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Invited Perspective

A Future Research Agenda for Digital Geriatric Mental Healthcare

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ABSTRACT

The proliferation of mobile, online, and remote monitoring technologies in digital geriatric mental health has the potential to lead to the next major breakthrough in mental health treatments. Unlike traditional mental health services, digital geriatric mental health has the benefit of serving a large number of older adults, and in many instances, does not rely on mental health clinics to offer real-time interventions. As technology increasingly becomes essential in the everyday lives of older adults with mental health conditions, these technologies will provide a fundamental service delivery strategy to support older adults' mental health recovery. Although ample research on digital geriatric mental health is available, fundamental gaps in the scientific literature still exist. To begin to address these gaps, we propose the following recommendations for a future research agenda: 1) additional proof-of-concept studies are needed; 2) integrating engineering principles in methodologically rigorous research may help science keep pace with technology; 3) studies are needed that identify implementation issues; 4) inclusivity of people with a lived experience of a mental health condition can offer valuable perspectives and new insights; and 5) formation of a workgroup specific for digital geriatric mental health to set standards and principles for research and practice. We propose prioritizing the advancement of digital geriatric mental health research in several areas that

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are of great public health significance, including 1) simultaneous and integrated *treatment of physical health and mental health conditions; 2) effectiveness studies that explore diagnostics and treatment of social determinants of health such as "social isolation" and "loneliness;" and 3) tailoring the development and testing of innovative strategies to minority older adult populations.* (Am J Geriatr Psychiatry 2019; ■■:■■–■■)

The past two decades have seen major advances in geriatric mental health research in an effort to prepare for the doubling of the population of older adults with mental health conditions.[1] From breakthroughs in genomics,[2] advances in Alzheimer's biological markers,[3] improvement in treatment,[4] to redesigning healthcare[5,6]—the healthcare system has advanced to help older adults with mental health needs. However, many of the same issues persist and new crises have arisen that require our dedicated effort. To begin, opioid misuse among older adults has doubled from 1.1% in 2002 to 2.0% in 2014.[7] Alzheimer's disease now impacts approximately 5.5 million adults aged 65 years and older,[8] and in 2018 alone, Alzheimer's and other dementias cost the United States $277 billion.[9] Additionally, despite years of dedicated efforts and funding, the gap in life expectancy between the general population and middle-aged and older adults with serious mental illness is actually growing.[10] Finally, there is still a shortage of a skilled geriatric workforce to address these needs.[1]

Digital mental health is positioned to lead to the next breakthrough in mental health intervention and services research. Digital geriatric mental health uses mobile, online, and remote monitoring technologies to enhance screening, assessment, and treatment of mental health conditions in older adults. Potential advantages to digital geriatric mental health are the ability to engage people who would otherwise might not engage in traditional mental health services, improve the reach of services, increase intervention dose outside of a clinical environment without additional demands on providers, and overcome geographic barriers by delivering services remotely.[11] Digital geriatric mental health can also be automatically customized to patients' preferences and recovery goals in order to simultaneously address *multiple* conditions[12] and monitor early warning signs of relapse, recurrence, or decline.[13]

Emerging research has found potential utility in digital mental health in diagnostics[13–15] and treatment [16–18] for people aged 18+ years. However, few studies focus on older adults, who experience unique barriers to care and engagement in digital interventions (e.g., different rates of technology adoption,[19] need for specific technology design principles,[20] different technology preferences,[21] and a higher need for interventions that address multimorbidity[22]) compared to their younger counterparts. The goal of this report is to highlight novel digital diagnostics and treatments for older adults with mental health conditions and offer recommendations for a future research agenda. This selective review highlights advances in the research literature on digital geriatric mental health services. Our objective was to critically evaluate the literature published relevant to digital geriatric mental health research, with an emphasis on the most promising findings and observations of progress made, and future opportunities. This selective review considered literature published in peer-reviewed journals in the past 36 months.

NOVEL EARLY PROGRAMS OF DIGITAL GERIATRIC MENTAL HEALTH RESEARCH

Here, we briefly highlight selected innovative digital geriatric mental health programs of research, including motion sensor technologies used to clinically support a mental health diagnoses,[23] machine learning to supplement clinical decision-making,[24,25] socially assistive robots designed to improve social connectedness,[26,27] and the augmentation of traditional service delivery with asynchronous technology.[28] All of these innovations have laid the groundwork for novel digital diagnostics and treatments for older adults with mental health conditions.

Motion Mapping

Motion mapping utilizes motion sensor data to develop phenotypic biomarkers of behavior.[23] Motion sensor data are collected from technologies

(e.g., accelerometers, gyroscopes, cameras, thermal sensors, lasers, radio wave sensors, global positioning system, and satellite imaging).[23] For example, researchers used motion sensor data to measure radio signals to determine a patients' gait speed, patterns, and spatial location.[23] These data have also served as phenotypic biomarkers of behavior for apathy, pacing, and disrupted circadian rhythms to clinically support a diagnosis of dementia.[23]

Machine Learning

With advancements in the sophistication, ease, and unobtrusiveness of data collection, digital geriatric mental health necessitate the use of analytical strategies such as artificial intelligence systems[29] that expand beyond traditional psychiatric epidemiology. In contrast to traditional statistical modeling, which primarily aims to draw population-level inferences from sample data, machine learning—a form of artificial intelligence—relies on patterns and interpretations of data to execute tasks without directives, with the intent to find generalizable and predictive patterns.[30] The use of advanced analytical techniques such as machine learning offers providers with tools to augment diagnostic decision-making and provide insights into how an individual might respond to particular treatment.[31] For example, recent studies of late-life depression have employed machine learning techniques to identify placebo-responders[24] and have predicted treatment response with 89% accuracy.[25] In the context of digital geriatric mental health, the use of machine learning is particularly advantageous in its capacity to identify predictive patterns using large datasets where there are many more variables than subjects.[32]

Socially Assistive Robots

Socially assistive robotics is a relatively new field of robotics that provides assistance to older adults in areas such as rehabilitation, learning, activities of daily living, and expressing emotions.[33] For example, the Pearl robot was designed to assist older adults in daily cognitive and physical activities, including 1) reminding older adults about basic and instrumental activities of daily living (e.g., eating, drinking, medication management, and personal hygiene) and 2) guiding the mobility of older adults in their physical environments.[26] Socially assistive robots have shown utility for improving social connectedness in individuals with dementia and their caregivers[34] and improving depressive symptoms in older adults.[27] Barriers to using socially assistive robotics with older adults include adoption barriers, engagement, privacy, cost, and access.[35,36]

Asynchronous Communication Technology

Asynchronous technology assists patients and providers in corresponding with one another without the need for communication to be time synchronized.[37] For example, an email or text message is asynchronous. By contrast, synchronous technology requires time-dependent communication such as a teleconference.[37] An example of the use of asynchronous technology is illustrated in one promising intervention, PeerTECH, in which older adults use a smartphone app to asynchronously communicate with an *older* peer support specialist regarding their daily self-management challenges and accomplishments.[38] The PeerTECH intervention demonstrated statistically significant improvements in psychiatric self-management skill development. A peer support specialist is an individual with a mental health condition who is providing support services within the mental health system.[39]

TOWARD A DIGITAL GERIATRIC MENTAL HEALTH RESEARCH AGENDA

Need for Proof-of-Concept Studies

Digital geriatric mental health has a similar challenge that is being experienced by the whole discipline of digital psychiatry—the need for additional methodologically rigorous proof-of-concept studies. Most studies that focus on older adults have included small, proof-of-concept pre/postdesigns that are not powered to test effectiveness[40–44] or case studies that examine usability and feasibility.[23] Additional proof-of-concept studies are needed. Few studies have completed adequately powered randomized controlled trials. Early phase studies should continue to examine the feasibility and acceptability of digital geriatric mental health interventions and also adapt study protocol and procedures for older adults whom may

present unique cognitive, social, and behavioral challenges compared to their younger counterparts. Feasibility should also examine engagement/adherence as many people of all ages discontinue use of technology prior to receiving intervention effects.[45]

Integrate Engineering Principles in Methodologically Rigorous Research to Help Science Keep Pace With Technology

As the field moves forward, studies that include conducting a fully powered randomized control trial will require an extensive amount of time. Within that timeframe, technology may have changed prior to completing the trial. As such, we recommend integrating engineering principles in methodologically rigorous digital geriatric mental health research to help science keep pace with technology. The Multiphase Optimization Strategy (MOST) and Sequential, Multiple Assignment Randomized Trial (SMART) research methodology, borrowed from engineering, have particular relevance to studies with older adults given the heightened and appropriate concerns about unnecessary burden on research participants.

The MOST is an adapted engineering framework designed to optimize and evaluate multicomponent interventions rapidly.[46,47] MOST involves three phases of research: 1) preparation (selecting components, collecting pilot and feasibility data, identifying criteria for the minimum effectiveness of individual or combined components for inclusion in an evaluation), 2) optimization (typically using a factorial experiment to determine which of the components, or which combination of components, meet the criteria for minimum effectiveness, and then determining the ideal ultimate treatment package), and 3) evaluation (testing that optimized treatment package in an effectiveness trial such as a randomized controlled trial).[46,47] Based on the results of the evaluation phase, the package is constantly refined through additional optimization phases whenever new components become available or when tailoring for specific populations is necessary. MOST's optimization phase is advantageous over other research designs because it allows for direct observation of the effect of individual or combined components with more accurate estimates of their effects (compared to post-hoc dismantling).[46,47] Additionally, MOST frameworks can facilitate the identification of mechanisms of action on outcomes and identify active intervention ingredients,[46] both of which creates a more efficient intervention.

The SMART design also uses an adapted engineering framework and is a useful technique for building stepped care models and just-in-time adaptive interventions. SMART trials allow for re-randomization based on response to an intervention while not overburdening responsive patients. Adaptive interventions can be built to only deliver interventions to the person in their moment of need. Incorporating adapted engineering research methodology can allow for the field of geriatric mental health to progress more rapidly, hopefully reducing the time for effective interventions to be implemented.

Specifically for older adults, SMART and MOST research designs may offer some additional protections against iatrogenic intervention effects (i.e., adverse effects of interventions) compared to their younger counterparts. Due to multimorbidity, which becomes increasingly common as individuals age with a mental health condition, older adults may experience worse health outcomes when a treatment is not as effective for them compared to a younger adult. By being more responsive to nonresponsivity in SMART designs or only giving participants components of an experimental intervention in a MOST trial, older adults may be less likely to be negatively impacted by trying new treatments.

Identification of Implementation Issues Specific to Older Adults

Understanding adoption and sustainment factors related to digital geriatric mental health may enhance uptake and facilitate implementation. Unlike younger adults, older adults have unique technology preferences, receive mental health services not only within mental health facilities and primary care, but also within aging agencies such as senior centers or meals on wheels services, and qualify for Medicare reimbursements. All of which present unknown implementation challenges and potential opportunities. A potential opportunity may be a nationwide reimbursement structure for technologies for older adults using the Medicare Advantage Plans, which could allow for community-based support services such as Certified Older Adult Peer Specialists services for homebound older adults; however, all of which, to our knowledge, needs to be explored using established implementation

frameworks. Incorporating established implementation frameworks can systematically identify variables of interest, and guide data collection, analysis, and interpretation of data. We also recommend exploration of opportunities for industry partnerships and technology transfer. One method to make an impact on population health is developing partnerships with industry. Industry partnerships can help researchers explore entrepreneurial opportunities for commercialization such as Small Business Innovation Research (SBIR) or the Small Business Technology Transfer (STTR) mechanisms.

Inclusivity of People With a Lived Experience of a Mental Health Condition Can Offer Valuable Perspectives and New Insights

Usability testing with end users (i.e., service users) in digital mental health intervention development promotes use and engagement in digital interventions.[48] A guide for usability testing with older adults with mental health conditions has been developed and is available for researchers.[11]

This usability testing guide was specifically developed for older adults with mental health conditions.[11] For example, researchers proposed smartphone design features needed for older adults with mental health conditions based on older adults' unique needs (see Table 1).

TABLE 1. Smartphone Design Features for Older Adults With Mental Health Conditions

Capacity to address multimorbidity	In real-world environments older adults commonly present with multimorbidity.
Access to live and automated self-management support	Consumers adopt and engage with health technology more if a human is part of an intervention.
Behavioral tailoring for adherence	Age-related memory loss and cognitive deficits result in poor medication adherence. Notifications may help with medication management.
Multimodal capacity	As the aging processes impacts recent memory or the formation of new memories, multimodal delivery of psychoeducation may decrease memory load.
On-demand features	To facilitate adoption, on-demand features can be accessed at any time, in any place.
Game playing	Adults with serious mental illness commonly experience depressive symptoms or anxiety and difficulty in forming new memories — both of which can inhibit working memory function and motivation. By contrast, game playing motivates engagement, learning, and behavioral change.

Additionally, researchers' combined the "think aloud" and verbal probing approach to usability testing to detect design issues with older adults.[11] These two approaches were combined as older adults had limited technology adoption and needed additional involvement via verbal probing by the researchers to solicit design feedback.[11]

However, usability testing is not enough. Older adults with a lived experience of a mental health condition, unlike most researchers, have unique expertise into the mental healthcare system as they have a lived experience utilizing this system for their personal needs.[39] Older adults with a lived experience of a mental health condition, similar to younger adults, have the potential to be instrumental members of research teams in developing digital interventions — from idea conception to effectiveness testing.[49] They can provide guidance on digital intervention development related to ethics and privacy, technology preference, and research procedures that are acceptable to older individuals and the organizations they access services from, such as aging service agencies. For example, older adults can assist with developing informed consent procedures to ensure older adult participants understand the technology they are agreeing to engage with (e.g., differentiating passive monitoring or engaging with interactive technology).

Additionally, incorporating older adults with a lived experience of a mental health condition as *equal* partners in digital geriatric mental health intervention development and implementation can potentially enhance intervention success.[50] Working with older adults as equal partners in research is likely a new role for older adults with lived experiences of mental health conditions that will require learning new skills. As such, we recommend utilizing adult learning theories to guide this process. For example, as many older adults have developed skills and knowledge through a lifetime of experiences, experiential learning theory emphasizes the importance that life experiences have in the learning process.[51] Experiential learning theory consists of four principles: 1) concrete experience; 2) observation and reflection; 3) forming abstract concepts; and 4) testing in new situations.[51] Older adult learners can

enter the learning process at any one of the principles and move to the next principle after they process their experience in a prior step.[51] Using established community engagement frameworks (e.g., community-based participatory research[52]) and research methodology (e.g., community engagement studios[53] or photovoice[54]) can also systematically guide the entire research process. A guide for community engagement with older adults with mental health conditions has been developed for

TABLE 2. Future Directions in Digital Geriatric Mental Health Research

Priority Area	Summary	Considerations for Older Adults
Need for proof-of-concept studies	Digital geriatric mental health has a similar challenge that is being experienced by the whole discipline of digital psychiatry—the need for additional methodologically rigorous proof-of-concept studies.	Early phase studies should continue to examine the feasibility and acceptability of digital geriatric mental health interventions and also adapt study protocol and procedures with older adults whom may present unique cognitive, social, and behavioral challenges compared to their younger counterparts.
Integrate engineering principles in methodologically rigorous research to help science keep pace with technology	As the field moves forward, studies that include conducting a fully powered randomized control trial will require an extensive amount of time. Within that timeframe, technology may have changed prior to completing the trial.	Specifically for older adults, SMART and MOST research designs may offer some additional protections against iatrogenic intervention effects (i.e., adverse effects of interventions) compared to their younger counterparts. Due to multimorbidity, which becomes increasingly common as individuals' age with a mental health condition, older adults may experience worse health outcomes when a treatment is not as effective for them compared to a younger adult. By being more responsive to nonresponsivity in SMART designs or only giving participants components of an experimental intervention in a MOST trial, older adults may be less likely to be negatively impacted by trying new treatments.
Identification of implementation issues specific to older adults	Understanding adoption and sustainment factors related to digital geriatric mental health may enhance uptake and facilitate implementation.	Unlike younger adults, older adults have unique technology preference (e.g., larger screen, tablets), receive services within aging agencies such as senior centers or meals on wheels services, and qualify for Medicare reimbursements. All of which present unknown implementation challenges and potential opportunities.
Inclusivity of people with a lived experience of a mental health condition can offer valuable perspectives and new insights.	Older adults with a lived experience of a mental health condition, similar to younger adults, have the potential to be instrumental members of research teams in developing digital interventions—from idea conception to effectiveness testing.[49]	Usability testing with older adults should combine the "think aloud" and verbal probing approach to usability testing to detect design issues with older adults.[11] A previous study combined these two approaches as the older adult participants had limited technology adoption and needed additional involvement via verbal probing by the researchers to solicit design feedback.[11] Working with older adults as equal partners in research is likely a new role for older adults with lived experiences of mental health conditions that will require learning new skills. As such, we recommend utilizing adult learning theories to guide this process such as experiential learning theory.[51]
Formation of a workgroup specific for digital geriatric mental health to set standards and principles for research and practice.	We propose the workgroup can use this selective review and related recommendations as a starting point to set standards and principles for research and practices for this burgeoning area of study.	The workgroup should review existing research portfolios of national institutes (e.g., National Institute on Aging and National Institute of Mental Health), foundations (e.g., Robert Wood Johnson Foundation), and industry in behavioral and social sciences to identify existing digital geriatric mental healthcare research and determine under-researched areas. Finally, the workgroup convene to discuss how to advance the science of digital geriatric mental healthcare—as related to behavioral and social sciences. We recommend a workgroup that includes the following expertise: (1) academic disciplines including medicine, psychology, public health, social work, engineering, and computer science that work within the Veterans Administration (VA) and outside of the VA; (2) formalized professional groups of people with a lived experience of a mental health condition such as Certified Older Adult Peer Specialists; (3) members from professional societies such as the American Association of Geriatric Psychiatry; and (4) community stakeholder partners such as the American Association of Retired Persons.

mobile health technologies and is available for researchers.[49]

Formation of a Workgroup Specific for Digital Geriatric Mental Health to Set Standards and Principles for Research and Practice

Finally, similar to the National Institute of Health's National Advisory Mental Health Council on Opportunities and Challenges of Developing Information Technologies on Behavioral and Social Science Clinical Research, we recommend the formation of a digital geriatric mental health workgroup. We propose the workgroup use this selective review and related recommendations as a starting point to set standards and principles for the research and practices of this burgeoning area of study. Next, the workgroup will review existing research portfolios of national institutes (e.g., National Institute on Aging and National Institute of Mental Health), foundations (e.g., Robert Wood Johnson Foundation), and industry in behavioral and social sciences to identify existing digital geriatric mental healthcare research and determine underresearched areas. Finally, the workgroup should convene to discuss how to advance the science of digital geriatric mental healthcare—as related to behavioral and social sciences. We recommend a workgroup that includes the following expertise: 1) academic disciplines including medicine, psychology, public health, social work, engineering, and computer science that work within the Veterans Administration and outside of the Veterans Administration; 2) formalized professional groups of people with a lived experience of a mental health condition such as Certified Older Adult Peer Specialists; 3) members from professional societies such as the American Association of Geriatric Psychiatry; and 4) community stakeholder partners such as the American Association of Retired Persons. Table 2 below details our proposed future directions in digital geriatric mental health research.

CONCLUSION

In summary, the field of digital geriatric mental health is in its nascence. In line with our above recommendations, we propose prioritizing the advancement of digital geriatric mental health research in several areas that are of great public health significance. First, older adults with mental health conditions commonly have co-morbid physical health conditions.[55] As such, *simultaneous and integrated* treatment of physical health and mental health conditions is an important area of digital geriatric mental health research yet to be rigorously examined. Second, effectiveness studies should explore diagnostics and treatment of social determinants of health such as "social isolation" and "loneliness." Both of which are particularly important intervention targets for older adults with mental health conditions considering the high prevalence and incidence of social isolation and loneliness and their impact on functioning, health, and early death in older age.[56–60] Third, the burgeoning aging populace is characterized by increasing racial and ethnic diversity.[61,56] Of whom, experience disparities in access to the mental healthcare and technology compared to white/Caucasian older adults.[62–69] As such, the development and testing of innovative strategies to advance digital geriatric mental health tailored to minority populations are of great public health significance, and novel tools should not create new barriers to access. For example, most automated communication technologies are programmed in the English language. Addressing the proposed research agenda can help enhance the field to meet the complex needs of older adults and advance programs of research beyond small, efficacy studies to wide-scale implementation in real-world settings.

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