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DIGITAL HEALTH INTERVENTIONS TO PROMOTE LIFESTYLE CHANGES FOR SECONDARY STROKE PREVENTION: A SCOPING REVIEW

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ABSTRACT
Stroke survivors remain at risk of recurrent stroke, making sustained lifestyle modification and long-term risk-factor management essential components of secondary prevention. Digital health interventions have increasingly been developed to support lifestyle change and self-management among people with stroke or transient ischemic attack. This scoping review aimed to map the available evidence on digital health interventions designed to promote lifestyle changes for secondary stroke prevention. A scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). . Literature searches were conducted in Scopus, PubMed, and EBSCO using terms related to stroke, digital health, lifestyle modification, and secondary prevention. Search terms included, : ("stroke" OR "cerebrovascular accident" OR "brain ischemia") AND ("digital health" OR "mHealth" OR "telemedicine" OR "mobile applications" OR "smartphone" OR "wearable devices" OR "remote monitoring") AND ("lifestyle modification" OR "physical activity" OR "exercise" OR "dietary habits" OR "smoking cessation" OR "medication adherence") AND ("secondary prevention" OR "prevention of recurrence"). Studies published within the past six years and in English were considered. Records were managed using Mendeley Reference Manager, duplicates were removed, and titles and abstracts were screened before full-text assessment according to the eligibility criteria. Data were extracted on study characteristics, digital intervention modalities, lifestyle targets, outcome measures, and main findings. Of the 153 records identified, 49 duplicates were excluded, 35 full-text articles were evaluated, and 9 studies met the inclusion criteria. The interventions involved smartphone applications, telehealth, web-based education, mobile video conferencing, wearable devices, and multifunctional digital platforms targeting physical activity, diet, self-management, blood pressure control, medication adherence, and other cardiovascular risk factors. Overall, digital health interventions were feasible and generally acceptable and showed promising behavioral and clinical outcomes. This review contributes to the scientific evidence by mapping intervention approaches, targets, outcomes, and research gaps for future scalable secondary stroke prevention strategies.

Keywords: digital health; lifestyle changes; secondary prevention; stroke

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INTRODUCTION

Stroke is a leading cause of death and long-term disability worldwide and continues to impose a substantial burden on individuals, families, and healthcare systems. According to the World Health Organization (WHO), stroke was the third leading cause of death and disability worldwide in 2021, with approximately 11.9 million new cases reported globally. A substantial proportion of the global stroke burden is attributable to modifiable risk factors, including hypertension, smoking, high low-density lipoprotein cholesterol, unhealthy diet, physical inactivity, excess body weight, harmful alcohol use, and elevated blood glucose levels(Organization, 2024). Stroke survivors also remain at considerable risk of recurrent vascular events. Recurrent stroke has been reported in approximately 4% of survivors within 90 days and 26% within five years, while the risk following transient ischemic attack may reach 20% within 90 days(Bailey, 2018; Govori et al., 2024). These findings highlight the importance of secondary prevention after stroke.

Secondary stroke prevention requires more than pharmacological treatment. It includes lifestyle modification, such as increasing physical activity, maintaining a healthy diet and body weight, controlling blood pressure, cholesterol and blood glucose, and avoiding smoking and harmful alcohol consumption (Bailey, 2018; Govori et al., 2024). However, maintaining these behaviors can be difficult because stroke survivors may experience physical, cognitive, emotional, and social challenges. Motor impairment, cognitive difficulties, depression, reduced mobility, communication problems, limited transportation, and inadequate follow-up may reduce patients' ability to participate in long-term self-managemen(Hwang et al., 2021; Niyomyart et al., 2024).

Digital health has emerged as a potential approach to extend secondary prevention services beyond conventional face-to-face care. The World Health Organization defines digital health as the use of digital technologies to improve health and healthcare delivery(Organization, 2024). In stroke care, digital health may include mobile applications, telemedicine, web-based education, messaging systems, wearable devices, remote monitoring, clinician portals, and integrated digital platforms. These technologies can support health education, goal setting, lifestyle monitoring, medication reminders, rehabilitation, communication with healthcare professionals, and management of vascular risk factors(Organization, 2024; Silvera-tawil et al., 2024; Thompson et al., 2023).

Previous studies have demonstrated that digital technologies may support several aspects of post-stroke self-management and secon dary prevention. Telehealth interventions have shown potential to improve self-management among stroke survivors, while mobile technology-based interventions have addressed physical activity, risk-factor management, medication adherence, stroke education, and weight management(Hwang et al., 2021; Thompson et al., 2023). However, the available interventions vary in terms of technology, intervention components, duration, intensity, professional involvement, and targeted lifestyle behaviors. This heterogeneity makes it difficult to determine the overall scope of digital health interventions for secondary stroke prevention.

The implementation of digital health also requires consideration of accessibility, usability, acceptance, and the digital divide. Although many stroke survivors and caregivers have access to smartphones and the internet, digital access and confidence may differ according to age, functional status, socioeconomic conditions, and time since stroke(Clancy et al., 2022; Naqvi et al., 2021). Stroke survivors generally prefer digital systems that are simple, credible, intuitive, and easy to navigate(Bally et al., 2023). Therefore, interventions should be designed according to users' needs and capabilities, particularly for individuals with physical, cognitive, or communication difficulties(Niyomyart et al., 2024).

Although research on digital health in stroke care is increasing, the evidence remains fragmented. Previous reviews have focused on telehealth-based self-management, mobile technology for post-stroke care, or barriers to mHealth access(Hwang et al., 2021; Niyomyart et al., 2024; Thompson et al., 2023). However, limited reviews have specifically mapped digital health interventions that promote lifestyle changes within the context of secondary stroke prevention. A comprehensive mapping of the evidence is therefore needed to identify the types of digital technologies used, targeted lifestyle domains, assessed outcomes, and remaining research gaps. This scoping review aimed to map evidence on digital health interventions promoting lifestyle changes for secondary stroke prevention among people with stroke or transient ischemic attack. The review focused on intervention modalities, lifestyle and cardiovascular risk domains, outcome measures, feasibility, acceptability, and reported behavioral and clinical findings.

METHOD

Study Design end Review Questions

This study used a scoping review design to map evidence on digital health interventions promoting lifestyle changes for secondary stroke prevention. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping

Reviews (PRISMA-ScR). The review question was: What evidence is available regarding digital health interventions to promote lifestyle changes for the prevention of recurrent stroke among people living with stroke or transient ischemic attack?

Information Sources and Search Strategy

The literature search was conducted in three databases: Scopus, PubMed, and EBSCO. A search strategy was developed to capture four key concepts: stroke, digital health, lifestyle changes, and secondary prevention. The following Boolean search strings were used as the core search strategy and were adapted as needed to meet the syntax and indexing requirements of each database : ("stroke" OR "cerebrovascular accident" OR "brain ischemia") AND ("digital health" OR "mHealth" OR "telemedicine" OR "mobile applications" OR "smartphone" OR "wearable devices" OR "remote monitoring") AND ("lifestyle modification" OR "physical activity" OR "exercise" OR "dietary habits" OR "smoking cessation" OR "medication adherence") AND ("secondary prevention" OR "prevention of recurrence"). Additional database filters were applied in accordance with the scope of the review, including publications from the past 6 years, articles in English, and journal articles. Based on the review records, the search identified a total of 153 articles, including 73 from Scopus, 57 from PubMed, and 23 from EBSCO

Study Selection and Data Extraction

Search results were managed using Mendeley Reference Manager, and duplicate records were removed. Titles and abstracts were screened, followed by full-text assessment of potentially relevant articles. The selection process identified 153 records, from which 9 studies were included in the review. The study selection process is presented in the PRISMA-ScR flow diagram. Data were extracted on author and year, study design, sample characteristics, digital modality, lifestyle targets, outcome measures, and main findings.

RESULT

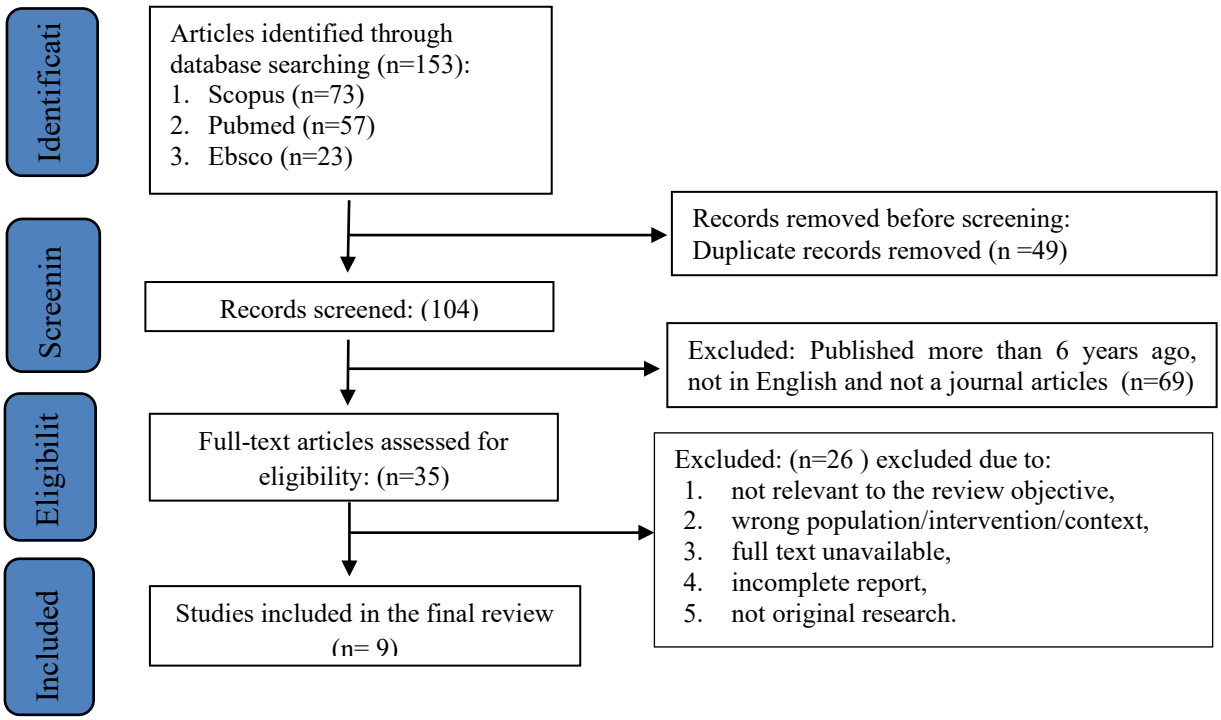


Figure 1. PRISMA-ScR Diagram of the Literature Search and Selection Process for a Literature Review

Table 1.
Matrix of Included Studiens

Study Title end Author	Sample Characteristics	Digital Modality	Lifestyle target	Outcome measures	main findings
Feasibility of an Application-Based Outpatient Rehabilitation Program for Stroke Survivors: Acceptability and Preliminary Results for Patient-Reported Outcomes (Bindschedler et al., 2024)	Retrospective pre-post; 122 recruited, 96 started, 88 completed	Home-exercise app + messenger coaching + BP/activity monitoring	Physical activity, self-monitoring	Feasibility, acceptability, QoL, BP, mobility, step count	Feasible and well accepted; improvements in some QoL domains, though mobility outcomes were not significantly changed
Secondary prevention of stroke. A telehealth-delivered physical activity and diet pilot randomized trial (ENAbLE-pilot) (English et al., 2024)	Pilot 2×2 factorial RCT; 40 randomized	Telehealth program	Physical activity and diet	Feasibility, safety, BP, PA, diet quality, fatigue, mood, QoL	Safe and feasible; trends toward improvement in PA, diet quality, and BP
Evaluation of a Newly Developed Smartphone App for Risk Factor Management in Young Patients With Ischemic Stroke: A Pilot Study (Fruhwirth et al., 2022)	Prospective two-group pre-post; 21 intervention, 21 control	Smartphone app	Physical activity, diet, alcohol, smoking, obesity, BP self-management	Lifestyle risk factors, QoL, clinical/cognitive outcomes	App users showed higher physical activity and lower unhealthy food intake; QoL also improved
Multicomponent Support Program for Secondary Prevention of Stroke Using Digital Health Technology : Co-Design Study With People Living With Stroke or Transient Ischemic Attack (Silvera-Tawil et al., 2024)	Mixed-methods co-design	Patient app + wearable + clinician portal	Lifestyle monitoring and risk-factor management	User needs, priority functions, monitored indicators	Produced a co-designed digital program concept for secondary stroke prevention
Adapting a Telehealth Physical Activity and Diet Intervention to a Co-Designed Website for Self-Management After Stroke : Tutorial (Pogrebnoy et al., 2024)	Methodological/design paper	Website adaptation (i-REBOUND)	Physical activity and diet self-management	Development outputs, usability/accessibility needs	Developed an accessible web-based self-management resource; no clinical effectiveness testing yet
Effectiveness of a primary care-based integrated mobile health intervention for stroke management in rural China (SINEMA): A cluster-randomized controlled trial (Yan et al., 2021)	Cluster RCT; 50 villages, 1,299 patients	mHealth app + village doctor follow-up + daily voice messages	Risk-factor control, physical activity, self-management	SBP, DBP, QoL, PA, medication adherence, recurrence-related outcomes	Significantly reduced SBP and improved several secondary outcomes, including recurrence-related indicators
Effects of a Planned Web-Based Educational Intervention Based on the Health Belief Model for Patients With Ischemic Stroke in Promoting Secondary Prevention During the COVID-19 Lockdown in China: Quasi-Experimental Study (Liu et al., 2024)	Quasi-experimental ; 315 patients	Web-based education via Tencent Meeting	Risk-factor control and healthy self-management	BP, LDL-C, HbA1c, adherence, mRS	Better achievement of BP, LDL-C, HbA1c targets and improved medication adherence
Novel Multicomponent Digital Care Assistant and Support Program for People After Stroke or Transient Ischaemic Attack: A Pilot Feasibility Study (Allan et	Single-group feasibility study; 34 started	Goal setting + clinician portal + SMS + mobile app + wearable	Lifestyle/risk-factor monitoring and behavior change	Recruitment, retention, usability, self-efficacy, cardiovascular	Acceptable and engaging; improvements in self-efficacy and cardiovascular

Study Title end Author	Sample Characteristics	Digital Modality	Lifestyle target	Outcome measures	main findings
al., 2024)				health	health
Using Mobile Video-Teleconferencing to Deliver Secondary Stroke Prevention Interventions: A Pilot Study. (Anderson et al., 2022)	Within-subjects pilot; 106 participants	Mobile video-teleconferencing	Exercise behavior and self-management	Acceptability, stroke knowledge, self-efficacy, exercise, psychological outcomes, QoL	Feasible and acceptable; improved exercise behavior and psychosocial outcomes

DISCUSSION

Principal Findings

This scoping review maps the available evidence on digital health interventions to promote lifestyle changes and support secondary stroke prevention. Nine studies were included, covering feasibility studies, pilot trials, quasi-experimental studies, cluster-randomized controlled trials, and intervention development or co-design studies(Allan et al., 2024; Anderson et al., 2022; Bindschedler et al., 2024; English et al., 2024; Fruhwirth et al., 2022; Liu et al., 2024; Pogrebnoy et al., 2024; Silvera-tawil et al., 2024; Yan et al., 2021). Overall, these findings indicate that digital health approaches are increasingly being used to support physical activity, dietary habits, self-management, blood pressure control, medication adherence, and the broader management of vascular risk factors following a stroke or transient ischemic attack(Allan et al., 2024; English et al., 2024; Fruhwirth et al., 2022; Liu et al., 2024; Silvera-tawil et al., 2024; Yan et al., 2021). At the same time, the evidence base remains heterogeneous and is dominated by early-stage studies rather than large, definitive clinical trials(Allan et al., 2024; English et al., 2024; Hunter et al., 2023; Pogrebnoy et al., 2024; Silvera-tawil et al., 2024).

Digital Modalities in Secondary Stroke Prevention

One of the key findings of this review is the widespread use of digital modalities in secondary stroke prevention. The studies included in this review utilized smartphone apps, telehealth programs, web-based education, mobile video conferencing, and multifunctional systems that combine wearable devices, clinician portals, SMS support, remote monitoring, and goal-setting tools(Allan et al., 2024; Anderson et al., 2022; English et al., 2024; Fruhwirth et al., 2022; Liu et al., 2024; Silvera-tawil et al., 2024; Yan et al., 2021). This diversity indicates that digital health should not be regarded as a single intervention model. Instead, digital health represents a flexible approach to supporting prevention and self-management that may be adapte(Hwang et al., 2021; Thompson et al., 2023).

The findings also demonstrate that digital interventions are frequently combined with professional support rather than being delivered as completely independent technologies. Several interventions integrated digital platforms with healthcare provider feedback, telemedicine sessions, structured monitoring, messaging, or follow-up by healthcare professionals (Anderson et al., 2022; English et al., 2024; Silvera-tawil et al., 2024; Yan et al., 2021). his pattern is clinically relevant because post-stroke lifestyle modification often requires continued reinforcement and individualized support. Therefore, digital technology may be most useful when functioning as an extension of professional care rather than as a complete substitute for healthcare services(Hwang et al., 2021; Thompson et al., 2023).

Lifestyle Goals and Their Relevance to Secondary Stroke Prevention

The interventions identified in this review predominantly targeted modifiable lifestyle and behavioral risk factors. Physical activity was one of the most frequently addressed targets, followed by dietary behavior, self-management, blood pressure control, and medication adherence(Allan et al., 2024; English et al., 2024; Fruhwirth et al., 2022; Liu et al., 2024; Pogrebnoy et al., 2024; Yan

et al., 2021). Several interventions also addressed smoking, alcohol consumption, obesity, and broader cardiovascular risk management(Fruhwirth et al., 2022; Liu et al., 2024; Silvera-tawil et al., 2024; Yan et al., 2021). This multidimensional focus is important because secondary stroke prevention involves the management of multiple interacting risk factors rather than a single health behavior. Lifestyle modification may include physical activity, healthy diet, smoking cessation, alcohol reduction, weight management, and adherence to treatment recommendations. Recent literature similarly emphasizes comprehensive lifestyle management as an important component of secondary stroke prevention(Bally et al., 2023; Govori et al., 2024).

The studies included in this review also indicate a movement from interventions targeting a single behavior toward more comprehensive digital prevention models. Some interventions focused primarily on exercise or diet, whereas others combined lifestyle monitoring, self-management support, medication adherence, risk-factor control, and healthcare professional feedback within the same intervention (English et al., 2024; Fruhwirth et al., 2022; Liu et al., 2024; Yan et al., 2021). Such integrated approaches may better reflect the complex needs of stroke survivors during long-term secondary prevention.

Feasibility, Acceptance, and Early Indicators of Effectiveness

Feasibility and acceptability were among the most consistent findings across the included studies. Several feasibility and pilot studies reported satisfactory engagement, retention, usability, and positive perceptions of digital interventions(Allan et al., 2024; Anderson et al., 2022; English et al., 2024; Hunter et al., 2023; Silvera-tawil et al., 2024). Positive trends were also observed in self-efficacy, quality of life, physical activity, dietary behavior, and cardiovascular health indicators(Allan et al., 2024; Anderson et al., 2022; English et al., 2024; Fruhwirth et al., 2022; Hunter et al., 2023). These findings indicate that stroke survivors can engage with different forms of digital technology, including relatively complex systems incorporating wearable devices, clinician portals, remote monitoring, and multiple communication functions. This observation is supported by previous studies showing that stroke survivors and their caregivers increasingly use internet-based and digital technologies, although access and usage may vary across populations(Bally et al., 2023; Clancy et al., 2022; Naqvi et al., 2021).

Nevertheless, feasibility and acceptability should be distinguished from clinical effectiveness. A digital intervention may be feasible and well accepted without necessarily producing sustained reductions in recurrent stroke risk. Therefore, the current evidence provides relatively strong support for the practicality and acceptability of digital interventions but more limited evidence regarding their long-term effectiveness. More direct evidence of effectiveness was identified in studies evaluating clinical and behavioral outcomes. Improvements were reported in systolic blood pressure, achievement of lipid and glycemic targets, medication adherence, and other secondary prevention indicators(Liu et al., 2024; Yan et al., 2021). These findings suggest that digitally supported interventions may contribute to improved vascular risk-factor management, particularly when technology is combined with structured clinical support. At the same time, these findings should be interpreted cautiously because the evidence base remains relatively heterogeneous. The presence of pilot, feasibility, quasi-experimental, and developmental studies means that the available literature does not yet provide sufficient evidence to establish the long-term effectiveness of one specific digital intervention model.

Development and Co-Design as Key Stages in This Field

One distinctive feature of the literature included in this review is the presence of intervention development and co-design studies. Two of the nine studies included in this review focused primarily on the development or adaptation of digital platforms rather than on evaluating clinical outcomes(Pogrebnoy et al., 2024; Silvera-tawil et al., 2024). This is not a weakness in this field; rather, it reflects an important stage of development. Stroke survivors may face physical, sensory, cognitive, and communication challenges that directly affect how they use digital tools(Bally et al.,

2023; Niyomyart et al., 2024). Consequently, usability, accessibility, personalization, and alignment with patient priorities are key to the success of interventions(Bally et al., 2023; Niyomyart et al., 2024; Silvera-tawil et al., 2024).

The application of co-design and adaptation studies indicates that this field is moving in a clinically sound direction. Before large-scale efficacy trials can be meaningful, interventions must first be usable, acceptable, and realistically integrated into the daily lives of stroke survivors(Bally et al., 2023; Pogrebnoy et al., 2024; Silvera-tawil et al., 2024). In this regard, the development studies in this review provide an important foundation for implementation and future trials. They also reinforce the idea that successful digital health interventions for stroke prevention require more than just the delivery of information; they require careful design regarding how patients interact with the technology over time(Pogrebnoy et al., 2024; Silvera-tawil et al., 2024).

Comparison with the Broader Digital Health Literature on Stroke

The patterns observed in this review are generally consistent with the broader digital health literature on stroke, which also describes significant variation in intervention focus, device types, delivery features, and behavioral targets(Hwang et al., 2021; Thompson et al., 2023). A JMIR scoping review of post-stroke mobile technology-based interventions also covered a variety of focus areas, device types, and technological functions, while the authors concluded that this field remains heterogeneous and would benefit from more theory-based and larger-scale research(Thompson et al., 2023). This scoping review reached similar conclusions, although its focus is narrower and more clinically specific, as it centers on lifestyle modifications for secondary stroke prevention rather than general post-stroke self-management support(Hwang et al., 2021; Thompson et al., 2023). This distinction is important, Compared to the broader literature on digital post-stroke rehabilitation, the studies included in this review more clearly focus on reducing vascular risk, health behavior changes, and prevention-oriented self-management(English et al., 2024; Liu et al., 2024; Yan et al., 2021). This makes this review clinically relevant for secondary prevention and highlights a focused niche of evidence within the broader landscape of digital stroke care(Bally et al., 2023; Govori et al., 2024).

Implications for Research and Practice

From a clinical perspective, digital health interventions have the potential to extend lifestyle counseling, self-management support, and risk-factor monitoring beyond routine face-to-face care. Digital approaches may facilitate communication between patients and healthcare professionals, support self-monitoring, reinforce healthy behaviors, and maintain patient engagement between clinical visits(Allan et al., 2024; Anderson et al., 2022; Yan et al., 2021). These interventions may be particularly useful where access to continuous rehabilitation or prevention services is limited. However, implementation should take into account digital access, digital literacy, functional limitations, cognitive difficulties, and individual patient preferences. Previous evidence indicates that access to digital health is not uniform among stroke survivors, highlighting the importance of addressing barriers to equitable use(Clancy et al., 2022; Naqvi et al., 2021; Thompson et al., 2023)

From a research perspective, future studies should prioritize larger and more rigorous comparative designs with longer follow-up periods. These studies should evaluate whether improvements in lifestyle behaviors and vascular risk factors are sustained and whether they translate into clinically meaningful outcomes, including reduced recurrent stroke risk. Future research should also examine which components of digital interventions are most influential. These may include goal setting, healthcare professional feedback, educational content, supportive messaging, remote monitoring, and wearable technologies(Pogrebnoy et al., 2024; Silvera-tawil et al., 2024). Greater consistency in outcome measurement would also improve comparability across studies and strengthen future evidence synthesis. Overall, the findings suggest that digital health represents a promising but still developing approach to secondary stroke prevention. The strongest evidence currently concerns feasibility, acceptability, and preliminary improvements in health behaviors and risk-factor

management, while definitive.

CONCLUSION

This scoping review indicates that digital health interventions have promising potential to support lifestyle modification and secondary stroke prevention. Smartphone applications, telehealth, web-based education, mobile video conferencing, wearable technologies, remote monitoring, and digitally supported healthcare professional interactions can facilitate self-management, physical activity, dietary improvement, risk-factor monitoring, and medication adherence. However, the current evidence remains heterogeneous, with many studies focusing on feasibility, acceptability, intervention development, and preliminary outcomes rather than definitive long-term clinical effectiveness. The scientific contribution of this review is the identification of digital health as a flexible and potentially integrated approach to supporting multiple modifiable risk factors within secondary stroke prevention

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