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A systematic review of digital health technologies for the care of older adults during COVID-19 pandemic

Chenyu Zou, Abbey Harvard, Jingjing Qian and Brent I Fox

Abstract

Objective: During the Coronavirus Disease 2019 (COVID-19) pandemic, digital health technologies (DHTs) became increasingly important, especially for older adults. The objective of this systematic review was to synthesize evidence on the rapid implementation and use of DHTs among older adults during the COVID-19 pandemic.

Methods: A structured, electronic search was conducted on 9 November 2021, and updated on 5 January 2023, among five databases to select DHT interventional studies conducted among older adults during the pandemic. The bias of studies was assessed using Version 2 of the Cochrane Risk-of-Bias Tool for randomized trials (RoB 2) and Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I).

Results: Among 20 articles included in the review, 14 (70%) focused on older adults with chronic diseases or symptoms, such as dementia or cognitive impairment, type 2 diabetes, and obesity. DHTs included traditional telehealth interventions via telephone, video, and social media, as well as emerging technologies such as Humanoid Robot and Laser acupuncture teletherapy. Using RoB 2 and ROBINS-I, four studies (20%) were evaluated as high or serious overall risk of bias. DHTs have shown to be effective, feasible, acceptable, and satisfactory for older adults during the COVID-19 pandemic compared to usual care. In addition, some studies also highlighted challenges with technology, hearing difficulties, and communication barriers within the vulnerable population.

Conclusions: During the COVID-19 pandemic, DHTs had the potential to improve various health outcomes and showed benefits for older adults' access to health care services.

Keywords

COVID-19 pandemic, digital health, older adults, systematic review, telehealth

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Introduction

Healthcare systems around the world experienced challenges due to the Coronavirus Disease 2019 (COVID-19) pandemic. Therefore, routine healthcare services were severely restricted in many parts of the world, especially for vulnerable populations such as older adults. During the COVID-19 outbreak, many community services, which are deemed "nonessential," were suspended, including senior citizen centers, dementia care centers, geriatric clinics, and long-term care facilities.[1] According to findings from the National Poll on Healthy Aging, 29% of participants indicated a disruption of primary care appointments and 28% indicated a disruption of procedures, tests, or operations in 2021.[2] A specialized dental clinic for older adults in Switzerland reported a potential 81% decrease in clinical activity by December 2020 compared to 2019 ($p < 0.0001$).[3] The pandemic and lockdowns also brought

Department of Health Outcomes Research and Policy, Harrison College of Pharmacy, Auburn University, Auburn, AL, USA

Corresponding author:
Chenyu Zou, Department of Health Outcomes Research and Policy, Harrison College of Pharmacy, Auburn University, Auburn, AL 36849, USA.
Email: czz0063@auburn.edu

significant challenges to the care for older adults with cancer[4–6] and mental health.[7–9] Additionally, older adults living in rural areas faced additional risks and challenges related to COVID-19 as rural hospitals and clinics were vulnerable to closure during this pandemic, due to limited elective and routine procedures.[10,11] Other social and economic infrastructure collapse in rural communities also had negative long-term impact on rural older adults beyond COVID-19.[10,12]

According to the U.S. Food and Drug Administration (FDA), digital health technologies (DHTs) are electronic tools, systems, software, or devices that collect, share, and analyze health information for purposes of improving health outcomes and healthcare delivery.[13–15] During the pandemic, DHTs played essential roles in aiding diagnosing, monitoring, screening, and prognosticating the infection.[16,17] As a result, DHT usage for older adults surged in 2020. In the US, the growth of telemedicine offset about two-thirds of the decrease in in-person clinical visits during the COVID-19 pandemic.[18] Data from Singapore indicated that a larger proportion of older adults accepted teleconsultations compared with younger patients seen by the general medicine department.[19] A study conducted in the UK assessed consultations between February and May 2020 for older adult patients and found the rate of telephone and electronic/video consultations more than doubled across the study period (106% and 103%, respectively), while face-to-face consultations fell by 65% and home visits decreased by 63%.[20]

There was increasing evidence in challenges of implementation and utilization of DHTs for older adults during unique circumstances, such as the COVID-19 pandemic, when DHTs were the only available options for healthcare.[21] The sudden surge in demand and limited transition time placed immense pressure on digital health systems, leading to technical difficulties and service delays.[22] Also, the pandemic has highlighted disparities in access to digital health tools particularly among vulnerable populations who may not have access to the necessary technology or internet connectivity, such as older adults.[23–25] An umbrella review of systematic reviews evaluated publications from January 2000 to October 2019, indicating the possibility for digital interventions to reduce demands on hospitals.[14] Scoping reviews reported that mental health and DHTs were major factors influencing older people's health during the pandemic.[26–28] A systematic review found that telemedicine was a feasible approach to assist older patients with dementia.[29] A comprehensive understanding of what happened in the wake of the rapid implementation and use of DHTs be vital for communities, health professionals and stakeholders. Lessons learned during pandemic can be used beyond the pandemic. Therefore, the aim of this systematic review is to answer the research question: what is the current evidence on the overall implementation and use of DHTs among older adults during the COVID-19 pandemic?

Methods

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines provided the framework for this systematic review. Databases included in the search were PsycINFO, Ovid National Library of Medicine's bibliographic database/article index (MEDLINE), Cumulative Index to Nursing and Allied Health Literature (CINAHL), International Pharmaceutical Abstracts (IPA), and Web of Science. The search dates included 1 January 2020, the beginning of the pandemic, to 9 November 2021. The search was then updated on 5 January 2023, to include newer studies published after 9 November 2021.[30] To identify relevant articles, we also hand searched the reference lists of included articles and review papers and those articles identified via this method were also evaluated for eligibility.[31] An extensive search strategy was developed with the guidance of a Health Sciences Librarian at the primary author's university (Supplementary Appendix 1). To detect duplicates and screen articles in accordance with the PRISMA guidelines, all study citations were exported into the Endnote X9 (Philadelphia, PA, USA) reference management software. Participant consent was not required for this study because all data were from previously published articles. Additionally, there was no direct involvement with patients in the current study.

Eligibility criteria

To identify eligible studies, CZ and AH independently screened these studies based on their titles and abstracts, and all duplicates were removed. Full text articles meeting the following criteria were retained and reviewed by CZ and AH: (a) peer-reviewed studies written in English and with completed results; conference abstracts, letters to editors, and research proposals were excluded; (b) applied experimental study design instead of observational studies; (c) the targeted interventions were related to any kind of DHTs; (d) the target population included older adults (aged 65+) only with samples specifically identified (i.e. aged 60+ or aged 55+, vs "older adults" or "elder population"); (e) the interventions were conducted after the start of COVID-19; (f) the study was focused on clinical or humanistic outcomes (e.g. acceptability, feasibility, effectiveness, adherence, and satisfaction) of DHTs. Studies focused economic outcomes,[32] were excluded. All included and excluded items were reviewed by CZ and AH to determine whether they met the criteria, and conflicts were solved by discourse and consensus among the research team. This review followed the FDA definition of digital health, which includes "mobile health (mHealth), health information technology (IT), wearable devices, telehealth

and telemedicine, and personalized medicine."[15] Artificial intelligence (such as robotic devices) was also included as a digital health intervention.[33]

Data extraction

Data extraction was performed by CZ and verified by AH, JQ, and BIF. The following data were extracted from the selected full-text studies: (a) authors; (b) study design (i.e. quasi-experimental study, randomized controlled trial (RCT); non-RCT); (c) DHT interventions; (d) comparations; (e) sample size; (f) samples; (g) settings; (h) outcomes; (i) results; and (j) location.

This study followed the Synthesis without meta-analysis in systematic reviews guidance.[34] Because of the heterogeneity in settings, outcome measures, and study designs, conducting a meta-analysis was not feasible for this study.[35] A narrative synthesis was performed by grouping DHT outcomes: effectiveness, feasibility, acceptability, and satisfaction. Effectiveness was measured by the P-values for the clinical outcomes from the individual study,[34] while feasibility was assessed based on the recruitment and retention.[36] Acceptability and satisfaction were evaluated through humanistic outcomes.[37]

Quality assessment

The bias of RCT studies was assessed using Version 2 of the Cochrane Risk-of-Bias Tool for randomized trials (RoB 2).[38] This tool includes five domains of bias: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported results. All domains of RoB 2 and the overall risks of bias were judged as high, low, or some concerns.[39] The bias of other studies (including both quasi-experimental studies and non-randomized clinical trials) was assessed using Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I).[40] This tool includes seven domains of bias: confounding, selection of participants into the study, classification of interventions, deviation from intended interventions, missing data, measurement of outcomes, and selection of reported result. Domains for ROBINS-I were judged as low, moderate, serious, critical, no information, and overall risks of bias were judged as low, moderate, serious, and critical.[41]

Results

A total of 569 records were identified through database searching and hand-searching, and 52 articles were excluded after removing duplications. After screening titles and abstracts, we included 42 articles for full-text review. Finally, 15 full-text articles met all inclusion and exclusion criteria and were selected for this systematic review based on the original search, and additional five articles were included from the updated search conducted on 5 January 2023 (Figure 1).

Characteristics of the studies

The overall characteristics of the 20 included studies are described in Table 1. Most (12, 60%) were published in 2021. Five (25%) studies were conducted in Asia, five (25%) in Europe, and three (15%) in the Middle East. There were six (30%) RCTs, while the rest 14 were quasi-experimental studies (one study with a separate comparison group and thirteen studies with one-group pretest–posttest design). The total number of participants of RCTs and non-RCTs was 542, accounting for 47.70% of the total number of participants of 20 included studies. The longest duration of interventions was 6 months,[42] while most studies lasted for 1 to 3 months. Hsieh CH et al. explored immersive garden experience using virtual reality devices in nursing homes, so their intervention lasted 6 min.[43]

Features for participants and interventions

Most (14, 70%) studies focused on older adults with chronic diseases or symptoms, and eight studies targeted older adults with mental health issues, including cognitive impairment or dementia,[43–47] memory concerns,[48] neurocognitive disorder,[49] and affective disorders.[50] Other chronic diseases or symptoms included pain,[51] type 2 diabetes,[42,52] Parkinsonism,[53] rheumatoid arthritis,[54] and obesity.[42,55] It is worth mentioning that two studies targeted both older adults and caregivers,[49,56] and one study also included grandparents and grandchildren.[57]

DHTs encompassed various distinct applications, such as health care services delivered via television,[47] telephone,[51,58,59] video meeting,[46,48,49,60] social media,[45,61] mobile applications,[53,56] and website-based telehealth.[50,52,55] In addition to "traditional" DHTs, several new approaches were implemented in health care sectors. Adly AS et al. evaluated a novel teletherapy approach (i.e. laser acupuncture) for older adults with rheumatoid arthritis.[54] Park EA, Jung AR, and Lee KA conducted an RCT and indicated that robot-assisted, multi-domain cognitive training can promote cognitive function and depression for older adults with mild cognitive impairment.[44] Some studies investigated the utilization of wearable devices, such as virtual reality devices,[43,57] and self-monitoring Fitbit devices.[42]

Effectiveness

These twenty studies used various measures and outcomes to assess the effectiveness of DHTs, including mental well-being, physical activity, quality of life, and other clinical

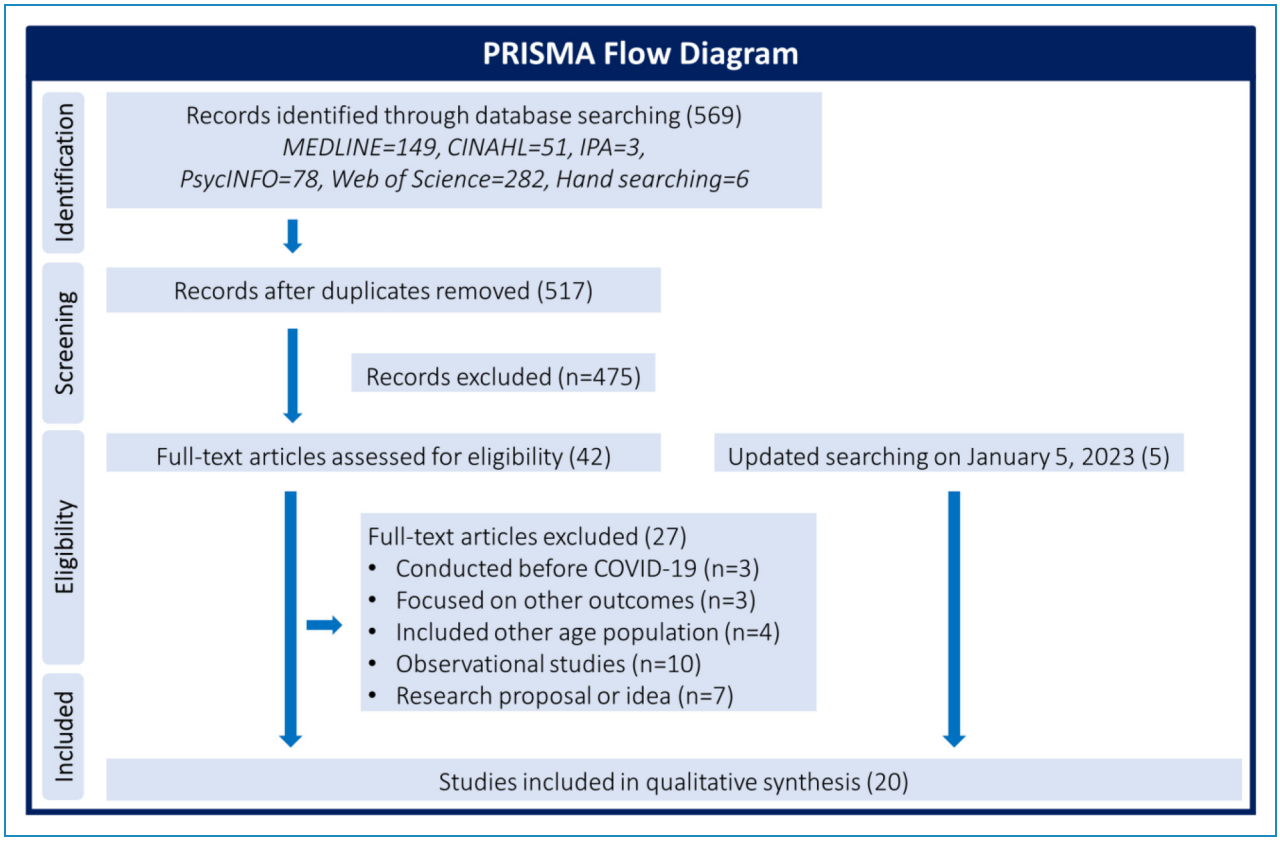

Figure 1. Study selection flowchart.

outcomes. Studies reported various mental health-related outcomes.[44,47,49,51,53,59,60] Park EA, Jung AR, and Lee KA found that participants receiving robot-assisted cognitive training had significant improvement in cognitive function ($t = 4.707$, $p < 0.001$), memory ($t = -2.282$, $p = 0.007$), executive function ($t = 4.610$, $p < 0.001$), and depression ($t = -3.307$, $p = 0.004$). Shapira S et al. found a medium ameliorative effect on loneliness ($d = 0.58$), and marginally significant improvement on depressive symptoms ($d = 0.43$) for the intervention group, which completed online, guided sessions via the Zoom videoconferencing platform.[60]

DHT interventions also focused on sedentary behavior and physical activity among older adults.[52,53,55] During the COVID-19 pandemic, an in-person, community-based exercise program for adults with type 2 diabetes was transited to a web-based group program, and significant improvements were found in five physical fitness outcomes.[52] Kim A et al. used International Physical Activity Questionnaire (IPAQ), Parkinson's Disease Questionnaire-39 (PDQ-39), and Geriatric Depression Scale (GDS) to measure physical activity levels for older adults with Parkinsonism.[53] After an 8-week home-based exercise program, participants reported a significant increase in the total amount of exercise ($p < .001$) and significant improvements in the IPAQ ($p = 0.006$), PDQ-39 ($p = 0.02$), and GDS ($p = 0.04$) scores.

Feasibility

Several studies included in this review reported the high feasibility of DHTs for older adults. Brandao L et al. found that the group-based remote activities were feasible and well-received among older adults living with cognitive impairments.[45] Additionally, a physical activity protocol that involved training at home was shown to be feasible for community-dwelling older adults,[61] and sessions were also found to be "relaxing and fun" for patients with affective disorders.[50] Despite the promising feasibility of DHTs for older adults, Prieto-Moreno et al. emphasized the limitations in preliminary results and called for future RCTs to better measure the clinical outcomes of DHTs.[56]

Acceptability and satisfaction

Studies focusing on participants' acceptability and experience applied qualitative methods, such as focus groups and interviews. Included studies reported high acceptability of DHTs, and participants reported favorable experiences.[42,43,45,48,50,51,54,61] Cooper C et al. identified that the overarching theme during the APPLE-Tree program

Table 1. Characteristics of included studies.

Author	Study design	DHT interventions	Comparisons	Sample size	Participants	Settings	Outcomes	Results	Location
Plumb Vilardaga et al.	RCT	Two telephone-delivered treatment sessions with a fitness tracker, and 6 weeks follow-up	Usual care plus a fitness tracker	40	Adults (>65 yrs) with OA pain in the knee or hip	Individual	Feasibility and acceptability	Significant improvements in arthritis pain severity ($M_{diff} = 1.68$, $p = 0.044$) and self-reported activity ($M_{diff} = 0.875$, $p = 0.038$) for intervention group. 5% attrition, 100% completion, and 89% satisfaction.	USA
Adly AS et al.	RCT	Laser acupuncture (6 sessions per week for 4 weeks), methotrexate and a tele-rehabilitation program	Methotrexate and a tele-rehabilitation program	60	Adults (65–75 yrs) with rheumatoid arthritis	Individual	Effectiveness and satisfaction	Statistically significant differences ($p < 0.05$) in CRP, RAQoL, IL-6 and MDA for intervention group. Satisfaction scored 4.7/5.0.	Cairo
Wong AKC et al.	RCT	Weekly case management via telephone call and video messages for 3 months	Monthly social telephone calls	68	Homebound adults (>60 yrs)	Individual	Effectiveness	Significant improvement in group interactions, time's effects on medication adherence ($\beta = -8.30$; $p = .001$), and QoL ($\beta = 4.99$; $p = .04$) for intervention group.	China
Goodman-Casanova JM et al.	RCT	TV-based Assistive Integrated Service for 12 months	No intervention	93	Community-dwelling adults (>60 yrs) with mild cognitive impairment or dementia	Community	Effectiveness	Respondents with TV-AssistDem performed more memory exercises (52% vs 17.4%; $p < .001$).	Spain and Romania
Park EA, Jung AR, & Lee KA	RCT	Robot-assisted cognitive training program, twice a week for 6 weeks	No intervention	135	Community-dwelling adults (>60 yrs) with mild cognitive impairment	Community	Effectiveness	Significant improvement in in cognitive function ($t = 4.707$, $p < 0.001$), memory ($t = -2.282$, $p = 0.007$), executive function ($t = 4.610$, $p < 0.001$), and depression ($t = -3.307$, $p = 0.004$) for intervention group.	Korea

(continued)

Table 1. Continued.

Author	Study design	DHT interventions	Comparisons	Sample size	Participants	Settings	Outcomes	Results	Location
Shapira S et al.	RCT	Seven twice-weekly online online guided sessions via Zoom	No intervention	86	Community-dwelling adults (>65 yrs)	Community	Effectiveness	Significant improvement in loneliness ($d = 0.58$) and depressive symptoms ($d = 0.43$) for intervention group.	Israel
Lai FH-Y et al.	Non-randomized controlled trial	Weekly health services are delivered through video communication apps and weekly care service via telephone	Weekly care service via telephone	60	Adults (65–80 yrs with NCD) and caregivers	Community	Effectiveness	Supplementary telemedicine had averted the deterioration cognitive assessment ($\eta_p^2 = 0.50$) and QoL-AD ($\eta_p^2 = 0.23$).	China
Jiwani R et al.	Pre-Post	Self-monitoring Fitbit device for 6 months	N/A	20	Community-dwelling overweight or obese adults (>65 yrs) with T2D	Community	Acceptability	High acceptability of the program. Participants reported favorable experiences and high QoL.	USA
Brandao L et al.	Pre-Post	Playful living program, video calls, and WhatsApp groups for 3 months	N/A	24	Adults (>60 yrs) with low socioeconomic conditions and medical history of stroke or diagnosis of dementia	Individual	Feasibility	83.7% of adherence and sustainability.	Brazil
Cooper C et al.	Pre-Post	Weekly group-based video-call for 10 weeks	N/A	17	Adults (>60 yrs) with memory concerns but without dementia	Individual	Acceptability and feasibility	83.3% sessions were attended. Social connections supported group attendance and implementation of lifestyle changes.	UK
Schwartz H et al.	Pre-Post	Online PA protocol via Zoom and WhatsApp for 8 weeks	N/A	30	Community-dwelling adults (>60 yrs)	Community	Feasibility and satisfaction	90% Adherence. Satisfaction 6/7.	Israel

(continued)

Table 1. Continued.

Author	Study design	DHT interventions	Comparisons	Sample size	Participants	Settings	Outcomes	Results	Location
van Dijk SDM et al.	Pre-Post	Online therapy program for 20 weeks	N/A	4	Adults (>60 yrs) with chronic affective disorders and personality problems	Individual	Feasibility	100% Adherence. High Satisfaction.	Netherlands
Gareri P et al.	Pre-Post	Remote care management via telephone/video call for 90 days	N/A	90	Older adults with cognitive disorders	Ambulatory outpatients and home care patients	Effectiveness	Significant decrease in ADL ($p = 0.001$), MMSE ($p < 0.001$), and EuroQoL ($p = 0.005$).	Italy
Hsieh CH et al.	Pre-Post	6 min garden video experience	N/A	14	Adults (>50 yrs) with mild-to-moderate cognitive impairment living in nursing homes	Long-term care facilities	Effectiveness and satisfaction	Significant improvement in SDNN ($Z = 2.229$, $p = 0.026$). Participants expressed their satisfaction.	Taiwan
Prieto-Moreno et al.	Pre-Post	ActiveHip + mHealth mobile application for 12 weeks	N/A	69	Adults (>60 yrs) had undergone hip surgery and their caregivers	Individual	Feasibility	Positive effects on functional status (68.30/105.73 vs. 109.20/121.21), physical performance (3.14/7.22 vs. 3.36/6.85) and pain (5.28/2.14) vs. 5.21/3.06).	Spain and Belgium
Appel et al.	Pre-Post	VR films and weekly online sessions for 4 weeks	N/A	10	Grandchildren and grandparents (66–84 yrs)	Community	Effectiveness	Feel less isolated, more connected with other people and more confident in learning technology	Canada
Sekhon et al.	Pre-Post	Weekly phone calls from trained volunteers for 8 weeks	N/A	112	Adults (>60 yrs). Exclude individuals had psychotic symptoms, severe hearing	Community	Effectiveness	Significant improvements in depression (mean change score = −2.27, $p = 0.003$) for participants with higher	Canada

(continued)

Table 1. Continued.

Author	Study design	DHT interventions	Comparisons	Sample size	Participants	Settings	Outcomes	Results	Location
					impairment, or active suicidal ideation.			baseline depression scores.	
Johnson N et al.	Pre-Post	Online intervention contents via Google Classroom for 6 weeks	N/A	13	Cognitively intact adults (>65 yrs) with BMI $\geq$ 30 kg/m^2	Individual	Effectiveness	Moderate-to-vigorous PA increased by 2 min/day (CI: −21, 26) and 12 min/week (CI: −154, 180).	USA
Kim A et al.	Pre-Post	Home-based telehealth exercise program for 8 weeks	N/A	21	Adults (>62 yrs) with parkinsonism	Outpatient	Effectiveness	Significant increase in the total amount of exercise ($p < .001$), PDQ-39 ($p = 0.02$), and GDS ($p = 0.04$).	Korea
Kirwan et al.	Pre-Post	Twice-weekly supervised group exercise and education program via videoconference for 8 weeks	N/A	171	Adults with T2D	Community	Effectiveness	Significant improvements in waist circumference, aerobic capacity, muscular strength, flexibility, and balance (all $p < 0.001$).	Australia

Note: BMI: body mass index; CRP: C-reactive protein; GDS: geriatric depression scale; IL-6: interleukin-6 inflammatory markers; MDA: plasma malondialdehyde oxidative marker; NCD: neurocognitive disorder; OA: osteoarthritis; PA: physical activity; PDQ-39: Parkinson's disease questionnaire-39; Pre-Post: one-group pretest-posttest design; QoL: quality of life; QoL-AD: quality of life in Alzheimer's disease; RAQoL: rheumatoid arthritis quality of life; RCT: randomized control trails; SDNN: standard deviation of NN intervals (interval between two heartbeats); T2D: type 2 diabetes.

was social connectedness, as well as three sub-themes: retaining independence and social connectedness, adapting social connectedness in the pandemic, and managing social connections within and through the intervention.[48]

Challenge and difficulties for older adults to adopt DHTs

Studies also highlighted challenges within this population. Jiwani R et al. reported that challenges during the Fitbit Program included "physical impediments", "resistance to lifestyle changes", and "operating a new piece of technology".[42] Schwartz H et al. found that some participants reported technology issues, such as login difficulties, unstable internet connection, and inability to turn on the camera. Other comments are about the only exercise protocol that some instructions were difficult and unclear.[61]

Quality of included studies

The results of quality assessment of RCT studies using RoB 2 are shown in Table 2. Because of missing information about allocation concealment, blinding, or random sequence generation, five studies have some concerns of the overall risk of bias, and one was judged as serious overall risk. The results of quality assessment of the other studies using ROBINS-I are shown in Table 3. There were three studies judged as serious risk of bias in at least one domain, nine were judged as moderate overall risk of bias, and two were judged as low risk of bias at all seven domains. No study is judged to be at critical risk of bias.

Discussion

This systematic review synthesized evidence in the implementation and use of DHTs among older adults during the COVID-19 pandemic. In this systematic review, 20 articles implemented various forms of DHT programs in different settings, highlighting the breakthrough of DHTs in healthcare, mental health, community, and long-term care among older patients and caregivers. During the COVID-19 pandemic, DHTs met the current health care needs of older adults while demonstrating the potential to improve various health outcomes.

Current evidence supported the importance of DHTs among the older adult population. This systematic review found that DHTs had been implemented or incorporated into other programs to address the challenges and difficulties associated with healthcare for older adults. During the COVID-19 pandemic, DHTs were used as a feasible alternative and adjunct to conventional usual care delivery to improve clinical outcomes, promote mental well-being, and provide educational and communicational support. Banskota S et al. evaluated 15 smartphone applications for older adults during the COVID-19 pandemic lockdown, indicating the potential of mobile technologies to improve older adults' well-being and quality of life.[62] Recent systematic reviews of telehealth have demonstrated its capability to improve health service delivery, reduce medical costs, and decrease the risk of morbidity and mortality among older adults.[63,64] Consistent with these studies, the current systematic review found DHTs to be effective among the elder population, including participants with chronic diseases or mental health problems. Results of this study are consistent with a previous meta-analysis focusing on telemedicine in patients with chronic disease.[65] Authors reported that telemedicine had a positive effect on the management of several chronic diseases during the COVID-19, including diabetes, hypertension, and rheumatoid arthritis. Findings of this systematic review are consistent with the previous review conducted by Rodrigues NG et al. that summarized the benefits of online interventions to combat social isolation among older adults, revealing that remote

Table 2. Quality assessment of five RCT studies using RoB 2.

Author	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Overall
Adly AS et al.	Some concerns	Some concerns	Low risk	Some concerns	Low risk	Some concerns
Goodman-Casanova JM et al.	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Park EA, Jung AR, & Lee KA	Some concerns	Low risk	Low risk	Low risk	Low risk	Some concerns
Plumb Vilardaga et al.	High risk	Low risk	Low risk	Some concerns	Low risk	High
Shapira S et al.	Some concerns	Some concerns	Some concerns	Low risk	Low risk	Some concerns
Wong AKC et al.	Some concerns	Some concerns	Low risk	Low risk	Low risk	Some concerns

Note: Domain 1: risk of bias arising from the randomization process; Domain 2: risk of bias due to deviations from the intended interventions; Domain 3: missing outcome data; Domain 4: risk of bias in measurement of the outcome; Domain 5: risk of bias in selection of the reported result.

Table 3. Quality assessment of the other 10 studies using ROBINS-I.

Author	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Domain 6	Domain 7	Overall
Appel et al.	Moderate	Moderate	Low	Low	Low	Moderate	Low	Moderate
Brandao L et al.	Moderate	Low	Low	Moderate	Low	Moderate	Low	Moderate
Cooper C et al.	Serious	Serious	Low	Moderate	Moderate	Low	Low	Serious
Gareri P et al.	Moderate	Low	Serious	Serious	Low	Low	Moderate	Serious
Hsieh CH et al.	Moderate	Low	Low	Moderate	Low	Low	Low	Moderate
Jiwani R et al.	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Johnson N et al.	Moderate	Moderate	Low	Moderate	Low	Low	Low	Moderate
Kim A et al.	Low	Low	Low	Low	Low	Low	Low	Low
Kirwan et al.	Low	Low	Low	Low	Low	Low	Low	Low
Lai FH-Y et al.	Moderate	Low	Moderate	Moderate	Low	Low	Low	Moderate
Prieto-Moreno et al.	Moderate	Low	Low	Low	Low	Moderate	Low	Moderate
Sekhon et al.	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Schwartz H et al.	Moderate	Low	Moderate	Moderate	Low	Low	Low	Moderate
van Dijk SDM et al.	Moderate	Serious	Serious	Serious	Low	Serious	Low	Serious

Note: Domain 1: confounding; Domain 2: selection of participants; Domain 3: classification of interventions; Domain 4: deviations from intended interventions; Domain 5: missing data; Domain 6: measurement of outcomes; Domain 7: selection of reported results.

interventions could be the "new normal in the COVID era."[66]

Implications

The COVID-19 pandemic accelerated the adoption of DHTs, and this transit has important implications for older adults and health providers. Despite the importance and popularity of DHTs, health providers should be aware that not all older patients may be amenable to DHTs, and the implementation of DHTs may not be appropriate in all settings.[67] Studies included in this systematic review revealed barriers and challenges, such as patient resistance of change and technology issues.[42,61] Older adults may benefit from health services via DHTs, while Haimi, M and Gesser-Edelsburg, also reported insufficient services were developed and implemented to fully satisfy the needs of this population.[64] Hawley CE et al. identified patient-reported challenges to integrating home telehealth visits, including interest, access to technology, and confidence.[68] Additionally, DHTs cannot substitute completely for in-person visits in some specific settings. Research conducted in Spain found that the reduction in face-to-face visits may negatively impact follow-up and blood sugar control among patients with type 2 diabetes mellitus. Regulation issues, such as privacy disclosures and reimbursement policies, are also vital factors during the implementation of DHTs. In the U.S., the government issued an emergency waiver suspending the requirement to comply with the Health Insurance Portability and Accountability Act (HIPAA), meaning that video platforms like Apple FaceTime and Facebook Messenger video chat —which are not HIPAA compliant—may be used.[69] The U.S. Center for Medicaid and Medicare Services also updated their guidelines to allow patients to use remote counseling for Medicare telehealth encounters. As flexible interventions, DHTs may contribute to various programs for older adults, but further research is needed to optimize DHTs across settings.

While the use of DHTs among older adults has been shown to be important, external factors such as socioeconomic status, geographic location, and digital literacy can pose barriers to older adults seeking to adopt DHTs, which could increase the health disparities.[70–72] To address these issues, efforts can be made to provide training and resources to increase digital literacy among underserved

populations.[73] Additionally, expanding access to affordable DHTs, such as through subsidized programs or partnerships with healthcare providers, could help to increase the adoption rates and feasibility of DHTs.[74,75] It is also crucial to consider diversity in study populations and ensure that DHT interventions are accessible, affordable, user-friendly, and tailored to meet the unique needs of all older adults, including those from diverse backgrounds.[76,77] By addressing these challenges and promoting equitable access to DHTs, older adults could benefit from the full potential of these technologies to improve their health outcomes and quality of life.

The diverse characteristics of DHTs studies, such as design methodologies, target populations, and intervention and delivery types, may impact the outcomes of these studies. It is possible that studies with different designs (e.g. RCTs, quasi-experimental studies, and qualitative studies) yield different results, with RCTs generally considered more robust than quasi-experimental studies.[78] Also, the inclusion of diverse populations could lead to various experiences of DHTs. For example, older adults with cognitive impairments may face additional challenges in using DHTs, such as difficulties with technology and communication and need more personalized and accommodated support.[79–81] Additionally, preferences of patients and health providers regarding the intervention and delivery types of DHTs may vary. Lai R et al. reported that older adults with cognitive impairment were more receptive to the reminder function, emergency feature, and wearable form of the telehealth than carer monitoring.[79] Future study is needed to understand to whom, when, and how clinicians and institutions should deploy larger-scale efforts to integrate DHTs into the care of older adults, with a larger sample size and longer follow up.

Limitations

This study includes articles published from the beginning of the pandemic (1 March 2020) until data extraction (5 January 2023), for a total of approximately 22 months. Relevant articles were identified through a comprehensive literature search using well-defined inclusion criteria. However, there are several limitations and challenges in this systematic review. First, our search might have missed studies published after the date of data extraction, conducted during the early months of the pandemic that are not yet published, missing from the search-engines or databases, or published in a language other than English.[66] Second, since we are limited to interventional studies and original research papers, considering the complexity and time requirement to conduct randomized or controlled experiments, it is difficult to report new insights in a short period of time. Most experimental studies applied non-randomized or no controlled study design and for RCTs, the sample size is relatively small with short follow-up. Typically, studies with small numbers of observations and less robust designs may result in unreliable or inconclusive results.[82,83] Another limitation is that a variety of sampling, designs, qualities, and settings in the included articles may affect synthesis. Rodrigues NG et al. also indicated that it could result in bias to combine community-based studies and research conducted in long-term care facilities in a single review.[66] In addition, a meta-analysis could not be conducted in this study, which limits the generalizability and broader implications of findings.

Conclusion

This systematic review found that DHTs have been shown to be effective, feasible, acceptable, and satisfactory in delivering care for older adults during the COVID-19 pandemic. The significance of this study lies in its contribution to the understanding of the challenges and opportunities—broadly—of implementing DHTs in older adult populations. Patients in the older adult population need more resources to improve their awareness of and technical skill with mobile devices. One example could be creating user-friendly digital health tools that are specifically tailored to older adults' needs and preferences, such as larger text, simple navigation, and voice commands.[84,85] However, due to the heterogeneous methodologies and varying quality of the studies included in this review, it was challenging to draw definitive conclusions on certain aspects, such as calculating the exact efficacy size of DHTs. For future studies, RCTs with larger sample sizes, blinding techniques, and longer follow-up periods are expected to minimize the risk of bias.

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ORCID iD: Chenyu Zou https://orcid.org/0000-0003-3151-1527

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