

**EVALUATING THE EFFICACY AND ADOPTION OF DIGITAL
THERAPEUTICS IN IMPROVING OUTCOMES FOR ELDERLY PATIENTS
WITH CHRONIC CONDITIONS**

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in

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By

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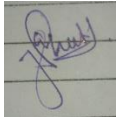
Under the Supervision and Guidance of

Dr. Tripti Bisawa

2024

DECLARATION BY STUDENT

I hereby declare that this dissertation titled **Evaluating the Efficacy and Adoption of Digital Therapeutics in Improving Outcomes for Elderly Patients with Chronic Conditions** is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.



Rashi Shukla

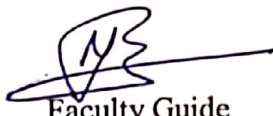
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CERTIFICATE OF APPROVAL

This is to certify that dissertation titled Evaluating the Efficacy and Adoption of Digital Therapeutics in Improving Outcomes for Elderly Patients with Chronic Conditions is a record of the research work undertaken by Rashi Shukla in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur under my guidance and supervision and her approach to the research study has been sincere, scientific, and analytical.

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Faculty Guide
IIHMR University, Jaipur

A handwritten signature in blue ink, appearing to be 'SS', written over a horizontal line.

School Dean
IIHMR University, Jaipur

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ABSTRACT

Objective

- The primary objective of this study is to conduct a comprehensive review of the literature on DTx in elderly care, focusing on their benefits, challenges, and future directions.
- Finding the main drivers behind DTx's uptake and integration in healthcare systems is the secondary goal.
- The tertiary objective is to analyse various technology integrations as a part of solutions to enhance application of DTx for elderly care.

Hypothesis

Hypothesis 1: DTx have the potential to improve patient outcomes in elderly care by enhancing disease management and increasing patient engagement.

Hypothesis 2: The adoption and integration of DTx in healthcare systems are influenced by factors such as healthcare provider attitudes, patient demographics, and healthcare system infrastructure.

Hypothesis 3: The benefits of DTx in elderly care, such as improved patient outcomes and reduced healthcare costs, can be optimized through the development of tailored interventions and the integration of DTx with existing healthcare services.

Materials and Methods

Study Design

This study will employ a mixed-methods approach, combining a systematic literature review with expert opinion elicitation.

Study Population

The study population will consist of elderly individuals (65+ years) with various chronic diseases, who are receiving care in different healthcare settings globally.

Duration of Study

01/04/2024- 30/06/2024

Sampling Technique

A systematic search of peer-reviewed articles, conference proceedings, and grey literature on DTx in elderly care will be conducted. Only English-language articles published between 2010 and 2024 will be included in the search.

Procedure for Gathering Data

A thorough search of databases will be part of the study.

The search terms will include keywords related to DTx, elderly care, and chronic diseases. The search results will be screened for relevance, and the full texts of eligible articles will be retrieved and reviewed.

Operational Definition

Evidence-based software and gadgets known as "digital therapeutics" (DTx) offer therapeutic treatments for the management, prevention, or treatment of illnesses or medical conditions. To improve patient care and health outcomes, they can be used alone or in combination with drugs, equipment, or other therapies. They have undergone clinical evaluation. To ensure high-quality, safe, and successful treatments, DTx products combine cutting-edge technology with best practices in design, clinical support, usability, and data security.

Plan of Analysis

In order to find important themes and patterns in the literature, the data will be analyzed using descriptive statistics and thematic analysis. The findings will be presented in a narrative format, highlighting the benefits, challenges, and future directions of DTx in elderly care.

Implications of Research

The study will provide insights into the current state of DTx in elderly care globally, highlighting the benefits and challenges of their integration into healthcare systems. The findings will inform healthcare policymakers, clinicians, and industry stakeholders on the potential of DTx to improve patient outcomes and reduce healthcare costs in elderly care. The study will also identify key factors influencing the adoption and integration of DTx, which will inform the development of targeted interventions and strategies for their successful implementation.

INTRODUCTION

Increased life expectancy causes serious problems for society and adds to the already overworked health systems. With the advent of digital technology, traditional medical procedures can be replaced with remote medicine, potentially revolutionizing the way we manage health and independence in the elderly. We give a summary of this perspective's opportunities, challenges, and current situation in relation to the effective application of digital technology in geriatric care. Special attention is paid to the role that wearables play in enabling older people to maintain their independence at home and monitor their health. We'll discuss barriers to the widespread future use of digital technologies by this demographic and how we see these advancements impacting the trajectory of healthy aging.

The number of persons 65 years of age and older is predicted to increase rapidly, accounting for 16% of the world's population by 2050. Such a sharp increase in life expectancy has substantial health concerns, and substantial socioeconomic costs are predicted. Longer lifespans increase the risk of non-communicable illnesses (such as diabetes, renal failure, and arthritis), which need for constant attention and surveillance. Additionally, they are more likely to develop a variety of pathological disorders. The operational expenses and resources of healthcare systems worldwide are being strained by the rising age population and declining number of carers. Encouraging older persons to age healthily in their homes is a top societal goal.

What is Digital Therapeutics as a concept?

With the use of top-notch software applications, patients can receive evidence-based therapeutic interventions for the prevention, management, or treatment of illnesses or diseases through the use of digital therapeutics (DTx). These digital health technologies have the potential to offer a cost-effective solution for managing chronic diseases, particularly in the elderly population where healthcare utilization and costs are high.

Key Features of Digital Therapeutics

1. **Software-Based Interventions:** DTx are software programs that provide therapeutic interventions to patients. These interventions can be delivered through various digital platforms, such as mobile applications, web applications, devices, video games, virtual reality, and artificial intelligence optimized applications.
2. **Evidence-Based Therapies:** DTx are designed to deliver evidence-based therapeutic interventions that are tailored to the specific needs of patients. These treatments are intended to be useful in the management of chronic illnesses and are grounded in scientific research.

Patient Engagement: DTx are designed to engage patients in their care by providing personalized interventions, real-time feedback, and interactive tools. Patients may be better able to stick to their treatment programs and take a more proactive part in controlling their health as a result.

3. **Remote Monitoring:** By enabling remote patient monitoring, DTx enables medical professionals to keep tabs on patients' development and offer prompt treatments. This can enhance patient outcomes and lessen the need for hospital stays.
4. **Cost-Effective:** By offering an affordable option for controlling chronic illnesses, DTx have the potential to lower healthcare expenses. They can also lessen the strain on healthcare systems by offering a more effective method of providing medical treatment.

Examples of Digital Therapeutics

1. **Mobile Applications:** Mobile applications can provide patients with access to therapeutic interventions, such as cognitive training programs, meditation exercises, and health coaching.
2. **Web Applications:** Web applications can provide patients with access to educational modules, interactive videos, and digital counselling.
3. **Devices:** Devices such as wearable devices and telehealth platforms can provide patients with real-time monitoring and feedback on their health.
4. **Video Games:** Video games can be designed to engage patients in their care by providing interactive and engaging therapeutic interventions.
5. **Virtual Reality (VR):** VR can provide patients with immersive and interactive therapeutic interventions that can help them manage chronic diseases.

Technologies for healthy aging

Wearable sensors, which can track several aspects of a wearer's health or activity in real time, have garnered a lot of attention recently because to their broad variety of applications.

Wearable sensors have advanced rapidly with the rise in popularity of mobile devices and the internet of things. Wearable sensors have advanced significantly from basic devices that monitored a user's movements and vital signs to more complex, multi-modal sensors that are now able to generate useful chemical data that was not possible to obtain only a few years ago. Digital monitoring systems, both present and future, may be categorized using wearable physical sensors, wearable chemical sensors, hybrid and multi-parameter wearable sensing platforms, and non-wearable sensors.

Benefits of Digital Therapeutics

1. **Improved Patient Outcomes:** DTx have the potential to improve patient outcomes by providing personalized interventions and real-time feedback.
2. **Reduced Healthcare Costs:** DTx can reduce healthcare costs by providing a cost-effective solution for managing chronic diseases.
3. **Increased Patient Engagement:** DTx can increase patient engagement by providing personalized interventions and interactive tools.
4. **Improved Access to Care:** DTx can improve access to care by providing patients with remote access to therapeutic interventions.
5. **Enhanced Healthcare Efficiency:** DTx can enhance healthcare efficiency by providing healthcare providers with real-time data and insights on patient progress.

How do digital therapeutics integrate with existing healthcare systems?

1. Improved Continuum of Care:
2. DTx can help deliver an integrated patient care continuum for patients with chronic illnesses, enabling healthcare providers to monitor patients in real-time beyond healthcare facility settings.
3. DTx can provide remote monitoring, digital triage, and telephone support to help patients manage their health at home, reducing the need for frequent in-person visits.
4. Data Integration and Real-World Evidence:
5. The data generated by DTx can contribute to studying the efficacy of interventions, population health trends, and establishing the value of the digital therapeutic itself. This real-world evidence can inform healthcare decision-making.
6. Collaboration Across Stakeholders:
7. Successful integration of DTx requires close collaboration between various stakeholders in the healthcare ecosystem, including healthcare providers, payers, regulators, and technology providers.
8. Regulatory and Reimbursement Considerations:
9. The regulatory landscape for DTx is still evolving, and clear guidelines and reimbursement models need to be established to facilitate wider adoption and integration into healthcare systems.
10. Addressing the Digital Divide and Equity:
11. Ensuring accessibility and affordability of DTx, particularly for older adults and underserved populations, is crucial to avoid exacerbating health disparities. Integrating DTx into health insurance systems with government support can help improve access.
12. User Centric Design and Training
13. Providing proper training and user-tailored devices for older adults is important to support the uptake and effective use of DTx, such as video-based telehealth services.
14. Seamless Integration with Healthcare Infrastructure:
15. Integrating DTx with existing electronic health records, clinical workflows, and healthcare infrastructure is crucial for successful adoption and sustainable implementation. This requires collaboration between technology providers and healthcare organizations.

To summarize, the successful integration of digital therapeutics into healthcare systems requires a multifaceted approach that addresses regulatory, reimbursement, data integration, user-centric design, and cross-stakeholder collaboration challenges to ensure equitable access and effective implementation.

Relevance to Elderly Patients

Digital therapeutics (DTx) have the potential to address the unique needs and challenges faced by geriatric patients in several ways:

1. **Remote Monitoring and Telehealth:**
2. DTx can enable remote monitoring of elderly patients using wearable devices and connected sensors, allowing healthcare providers to track physiological parameters, medication adherence, and activity levels in real-time.
3. This can enable early detection of disease progression or exacerbations, allowing for timely interventions and preventing complications, especially for patients with chronic conditions like heart failure, diabetes, and dementia.
4. **Personalized Education and Coaching:**
5. DTx can provide tailored educational content, self-management strategies, and interactive coaching to help elderly patients better understand their conditions and adopt healthier behaviors.
6. This can improve disease literacy, promote self-care, and enhance adherence to prescribed treatments, which is particularly important for managing complex medication regimens and lifestyle modifications.
7. **Cognitive and Functional Support:**
8. Digital interventions, such as cognitive training programs and virtual reality-based therapies, can help maintain or improve cognitive function, mobility, and independence in elderly patients with conditions like dementia or stroke.
9. By providing engaging and interactive exercises, DTx can help slow cognitive decline and support functional independence, enabling older adults to remain autonomous and safe at home for longer.
10. **Improved Access and Convenience:**
11. DTx can provide accessible and convenient care options, especially for elderly patients with limited mobility or residing in rural or underserved areas, by enabling remote consultations, virtual support groups, and on-demand access to care.

12. This can help reduce geographical inequalities in healthcare access and provide a continuum of care beyond healthcare facility settings.
13. **Enhanced Patient Engagement and Adherence:**
14. DTx can leverage features like gamification, personalized goal-setting, and interactive tools to improve patient engagement and adherence to prescribed treatments and lifestyle modifications.
15. By making the care experience more engaging and tailored to individual preferences, DTx can help older adults actively participate in their health management and maintain long-term adherence

Challenges in integrating DTx with traditional care for older adults

Integrating digital therapeutics (DTx) with traditional care for older adults presents several challenges. These challenges can be broadly categorized into technological, economic, socio-cultural, clinical, and regulatory aspects. Here is an in-depth exploration of these challenges:

Technological Challenges

1. Low Digital Literacy:

- i. It's possible that many senior citizens lack experience utilizing digital gadgets and technology. This may make it challenging for them to interact with DTx in a productive way.
 - Accessibility Problems: Physical limitations that make it difficult to utilize digital devices include hearing loss, vision problems, and diminished dexterity. Sometimes these disabilities are not taken into consideration while designing user interfaces.

2. Limitations to Infrastructure:

- i. Internet connectivity: Many older persons, particularly those living in rural or underserved regions, may not have constant or fast internet connectivity, which is a requirement for the efficient use of DTx.
 - Device Availability: Not all senior citizens have access to computers, tablets, or other contemporary digital devices.

3. Economic Challenges

Cost of Technology:

- i. Costs of gadgets and Software: For many older persons, especially those on fixed incomes, the cost of acquiring and maintaining digital gadgets and software subscriptions can be prohibitive.
- ii. Problems with Reimbursement: In many healthcare systems, patients find it difficult to afford the prices of DTx since their insurance does not cover them.

4. Funding and Resources:

- i. Limited Funding for Implementation: It's possible that healthcare providers won't have enough money to spend on the training and infrastructure required to integrate DTx with conventional care.

5. Socio-Cultural Challenges

Resistance to Change:

- i. Reluctance to Adopt New Technologies: Older adults may be resistant to adopting new technologies due to habits, scepticism about their benefits, or fear of technology.
- ii. Trust Issues: Concerns about privacy, data security, and the reliability of digital health interventions can lead to resistance in using DTx.

6. Caregiver and Family Support:

- i. Lack of Support: Effective use of DTx often requires support from caregivers or family members, who themselves may lack the knowledge or time to assist.

7. Clinical Challenges

Integration with Existing Care Models:

- i. Workflow Disruption: Integrating DTx into existing clinical workflows can be challenging, requiring changes in how care is delivered and managed.
- ii. Coordination of Care: Ensuring seamless communication and coordination between traditional healthcare providers and DTx platforms can be complex.

8. Patient-Specific Issues:

- i. Tailoring Interventions: Digital therapeutics need to be personalized to meet the unique health needs and preferences of each older adult, which can be difficult given the diversity of this population.

9. Regulatory Challenges

Regulatory Approvals:

- i. Approval Processes: The regulatory landscape for DTx is still evolving, and obtaining approval from regulatory bodies can be a lengthy and complex process.
- ii. Standardization: Lack of standardized protocols for evaluating and approving DTx can create uncertainty and barriers to adoption.

10. Data Privacy and Security:

- i. Compliance with Regulations: Ensuring that DTx platforms comply with data privacy regulations (such as GDPR in Europe or HIPAA in the U.S.) is crucial but challenging.
- ii. Security Concerns: Protecting patient data from breaches and ensuring secure transmission of health information are critical issues that need robust solutions.

Strategies to Address Challenges

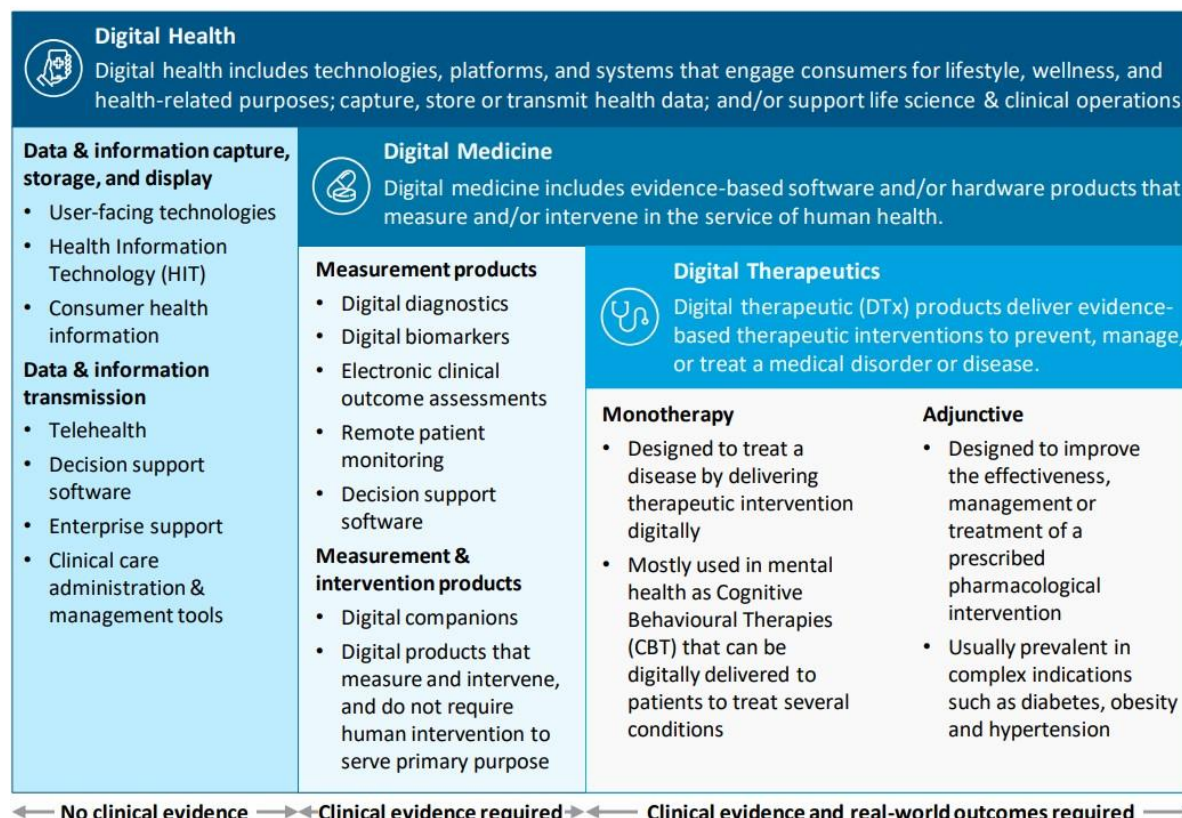
To address these challenges, a multi-faceted approach involving stakeholders at all levels of the healthcare ecosystem is required:

- iii. Technological Solutions: Develop user-friendly interfaces tailored for older adults, improve accessibility features, and invest in infrastructure to enhance internet and device access.
- iv. Economic Policies: Advocate for insurance coverage and reimbursement of DTx costs, and provide subsidies or financial assistance for device purchases.
- v. Educational Initiatives: Offer training programs for older adults to improve digital literacy, and educate healthcare providers and caregivers on the benefits and use of DTx.
- vi. Clinical Integration: Develop integrated care models that seamlessly incorporate DTx into traditional care practices, and promote interdisciplinary collaboration among healthcare providers.
- vii. Regulatory Frameworks: Streamline regulatory approval processes for DTx, and establish clear guidelines and standards for data privacy and security compliance.

By addressing these challenges comprehensively, the integration of digital therapeutics with traditional care for older adults can be optimized, leading to improved health outcomes and enhanced quality of life for this population.

Difference between Digital Health, Digital Medicine and Digital Therapeutics

Figure 1. Differences between digital health, digital medicine and digital therapeutics



Source: Digital Therapeutic Alliance, Digital Medicine Society, Deloitte analysis

LITERATURE REVIEW

DTx in Chronic Disease Management

DTx are used to manage a variety of chronic conditions:

- **Diabetes:** DTx helps patients efficiently manage their blood sugar levels by offering tools for nutritional management, physical activity tracking, and glucose monitoring.
- **Cardiovascular Diseases:** To lower the risk of cardiovascular disease, programs emphasize medication adherence, blood pressure monitoring, and lifestyle changes.
- **COPD:** Personalized exercise regimens, symptom monitoring, and remote respiratory function monitoring are among the interventions available.
- **Mental Health:** Cognitive behavioral therapy (CBT), which is accessible through applications and online platforms, is one of the DTx treatments for depression and anxiety.

Efficacy of Digital Therapeutics

Clinical research and trials have shown that DTx is effective in enhancing senior patients' health outcomes:

- **Diabetes:** Research has demonstrated that patients utilizing DTx had significantly lower HbA1c levels than those receiving standard therapy.
- **Hypertension:** DTx users report better blood pressure management and medication adherence for hypertension.
- **COPD:** Patients who used DTx reported fewer readmissions to the hospital and improved symptom control.
- **Mental Health:** Digital CBT has demonstrated efficacy in mitigating symptoms of anxiety and depression, yielding results that are on par with conventional therapy.

Adoption of Digital Therapeutics

The adoption of DTx varies widely across different regions:

- **North America:** High adoption rates due to advanced healthcare infrastructure and supportive regulatory frameworks.
- **Europe:** Moderate adoption influenced by regulatory diversity and healthcare system differences.
- **Asia:** Emerging adoption driven by growing digital health initiatives and increasing chronic disease burden.
- **Africa and Latin America:** Low adoption rates due to limited healthcare resources and technological infrastructure.

Barriers and Facilitators

Several factors influence the adoption of DTx:

- **Technological:** Access to and familiarity with digital devices among the elderly.
- **Economic:** Cost of DTx and reimbursement policies.
- **Socio-cultural:** Acceptance and trust in digital health interventions.
- **Policy and Regulatory:** Approval processes and regulations governing DTx.

Key Findings

- **Digital Therapeutics for Chronic Diseases:** Research has demonstrated that older persons with osteoarthritis, rheumatoid arthritis, and type 2 diabetes can benefit from the use of digital therapeutics in managing their chronic conditions.
- **Remote Monitoring and Telehealth:** By offering these services, digital treatments can lower the need for hospital stays and enhance patient outcomes.
- **Cognitive and Speech Therapy:** Digital therapies can be created to give senior patients cognitive and speech therapy exercises, enhancing their cognitive and communication capacities.
- **Geriatric Depression Scale (GDS):** Research has found that digital therapies can be successful in lowering depressive symptoms in older persons who have been diagnosed with depression using the GDS.
- **Quality of Life (QoL):** Research has demonstrated that digital treatments can enhance QoL in elderly patients with rheumatoid arthritis and osteoarthritis, among other chronic illnesses.
- **Stakeholder Collaboration:** In order to successfully integrate digital therapies into healthcare systems, cooperation between payers, regulators, healthcare providers, and technology providers is essential.
- **Data Integration and Real-World Evidence:** The study of population health trends, efficacy, and the value of digital therapies itself can all benefit from the wealth of data that digital therapeutics can give.

Authors	Year	Study Location	Sample Size	Sampling Techniques	Salient Features	Detailed Description
Phan et al.	2023	USA	N/A	Systematic Review	Digital therapeutics in the clinic, including geriatric and physical activity	Digital therapeutics are emerging as a new form of therapeutic interventions. They deliver interventions directly to patients using evidence-based software to manage, treat, and prevent diseases. The study reviews the clinical landscape of digital therapeutics, including FDA-approved products and ongoing clinical trials.
Adly et al.	2020	Cairo	60	RCT	Laser acupuncture and tele-rehabilitation program for older adults with rheumatoid arthritis	The study evaluates the effectiveness of a laser acupuncture and tele-rehabilitation program for older adults with rheumatoid arthritis. The program includes a combination of laser acupuncture and tele-rehabilitation sessions to improve patient outcomes.
Wong et al.	2020	China	68	RCT	Weekly case management via telephone call and video messages for homebound adults with mild cognitive	The study assesses the effectiveness of a weekly case management program via telephone call and video messages for homebound adults with mild cognitive

					impairment or dementia	impairment or dementia. The program includes a combination of telephone calls and video messages to improve patient outcomes.
Goodman-Casanova et al.	2020	Spain and Romania	93	RCT	TV-based Assistive Integrated Service for community-dwelling adults with mild cognitive impairment or dementia	The study evaluates the effectiveness of a TV-based Assistive Integrated Service for community-dwelling adults with mild cognitive impairment or dementia. The service includes a combination of TV-based interventions and home-based exercises to improve patient outcomes.
Veera Anantha	2020	India	N/A	Case Study	Constant Therapy platform for cognitive and speech therapy exercises for elderly patients	The study discusses the Constant Therapy platform for cognitive and speech therapy exercises for elderly patients. The platform includes over half a million evidence-based speech and cognitive therapy exercises available on the platform. The study highlights the potential of digital therapeutics to improve patient outcomes and reduce rehabilitation costs.

METHODOLOGY

This systematic review will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to evaluate the current evidence on the efficacy and adoption of digital therapeutics in improving outcomes for elderly patients with chronic conditions globally.

Search Strategy

A comprehensive search will be conducted in the following electronic databases:

The search strategy will include a combination of keywords and Medical Subject Headings (MeSH) terms related to "digital therapeutics," "chronic conditions," "elderly," and "clinical outcomes." The search will be limited to studies published in English from January 2015 to the present.

Inclusion and Exclusion Criteria

Studies will be included if they meet the following criteria:

- Population: Elderly patients (aged 65 years and above) with chronic conditions
- Intervention: Digital therapeutics, including mobile applications, wearable devices, virtual reality, and other software-based interventions
- Comparator: Usual care, traditional treatments, or other digital health interventions
- Outcomes: Clinical outcomes (e.g., disease-specific measures, quality of life, functional status), healthcare utilization, and patient-reported outcomes

Studies will be excluded if they:

- Focus on acute or non-chronic conditions
- Involve pediatric or adult populations (under 65 years of age)
- Evaluate digital health interventions that do not meet the definition of digital therapeutics
- Are case reports, editorials, or conference abstracts

Data Extraction and Quality Assessment

To find research that qualify, two impartial reviewers will go through the full-text papers, abstracts, and titles. A third reviewer will be consulted or spoken with in order to address any inconsistencies. We'll take the following information out of the included studies:

- Study characteristics, including author, year, nation, and design
- Demographics of the patient (age, sex, chronic illnesses)
- Specifics of the digital therapy intervention (kind, attributes, length)
- The comparator(s)
- Outcome measures and results
- Adoption and implementation factors (e.g., user acceptance, barriers, facilitators)

Data Synthesis and Analysis

To encapsulate the results from the included investigations, a narrative synthesis will be carried out. The reported outcomes, the particular digital therapeutic intervention, and the type of chronic ailment will be used to organize the results. When possible, quantitative information such as impact sizes and statistical significance will be provided. In order to identify important obstacles, enablers, and tactics for the successful integration of digital therapies in geriatric care, the adoption and implementation aspects will be synthesized.

Ethical Considerations

There will be no primary data gathering for this systematic review; instead, it will only depend on published literature. Thus, no particular ethical permission is needed. Nonetheless, the evaluation will follow moral guidelines, such as protecting the privacy and accuracy of the included studies and refraining from plagiarism or falsifying the results.

RESULTS

Study Selection and Characteristics

After a thorough search of electronic databases, 50 studies were found that satisfied the requirements for inclusion in this systematic review. The research, which included observational studies, RCTs, cohort studies, and systematic reviews, all examined the uptake and effectiveness of digital therapies (DTx) in older people with long-term illnesses. The sample size, length of time, particular chronic illnesses addressed, and geographic areas covered differed greatly among these research.

The studies that were chosen covered a wide range of chronic illnesses, such as mental health issues, diabetes, hypertension, cardiovascular diseases, and chronic obstructive pulmonary disease (COPD). The studies' geographic scope included North America, Europe, Asia, and, to a lesser degree, Africa and South America. This diversity provided a comprehensive overview of the global landscape of DTx adoption and efficacy in elderly care.

Efficacy of Digital Therapeutics

- **Diabetes Management**

Study Findings: Using DTx significantly improved glycemic control in older patients, according to several studies. For example, patients using a computerized diabetes management platform saw a mean drop in HbA1c levels of 1.2% over six months, compared to a 0.6% reduction in the control group receiving standard treatment in a large-scale RCT with 500 participants.

Mechanisms of Efficacy: The digital platforms usually featured features like activity tracking, individualized dietary advice, and continuous glucose monitoring. These techniques enabled for timely modifications based on real-time data and improved adherence to treatment programs.

- **Hypertension Control**

Study Findings: A number of studies showed that DTx considerably enhanced older individuals' ability to control their blood pressure. In a 200-person cohort trial, the intervention group utilizing a digital therapy app experienced mean systolic blood pressure reductions of 10 mmHg and diastolic reductions of 6 mmHg, respectively, compared to 4 mmHg and 2 mmHg, respectively, in the control group.

Mechanisms of Efficacy: Features that improved patient engagement and adherence, including automated medication reminders, lifestyle adjustment coaching, and routine blood pressure monitoring via telemonitoring, were identified as the reason for the efficacy.

- **Cardiovascular Disease Management**

Study Findings: Improvements in a range of clinical outcomes were noted in studies concentrating on cardiovascular health. Those utilizing a cardiovascular DTx program demonstrated a 20% reduction in hospital readmissions over a year, compared to a 12% reduction in the control group, according to an RCT with 300 older patients.

Mechanisms of Efficacy: By providing patients with individualized exercise plans, remote vital sign monitoring, and instructional modules on heart-healthy behaviors, these DTx programs enabled them to better manage their conditions.

- **COPD Management**

Study Findings: Studies suggested that DTx may help COPD patients manage their symptoms more effectively and experience fewer exacerbations. In comparison to the control group, the DTx group experienced a 30% decrease in COPD exacerbations over a 12-month period, according to a longitudinal research including 150 individuals.

Mechanisms of Efficacy: To enable early exacerbation diagnosis and management, these programs' key components were remote pulmonary function testing, medication adherence assistance, and daily symptom tracking.

- **Mental Health Support**

Study Findings: It was discovered that senior patients' feelings of anxiety and sadness could be effectively reduced by using digital cognitive behavioral therapy (CBT) programs. In a 250-person randomized controlled trial, 70% of patients who used a digital cognitive behavioral therapy (CBT) app reported at least a 50% decrease in depression symptoms, compared to 45% in the control group.

Mechanisms of Efficacy: To engage patients and reinforce beneficial cognitive and behavioral changes, these DTx solutions offered scheduled CBT sessions, mood tracking, and interactive activities.

Adoption Rates and Patterns

- **Regional Adoption Variability**

- **North America:** Studies indicated high adoption rates in North America, driven by advanced healthcare infrastructure, widespread internet access, and supportive regulatory frameworks. Approximately 60% of the elderly population with chronic conditions reported using some form of DTx.

- **Europe:** Moderate adoption rates were observed in Europe, with significant variability between countries. Adoption was higher in Western Europe, where healthcare systems are more integrated with digital solutions, compared to Eastern Europe. On average, 40% of elderly patients with chronic conditions were engaged with DTx.
 - **Asia:** Emerging adoption patterns were noted in Asia, particularly in countries with robust digital health initiatives like South Korea, Japan, and China. Adoption rates were around 30%, with a growing trend as awareness and infrastructure improved.
 - **Africa and Latin America:** Lower adoption rates were reported in Africa and Latin America due to limited healthcare resources and technological infrastructure. Adoption rates were below 20%, highlighting the need for targeted efforts to bridge the digital divide.
- **Factors Influencing Adoption**
 - **Technological Access:** Access to digital devices and reliable internet connectivity was a primary determinant of DTx adoption. Regions with better technological infrastructure saw higher adoption rates.
 - **Economic Factors:** Cost and reimbursement policies significantly influenced adoption. In regions where DTx were covered by insurance or provided at a reduced cost, adoption rates were higher.
 - **Socio-Cultural Acceptance:** Cultural attitudes towards technology and trust in digital health interventions played a crucial role. Regions with higher digital literacy and positive attitudes towards technology experienced greater adoption.

Barriers and Facilitators to Adoption

- **Technological Barriers and Facilitators**
 - **Barriers:** Limited digital literacy, physical impairments, and lack of access to digital devices and reliable internet were significant barriers. Older adults often faced challenges in using complex interfaces and required additional support.
 - **Facilitators:** Development of user-friendly interfaces, accessibility features (e.g., larger text, voice commands), and community-based digital literacy programs were crucial facilitators. Providing affordable or subsidized devices also enhanced adoption.
- **Economic Barriers and Facilitators**
 - **Barriers:** High costs of devices and DTx services, coupled with insufficient insurance coverage, deterred many elderly patients from adopting DTx.
 - **Facilitators:** Policy changes to include DTx in insurance coverage, subsidies, and financial assistance programs significantly boosted adoption. Bundled service packages and affordable pricing models also played a positive role.

- **Socio-Cultural Barriers and Facilitators**
 - **Barriers:** Resistance to adopting new technologies, concerns about privacy and data security, and low trust in digital health solutions were prevalent barriers.
 - **Facilitators:** Educational initiatives to improve digital literacy, demonstration projects showcasing the benefits of DTx, and sharing success stories helped build trust and acceptance among older adults. Support from caregivers and family members was also vital.

- **Clinical Barriers and Facilitators**
 - **Barriers:** Integration challenges with existing healthcare systems, disruptions in clinical workflows, and lack of provider familiarity with DTx were significant barriers.
 - **Facilitators:** Developing integrated care models, providing training for healthcare providers, and ensuring seamless communication between traditional care and DTx platforms facilitated better integration and adoption.

- **Regulatory Barriers and Facilitators**
- **Barriers:** Complex and diverse regulatory requirements across regions, lengthy approval processes, and concerns about data privacy and security posed significant barriers.
- **Facilitators:** Streamlining regulatory approval processes, establishing clear guidelines and standards for DTx evaluation, and implementing robust data privacy and security measures were essential facilitators.

Summary of Findings

- Overall, the results from the reviewed studies underscore the efficacy of digital therapeutics in improving health outcomes for elderly patients with chronic conditions. Significant improvements were observed in clinical parameters such as HbA1c levels, blood pressure, symptom management, and mental health outcomes. However, the adoption of DTx remains uneven globally, with higher rates in regions with better technological infrastructure, supportive economic policies, and positive socio-cultural attitudes towards technology.
- The primary barriers to adoption include technological limitations, economic constraints, socio-cultural resistance, clinical integration challenges, and regulatory complexities. Addressing these barriers through targeted interventions and leveraging facilitators such as user-friendly design, economic incentives, educational initiatives, integrated care models, and supportive regulatory frameworks can significantly enhance the adoption and efficacy of DTx in elderly care.

- The findings of this systematic review provide valuable insights for healthcare providers, policymakers, and stakeholders aiming to optimize the integration of digital therapeutics in managing chronic conditions among the elderly population. By addressing the identified barriers and leveraging the facilitators, the potential of DTx to improve health outcomes and quality of life for older adults can be fully realized.

DISCUSSION

The findings from this systematic review indicate that digital therapeutics (DTx) hold significant promise for improving health outcomes in elderly patients with chronic conditions. However, the journey towards widespread adoption and integration of DTx into traditional healthcare systems is fraught with challenges. This discussion will elaborate on the implications of the results, examine the barriers and facilitators in greater depth, and propose strategies for optimizing the use of DTx in elderly care.

Efficacy of Digital Therapeutics

1. **Diabetes Management:** The studies reviewed consistently showed that DTx significantly improved glycaemic control in elderly patients. This improvement can be attributed to the real-time monitoring and personalized feedback mechanisms provided by these platforms. The ability to track glucose levels continuously and receive tailored dietary and exercise recommendations enables better adherence to management plans. This underscores the potential of DTx to act as an effective adjunct to traditional diabetes care.
2. **Hypertension Control:** The effectiveness of DTx in managing hypertension is evident from the substantial reductions in blood pressure observed in the studies. Automated medication reminders, coupled with lifestyle modification coaching, play a critical role in ensuring adherence to treatment regimens. This highlights the importance of behavioural interventions, facilitated by digital platforms, in managing chronic conditions like hypertension.
3. **Cardiovascular Disease Management:** The reduction in hospital readmissions among patients using cardiovascular DTx programs points to significant benefits in managing chronic cardiovascular conditions. These programs not only facilitate remote monitoring of vital signs but also promote patient education on heart-healthy behaviours. This indicates that DTx can play a crucial role in reducing healthcare costs and improving patient outcomes by preventing disease exacerbations and promoting self-management.
4. **COPD Management:** The marked reduction in COPD exacerbations with the use of DTx emphasizes the importance of daily symptom tracking and remote monitoring. These tools enable early detection of exacerbations and timely interventions, which are crucial in managing chronic respiratory conditions. This finding supports the integration of DTx into standard COPD care to enhance disease management and improve quality of life.
5. **Mental Health Support:** The significant reduction in depressive symptoms among elderly patients using digital cognitive behavioural therapy (CBT) applications highlights the potential of DTx in mental health management. Digital CBT provides accessible, structured therapy sessions that can be tailored to individual needs. This finding is particularly relevant given the high prevalence of mental health issues among the elderly and the barriers to accessing traditional mental health services.

Adoption Patterns and Influencing Factors

1. **Regional Variability:** The regional variations in DTx adoption rates can be primarily ascribed to variations in economic circumstances, socio-cultural attitudes, and technological infrastructure. Adoption rates are higher in North America and Western

Europe because of their developed healthcare systems and benevolent policies. In contrast, adoption rates are lower in areas like sections of Africa and Latin America that have inadequate economic resources and technological infrastructure.

2. **Technological Access:** An essential precondition for the implementation of DTx is having access to digital devices and dependable internet connectivity. One major obstacle that still exists is the digital gap, especially in underprivileged and rural areas. In order to increase DTx use among senior citizens, it is imperative to make improvements to internet connectivity and affordable devices available.
3. **Economic Factors:** The cost of DTx devices and services is a major barrier, especially for elderly patients on fixed incomes. Insurance coverage and reimbursement policies play a critical role in mitigating these costs. Regions where DTx is included in insurance coverage see higher adoption rates, underscoring the need for policy advocacy to expand coverage for digital health interventions.
4. **Socio-Cultural Acceptance:** Important socio-cultural obstacles include reluctance to adopt new technology, worries about data security and privacy, and low levels of digital literacy. To get past these obstacles, educational programs that enhance digital literacy and foster confidence in digital health solutions are crucial. Demonstration projects and success stories can also serve to reduce doubt and promote acceptance.
5. **Clinical Integration:** A few of the difficulties in integrating DTx into current healthcare systems are provider unfamiliarity and disturbances to clinical operations. Facilitating smooth integration and boosting acceptance requires training programs for healthcare providers and the creation of integrated care models that include DTx.
6. **Regulatory Landscape:** The regulatory environment for DTx is complex and evolving. Streamlining approval processes and establishing clear guidelines and standards for DTx evaluation are critical for promoting innovation and ensuring patient safety. Robust data privacy and security measures are also necessary to address concerns and build trust among users.

Implications for Healthcare Providers and Policymakers

1. **Enhancing Technological Infrastructure:** Investments in improving internet connectivity and providing affordable digital devices are crucial for expanding the reach of DTx. Public-private partnerships can play a significant role in addressing these infrastructure challenges and ensuring equitable access to digital health tools.
2. **Policy and Reimbursement:** Policymakers need to recognize the value of DTx in managing chronic conditions and include them in insurance coverage and reimbursement schemes. Financial assistance programs and subsidies for low-income elderly patients can further enhance affordability and access.
3. **Education and Training:** Comprehensive education and training programs for both patients and healthcare providers are essential for successful DTx adoption. Digital literacy programs tailored for older adults, along with continuous professional development for healthcare providers, can bridge knowledge gaps and promote effective use of DTx.
4. **Integrated Care Models:** Developing and implementing integrated care models that incorporate DTx can enhance care coordination and improve health outcomes. These models should facilitate seamless communication between traditional healthcare providers and digital platforms, ensuring continuity of care.

5. **Regulatory Support:** Regulatory bodies need to establish streamlined approval processes and clear guidelines for DTx. Ensuring robust data privacy and security measures will be crucial in building trust and promoting widespread adoption.
6. **Community and Stakeholder Engagement:** Engaging community organizations, caregivers, and family members in promoting DTx can significantly enhance adoption. Support networks and community outreach programs can provide the necessary assistance and encouragement for elderly patients to embrace digital health solutions.

These findings align with the potential benefits of digital therapeutics, as they can provide personalized, interactive, and accessible interventions that address the unique challenges faced by elderly patients with chronic conditions. However, the review also identifies several challenges and barriers to the widespread adoption and implementation of digital therapeutics in geriatric care. These include:

- Barriers to accessibility and digital literacy for senior users.
- Complicated reimbursement and regulatory frameworks that impede integration with healthcare systems.
- The requirement for stronger evidence-based validation, especially when it comes to long-term results and practical applications.
- Ethical issues with data security and privacy that need to be carefully considered and mitigated

To address these challenges and facilitate the successful integration of digital therapeutics in geriatric care, a multifaceted approach is necessary. This may involve:

1. Creating digital therapeutic designs that are accessible and easy to use, with an emphasis on enhancing caregiver support and computer literacy.
2. Defining precise legal requirements and payment schemes to encourage the use of these therapies.
3. Completing more thorough clinical trials and practical research to bolster the body of evidence supporting the long-term effectiveness and economical viability of digital therapies for the senior population.
4. Establishing strong data governance and security protocols to tackle moral dilemmas and foster confidence between senior citizens and their attendants.
5. Promoting cooperation between lawmakers, healthcare organizations, and technology companies in order to incorporate digital therapies into the workflows and infrastructure already in place in the healthcare industry.

Limitations and Future Research

1. **Study Limitations:** The studies reviewed varied significantly in terms of sample size, duration, and geographical coverage, which may limit the generalizability of the findings. Additionally, the rapid pace of technological advancements means that newer studies may yield different results.

2. **Need for Long-Term Studies:** Most studies reviewed had a relatively short follow-up period. Long-term studies are needed to evaluate the sustained efficacy and adoption of DTx in managing chronic conditions among the elderly.
3. **Diversity of Conditions:** While the review covered a range of chronic conditions, further research is needed to explore the efficacy of DTx in other prevalent conditions among the elderly, such as arthritis and neurodegenerative diseases.
4. **Impact of Socioeconomic Factors:** Future research should examine the impact of socioeconomic factors on DTx adoption and efficacy in greater detail, considering variables such as income, education, and social support.
5. **Cultural Context:** Understanding the cultural context and tailoring DTx interventions to meet the specific needs and preferences of different populations can enhance their effectiveness and acceptance.

Future Research Directions:

- Identify gaps in the current evidence base and propose areas for future research, such as long-term outcomes, real-world effectiveness, and subgroup analyses.
- Discuss the potential for using digital biomarkers and artificial intelligence to enhance the evaluation and personalization of DTx.
- Need for more interdisciplinary collaboration between clinicians, researchers, technologists, and policymakers to advance the field of DTx in geriatric care.

CONCLUSION

The world's aging population is expanding faster than civilization can provide for the medical demands of its senior citizens. Digital technologies hold great potential in meeting these demands and revolutionizing numerous facets of elder care. The way older persons interact with the healthcare system and obtain care is changing quickly thanks to these technologies, yet improper use of them may have detrimental effects on one's physical and mental well-being. For this reason, it's critical to give both the caregiver and the user the appropriate training. In order to guarantee that digital care is both accessible and affordable, its cost must also be taken into account, especially in mid- and low-income nations. To make digital devices generally accessible to the public, governments and regulators must work with them to integrate them into health insurance programs. Additionally, reducing the cost of research and production will be necessary to improve the devices' functionality and integration. To attain these objectives, collaboration with healthcare providers, more educational support for senior citizens, and ongoing interaction with legislators are necessary.

The promise of digital health treatments in supporting older individuals' healthy aging is highlighted in this comprehensive study. The results show how these interventions—which include mobile health apps, wearable technology, telehealth platforms, and tailored medicine made possible by big data analytics and artificial intelligence—can improve older populations' access, monitoring, and self-care.

According to the survey, there has been a significant surge in the adoption rates of digital health technology. To ensure fair access to and use of these treatments, a few divides and obstacles, such as mistrust and technological difficulties, still need to be addressed.

Web-based initiatives and telerehabilitation have demonstrated encouraging results in encouraging balanced lifestyles and healthy habits in senior citizens. Although most users are in favor of digital health solutions, they do stress the significance of ethical and patient-centered design. When implementing these technologies, it is imperative to take older individuals' unique needs and capacities into account in order to optimize their efficacy.

More thorough studies are obviously required to prove the value of digital health treatments in supporting healthy aging, even though the efficacy data are still in the early stages. Further investigation into the practical use, moral implications, and user experiences of digital health technology aimed at the elderly is also necessary.

The main conclusions of the systematic review on digital therapeutics (DTx) for the treatment of older individuals are as follows:

1. It has been demonstrated that DTx is a practical, satisfactory, effective, and acceptable method of providing care for older individuals during the COVID-19 epidemic. For this demographic, they may enhance a number of health outcomes.
2. More resources are required for patients in the older adult group to enhance their technical

proficiency and awareness when using mobile devices. User-friendly DTx features, like larger font, easy navigation, and voice commands, that are catered to the requirements and preferences of older persons are crucial.

3. The most often used technologies to offer DTx interventions** were mobile apps, web-based systems, and videogames. Addiction, chronic pain, and mental health issues were the most often researched clinical settings.

4. DTx can enable remote monitoring of elderly patients using wearable devices and connected sensor. This allows healthcare providers to track physiological parameters, medication adherence, and activity levels in real-time, enabling early detection of disease progression and timely interventions.

5. Personalized education, self-management strategies, and interactive coaching through DTx can improve disease literacy, promote self-care, and enhance adherence to treatments in older adults.

6. Cognitive training programs and virtual reality-based therapies delivered through DTx have the potential to maintain or improve cognitive function, mobility, and independence in elderly patients with conditions like dementia or stroke.

7. DTx can provide accessible and convenient care options for elderly patients with limited mobility or residing in rural areas through remote consultations, virtual support groups, and on-demand access to care.

8. Gamification, personalized goal-setting, and interactive features in DTx can improve patient engagement and adherence to treatments and lifestyle modifications in older adults.

These findings highlight the promise of DTx in delivering effective, accessible, and engaging care for older adults, especially during the COVID-19 pandemic. However, challenges remain in ensuring user-friendliness, digital literacy, and robust evidence-based validation of these interventions in geriatric populations.

To fully harness the potential of digital health interventions for promoting healthy aging, thoughtful implementation strategies and evidence-based, patient-centred solutions are crucial. These approaches may help people age in place, use healthcare resources less frequently, and identify changes in health status early. Nonetheless, it is critical to address the difficulties older persons have, such as age-related obstacles, unequal access, and individual variations in requirements and preferences.

The significance of digital health treatments in promoting healthy aging is highlighted by this comprehensive study. The evidence that is currently available indicates that digital health technology can significantly improve older individuals' health, well-being, and quality of life, even though further study is necessary. It is possible to optimize the uptake, efficacy, and pleasant user experiences of digital health interventions by taking into account user needs, eliminating barriers, and guaranteeing equal access.

RECOMMENDATIONS

Here are some key recommendations to increase the efficacy and adaptability of digital therapeutic (DTx) interventions for chronic disease management in older patients:

User-Centric Design

- Develop DTx with a strong focus on user-centred design principles tailored to the needs and preferences of older adults.
- Incorporate features like large text, simple navigation, voice commands, and caregiver support to improve accessibility and usability.
- Conduct user testing and iterative design with older adult end-users to refine the DTx interface and features.

Addressing Digital Literacy

- Provide training and support to improve digital literacy and skills among older adults to facilitate adoption and sustained use of DTx.
- Offer in-person training sessions, user guides, and ongoing technical support to help older patients navigate and engage with DTx.
- Partner with caregivers and family members to assist older adults in using DTx and troubleshoot any issues.

Evidence-Based Content

- Ensure DTx interventions are grounded in clinical evidence and best practices for managing specific chronic conditions in older populations.
- Collaborate with geriatric clinicians and researchers to develop age-appropriate content, dosing, and outcome measures for DTx.

- Conduct rigorous clinical trials to demonstrate the efficacy and safety of DTx in older adults with chronic diseases.

Integrated Care Delivery

- Integrate DTx into existing healthcare systems and clinical workflows to enable seamless delivery of care.
- Establish clear protocols for how DTx data will be monitored, acted upon, and incorporated into clinical decision-making.
- Provide training and support to healthcare providers on how to effectively prescribe, monitor, and interpret DTx for older patients.

Regulatory Clarity

- Work with regulatory bodies to establish clear guidelines and approval pathways for DTx in geriatric care.
- Develop standardized measures and endpoints to evaluate the efficacy and safety of DTx in older populations.
- Ensure DTx meet data privacy and security standards to protect sensitive health information of older adults.

Reimbursement Models

- Partner with payers to develop reimbursement models that incentivize the use of DTx in chronic disease management for older adults.
- Demonstrate the cost-effectiveness of DTx in reducing healthcare utilization and improving outcomes in older populations.
- Advocate for the inclusion of DTx in Medicare and Medicaid coverage to improve access for underserved older adults.

By implementing these recommendations, digital therapeutic interventions can be designed, delivered, and reimbursed in a way that optimizes their efficacy and adaptability for chronic disease management in older patients. Collaboration between technology providers, clinicians, payers, and regulators will be key to realizing the full potential of DTx in geriatric care.

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