhibited promising potential but had limited impact on visit attendance. Long-term effects were mixed, with digital health solutions like the iHEC-APP showing early signs of sustained blood pressure improvements but requiring further evaluation.

Conclusion: Hypertension interventions show promise, but long-term efficacy, scalability, gender-sensitive approaches, and patient engagement remain key challenges, necessitating further research and development.

Key words. Medical technologies, telemedicine, digital diagnostics, therapeutic strategies for hypertension, mobile health applications, artificial intelligence.

Introduction.

A significant worldwide health issue, hypertension, also known as high blood pressure, is thought to impact 1.28 billion persons between the ages of 30 and 79, with two-thirds of them residing in low- and middle-income nations [1]. Cardiovascular disorders continue to be the world's top cause of mortality and have a significant role in both health loss and rising health system expenses [2]. Hypertension is an essential risk factor for cardiovascular diseases and was estimated to affect nearly 48% of adults in the United States [3].

Men are 50.8% more vulnerable than women to have hypertension, a significant risk factor for cardiovascular illnesses, which affects 47.7% of American adults. The prevalence increases with age: 23.4% among those aged 18 to 39, 52.5% among those aged 40 to 59, and 71.6% among those aged 60 and above. Only 54% of adults with hypertension worldwide are aware that they have the condition, 42% are receiving treatment, and just 21% are keeping their blood pressure under control, according to the WHO [4]. Regional variations in hypertension prevalence show the lowest rate in men in South Asia, 26.4%, and the highest in Eastern Europe and Central Asia, 39.0%. For women, the lowest prevalence is in high-income countries, 25.3% and the highest in Sub-Saharan Africa, 36.3% [5]. According to recent research, hypertension is becoming more prevalent worldwide, particularly in low- and middle-income countries, where it remains a major cause of morbidity and mortality. By 2040, the prevalence is projected to increase to 28.4% in males and 30.1% in females, driven by ageing populations and lifestyle factors [6].

However, there are key challenges in the diagnosis and management of hypertension that are a matter of concern. Many patients with hypertension remain undiagnosed or inadequately treated, resulting in poor blood pressure control [7]. Ensuring that patients adhere to the treatment schedule has always been a challenge for longer-term blood pressure control. Standard blood pressure measurements obtained in the office are often affected by masked hypertension, resulting in unintended misdiagnosis and poor treatment [8,9].

Despite the pivotal role of hypertension management in preventing cardiovascular disease and mortality, the current state of evidence-based hypertension management is characterized by massive ineffectiveness, lack of access, and patient mistrust. These challenges are emerging with the integration of digital technologies, which is a promise that has been built for its solutions [10]. Conventional strategies to manage hypertension often do not offer continuous monitoring, which can result in inadequate blood pressure control. Digital health solutions, such as wearables and mobile apps, can help in this regard, especially in providing real-time data and enabling tailored care [11,12]. Digital interventions may also increase treatment adherence by enabling more interactive communication between the patient and healthcare provider. Connected devices can also notify clinicians when a patient experiences a change in status, prompting an earlier clinical response to adjust the treatment plan accordingly [13].

It is an evolving discipline that uses Information and Communication Technology (ICT) to improve the management of hypertension. This involves telehealth, wearables and mobile health apps enabling patients to monitor their health [14]. Digital platforms not only assist in medication management but also provide tools for lifestyle changes and patient education. Previous research suggests that patients receiving digitally-enabled management have superior blood pressure control in comparison to control patients receiving usual care [15]. No immediate investment cost is suggested for the implementation of digital solutions. In the long term, investments are most likely to be cost-saving due to improvements in cardiovascular health and decreases in the incidence and complications of hypertension-related diseases [16,17].

Hypertension management will be based on patient individualization supported by the use of technologies. That includes using AI to make treatment effectiveness more effective through data analysis and predictive modelling [18]. Despite their limited use in primary care, emerging evidence suggests digital interventions related to health can effectively improve blood pressure in populations with health disparities, implying their role in equity regarding healthcare accessibility and outcomes. Therefore, addressing the current research issues in hypertension management through the use of digital technologies remains a priority in clinical practice and research.

Purpose of the Study.

To assess and compare relevant innovations in the management of hypertension, primarily related to digital health technology, telemedicine, wearable devices, and hybrid approaches, to evaluate the short-term and long-term effectiveness of these interventions on blood pressure control, patient engagement, and overall health outcomes. Through analysis of existing challenges, the study aims to uncover obstacles to the implementation and scaling of these interventions in diverse populations.

Research Question.

1. How effective are digital health technologies, telemedicine, wearable devices, and hybrid approaches in managing hypertension in the short and long term?
2. What demographic factors influence the success of hypertension management interventions?
3. What are the current challenges faced in implementing and scaling these interventions across different populations?

Materials and Methods.

Study design: A systematic review from 2020 to 2025.

Search strategy:

PRISMA flow diagram shows the search strategy in Figure 1 for the systematic review. The identification phase involved searching four databases: Scopus 2,880, WoS 774, PubMed 19,554, and IEEE Xplore 1,758. These records were retrieved based on keywords ("Hypertension diagnosis technology" OR "Hypertension treatment innovation" OR ("Artificial intelligence" AND "hypertension management")

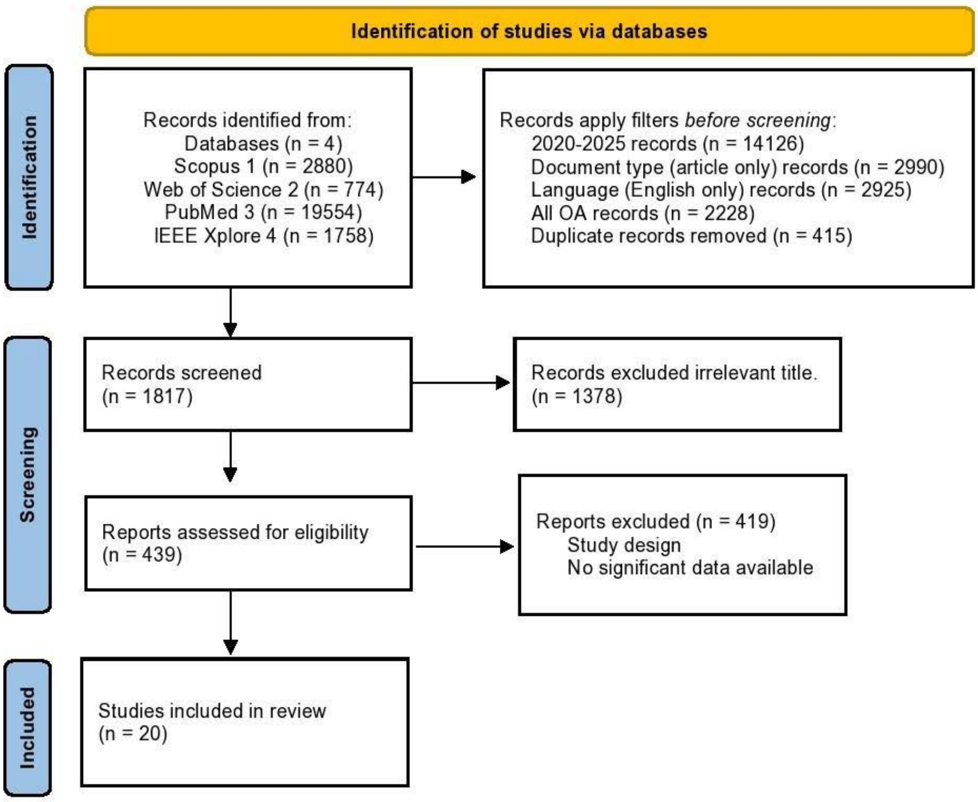

Figure 1. *PRISMA Flow Diagram.*

OR ("Telemedicine" AND "hypertension") OR ("Wearable devices" AND "blood pressure monitoring") OR ("Personalized medicine" AND "hypertension therapy")). After applying the initial filters, 14,126 records from 2020 to 2025 were retained. The search was further narrowed to 2,990 journal articles, with only English-language records considered, resulting in 2,925 articles. Additionally, 415 duplicate records were removed. In the screening phase, 439 unique studies were evaluated for eligibility. Thus, from the 2,221 identified studies, 419 were excluded for the following reasons: insufficient study design or lack of significant data related to the review. As a result, 20 studies [19-38] were considered suitable and incorporated into the final review.

Inclusion Criteria:

This review includes studies published from 2020 to 2025, employing innovative technologies for hypertension diagnosis and treatment via artificial intelligence, telemedicine, wearable devices, and personalized medicine. Studies published in both open-access and non-open-access journals are included. Only peer-reviewed journal articles containing substantial information pertinent to hypertension management and technological interventions are considered. The eligible studies must be original research articles, systematic reviews, or clinical trials using valid and reproducible data.

Exclusion Criteria:

The exclusion criteria for this review include studies published before 2020, non-English language articles, and duplicate records. Studies unrelated to hypertension diagnosis or management, or those that do not focus on technological approaches (such as AI, telemedicine, or wearable devices), are excluded. Studies with poor or invalid data, or those lacking a relevant study design, are also excluded. Additionally, non-peer-reviewed articles, including opinion pieces, conference abstracts, and editorials, as well as studies not specifically focused on hypertension management, are excluded.

Data Extraction:

Extraction of data was performed in a systematic manner by two independent observers in order to ensure accuracy and reduce bias. The two observers Dr. Umar Ghafoor and Dr. Muhammad Usman screened the studies by title, abstract, and keywords to determine their relevance to inclusion/exclusion criteria. Using the final list of eligible articles, each observer independently extracted relevant data from the articles retained. This data consisted of both study design and sample size, used technologies and outcomes of hypertension diagnosis and treatment. The Kappa value was calculated to evaluate inter-observer reliability, which quantifies the agreement between two observers. A Kappa value of more than 0.80 was considered strong agreement, and <0.60 indicated moderate agreement. Differences between the readers were discussed, and in cases of uncertainty, the study was reviewed again until a consensus was reached. This approach captured all relevant data without bias and handled data interpretation inconsistencies in a timely manner.

Risk of Bias Assessment:

Assessments of risk of bias were undertaken using the Cochrane Risk of Bias (RoB) tool for Randomized Controlled Trials (RCTs) and had low RoB in multiple domains. Individual and overall RoB were summarized using Figures 2A and 2B, respectively. For non-randomized controlled trial studies (e.g., cross-sectional and cohort studies), the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and Newcastle-Ottawa Scale (NOS) were applied, as shown in Table 1. The risk of bias assessment was low in all studies, with careful attention given to sampling, data collection, confounding and reporting.

Ethical Considerations.

This study used secondary published data. So, there is no ethical concern. However, all included studies adhered to ethical standards as evidenced by institutional review board approvals and informed consent from participants.

Results.

Table 2 summarizes the included studies, showcasing diverse study designs, countries, and demographics. The studies span multiple regions, including China, the United States, Sweden, Ethiopia, Jordan, Thailand, Singapore, Nepal, Iran, and India. The sample sizes range from 120 to 178,562 participants, aged 18 to 85 years. Gender distribution varies, with studies typically including both males and females, with some showing a higher percentage of one gender, such as 77.6% female in Maimaitiaili et al. (2022) [32] and 98.1% male in Aubert et al. (2021) [37].

Figure 3 illustrates the distribution of study designs included in the research. Randomized Controlled Trials (RCTs) constitute the largest proportion at 50%, followed by Cross-sectional studies at 25%. Observational studies account for 15%, while Cohort studies represent the smallest share at 10%. This depiction underscores the methodological diversity across the selected studies.

This chart highlights the various approaches used in the research.

Figure 4 illustrates the gender distribution across various studies. The percentage of male and female participants varies widely among the studies. For instance, some studies, like the one from 2023, show a significant gender imbalance with 99.4% male participants, while others, such as a 2022 study, have a higher proportion of female participants (77.6%). The table highlights the diversity in gender representation across the included studies, showing the varying balance between male and female participants.

Table 3 summarizes the short-term efficacy of various interventions in hypertension management. Digital health interventions, including remote blood pressure monitoring, mHealth apps, and AI-supported systems, showed significant blood pressure reductions and improved patient adherence. Telemedicine and wearable tech also demonstrated improvements in blood pressure control and patient engagement. Hybrid approaches, such as Artificial Intelligence-driven (AI-driven) decision support and machine learning models, showed promising potential for enhancing hypertension management, while some interventions, like WhatsApp reminders, had minimal impact.

Table 4 presents the long-term effectiveness of various interventions in hypertension management. Digital health

Table 1. *Risk of bias assessment for other studies study design.*

Studies	Study Design	Risk of Bias Tool	Assessment Criteria	Risk of Bias
Sagaro et al., 2023 [21]	Cross-sectional	STROBE Checklist	Sampling, Data collection, Bias, Confounding factors, Reporting	Low
Chen et al., 2023 [22]	Cross-sectional	STROBE Checklist	Sampling, Data collection, Bias, Confounding factors, Reporting	Low
Rojanasumapong et al., 2021 [27]	Cross-sectional	STROBE Checklist	Sampling, Data collection, Bias, Confounding factors, Reporting	Low
Ni et al,. 2020 [31]	Cross-sectional	STROBE Checklist	Sampling, Data collection, Bias, Confounding factors, Reporting	Low
Eze et al., 2024 [33]	Cross-sectional	STROBE Checklist	Sampling, Data collection, Bias, Confounding factors, Reporting	Low
Persell et al., 2022 [24]	Cohort	Newcastle-Ottawa Scale (NOS)	Selection, Comparability, Outcome assessment	Low
Agnihothri et al., 2021 [26]	Cohort	Newcastle-Ottawa Scale (NOS)	Selection, Comparability, Outcome assessment	Low
Davoudi et al., 2020 [30]	Observational	ROBINS-I	Confounding, Selection bias, Measurement bias, Outcome assessment	Low
Chen et al., 2022 [36]	Observational	ROBINS-I	Confounding, Selection bias, Measurement bias, Outcome assessment	Low
Aubert et al., 2021 [37]	Observational	ROBINS-I	Confounding; Selection bias; Measurement bias; Outcome assessment	Low

Table 2. *Demographic and Study Design Summary of Included Studies on Hypertension Diagnosis and Treatment.*

Studies	Country	Study Design	Sample Size	Age year	Gender
Jiang et al., 2024 [19]	China	RCT	540	71.4 ± 3.7	38.3% female
Hermansson-Borrebaeck et al., 2025 [20]	Sweden	RCT	862	62.7	42.20% female
Sagaro et al., 2023 [21]	Ethiopia	Cross-sectional	4318	37.95 ± 10.32	99.40% male
Chen et al., 2023 [22]	USA	Cross-sectional	4,893	61 ± 13	53% female
Alsaqer et al., 2022 [23]	Jordan	RCT	120	60.37	56.4% male
Persell et al., 2022 [24]	USA	Cohort	2,451	65-85	65.4% female
Wang et al., 2021 [25]	China	RCT	402	18-80	-
Agnihothri et al., 2021 [26]	USA	Cohort	1,633	61.2 ± 15.4	46% male
Rojanasumapong et al., 2021 [27]	Thailand	Cross-sectional	110	67 ± 5.23	57.3% female
Prendergast et al., 2021 [28]	USA	RCT	770	18-75	-
Bilger et al., 2021 [29]	Singapore	RCT	224	21-70	-
Davoudi et al., 2020 [30]	USA	Observational	201	18-75	70.6% female
Ni et al., 2020 [31]	Nepal	Cross-sectional	1113	56.3 ± 13.3	50% male
Maimaitiaili et al., 2022 [32]	China	RCT	358	43.9	77.6% female
Eze et al., 2024 [33]	USA	Cross-sectional	507	60 ± 14.7	60.4% female
Andersson et al., 2023 [34]	Sweden	RCT	949	62.9	42.9% female
Bozorgi et al., 2021 [35]	Iran	RCT	120	30-60	56.9% male
Chen et al., 2022 [36]	China	Observational	420	29	Pregnant women
Aubert et al., 2021 [37]	USA	Observational	178,562	75.8 ± 7.5	98.1% male
Favaretti et al., 2024 [38]	India	RCT	388	48.7 ± 11.4	66.5% female. 33.5% male

Table 3. *Short-Term Effectiveness of Interventions in Hypertension Management.*

Intervention	Author's / Year	Sub-Type	Short-Term Efficacy
Digital Health	Jiang et al., 2024 [19]	Intelligent hypertension excellence centers (iHEC) with remote blood pressure monitoring and AI follow-ups	Blood pressure reduction Enhanced self-care Improved blood pressure control Better self-management Increased engagement Better adherence
	Alsaqer et al., 2022 [23]	4 Mobile health apps + Public health nursing intervention	
	Persell et al., 2022 [24]	Remote patient monitoring RPM with digital tracking and physician alerts	
	Prendergast et al., 2021 [28]	Educational & Empowerment (E2) + Mobile blood pressure self-monitoring	
	Davoudi et al., 2020 [30]	Automated remote blood pressure monitoring via text	
	Eze et al., 2024 [33]	Remote blood pressure monitoring, mHealth, Electronic Health Record (EHR)	
	Andersson et al., 2023 [34]	Web-based self-management with blood pressure monitoring	
	Bozorgi et al., 2021 [35]	Mobile blood pressure Management App	
Telemedicine	Sagaro et al., 2023 [21]	Telemedicine-based hypertension risk prediction	Early identification and early intervention Better patient-provider interaction
	Chen et al., 2023 [22]	mHealth technology for decision-making and health tracking	
	Maimaitiaili et al., 2022 [32]	Single-pill-combination (SPC-based) telemedicine titration therapy + blood pressure monitoring	
Wearable & Mobile Tech	Hermansson-Borrebaeck et al., 2025 [20]	Electronic Health (e-Health) self-management system with daily blood pressure monitoring	Improved self-efficacy, Increased hypertension detection
	Agnihothri et al., 2021 [26]	mHealth app for blood pressure monitoring with Electronic Medical Record (EMR) integration	
	Ni et al., 2020 [31]	Volunteer-led mHealth screening and education	
Pharmaceutical Approach	Aubert et al., 2021 [37]	Antihypertensive Treatment Intensification – Adding a New Medication vs. Maximizing Dose	Blood pressure reduction but lower treatment adherence
Hybrid (Mixed Approaches)	Wang et al., 2021 [25]	Telehealth system with AI-driven decision support	Blood pressure control, adherence, and lifestyle changes High accuracy in predictive model no effect on visit attendance
	Rojanasumapong et al., 2021 [27]	eHealth-based integrated care model with AI decision support	
	Chen et al., 2022 [36]	Electronic health literacy in hypertension management	
	Favaretti et al., 2024 [38]	Machine-learning-based risk prediction	

Table 4. *Long-Term Effectiveness of Interventions in Hypertension Management.*

Intervention Type	Author's / Year	Long-Term Effectiveness
Digital Health	Jiang et al., 2024 [19]	Blood Pressure Control Improvement in Older Adults**:** Ongoing evaluation is needed to determine the sustainability of blood pressure control over an extended period. Evaluation in Progress: Early trends show that blood pressure improvements may be sustained, but these findings depend on enhanced digital access for broader reach; No Significant Difference at 12 Months: No notable difference in blood pressure control at 12 months, indicating the need for further validation beyond the 6-month mark;
	Alsaqer et al., 2022 [23]	
	Persell et al., 2022 [24]	
	Rojanasumapong et al., 2021 [27]	
	Andersson et al., 2023 [34]	
	Bozorgi et al., 2021 [35]	
Telemedicine	Sagaro et al., 2023 [21]	Improve hypertension screening and prevention among seafarers; Potential to improve hypertension control rates among racial/ethnic minorities needs further evaluation for sustained blood pressure control and racial disparities;
	Chen et al., 2023 [22]	
	Prendergast et al., 2021 [28]	
	Maimaitiaili et al., 2022 [32]	
Wearable & Mobile Tech	Hermansson-Borrebaeck et al., 2025 [20]	No significant long-term impact on blood pressure control; Blood pressure control sustained over 2+ years, improved self-monitoring adherence potential for integrating mobile health (mHealth) for hypertension management
	Agnihothri et al., 2021 [26]	
	Ni et al., 2020 [31]	
Pharmaceutical Approach	Aubert et al., 2021 [37]	-
Hybrid (Mixed Approaches	Wang et al., 2021 [25]	Potential to improve hypertension control and patient adherence with increased RBPM awareness; No evidence of sustained behavior change.
	Eze et al., 2024 [33]	
	Chen et al., 2022 [36]	
	Favaretti et al., 2024 [38]	

__Table 5.__ Current Challenges in Hypertension Management Interventions.

Intervention	Author's / Year	Current Challenges
Digital Health	Jiang et al., 2024 [19]	High device cost; Limited digital literacy in older patients; Potential regulatory hurdles; No direct blood pressure control effect; Gender differences in self-efficacy impact; Multiple apps required; Limited adoption by primary care physicians; Electronic health literacy (eHL); digital divide; preference for traditional media; lack of reliable language online health resources; lack of long-term adherence; scalability concerns.
	Hermansson-Borrebaeck et al., 2025 [20]	
	Alsaqer et al., 2022 [23]	
	Persell et al., 2022 [24]	
	Rojanasumapong et al., 2021 [27]	
	Andersson et al., 2023 [34]	
	Bozorgi et al., 2021 [35]	
Elemedicine	Sagaro et al., 2023 [21]	Self-Reported Hypertension May Underestimate Prevalence; Lack of Direct Blood Pressure Measurements; Occupational Stress; Long Working Hours; Digital Divide; Lack of Access to mHealth Tools Among Certain Racial Groups; Intervention Scalability; Participant Retention.
	Chen et al., 2023 [22]	
	Prendergast et al., 2021 [28]	
	Maimaitiaili et al., 2022 [32]	
Wearable & Mobile Tech	Agnihothri et al., 2021 [26]	Patient self-selection bias; digital literacy barriers; adoption hesitancy among providers; Limited impact in high-engagement users; lack of individualized intervention adjustments; Limited formal education; rural accessibility issues; Low awareness; lack of provider recommendation; preference for in-person visits.
	Davoudi et al., 2020 [30]	
	Ni et al., 2020 [31]	
	Eze et al., 2024 [33]	
Pharmaceutical Approach	Aubert et al., 2021 [37]	Adding a new antihypertensive medication was associated with more frequent discontinuation, lower sustainability of treatment, and slightly larger reductions in SBP. Observational bias and the predominantly male population may limit generalizability.
Hybrid (Mixed Approaches)	Wang et al., 2021 [25]	Digital literacy barriers; Implementation feasibility in different regions; Regulatory approval needed; Limited generalizability; Integration into clinical workflows; Limited engagement with intervention; Digital accessibility issues.
	Chen et al., 2022[36]	
	Favaretti et al., 2024 [38]	

Notes: *Challenges for each intervention include high costs, digital literacy barriers, scalability issues, adoption hesitancy, lack of direct measurements, treatment discontinuation, and integration difficulties.*

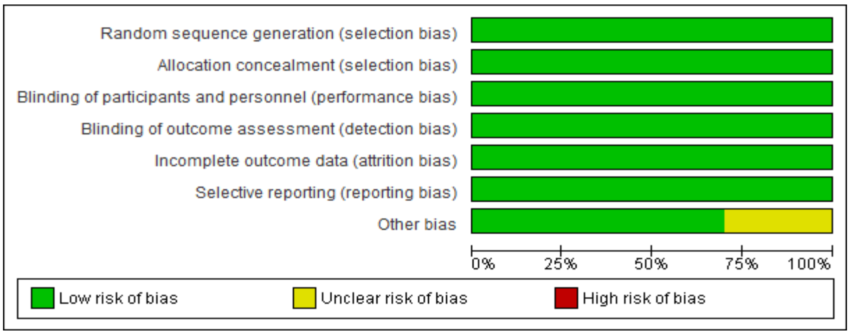

Figure 2A. *Risk of bias assessment of RCT studies.*

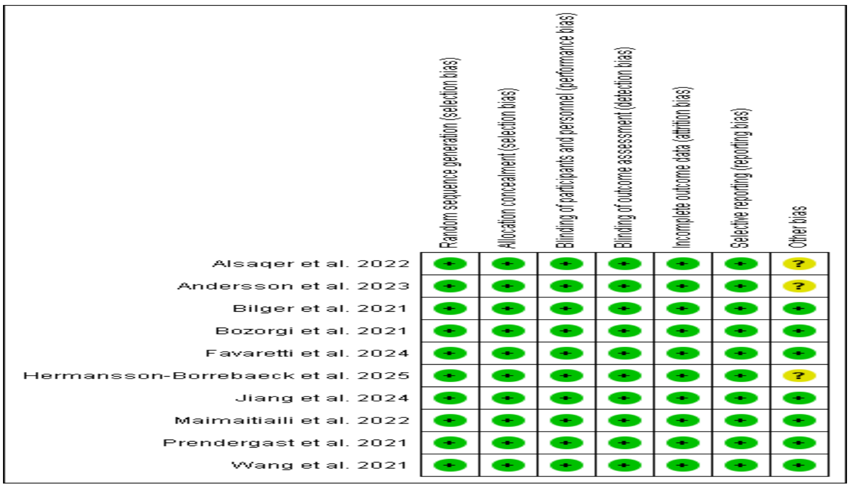

Figure 2B. *Risk of bias summary of RCT studies.*

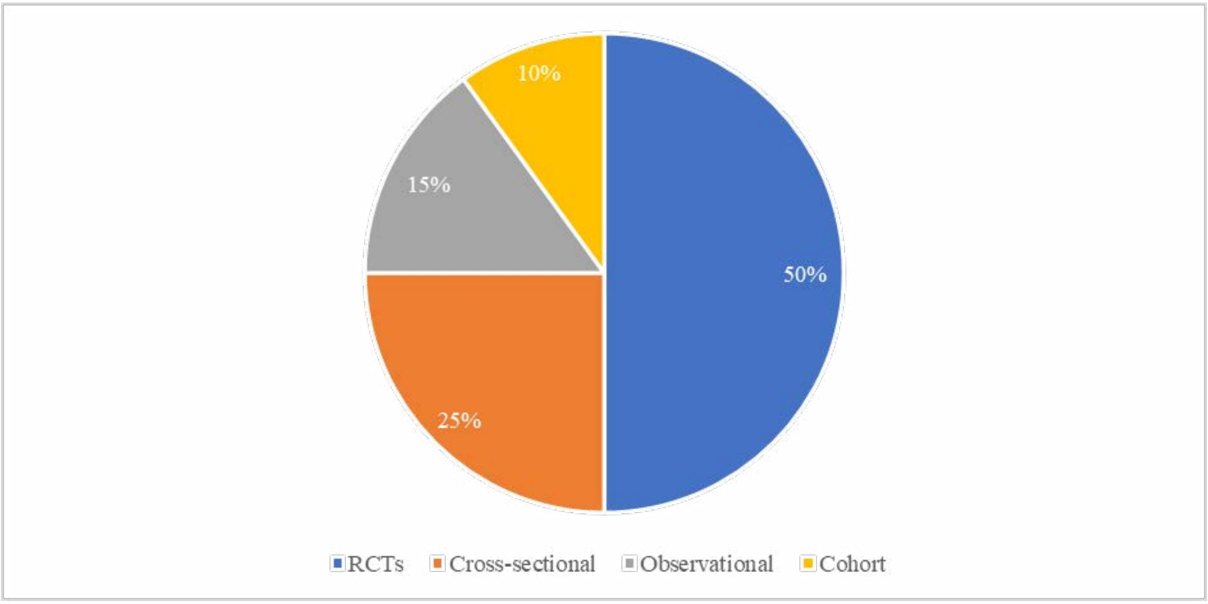

Figure 3. *Distribution of research methodologies used in the included studies.*

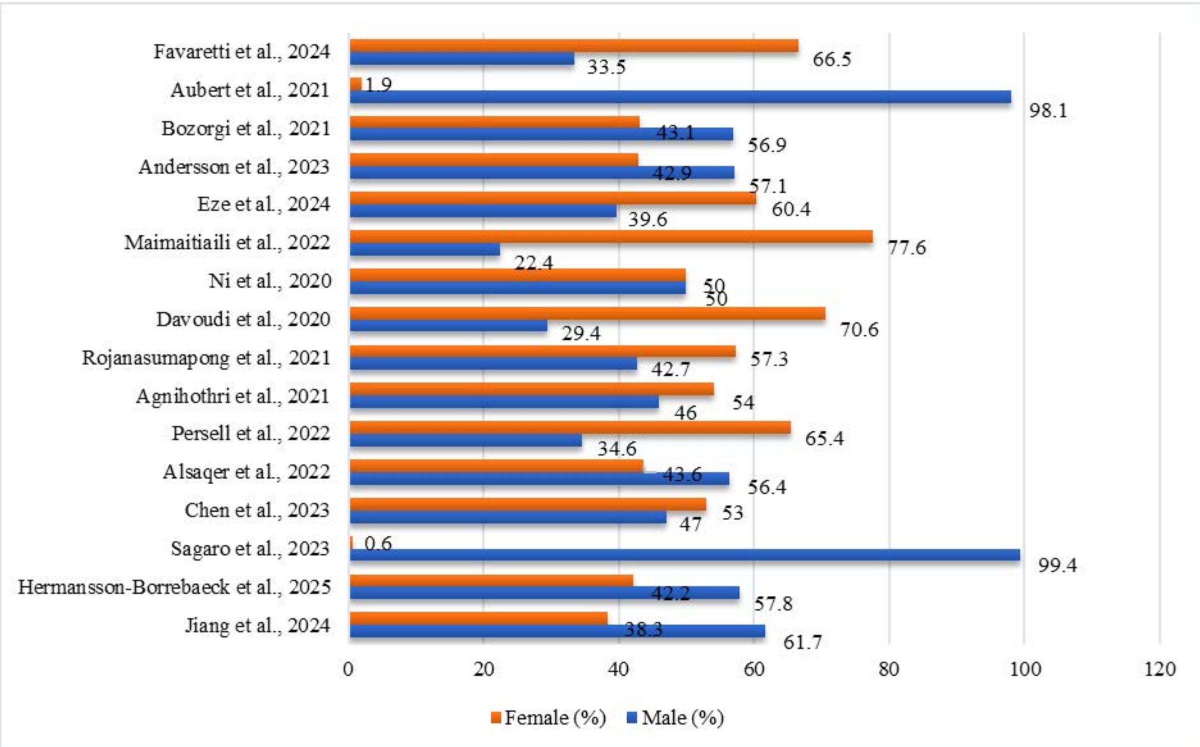

Figure 4. *Gender distribution of participants in the included studies.*

interventions, like iHEC-APP, show early trends of sustained blood pressure improvement but require further evaluation. Telemedicine, such as a study, shows potential for improving hypertension control among African American, Hispanic/Latino, and Native American populations but needs more research for sustained results. Wearable and mobile tech interventions, like those in another study, demonstrate sustained blood pressure control over two years with improved adherence.

Hybrid approaches show the potential to improve hypertension control and patient adherence by increasing awareness of RBPM, but there is no evidence of sustained behaviour change. Hybrid approaches have shown potential, but evidence for sustained behaviour change is limited.

Table 5 outlines the current challenges faced by various hypertension management interventions. Key issues include high device costs, digital literacy barriers, and limited clinical validation, especially for digital health solutions like iHEC-APP and mHealth apps. Telemedicine interventions face obstacles such as self-reported hypertension underestimation and the digital divide. Wearable tech struggles with adoption hesitancy and limited engagement. Hybrid approaches show the potential to improve hypertension control and patient adherence by increasing awareness of remote blood pressure monitoring, but there is no evidence of sustained behaviour change. Additionally, hybrid approaches require regulatory approval, real-world validation, and integration challenges, while some interventions show low participant retention and scalability concerns.

Discussion.

The studies analyzed in the current systematic review span multiple countries, including China, the USA, Sweden, and Ethiopia, and cover multiple study designs. The sample sizes range from 120 to 178,562 participants, with a broad age range from 18 to 85 years. Gender distribution varied, with some studies showing a higher percentage of one gender. These variations provide diverse insights into hypertension diagnosis and treatment across different populations. The international nature of these studies emphasizes the need for universally adaptable solutions, as cultural, socioeconomic, and healthcare system differences may impact the effectiveness of interventions. A study highlights the role of technologies like smartphones and Bluetooth-enabled telemonitoring in improving hypertension detection and management, offering continuous monitoring and real-time data, especially beneficial for elderly and pregnant populations [39,40]. Furthermore, the integration of telehealth systems in low-resource settings shows promising potential for overcoming barriers like distance and limited access to care. Advancements in diagnostic techniques, such as machine learning, genomic sequencing, and nanotechnology, improve early detection and personalized management of hypertension-related brain disorders, including through deep learning algorithms [41,42]. However, the widespread application of these techniques remains a challenge, especially in regions with limited infrastructure and expertise. Further, the wide range of study designs used in these analyses allows for broad insights into the diagnosis and treatment of hypertension. RCTs provide high-quality evidence generated through experimental conditions, and observational studies help define risk factors and outcomes in cohort studies. Cross-sectional studies give a snapshot of disease prevalence, and cohort studies offer an ideal framework for examining the evolution of such diseases [43].

Digital health interventions (e.g., remote blood pressure monitoring and mHealth apps) were associated with marked reductions in blood pressure as well as improved patient engagement and adherence. Interventions using telemedicine also resulted in better patient-provider interactions and earlier detection of risk for hypertension. Participants benefitted from increased hypertension detection, diagnosis, and self-efficacy stemming from the wearables. These interventions also demonstrated a potential to improve health literacy and empower patients by providing immediate access to health data and feedback. Various details in types of hybrid models, for example, AI-driven decision support, demonstrated potential regarding blood pressure control and adherence, but their influence on visit attendance was seen as scarce, emphasizing the necessity to explore the potential of these strategies further. In support of this, another study concluded that digital therapeutics interventions also significantly lowered blood pressure and improved lifestyle-related metrics as compared to usual care. This supports digital interventions as a key strategy for hypertension management [44]. The scalability of these interventions, particularly in low- and middle-income countries, remains a key consideration for their widespread implementation. In a study, digital health interventions were effective in reducing systolic blood pressure and blood pressure control in adult patients with hypertension in low- and middle-income countries. This demonstrates the global nature of the applicability of digital health solutions [45]. Furthermore, studies of telemedicine and home blood pressure monitoring indicate that these technologies can increase blood pressure control via the ability to personalize treatment and intensify adherence to therapy [46]. Research evaluating the use of mobile health technologies has consistently demonstrated they support long-term hypertension management by providing reminders, collecting biometric data, and enabling social support [47].

Digital health interventions, such as iHEC-APP, at best demonstrate early trends in sustained blood pressure improvement, but further evaluation is needed to attain durable effects. Thus, while there is the potential for telemedicine interventions to improve hypertension control in minority populations, literature requires further study to determine the long-term effects of these interventions. Wearable tech, e-Health self-management system, maintained blood pressure control for 2 years and improved of adherence. Despite the promise of hybrid approaches, a widespread understanding of long-term changes in behaviour post-intervention means they still struggle to prove sustainability and generate sufficient evidence of long-term effectiveness. In the same way, another systematic review reported consistently that digital health interventions, including digital therapeutics (DTx) are effective in lowering both systolic and diastolic blood pressure relative to usual care and revealed a significant decrease in systolic and diastolic blood pressure with digital therapeutics (DTx) interventions [46]. A meta-analysis showed that digital therapeutics significantly reduced blood pressure compared to the control group while also improving BMI, physical activity, waist circumference, waist/hip ratio, and other risk factors [48,49]. Research suggests smartphone applications are effective for hypertension management, improving blood pressure control, medication adherence, and health knowledge. With rapid technological advancements, digital health's role in hypertension care is crucial for future research [50]. Furthermore, a systematic review supports the use of digital health interventions in minority ethnic populations, addressing factors like beliefs, education, culture, and healthcare systems. Mobile and web-based interventions have proven effective in lowering blood pressure and improving health behaviours in LMICs [51], despite the need for further studies to overcome intervention heterogeneity and geographical variations. While promising, hybrid models are less successful in demonstrating sustained behaviour change and will require more evidence of long-term effectiveness. It is also encouraging, particularly in minority populations, but more studies are required to demonstrate long-term benefits [52,53]. In particular, there is a growing need for research into the specific contextual factors that affect the uptake and effectiveness of these interventions across diverse demographic groups. Factors such as cultural, socioeconomic, technological literacy, access to devices, health literacy, and healthcare system infrastructure play a critical role in determining the success of digital health interventions. Understanding the barriers to widespread adoption, such as cultural and socioeconomic factors, is essential for improving the scalability of digital health solutions. In conclusion, although early data suggest that digital health interventions hold promise for hypertension management, more long-term evidence is needed to establish their effectiveness in a variety of populations and delivery mechanisms. Moreover, it is critical to explore how personalized treatment plans tailored to individual needs can enhance the impact of digital interventions. A deeper understanding of patient preferences and behaviours is essential for optimizing these technologies for better outcomes.

Some critical challenges common across interventions are the high costs of devices, limited digital literacy and challenges with scale. Hence, hi-tech health solutions like iHEC-APP and mHealth apps experience issues of regulatory make-believe, lack of lifecycle validation, lack of an acceptable experimental model and poor implementation. Additionally, despite the growing popularity of wearables, there remains resistance among certain populations to fully embrace these technologies. Factors such as privacy concerns, perceived complexity, and scepticism about their effectiveness contribute to this hesitance. Self-reported hypertension underestimations have escalated with telemedicine interventions among races. Consumers hesitate to adopt wearable tech, and so do healthcare providers. Hybrid models involve regulatory approval and real-world validation, and maintaining engagement and retention among participants is still a challenge in some interventions that have not seen widespread success. Despite promising benefits, digital health innovation raises ethical concerns, including privacy risks and biases that may exacerbate health inequalities. Addressing these requires stakeholder commitment to reframe innovation, regulation, and co-creation in development [54]. They highlighted the lower prevalence of treated hypertension despite the better control of blood pressure owing to the advancements in antihypertensive drugs, emphasizing improvements in the management of blood pressure [55]. Another study also highlights that worldwide, the approach highlights lifestyle interventions, pharmacotherapy, and device interventions, yet progress is hindered by poor adherence and therapeutic inertia [56]. This is particularly evident in low-resource settings, where access to healthcare infrastructure and trained professionals is limited. Strengthening healthcare systems is essential for ensuring the effectiveness of digital health interventions on a broader scale. Another study highlights clear, comprehensive policies that address data protection, clinical, ethical, legal, and operational aspects, which should be established and must provide a structured framework for the adoption and effective use of digital health solutions.

Conclusion.

In summary, this study highlights the diverse interventions and challenges in hypertension management, focusing on digital health, telemedicine, wearable technologies, and hybrid approaches. According to the study, digital health solutions, including remote blood pressure monitoring and AI-enabled systems, demonstrate promising short-term effectiveness in lowering blood pressure and improving patients' engagement. Yet these interventions need further appraisal to prove their long-term worth, particularly in older people and groups with poor digital connectivity. Similar telemedicine interventions show promise in increasing hypertension screening and control rates, especially in minority populations; however, limitations such as underreporting and the digital divide are barriers to implementation. Smart wearable & mobile technologies (e-Health self-management systems) presented sustained blood pressure control for long periods and better adherence, but with unclear long-term effects.

Hybrid models combining digital health and AI-driven decision support promise to improve blood pressure control and adherence but require more evidence regarding their long-term efficacy and scalability. An important observation in this review is the notable variation in gender representation across the studies. This highlights the importance of considering gender differences in hypertension care, as men and women may experience varying prevalence rates, treatment responses, and engagement with interventions. Specifically, the rise in hypertension risk among women post-menopause emphasizes the need for tailored approaches. Future research should focus on achieving a more balanced gender representation to better understand these differences and refine treatment strategies accordingly. The study also identifies several common challenges, including high device costs, digital literacy barriers, limited clinical validation, and the need for regulatory approval. These challenges hinder the widespread adoption and effectiveness of these interventions.

Practical Recommendations.

Further healthcare research is needed to overcome these challenges, particularly long-term assessments, clinical workflow integration, and access for marginalized groups. More research is needed on the applicability of therapeutic health systems, especially in resource-poor countries that face infrastructural barriers. These studies require special focus to enable older adults and those with low internet usage to participate. Moreover, there is a gap in how hybrid models of AI and digital health intervention are implemented in clinical practice in ways that maintain long-term effectiveness. Innovation is needed to address the digital illiteracy gap and to facilitate the uptake of the technologies by clinicians and patients to broaden their impact. Lastly, regulatory barriers, along with adequate clinical safety evaluation of the technologies, need to be tackled in order to use the technologies freely and confidently.

Limitations.

This study, while offering valuable insights, is not without limitations. The sample size was relatively small and limited to a specific cultural and geographical context, which may affect the generalizability of the findings. Data were based on self-reported experiences, which may carry biases such as selective memory or emotional filtering. Additionally, the cross-sectional design does not allow for causal interpretations.

Ethical Statement & Informed Consent.

This systematic literature review adhered to ethical guidelines. No primary data collection was involved, so informed consent from participants was not applicable. The review followed established ethical standards for data handling, ensuring confidentiality and respect for privacy. Ethical approval was not required as the study analyzed publicly available data from previous research.

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Conflicts of Interest.

The authors declare no conflicts of interest.

Data Availability.

The authors confirm that the data supporting the findings of this study are included within the article.

Abbreviations and Acronyms.

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology.
NOS: Newcastle-Ottawa Scale.
iHEC-APP: Intelligent Hypertension and Evidence-based Care Application.
WHO: World Health Organization.
ICT: Information and Communication Technology.
AI: Artificial Intelligence.
IEEE: Institute of Electrical and Electronics Engineers.
PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses.
RoB: Risk of Bias.
RCTs: Randomized Controlled Trials.
mHealth apps: mobile Health Applications.
EHR: Electronic Health Records.
RBPM: Remote Blood Pressure Monitoring.
eHL: Low eHealth literacy.
DTx: Digital Therapeutics.
BMI: Body Mass Index.
LMICs: Low- and Middle-Income Countries.

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