Using Smart Displays to Implement Evidence-Based eHealth System for Older Adults with Multiple Chronic Conditions

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STUDY SUMMARY

The primary purpose of this study is to investigate whether a voice-based platform is better for delivering an electronic health intervention to older adults than a text/typing-based platform. We have an evidence-based electronic health intervention (Elder Tree, ET) that has been shown to improve quality of life, physical and socio-emotional health outcomes for older adults with multiple chronic conditions when delivered via a text/typing-based system. The current project would test whether such patients would benefit even more if ET were delivered via a voice-based system (vs. the text-based system) because they would use it more consistently. ET is an existing intervention providing tools, motivation, and support on a computer platform to help older adults manage their health. An AHRQ-funded randomized controlled trial (RCT) found that ET improved quality of life and other factors among high users of primary care with multiple chronic conditions such as diabetes and hypertension. However, many people did not use it extensively, which is a common problem with all web apps.

ET is based on the extensively tested Comprehensive Health Enhancement Support System (CHESS).[1-7] ET is a "walled garden" free of ads, with design features based on older users' feedback as well as best-practice principles such as uncluttered screens and large type.[8] Like all CHESS systems, ET uses computers to deliver key elements of successful interventions: long duration, ongoing outreach, prompts, monitoring, cognitive reframing, action planning, problem solving, self-tailoring, and peer support.

Although voice-activated systems may offer an easy, engaging way to use an intervention, it is an open question whether older adults coping with complex arrays of chronic conditions would actually show more sustained use with voice interactivity and whether this would result in improved functional health and associated outcomes. We propose a pragmatic, 2-arm balanced RCT comparing the text/typing-based version delivered on a laptop or tablet as in our prior and current trials (ET-Text) to a voice-based version delivered on a smart display or equivalent (ET-Voice). The goal is to assess whether ET-Voice outperforms ET-Text in improving our primary outcome of functional health. Additional goals include testing effects on secondary outcomes (loneliness, number of symptoms, healthcare use, and ET use and perceptions).

1.0 BACKGROUND & SIGNIFICANCE

Multiple chronic conditions (MCCs) are costly and pervasive among older adults. MCCs account for 90% of Medicare spending, and 65% of Medicare beneficiaries have 3 or more chronic conditions; 23% have 5 or more. MCCs are often addressed in primary care, where time pressures force a focus on medication and lab results rather than self-management skills. Patients often struggle with treatment adherence and the emotional and physical burdens of self-management and health tracking.[9] Chronic conditions reduce quality of life (QOL) and increase loneliness, which exacerbate those conditions.[10-12]

ET laptop intervention. In the AHRQ-funded trial of the earlier ET, participants showed much more sustained use than has been observed for other health apps.[13, 14] In month 6, 83 participants (42%) still used it, and in month 12, 62 (31%) still used it. Despite this relative success, use could clearly be higher. Qualitative data suggested reasons why it declined: (1) The little hassles of going to the computer, turning it on, remembering and entering a password, and opening a service compounded to create a barrier to use. (2) Some faced barriers in typing due to arthritis or tremors. (3) It didn't seem easy to use the laptop for non-ET functions (news, music, videos), so the system gradually became less tempting to use. The current proposal would test whether offering ET via voice activation would reduce these barriers and thereby improve outcomes.

Enter the "voice-activated" devices. Voice-activated devices can potentially be easy to use, even by those with limited dexterity or computer experience. Smart displays (smart speakers combined with a screen and connected to the internet; SDs) respond to voice commands with results that can be seen, heard, and controlled from across the room. Patients could ask questions and get answers, listen, and respond to messages, request guided meditation, track health data, etc., just by talking. The screen adds the ability to make video calls, watch

online videos, be guided through activities such as exercises, and display graphs of health status. It also shows the patient's words on-screen, allowing them to see if they were misunderstood.

Although there are no prior RCTs of health interventions delivered in this way, there is some reason to think that such a system could help sustain engagement. In a 6-month pilot study of the voice-activated Amazon Alexa smart speaker with 18 older adults in a retirement community,[15] 100% said Alexa made their lives easier and 71% felt more connected to friends, family, and community. Uses included setting alarms and listening to music, weather, news, and other information. In another study, 100% of 12 veterans found the speaker "useful in their daily lives" and said they would be "very likely to continue using" it for services that include relaxation, information, reminders, and companionship.[16] Media reports indicate a groundswell of smart speaker use among the elderly and people with vision loss, tremors, mobility problems, and dementia.[17-21] Adding the visual display to the speaker would seem to increase usability and engagement even more.

Nonetheless, there are potential challenges to delivering a multi-faceted health intervention with these devices. A 6-month study of usage logs for the voice-activated Google Home[22] found that individuals quickly established a couple of uses (e.g. listening to music) but did not develop more over time. Moreover, individuals often changed commands for specific functions (e.g. asking for weather with different words each time), indicating the need for strong language processing systems to extract meaning from varied commands.

Smart displays. Speakers do have limitations. Without a visual display, it can be hard (particularly for those with memory challenges) to recall information they have heard but not seen. A smart speaker could link users to a laptop when they want information conveyed visually, but this is inconvenient. Smart displays are specifically designed to address such issues, including screen magnification for those with partial vision.

The Center for Health Enhancement Systems Studies (CHESS). CHESS is a research center at the University of Wisconsin–Madison. CHESS, or Comprehensive Health Enhancement Support System, is also the name of the platform we developed to help people cope with life's challenges. We have conducted 16 RCTs of our eHealth CHESS systems and published more than 190 peer-reviewed works, as well as over 100 about organizational change and implementation engineering. In randomized trials, CHESS significantly improved: 1) childhood asthma control and parent coping[1]; 2) QOL and cost of care in HIV patients[2]; 3) QOL and self-efficacy in breast cancer patients, including elderly women[3]; 4) physical activity for survivors of colon cancer[23]; 5) risky drinking[6]; 6) caregiver coping for patients with dementia[24]; and 7) caregiver burden, symptom distress, and median length of survival in lung cancer patients.[7] That experience bodes well for the success of this project.

Preliminary data. Our AHRQ-funded Center of Excellence in Active Aging developed ET to help older adults[25] remain independent. Our RCT followed 399 older adults from 3 Wisconsin counties (urban, suburban, rural). Among patients with more primary care visits, those assigned to ET (vs. control) showed greater improvement in QOL at the end of the 12-month intervention ($p_{interaction}$=.035; $d_{12\text{-months}}$= 0.24). Additional exploratory analyses post-study also showed interactions between study arm and number of chronic conditions. Among patients with high multimorbidity, those assigned to ET (vs. control) showed greater improvements in QOL and number of symptoms by the end of the intervention. Given this, in our ongoing NHLBI RCT (1-R01 HL134146), we are examining the impact of ET (via laptop) on QOL, lab scores, and healthcare use for older patients with 3+ chronic conditions. Now we are planning to compare it with ET delivered by a voice-based system (on a smart display).

Pilot testing the voice-based system. In an initial pilot test, we had 11 older adults pilot-test a voice-navigated speaker (the Google Mini) at home for 5 weeks. During that time, we asked them to try something new (e.g. make a phone call, set a reminder). All 11 felt the speaker was "very easy to use," 10 "strongly agreed" that it would improve quality of life for older adults, and all would recommend it to others. We have gone back to that

panel of older adults to test a voice-navigated screen during the past 6 months; their input has informed our team's development of voice-navigated tools needed for ET.

For a current AHRQ-funded R18, we conducted a 10-day usability test with 16 older adults with a smart display (Google Hub Max) to understand receptiveness to the system, what works well, identify areas for improvement, and test verbal guided prompts that lead the user through the system. Feedback gathered led to refinements to the system including improved video delivery and updated commands to increase voice recognition accuracy during dictation.

In addition, we have 115 enrolled participants, recruited between April and December of 2022, who were randomized to receive ET via a Google Nest Hub Max smart system or laptop. Due to a decision by Google to no longer support the key functionality that allows users to access ET starting June 14, 2023, we halted recruitment, are redeveloping ET on a comparable smart system (Amazon Echo Show) and will begin recruitment again in June 2023 for a goal of N=356, with revised accrual milestones.

The 115 enrolled participants will continue with the ET intervention uninterrupted until June. SS participants will be informed that at that point ET will no longer be accessible. Participants in both arms will be mailed a final survey in June as well. We will also continue to pay for internet service for the full 12 months as stated in the study consent for participants that needed that option.

Baseline data and data from the final survey collected in June from the 115 subjects will be used in two ways: 1) as pilot data to identify barriers to use, including physical limitations that are associated with lower levels of use in each study arm - this may provide key insights about ways to continue to adapt the system to be maximally accessible, and 2) as a means to test our final analysis so we can more efficiently analyze the full dataset when the RCT is complete. This will help us overcome the delay in getting this project done due to the Google issue.

Innovation. ET-Voice is highly innovative for the following reasons.

- *Text/typing - 2-way-voice-activated interface*. Most health apps, including ET on a laptop or tablet, require patients to read and respond by typing or on-screen touching. Physical limitations (e.g. vision, tremors, hand pain) can make this difficult for frail, home-bound older adults. Hands-free voice activation and communication could make interacting with ET much easier. But ET-Voice would also be innovative for additional reasons.
- One location - wider access. ET currently operates on a laptop because older adults often have difficulty using smartphones. However, though portable, laptops tend to sit in one place for older adults. For frail older adults, even walking to the computer can be a challenge. In the novel ET-Voice condition, the voice-activated display will be in one room and an inexpensive voice-activated speaker will be placed in another area of the home, enabling easy communication with ET without the need to walk to the device or carry it around.
- *Multi-step activation - single-step activation.* Text-based systems require multiple steps to engage with a desired feature: turning on the device, opening the application, logging on, and clicking through the site. With ET-Voice, a patient could simply say, "Hey ET, I'll answer my health survey now." Voice authentication even replaces activation, login, and site navigation.
- *Patient-activated communication - system-activated communication.* Currently, a patient must open the laptop to interact with ET and get notifications. In contrast, ET-Voice could initiate communication with the patient with a gentle alarm. If the patient is present and responding, ET-Voice could say, “Dave, you put in a reminder to check your blood pressure. Do you want to do that now?” and then begin to collect data.

- *Innovativeness of data collection.* It is innovative to collect data by voice. Dictating health-tracking scores (rather than entering them online or on paper) may reduce burden and increase completeness and accuracy. Additionally, ET automatically logs all ET-related keystrokes and voice commands. This allows for deep analyses of patients' ET use while avoiding measurement burden, recall, or social desirability issues.
- *Medical focus - functional health.* Life can be difficult for those restricted by MCCs. Older adults in our completed RCT reported that ET increased happiness by being fun, not just utilitarian. In our pilot work with a smart display or smart speaker, all older adults were enthusiastic about the potential of ET-Voice, not only for health-related tasks (e.g. medication reminders, recording blood pressure) but also for music, games, and social interaction. In a national survey of more than 1800 adult smart system users, top requests of SDs (e.g. music, jokes) underscored the expectation of pleasure via the device.[26] We predict patients with ET-Voice (vs. ET-Text) will use ET more, show higher use of the device for other functions (e.g. music), and show improved functional health (including depression and anxiety).
- *Theory.* Reviews note the lack of theory in the development and evaluation of smart devices for health interventions.[27, 28] Our thinking about the possible benefits of ET-Voice is driven by Self-Determination Theory (SDT), which asserts that satisfying three psychological needs contributes to adaptive functioning: competence (feeling effective, not overwhelmed), social relatedness (feeling connected to others, not isolated), and intrinsic motivation (feeling autonomous, not coerced).[29] We will test whether these elements mediate the hypothesized differences between study arms.
- *Groundbreaking.* This would be the first large RCT comparing a text-based system (on a laptop or tablet) versus a voice-based system (on a smart display) for delivering a health intervention.

2.0 STUDY OBJECTIVES

Overview of methods. We propose a 2-arm randomized clinical trial to test whether voice-based ET (ET-Voice), relative to text/typing-based ET (ET-Text) will lead to more sustained system use and thereby greater improvements in health. In the R61 portion, we will complete the development of the ET-Voice platform, identify eligible patients at one clinic, recruit one patient, and identify other clinics and recruitment strategies to implement. The RCT (R33 portion) will involve the full recruitment and intervention phase, analyses, and dissemination. For each participant, the intervention will last 1 year, plus 6 months of follow-up. Data will be collected every 6 months, for a total data period of 18 months. The final 12 months of the study will be spent analyzing and interpreting qualitative and quantitative data and disseminating results through publications, presentations, and real-world field tests.

Specific Aim 1: <u>Develop and test ET-Voice.</u> ET-Voice must be maximally easy for participants to use and maximally flexible for our programmers to be able to integrate different systems and functions.

Voice-based technology. We currently plan to give participants a smart display as the voice-based technology (e.g. Amazon Echo Show). Users activate SDs with a wake-up phrase (e.g. "Alexa, ElderTree"). *Voice authentication* gives individuals exclusive access to their content. All SDs have *security measures* to prevent wiretapping. Data transmitted to data centers (e.g. Google, Amazon) are *encrypted.* All ET-related requests are saved, allowing us to *measure ET-related use of the voice-activated device.*

ET description. ET provides tools, motivation, and social support to help patients manage chronic conditions and satisfy needs of competence, relatedness, and motivation.

Smart display screens tend to be too small for extensive reading. We will design ET-Voice so the screen is used to (a) navigate simple menus (e.g. lists of activity videos, tips & inspirations), (b) watch videos, see pictures, (c) and edit user-produced text before posting (such as dictated comments). ET-Voice and ET-Text will include similar ET services/content, yet because of the differences between platforms, we will leverage the capabilities of each

system to design a comparable suite of services for both arms. All patients receive a Quick-Start Guide outlining ET features, and ET prompts will remind users of functions while they are using the system. Our Center staff will provide tech support to both study arms throughout the study. Note that as with the vast majority of apps, the content will be refreshed regularly (new resources in Health Library; new Tips & Inspiration several times weekly, etc.). Refreshments will occur in both versions of ET at the same time.

Competence services include:

- Tracking: Weekly survey of health-tracking questions (e.g. sleep, mood, falls). Patients can view trend graphs over time.
- Exercise videos: information on the benefits of activity, safety instructions, and video demonstrations and classes will encourage participants to engage in physical activity regularly. The level of exercise content provided will be determined by participant responses to an exercise screener during the enrollment call. See Appendix B for more details.
- Pain learning modules: interactive lessons that focus on understanding chronic pain, learning coping skills, and suggested action steps.
- Easing distress: Tools such as cognitive reframing,[30] self-calming with movement activities, guided progressive relaxation recordings, deep breathing, and mindfulness meditations.
- Informational videos: topics such as exercise, pain, sleep, anxiety, falls and balance, grief and loss, nutrition, and talking with your doctor. Vetted by Dr. Mahoney.

Social relatedness services include:

- Regularly scheduled social "meetups" with research staff and guest speakers via Google Meet.
- Community Discussion Board: Monitored, online, anonymous discussion group for support and engagement. Research consistently indicates that participating in social interactions on CHESS predicts positive outcomes, including quality of life.[31,32]
- Private Messages: Email-like function for ET members to communicate privately with one another.

Intrinsic motivation services include:

- Thought of the Day: Daily motivational prompts to boost happiness and resilience.
- Personal stories: Audio/video of patients' advice/experiences (e.g. what to avoid, tips for coping).
- Journal: Daily writing prompts based on positive psychology.[33]

Clinician report (CR):

- The CR displays data from patients about general health variables relevant to all chronic conditions but rarely collected in clinical medicine (e.g. sleep, relationship quality, falls, missed medication). The variables were determined by practitioners in geriatrics and family medicine in the UW Health system. Data are displayed in at-a-glance graphics based on statistical process control,[34] allowing a clinician to identify problem areas and successes worth discussing.[35] When coupled with traditional clinical data (e.g. blood pressure), the CR adds an important dimension to the data set. The CR summary of trends is sent prior to appointments, facilitating more effective visits. Our lung cancer test of the CR found that issues were addressed more quickly, reducing the need for subsequent intensive clinician involvement.[36]

Design considerations.

How ET-Voice will protect privacy. We created several ways to protect the privacy of older adults and families and to alert when our system is recording. We will help users understand:

- *When recording is happening, and when it is off.* ET-Voice will not record during initial interactions or after users have indicated they are done. We will add a highly visible indicator light that turns on during audio recording. Users can turn off our program at any time. These features have been well received during past studies. Users are comfortable with the recording process, the indicator light, the transparency of our procedures, and the ability to control when recording ishappening.

- *How recorded data will be used.* Audio recordings will be copied and stored on a secure server that only the research team can access. Researchers may use the speech data in publications only if all identifiable information has been removed and will quote users only with their permission. Audio recordings not related to the study will be deleted. Participants can review what was recorded and consent to whether the recording can be used in research. These statements require additional initials on the consent form.
- *What happens if someone leaves the recording on?* ET-Voice will automatically shut down due to inactivity. After 3 minutes, it asks if the user is "still there." If no response within 30 seconds, the audio recorder is disabled. Users can pause audio recording by pressing a dedicated "pause" button.

Potential negative impacts and how are they addressed. A potential negative is that older adults may disengage because the novelty has worn off. ET-Voice will use two designs to promote long-term interaction: 1) using information from past interactions during current dialogue[37] and 2) revealing a personality.[38] To do so, it will keep track of previous sessions. Each session starts with ET-Voice reminding users of their previous activity. Also, over time, the system will reveal details of its own fictional personality during reading sessions (e.g. its favorite color is blue). These personal comments are designed to help build rapport during human–computer interactions.[39] Some older adults are ambivalent about artificial characters building an emotional connection. There is some research on how social robots should deliver on their social interaction potential.[40, 41] We are exploring ways in which ET-Voice could serve as a facilitator to engage family and friends.[42, 43]

Design decisions already made to limit frustration with technical problems during long-term in-home use.

1) ET-Voice is modeled after typical human behaviors that can help older adults interact with the system in socially positive ways.[44] 2) We will closely monitor and act on problems with ET-Voice. This monitoring will include regular email check-ins with users to conduct routine maintenance checks. We will also coach users on simple procedures for resetting the system as needed. 3) We will include proven ways to mitigate the impact of breakdowns[45] including recovery strategies and expectation setting.

Dealing with ways ET-Voice might interfere with older adults' lives. Co-designing with older adults will help us anticipate problems and design preventive solutions. Current designs include features that prevent interference with daily life, e.g. an automated option to avoid quiet time disturbances.[46] To ensure that privacy is respected, we provide, as noted above, a clear indication of when the device is listening and the opportunity to stop it at any time. We also use information about the user to personalize interactions but only with their knowledge and consent.[47] Concerns have been raised about using a device that is always listening. While microphones are always on, smart systems do not retain data until the wake word is used. Recordings will be stored on a distant server. We will periodically (or when requested) offer to delete those data.[48]

Ensuring patient safety. Mental health professionals are not allowed to break confidentiality except when there is imminent danger. In non-emergency situations patients will be encouraged to call their doctor or a trusted colleague. If we find that a patient is facing an emergency, we will contact appropriate others to intervene (e.g. primary care team, community mental health center, and/or police).

Specific Aim 2: Test the effects of ET-Voice vs. ET-Text. We hypothesize that intervention modality (voice versus text/typing) will affect our primary and secondary outcomes, and that this effect will be partially explained by higher use of ET and ensuing Self-Determination Theory variables of competence, social relatedness, and intrinsic motivation. Figure 1 shows the logic flow.

1. *Primary outcome:* Physical and socio-emotional functional health as assessed by the PROMIS-29 v2.1. This multi-dimensional variable includes physical function, pain interference and intensity, fatigue, sleep disturbance, anxiety, and depression.

2. *Secondary outcomes:* ET use @ 12 months, PROMIS-43 subscales including physical function, anxiety,

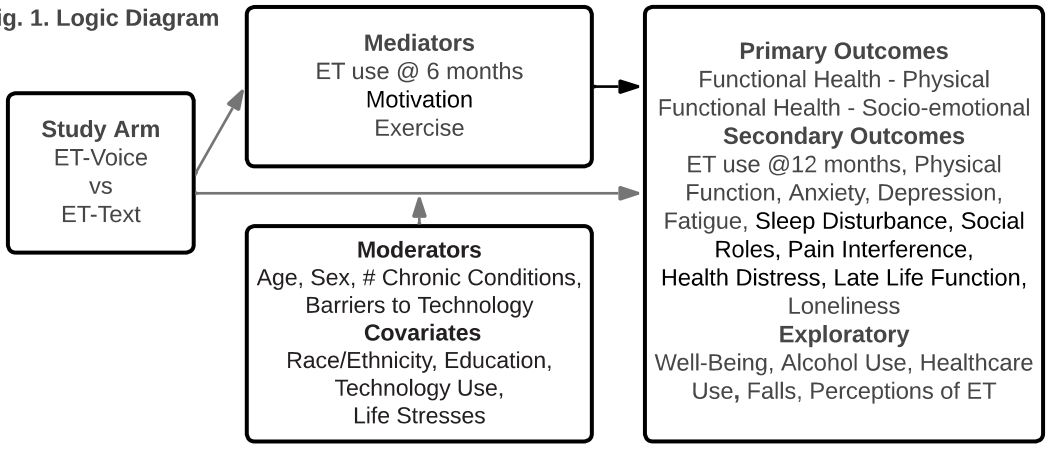
depression, fatigue, sleep disturbance,social roles, pain interference, health distress, late life function, and loneliness.

3. *Mediators:* Effects of study arm on outcomes are expected to be mediated by intervening variables: amount of ET use at 6 months, motivation, and exercise.

4. *Moderators*: The effects of study arm on outcomes may be moderated by sex, age, number of chronic conditions, and barriers to technology due to physical difficulties (e.g. vision, typing, hearing). The point of the moderator analyses is to assess whether specific subgroups (e.g. those who are oldest or sickest) benefit more from one platform than the other. Findings would improve recommendations about how ET should be implemented. Moreover, if replicated, such findings would contribute to the broader literature about the use of voice versus text for health interventions for older adults. Thus far, research on the use of smart speakers and displays among the elderly has small samples, and tends to use products that are still in development. An RCT with adequate power to examine moderation would move the field forward.

Study design and hypotheses. Figure 1 describes the 2-arm RCT. Baseline covariates include race/ethnicity, education, and outcome scores. Moderators (sex, age, number of chronic conditions, barriers to technology) may influence ET use at 6 months, which in turn may influence mediators of intrinsic motivation and exercise. These factors may lead to changes in primary, secondary, and exploratory outcomes. If we find that a moderator plays a role in amount of ET use (e.g. women use ET-Text more than men), we will explore this in interviews to decide how to improve ET or the arm itself. Alternatively, we might caution potential implementers to prepare for possible sex differences.

Fig. 1. Logic Diagram



ET implementation and operation.
Our Center developed the NIATx change model, which has been used by more than 3,000 behavioral health treatment agencies.[49] NIATx led to our extensive research on models to predict and explain implementation success,[50] ingredients of successful change,[51] and diffusion of innovations.[52] We will use this research to guide the implementation and operation of this study.

Initiate. Physician change leaders and clinic administrators have already been appointed in the 6 UW clinics we propose to use: 20 S. Park, 661 eligible patients; Yahara, 449 eligible patients; Odana, 541 eligible patients; Northeast, 294 eligible patients; UW East, 268 eligible patients; Sun Prairie, 237 eligible patients. We have active collaborations with those clinics (see letters of support). In fact, we recently completed recruitment of 346 subjects from UW clinics to an RCT five months ahead of schedule. The clinic administrators are familiar with our research team and UW Health clinic operations and have a strong relationship with clinical staff. Our research staff has engaged clinic staff to understand the clinic and refine our implementation process.

Prepare the environment. Clinic staff and patients will be asked to advise on SS design (already done for the LT) and implementation. We have personally experienced what it is like to be a patient at these clinics. This

"walk- through"[53] helps us tailor LT and SS operations to each clinic. Clinic staff will specify how operations will be handled to minimize frustration (e.g. in a given clinic we may decide to deliver the CR by fax, not email, 3 days before a scheduled patient visit). Clinic staff will help finalize processes for patient recruitment, data collection, and feedback about the study. We are experienced in community-based participatory research, most recently via our Center of Excellence in Active Aging, where we engaged 53 of 72 Wisconsin counties and hundreds of volunteers to implement the first version of ET.[54]

Refine systems. In the first 12 months, our team of clinicians, engineers, and scientists will make design modifications to integrate the smart display and associated smart speaker. Our information technology team is already addressing those issues, building on our previous experience with digital assistants and wireless devices. Dr. Mahoney will guide creation of symptom management tips, health trackers, and self-management materials. Some of the data collected by our technologies will be used for just-in-time tailoring of resources to participants., including 1) modifications to data entered at setup, 2) health behaviors, and 3) health status data.

Make ET easy to use. We'll do this by 1) designing interactions with the SS so they require no training (e.g. assessments/alerts) and 2) continuing our commitment to a simple, intuitive interface for ET.

Initiatives to sustain ET use. 1) *Moderators* (lay people selected for communication skills and empathy) will engage with study participants on ElderTree regularly by facilitating recurring social "meet-ups," monitoring the discussion group, and intervening quickly should the need arise (e.g. removing inappropriate posts and calming any conflict that may occur). Our project director will be the lead monitor, reviewing use data, sending encouraging notes, or making follow up phone calls. 2) *Weekly featured content* encourages participants to check out various ElderTree services and resources. The featured content is prominently displayed on the ET homepage and will rotate daily, and therefore keep ET fresh. *3) Notifications* will be used to alert participants when it is time to complete their weekly survey, when there is new featured content, or new messages or social events planned. Notifications will be a combination of email, text (based on participant preference), and homepage display and "indicators" identifying where to find the new content. 4) We will encourage patients to rate and provide feedback on the exercise content, and under the guidance of Dr. Mahoney we will make refinements as needed. 5) We avoid using unsustainable financial incentives.

3.0 SELECTION OF SUBJECTS

Patient eligibility. Patients must: 1) be age 60+; 2) have medical record diagnoses of at least 5 chronic conditions of which at least 3 must come from the following: hypertension, hyperlipidemia, obesity, prediabetes or diabetes, or depression; 3) report no current psychotic disorder that would prevent participation; 4) have no acute medical problem requiring immediate hospitalization; 5) need no interpreter; 6) be willing to share medical record data about healthcare use (30-day hospital readmissions and ER, urgent care, primary care, and specialty care visits); 7) allow researchers to share information with the patient's primary care provider; and 10) not report impairments preventing use of a computer or tablet (e.g. blind, deaf).

Recruitment process. <u>UW Health Family Medicine and General Internal Medicine Clinics:</u> UW's Clinical and Health Informatics Institute (CHI2) will use clinic records to identify patients meeting the eligibility criteria described above and send eligible patient data (including first and last name, address, birth date, age, UW clinic location, and primary care doctor) to the UW Office of Clinical Trials (OCT) via REDCap. Potential participants will receive an opt-in letter describing the study and consent form from the OCT, plus a stamped return letter inviting contact from the study team.

<u>Community Recruitment:</u> We will supplement recruitment at UW Health with community efforts aimed at reaching a diverse patient population. Targeted advertisements on local tv stations and facebook ads will be used in Madison, Milwaukee, Beloit, and other communities within driving distance of Madison. In addition, through collaborations with the African American Health Network (AAHN), Community-Academic Aging

Research Network (CAARN), and community leaders, we plan to reach out to black churches, community centers, senior learning initiatives, and other organizations in Madison, Beloit, and Milwaukee. We will distribute a recruitment flyer and consent with a return card/opt-in, run recurring advertisements in local publications (e.g. UMOJA, Capital City Hues), and conduct online and in-person community sessions, when possible, to introduce the study and invite participation.

UW Madison WiscList: We plan to send a one-time mass email to all current UW faculty/staff with information regarding the study, and ask interested employees to reply via email or call for more information. We will also encourage email recipients to share the email with others they feel may be interested (e.g. the UW faculty/staff member may have parents with multiple chronic conditions who may be a good fit for the study).

Access Community Health Centers (ACHC): In addition to our community recruitment efforts, working with ACHC, will help us reach a larger number African Americans and other participants of color, as well as expand our reach to underserved patients. We will work directly with ACHC staff to disseminate the recruitment flyer, consent, and return card/opt-in to potentially eligible patients.

Regardless of recruitment method, when a return card/opt-in is received or an interested potential participant calls, study staff will assess eligibility; provide a study overview that includes potential benefits and risks, study procedures, and compensation; thoroughly walk through informed consent; and conduct a brief exercise screen (Easy Exercise Tool: https://www.easyforyou.info/screening-tool) to allow tailoring of exercise content, and address questions. The baseline survey will be mailed. Patients will be given adequate time to make the decision whether or not to participate and in some cases a follow up phone call will be scheduled after the patient has time to review the survey and consent form.

Once a patient verbally confirms they want to participate, a home visit will be scheduled to collect the baseline survey, randomize, set up equipment, and train. Note that all study staff that conduct home visits will be fully vaccinated for Covid-19, will wear face masks, and socially distance as much as possible while in the patient's home. If no visit is desired, once the completed baseline is received via mail, equipment will be shipped, and technology setup and training will be conducted by phone. The baseline survey should take 20-30 minutes. Measures will be the same in both arms to avoid differential drop-out. We will document those who choose not to participate and why, following CONSORT standards.

4.0 METHODS

Patient Recruitment

The trial will involve 356 patients age 60 and older, recruited over 18 months, and randomized into two groups:

1. The ET-Voice: Patients in the experimental group will receive treatment as usual (TAU) + Smart Display + Internet access + ElderTree
2. ET-Text: Patients in the control group will receive TAU + laptop + Internet access + ElderTree

Patient Consent

Patients must agree to allow monitoring of their ElderTree use and for data to be collected from their EHR (UW Health patients only), as detailed below. The patient will be given the right not to share specific information and will retain the right to revoke their permission at any point.

The consent process will inform potential subjects of:

(1) the nature and purpose of the study

(2) the types of data that will be collected from the EHR (by the CHI2 – UW Health patients only)

- Chronic conditions
- health care utilization: hospitalizations (admission and discharge), number of ER visits, urgent care visits, PC visits, specialty care visits, long-term care visits, and rehab visits

(3) the types of data that will be collected from ElderTree

- Weekly survey data (missed medications, falls, thinking and memory, mood, healthy meals/snacks/drinks, physical activity, quality time with others, sleep, pain, and balance)
- Weekly meetup transcripts
- Use data

(4) the types of data that will be shared with their primary care physician (UW Health patients only) - a graph that charts weekly scores related to the quality of sleep, nutrition, physical activity, memory, falls, moods, balance, pain, medication adherence and quality time spent with others.

(5) study risks and measures taken to mitigate

(6) their right to leave the study at any time

(7) the timeline of the study

The research team will always have a member available during standard operating hours for participants to contact with questions or issues. If a patient declines to participate, a research team member will determine reasons for non-participation so we can examine how patients who opt out differ from those who choose to participate.

Patient Randomization
Once informed consent and baseline measures have been obtained from patients, they will be randomized to either the experimental (ET + Voice) or control (ET + Text) group, stratified on gender, clinic site, and number of chronic conditions (5-7 vs. 8+).

Setup and Training. Researchers will introduce patients in each arm to their technology and place the laptop or smart display in the preferred location. After explaining the implications, the smart speaker will go where patients least want a camera. Patients will play a 5-minute introductory video/audio recording that explains ET-Text or ET-Voice. During setup, information is entered to tailor ET, such as medications, contacts, and activities of interest.. A week later, they are encouraged to play the intro again and select another ET service to learn. Thus, patients can gradually increase the services they use. If necessary, UW staff will text or email patients to encourage them and resolve issues. Periodically, thereafter, a brief intervention will feature a different service, based on past use ("we see that you have not used the XXX service. We believe it is worth a try because…").

Costs to participants = $0. Patients will get laptops, smart systems, and Internet service (hot spots) for 12 months if they do not have them and will be paid $10 to complete each of the four surveys ($40 total).

Privacy and Confidentiality
To mitigate the risk of patient breaches of confidentiality, all subjects will be assigned a unique code number. Subject code numbers and all study data will be maintained by the UW project director and stored in UW ICTR Research Electronic Data Capture (REDCap). Members of the research team will be able to view de-identified individual and clinic-level aggregations of variables. When all study activities are complete identifiable information will be destroyed. De-identified study data will be stored on the secure servers for potential future unspecified research for which new IRB submissions will be initiated.

Potential Risks
The principal risks to participants include:

- There could be a breach of confidentiality that could result in disclosure of research data outside of the study team. To prevent this, all subjects will be assigned a blind code number. Data collected from clinic records will have the name removed and a code number attached. Project staff who have access to the data will not have access to subject names. ET will automatically collect data on how often and for how long participants use the specific services within ET. This information will be collected by subjects' ET code number only and will not be attached to real names or identities.
- There is a potential for subjects to receive and act on bad information or misinterpret accurate information. To mitigate this risk all ET content will be screened by Dr. Mahoney. ET information will be accessible by individuals who have low literacy skills to reduce the risk of misinterpretation. Additionally, messages within the ET discussion group will be monitored to make sure the information is accurate and that study participants are using the system for its intended purpose.
- There is a risk that information provided in ET will be used to the detriment of the subjects. All participants will receive information and guidelines on Internet safety and security during initial training.
- On surveys participants will be asked personal questions related to past or current behaviors and experiences, such as struggles with health issues, depression, etc. that may produce anxiety, distress, embarrassment, or feelings of sadness. Participants can opt not to answer questions if they choose.
- If participants engage in the social components of ET (e.g. discussion group, live meetups), they could get upset with opinions or comments from other participants. Research staff monitor all discussions daily and facilitate live meet-ups. Appropriate action will be taken if questionable posts/comments occur. Participants may choose not to participate in social components on ElderTree if they wish.
- If participants choose to do the exercise videos on ElderTree, there are risks involved including: a risk of falling when doing standing exercises; muscle soreness when doing the strength, endurance or flexibility exercises (muscle soreness that lasts through the day after is not considered an adverse event as it is consistent with strength gains); joint soreness during or persisting after the exercise; worsening arthritis in joints used in the exercise; back pain or exacerbated back pain (this is not expected to occur with any frequency because the exercises are not high intensity); or joint ligament injury (also deemed rare). The exercises provided are based on the Easy Exercise tool to ensure they are appropriate in terms of safety and the participants functional abilities. Participants are required to review the safety precaution videos before starting any exercise. Participants can choose not to do exercises if they wish.
- During study activities we may discover behavior that raises concern about elder abuse, harm to self or others. If we see anything that suggests that patient subjects or others face imminent risk of harm, we will contact appropriate others to intervene (e.g., State authorities, clinic, and/or police).
- Internet service will be stopped after 12 months. Subjects may feel some loss when they no longer have this service. Participants will receive notice in advance of internet termination, but will be allowed to keep their equipment in case they acquire internet service on their own.

Adverse Events

The research team will conduct the following standard procedures for the duration of the study to monitor for any adverse events (e.g. falls, increased daily pain, night pain, need for medication, difficulty with ADLs, new or increased swelling, or lost work days not alleviated by decreasing their exercise level) as described in Appendix A.

- Backup contacts: Participants are asked to provide at least one back up contact at enrollment in the event that we are unable to reach them.
- Survey follow up: If a participant does not respond to a survey after 2 weeks, staff call to follow up. If

they do not reach the participant, they call the backup contact.

- Weekly survey. A weekly prompt asks if the participant has experienced any problems with the intervention. Responses are monitored weekly, and staff follow up as needed to gather further information.
- Use data: Use data is reviewed monthly. If a participant's use has declined from their normal pattern, or they have not been on the intervention for a month, staff will call to follow up. If they do not reach the participant, they will call the backup contact.

Unanticipated Events

If any unanticipated problems are identified via the procedures describes above the UW research team will work with the UW MRR IRB and the ICTR DMC to immediately address the problem (see detailed Data and Safety Monitoring Plan).

Inappropriate use of ElderTree

It is anticipated that ElderTree could be used inappropriately. A research staff member will review and delete any comments deemed inappropriate (i.e nudity, threats, racism, bigotry) and follow up with the author of the inappropriate content. Discussion group guidelines will be reviewed with participants as part of training.

Reasons for removing a subject from study

Cases in which a subject has ongoing borderline behavior will be evaluated individually and the subject may be removed from study if we feel it is in the best interest of the individual as well as others on study.

5.0 MEASURES AND DATA COLLECTION

Participants will be tracked for a total of 18 months. Data will be collected from: electronic health records (EHR), participant surveys (at months 0, 6, 12, and 18 months), qualitative interviews, and ElderTree use data.
Table 2 lists quantitative and qualitative measures, data sources, psychometrics, and references to validation studies.

Variable	Measure	#Qs	Source	Reliability
Primary Outcomes				
Functional health - Physical	PROMIS-29 v2.1	29	Patient	$\alpha \geq 0.94$[55]
Functional health – Socio-emotional		29	Patient	$\alpha \geq 0.975$[55]
Secondary Outcomes				
12-month ET use	# of logins	N/A	ET	N/A
Physical function	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Anxiety	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Depression	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Fatigue	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Sleep disturbance	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Social roles	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Pain interference	PROMIS-43	6	Patient	$\alpha > 0.9$[56]*
Health distress	Lorig Health Distress Scale	4	Patient	$\alpha = .87$[57]
Late Life Function	Late Life Function Instrument	21	Patient	$\alpha = .77$
Loneliness	NIH Toolbox	5	Patient	$\alpha \geq 0.93$[58]
Primary Mediator Candidate				
6-month ET use	# of logins first 6 months	NA	ET	N/A
Secondary Mediator Candidates				
Motivation	Tx Self-Regulation subset	4	Patient	N/A
Exercise	# past 6 months	1	Patient	N/A
Moderator Candidates				
Sex	Baseline survey	1	Patient	N/A
Age	Baseline survey	1	Patient	N/A
Chronic conditions	Total # and type	N/A	EHR	N/A
Barriers to technology	Created for study	6	Patient	N/A
Other Measures				
Demographics	Race/ethnicity, education	3	Patient	N/A
Technology use	Type, frequency	6	Patient	N/A
Life stresses	# and type in last 6 months	1	Patient	N/A
Well-being	WHO (Five) Well-Being Index	5	Patient	$\alpha = .93$[59]
Alcohol use	AUDIT-C	3	Patient	$\alpha = .91$[60]
Healthcare use	UC, ER, readmit	6	Patient	N/A
Falls	# in last 6 months	1	Patient	NA
Perceptions of ET	USE Questionnaire and open-ended created for study	25	Patient	NA

* For the mean T-score, as seen in Figure 1 in the cited publication

Quantitative. Surveys conducted at months 0, 6, 12 and 18 are expected to take 30 minutes and will assess physical functional health, socio-emotional functional health, physical function, anxiety, depression, fatigue, sleep disturbance, social roles, pain interference, health distress, late life function, well-being, and loneliness. Hypothesized mediators are motivation and exercise. Along with demographics, other measures include total # of chronic conditions, barriers to technology,

use and frequency of technology use, life stresses, alcohol use, healthcare use, falls, and perceptions of ET. Surveys will be mailed to patients with a self-addressed stamped envelope. Patients will be phoned if they do not respond after 2 weeks. Patients can contact study staff for more detail if questions arise. Contact with patients can be requested by staff if data integrity or compliance issues are detected in ongoing data review. Survey data will be entered into REDCap.

ET use. Data about ET use is automatically collected continuously in time-stamped log files, including logins, services used, duration of use, pages viewed, messages posted and received, weekly surveys completed. Our secondary outcome of ET use during the 12-month intervention will be assessed by number of logins, but we will also explore pages viewed and use of services (e.g. discussion group). Within ET-Voice, data on voice commands will be collected.

Data quality plan. Most of our measures come from patients' self-reports because we are focused on their experiences. Given this, survey quality is very important. We have now surveyed two large sets of older adults and have developed the following strategies for data quality. Surveys are sent via hard copy in large print to all participants (with paid return envelopes). Participants can take as much time as they need and work on it when they choose. The visual formatting is simple and clear, with little clutter on the page. Tables of items and response options have alternate shading for lines, to reduce the likelihood that responses are circled for the wrong item. Instructions have been extensively pre-tested and as a result, we are very explicit as to how participants should respond if they feel a question does not apply to them or they do not know the answer. We use standardized measures that have been validated for this age group. We keep the survey as short as possible. These are all strategies to reduce errors and missing data. In addition, we have a clear protocol for evaluating surveys when they are returned. A trained member of the research staff goes through every survey within a week of its return, checking for any missing responses or items where several responses have been circled. In such cases, the staff member calls the participant and goes through the set of items to make corrections as needed.

Missingness. With regard to survey data, in the prior ET RCT, 351 of 390 participants (90.00%) completed the 6-month survey and 310 of 390 (79.49%) completed the 12-month survey. In completed surveys, data were missing on about 2% of core items. We expect similar rates in this study. Occasional out-of-residency is also expected for participants during the study (e.g. travel, hospitalizations). We will encourage patients to take ET (Voice or Text) with them when possible, but absences without ET will be addressed as covariates in missing data imputation models and our outcome models. Further details are given in the Statistical Considerations section.

Qualitative. Interviews will be conducted with patients and clinicians. Dr. Mares will train and monitor interviewers. *Patients.* In-depth phone interviews will be conducted with random samples of 16 patients from each arm, half at month 5 of their intervention and half at month 11 (N = 32). Of these, a random subset of 8 patients in each study arm will be re-interviewed 6 months post-intervention (18 months). This balances the need for insight into patients' experiences with reducing risk of confounding effects of repeated interviews with effects of ET. Interviewees will be asked about barriers to use, technical issues, how ET fits into their day, how ET can be more useful or appealing, perceived benefits and limitations of ET and the device(s), and whether and how ET came up in appointments with their doctor. The assumption, based on similar qualitative studies of this patient population,[61,62] is that about 6 patients will drop out, leaving about 26. Additionally, we will conduct interviews with 8 patients from racial/ethnic minorities (roughly half at 5 and half at 11 months of the intervention) to ensure that we have insight into their perceptions of the online community and the role that ET played in their interactions with their doctor. We will also interview 8 patients who maintained high use of ET across the 12 months of the intervention period to understand what motivated and sustained their use.

Clinic staff. We will record and analyze clinicians' comments and questions during meetings where we introduce the study and the CR to the clinics, and we will ask about anticipated barriers and benefits. We will document the protocols that clinics use to receive and disseminate the CR to clinicians. We will interview 5 clinicians at the end of data collection to get their feedback on feasibility and usefulness of the CR.

6.0 STATISTICAL CONSIDERATIONS

Quantitative analysis plan. Intention-to-treat will be the primary analytic strategy.
Assumptions and randomization effect. Participants will be assigned at random, with constraints that study arms will have roughly equal proportions for key covariates (e.g. race, education, baseline number of chronic conditions). Key covariates' effect on outcomes will be assessed for each model. We will assess whether there are main effects of clinic site or interactions with study arm (i.e. whether data can be pooled across sites). Variables will be examined using standard summary statistics, visualizations, and tests for normality and homoscedasticity. Data will be transformed as needed.

Analytical model: Effects of study arm on primary outcome. A linear mixed model will be used to examine effects of study arm (ET-Voice vs. ET-Text, a between-subjects factor) on functional health over time.

Analytical model: Effects of study arm on secondary outcomes. Linear mixed models will assess effects of study arm on each of the secondary outcomes over time (i.e. an interaction of the between-subjects factor of study arm and the within-subjects factor of time of measurement). In each analysis, a Holm-Bonferroni correction will be used to reduce Type 1 error. If healthcare use or number of symptoms lacks sufficient variability to be treated as a continuous outcome, it will be treated as dichotomous or as count data and run using a binomial or Poisson distribution for the linear mixed model.

Analysis: Mediation of effects of study arm on primary and secondary outcomes. We predict effects of study arm on functional health and secondary outcomes of loneliness, symptoms, and healthcare use will show serial mediation. That is, study arm → ET logins (first 6 months) → competence, relatedness, and motivation (in parallel) → outcomes. We will use structural equation modeling with separate models for each outcome.

Analysis: Moderation of study arm on primary outcome. We predict that effects of study arm on functional health will be moderated by age, sex, number of chronic conditions at baseline, and number of perceived physical barriers (e.g. tremors) to technology use. To test this, we will use linear mixed models, testing each moderator separately. We will conduct exploratory analyses on whether these moderation effects are also observed for the secondary outcomes.

Power analyses. The primary hypothesis is that intervention modality (voice vs. text/typing) will affect functional health. Based on PROMIS validation studies (e.g. chronic pain, arthritis, and cancer), a difference of 3 points or more between study arms was considered to indicate a clinically meaningful difference.[63] The PROMIS website also gives the mean and standard deviation of the T-score metric (M = 50, SD = 10).

Power calculations for this primary hypothesis were performed using SAS procedure PROC GLMPOWER (SAS Version 9.4[64]). The SAS code and additional details of assumptions are given in the Statistical Design and Power document. Results indicated that 282 participants (after attrition) would be needed for 80% power ($p<.05$) to observe a difference score of 3 points between study arms at 12 months. With regard to power for moderation analyses, we ran a sensitivity analysis to compute the smallest effect size our study would be powered to find using N = 280 given 4 groups (e.g. study arm x sex). With N = 280, G*Power calculations showed a 95% chance

(with p<.05) of observing a moderation effect as small as a Cohen's d of .22.

Total sample size needed (before attrition). We need 282 participants after attrition. In our previous ET study, at 12 months we retained 79% of the sample (i.e. 12-month surveys completed). Given this, we plan to recruit 178 per arm (356 total).

Qualitative analyses*.* For each data set, a coding scheme of key themes will be constructed, based on the research questions (perceived benefits, barriers to use) and examination of the data. Each scheme will be pilot tested, then 2 trained coders will code an overlapping subsample of 20% of content. Once reliability is established (minimum Krippendorff's alpha of .80 per category), the coders will work independently in NVivo.

7.0 RECORDS TO BE KEPT

- Subject Intake
- Subject Demographics
- Subject Consent Forms
- HIPAA Authorization Form
- Baseline and follow up survey data
- Coded ET use data
- Coded patient health care utilization and number of chronic conditions
- Coded transcripts from interviews with patients and meetups.

Appendix A

ElderTree Exercise Content Plan

Exercise videos:

These exercises included in this research have been selected from commonly used exercise programs for older adults and include balance, strengthening, endurance and stretching and range of motion exercises for upper and lower extremities, and are designed for participants to perform at home. Dr. Jane Mahoney, a UW Health geriatrician and Sue Wenker, a Certified Geriatric Physical Therapist, provided advice to the research team on the selection, development, and presentation of the exercises in ElderTree.

Exercise categories:

Each participant will be classified into one of three groups, based on the Easy Exercise tool to ensure the exercises provided on ElderTree are appropriate in terms of safety and their functional abilities.

The Easy Exercise tool will identify participants who report chest pain with activity, lightheadedness with standing, or falls, unsteadiness, or use of a mobility aid. For these participants, we will send a letter to their Primary Care Physician (PCP), describing the exercise component of the study, and ask them to provide permission, which will determine to which group they are assigned, as described below.

Group 0 will include:

- Participants who use a walker indoors, or any walker outdoors except a 4-wheeled walker.
- Participants with chest pain, falls, unsteadiness, lightheadedness with standing, or use a 4-wheeled walker outdoors or a cane indoors or outdoors who do not have their PCP's permission.
- Seated exercises, with only 1 or 2 steps to perform, of light exertion with few repetitions, and will not go to fullest range of motion. Dr. Mahoney and PT Wenker provided advice to the research team on exercises that meet these criteria.
- A required safety video which participants must watch before they can proceed to the exercises.
- Participants will be instructed to not exceed a level of exertion of fairly light. There will not be advancements.

Group 1 will include:

- Participants who do not use any type of walker indoors, or a standard, 2 or 3 wheeled walker outdoors.
- Participants whose PCP has provided permission for them to be included in Group 1 based on the Easy Exercise tool algorithm.
- Basic and advanced balance, endurance, flexibility, and strength exercises. We used knowledge gained from a previous study of online exercise to help us determine what exercises would be safe for Group 1. Pilot tests with sample videos to observe for safety and technique provided key findings that informed subsequent exercise instruction and video production. For example, we excluded any balance exercise where participants could not hold on at any time. We also excluded exercises that were cognitively challenging – i.e. involved a sequence of more than 2 movements to do the exercise.
- A required safety video that participants must watch, prior to having access to the exercises. The safety video provides safety recommendations based on the "Stepping On" falls prevention program (co-authored by Dr. Mahoney), and Dr. Mahoney and PT Wenker's combined 50 years of clinical and research experience with geriatric patient mobility.
- Safety warnings and recommendations at the beginning of each exercise, which are repeated throughout the video. These recommendations are tailored to each specific exercise.
- Advancement videos for each exercise that explains safety recommendations and warnings tailored to the exercise advancements. Individuals are instructed to never work above a level of "somewhat hard" and to advance only when the exercise is too easy, there is no pain with the exercise or the day after, and

the person is steady (if doing a standing exercise). Participants are instructed to begin any standing exercise holding on to a counter-high surface. If the standing exercise is for balance, they advance to fingertip holding, then to hand hovering over the surface, until they are stable, and the exercise is too easy.

Group 2:

- Participants that did not respond "Yes" to any Easy Screen question requiring a PCP's approval. Thus, Group 2 consists of people who self-report they do not have chest pain with activity, do not have lightheadedness with standing, and do not have falls, unsteadiness, or use an ambulation assistive device, and do not have cognitive impairment.
- A required safety video that participants must watch, prior to having access to the exercises. The safety video provides safety recommendations based on the Stepping On falls prevention program (co-authored by Dr. Mahoney), and Dr. Mahoney and PT Wenker's combined 50 years of clinical and research experience with geriatric patient mobility.
- Exercise videos separated into a basic and advanced level. We have recommended that participants only do the advanced exercises after they have done several weeks of basic-level exercises involving similar muscle groups.

For all Groups to monitor for adverse events:

- We will assess how exercises are going by asking a specific question on the ElderTree weekly survey. Any report of an adverse event related to exercise will be followed up within a day by phone call to the participant to identify details to determine whether an exercise should be pulled from the online platform or if additional safety recommendations need to be provided. Events will be reported to the DMC and serious events to the IRB as soon as discovered.
- Study participants are also instructed to call the study 1-800 line with any questions or concerns at any time. This phone line is monitored daily. Research staff will follow up within 48 hours to ascertain details and take further action as needed.
- If a participant is experiencing worsening symptoms (e.g. increased daily pain, night pain, need for medication, difficulty with ADLs, new or increased swelling, lost work days) not alleviated by decreasing their exercise level, then they will be instructed to stop the exercise and contact their participating physician to determine if they should or should not continue participating in the study.

References

1. Gustafson D, Wise M, Bhattacharya A, Pulvermacher A, Shanovich K, Phillips B, Lehman E, Chinchilli V, Hawkins R, Kim JS. The effects of combining Web-based eHealth with telephone nurse case management for pediatric asthma control: a randomized controlled trial. Journal of Medical Internet Research. 2012;14(4):e101. PMCID: PMC3409549.
2. Gustafson DH, Hawkins R, Boberg E, Pingree S, Serlin RE, Graziano F, Chan CL. Impact of a patient- centered, computer-based health information/support system. American Journal of Preventive Medicine. 1999;16(1):1-9.
3. Gustafson DH, McTavish F, Hawkins R, Pingree S, Arora N, Mendenhall J, Simmons GE. Computer support for elderly women with breast cancer. JAMA. 1998;280(15):1305.
4. Gustafson DH, Hawkins R, Pingree S, McTavish F, Arora NK, Mendenhall J, Cella DF, Serlin RC, Apantaku FM, Stewart J, Salner A. Effect of computer support on younger women with breast cancer. Journal of General Internal Medicine. 2001;16(7):435-45. PMCID: PMC1495237.
5. Gustafson DH, Hawkins R, McTavish F, Pingree S, Chen WC, Volrathongchai K, Stengle W, Stewart JA, Serlin RC. Internet-based interactive support for cancer patients: are integrated systems better? Journal of Communication. 2008;58(2):238-57. PMCID: PMC3144782.
6. Gustafson DH, McTavish FM, Chih MY, Atwood AK, Johnson RA, Boyle MG, Levy MS, Driscoll H, Chisholm SM, Dillenburg L, Isham A, Shah D. A smartphone application to support recovery from alcoholism: a randomized clinical trial. JAMA Psychiatry. 2014;71(5):566-72. PMCID: PMC4016167.
7. Gustafson DH, DuBenske LL, Namkoong K, Hawkins R, Chih MY, Atwood AK, Johnson R, Bhattacharya A, Carmack CL, Traynor AM, Campbell TC, Buss MK, Govindan R, Schiller JH, Cleary JF. An eHealth system supporting palliative care for patients with non-small cell lung cancer: a randomized trial. Cancer. 2013;119(9):1744-51. PMCID: PMC3684251.
8. Johnson J, Finn K. Designing user interfaces for an aging population: towards universal design. 1st ed. Cambridge, MA: Morgan Kaufmann; 2017.
9. Snoek FJ, Pouwer F, Welch GW, Polonsky WH. Diabetes-related emotional distress in Dutch and US diabetic patients: cross-cultural validity of the problem areas in diabetes scale. Diabetes Care. 2000;23(9):1305-9.
10. Burholt V, Scharf T. Poor health and loneliness in later life: the role of depressive symptoms, social resources, and rural environments. The Journals of Gerontology Series B, Psychological Sciences and Social Sciences.2014;69(2):311-24. PMCID: PMC3968864.
11. Luo Y, Hawkley LC, Waite LJ, Cacioppo JT. Loneliness, health, and mortality in old age: a national longitudinal study. Social Science & Medicine (1982). 2012;74(6):907-14. PMCID: PMC3303190.
12. Perissinotto CM, Stijacic Cenzer I, Covinsky KE. Loneliness in older persons: a predictor of functional decline and death. Archives of Internal Medicine. 2012;172(14):1078-83. PMCID: PMC4383762.
13. Perez S. Nearly 1 in 4 people abandon mobile apps after only one use. San Francisco: TechCrunch; 2016 May 31. Available from: https://techcrunch.com/2016/05/31/nearly-1-in-4-people-abandon-mobile-apps-after-only-one-use/. [Accessed July 15, 2020]
14. Perro J. Mobile apps: what's a good retention rate? Localytics; 2018 March 23. Available from: http://info.localytics.com/blog/mobile-apps-whats-a-good-retention-rate. [Accessed July 15, 2020]
15. Mizak A, Park M, Park D, Olson K. Amazon "Alexa" Pilot Analysis Report. Front Porch Center for Innovation and Wellbeing; 2017 Dec. Available at: http://fpciw.org/wp-content/uploads/sites/15/2017/12/FINAL-DRAFT-Amazon-Alexa-Analysis-Report.pdf.
16. Wallace T, Morris JT. Smart speaker usability by military service members with mTBI and PTSD. CSUN Assistive Technology Conference: The Journal on Technology and Persons with Disabilities; 2018. Available at: http://scholarworks.csun.edu/bitstream/handle/10211.3/202991/JTPD-2018-ID16-p127-139.pdf.
17. Capan F. Why Amazon device is a gift for healthcare. Medical Marketing & Media. 2016;51(1):20.
18. St. John A. Amazon echo voice commands offer big benefits to users with disabilities. Consumer Reports, Inc.; 2017 Jan 20. Available from: https://www.consumerreports.org/amazon/amazon-echo-voice-commands-offer-big-benefits-to-users-with-disabilities/. [Accessed July 15, 2020]

19. Thompson AC. Persuading your older parents to take the smart home leap. CNET; 2017 April 11. Available from: https://www.cnet.com/news/how-to-have-the-tech-talk-with-your-aging-parents/. [Accessed July 15, 2020]
20. Woyke E. The octogenarians who love Amazon's Alexa. Cambridge, MA: MIT Technology Review; 2017June 9. Available from: https://www.technologyreview.com/s/608047/the-octogenarians-who-love-amazons-alexa/. [Accessed July 15, 2020]
21. DailyCaring Editorial Team. Amazon Echo for dementia: technology for seniors. DailyCaring, LLC; 2018. Available from: https://dailycaring.com/amazon-echo-for-dementia-technology-for-seniors/. [July 15, 2020]
22. Bentley F, Luvogt C, Silverman M, Wirasinghe R, White B, Lottrjdge D. Understanding the long-term use of smart speaker assistants. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies. 2018;2(3):91.
23. Mayer DK, Landucci G, Awoyinka L, Atwood AK, Carmack CL, Demark-Wahnefried W, McTavish F, Gustafson DH. SurvivorCHESS to increase physical activity in colon cancer survivors: can we get them moving? Journal of Cancer Survivorship : research and practice. 2018;12(1):82-94. PMCID: PMC5911378.
24. Gustafson Jr DH, Gustafson Sr DH, Cody OJ, Chih MY, Johnston DC, Asthana S. Pilot test of a computer-based system to help family caregivers of dementia patients. Journal of Alzheimer's Disease : JAD. 2019;70(2):541-52.
25. Gustafson Sr. DH, McTavish F, Gustafson DH, Jr., Mahoney JE, Johnson RA, Lee JD, Quanbeck A, Atwood AK, Isham A, Veeramani R, Clemson L, Shah D. The effect of an information and communication technology (ICT) on older adults' quality of life: study protocol for a randomized control trial. Trials. 2015;16(1):191. PMCID: PMC4417513.
26. National Public Radio, Edison Research. The Smart Audio Report. Winter 2018. National Public Media LLC; 2019. Available at: https://www.nationalpublicmedia.com/wp-content/uploads/2019/01/Smart-Audio-Report-Winter-2018.pdf.
27. Liu L, Stroulia E, Nikolaidis I, Miguel-Cruz A, Rios Rincon A. Smart homes and home health monitoring technologies for older adults: a systematic review. International Journal of Medical Informatics. 2016;91:44-59.
28. Liu P, Li G, Jiang S, Liu Y, Leng M, Zhao J, Wang S, Meng X, Shang B, Chen L, Huang SH. The effect of smart homes on older adults with chronic conditions: a systematic review and meta-analysis. Geriatric Nursing (New York, NY). 2019.
29. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist. 2000;55(1):68-78.
30. Webb TL, Sheeran P. Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. Psychological Bulletin. 2006;132(2):249-68.
31. Namkoong K, Shah DV, Han JY, Kim SC, Yoo W, Fan D, McTavish FM, Gustafson DH. Expression and reception of treatment information in breast cancer support groups: how health self-efficacy moderates effects on emotional well-being. Patient Education and Counseling. 2010;81 Suppl:S41-7. PMCID: PMC2993816.
32. Han JY, Shah DV, Kim E, Namkoong K, Lee SY, Moon TJ, Cleland R, Bu QL, McTavish FM, Gustafson DH. Empathic exchanges in online cancer support groups: distinguishing message expression and reception effects. Health Communication. 2011;26(2):185-97. PMCID: PMC3551338.
33. Seligman ME, Csikszentmihalyi M. Positive psychology: an introduction. In: Csikszentmihalyi M, editor. Flow and the Foundations of Positive Psychology. Netherlands: Springer; 2014. p. 279-98.
34. Wheeler DJ, Chambers DS. Understanding Statistical Process Control. Knoxville, TN: SPC Press; 1992.
35. Parekh AK, Goodman RA, Gordon C, Koh HK. Managing multiple chronic conditions: a strategic framework for improving health outcomes and quality of life. Public Health Rep. 2011;126(4):460-71. PMCID: PMC3115206.
36. Gustafson DH, DuBenske LL, Atwood AK, Chih M-Y, Johnson RA, McTavish F, Quanbeck A, Brown RL, Cleary JF, Shah D. Reducing symptom distress in patients with advanced cancer using an eAlertsystem for

caregivers: pooled analysis of two randomized clinical trials. JMIR. 2017;19(11):e354. PMCID: PMC5705856.
37. Leite I, Martinho C, Paiva A. Social robots for long-term interaction: a survey. International Journal of Social Robotics. 2013;5(2):291-308.
38. Gockley R, Bruce A, Forlizzi J, Michalowski M, Mundell A, Rosenthal S, Sellner B, Simmons R, Snipes K, Schultz AC, eds. Designing robots for long-term social interaction. 2005 IEEE/RSJ International Conference on Intelligent Robots and Systems; 2005 Aug 2-6; Edmonton, Alberta: IEEE; 2005:1338-43.
39. Sinha T, Cassell J, editors. We click, we align, we learn: Impact of influence and convergence processes on student learning and rapport building. Proceedings of the 1st Workshop on Modeling INTERPERsonal SynchrONy And infLuence; 2015 Nov 13; Seattle, WA: ACM; 2015:13-20.
40. Spencer G. Much More than a Chatbot: China's Xiaoice Mixes AI with Emotions and Wins Over Millions of Fans: Microsoft; 2018 Nov 1. Available from: https://news.microsoft.com/apac/features/much-more-than-a-chatbot-chinas-xiaoice-mixes-ai-with-emotions-and-wins-over-millions-of-fans/. [Accessed July 15, 2020.]
41. Michaelis JE, Mutlu B, eds. Someone to read with: Design of and experiences with an in-home learning companion robot for reading. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems; 2017 May 6-11; Denver, CO: ACM; 2017:301-12.
42. Kidd CD, Taggart W, Turkle S, eds. A sociable robot to encourage social interaction among the elderly. Proceedings 2006 IEEE International Conference on Robotics and Automation; 2006 May 15-19; Orlando, FL: Wada K, Shibata T. Social effects of robot therapy in a care house–change of social network of the residents for one year. JACIII. 2009;13(4):386-92.
43. Wada K, Shibata T. Social effects of robot therapy in a care house–change of social network of the residents for one year. JACIII. 2009;13(4):386-92.
44. Wada K, Shibata T. Living with seal robots—its sociopsychological and physiological influences on the elderly at a care house. IEEE transactions on Robotics : a publication of the IEEE Robotics and Automation Society. 2007;23(5):972-80.
45. Lee MK, Kiesler S, Forlizzi J, Srinivasa S, Rybski P, eds. Gracefully mitigating breakdowns in robotic services. 2010 5th ACM/IEEE International Conference on Human-Robot Interaction (HRI); 2010 Mar 2- 5; Osaka, Japan: IEEE; 2010:203-10.
46. Šabanović S. Robots in society, society in robots. International Journal of Social Robotics. 2010;2(4):439-50.
47. Leite I, Lehman JF, eds. The robot who knew too much: toward understanding the privacy/personalization trade-off in child-robot conversation. Proceedings of the The 15th International Conference on Interaction Design and Children; 2016 Jun 21-24; Manchester, United Kingdom: ACM; 2016:379-87.
48. Barrett B. What Amazon Echo and Google Home Do With Your Voice Data. New York: Wired Magazine; 2017 Nov 24. Available from: https://www.wired.com/story/amazon-echo-and-google-home-voice-data-delete/. [Accessed July 15, 2020.]
49. McCarty D, Gustafson DH, Wisdom JP, Ford J, Choi D, Molfenter T, Capoccia V, Cotter F. The Network for the Improvement of Addiction Treatment (NIATx): enhancing access and retention. Drug and Alcohol Dependence. 2007;88(2-3):138-45. PMCID: PMC1896099.
50. Gustafson DH, Brennan PF, Hawkins RP. Investing in e-health: What it takes to sustain consumer health informatics. In: Hannah KJ, Ball MJ, eds. Health Informatics. New York: Springer Science+Business Media, LLC; 2007.
51. Gustafson DH, Hundt AS. Findings of innovation research applied to quality management principles for health care. Health Care Management Review. 1995;20(2):16-33.
52. Hoffman KA, Ford JH 2nd, Choi D, Gustafson DH, McCarty D. Replication and sustainability of improved access and retention within the Network for the Improvement of Addiction Treatment. Drug and Alcohol Dependence. 2008;98(1-2):63-9. PMCID: PMC2607248.
53. NIATxNPO. NIATx process improvement: conducting a walk-through. CHESS/NIATx, University of Wisconsin-Madison; 2009.
54. Gustafson Sr. DH, McTavish F, Gustafson DH, Jr., Mahoney JE, Johnson RA, Lee JD, Quanbeck A, Atwood AK,

Isham A, Veeramani R, Clemson L, Shah D. The effect of an information and communication technology (ICT) on older adults' quality of life: study protocol for a randomized control trial. Trials. 2015;16(1):191. PMCID: PMC4417513.
55. Hays RD, Spritzer KL, Schalet BD, Cella D. PROMIS((R))-29 v2.0 profile physical and mental health summary scores. Quality of Life Research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2018;27(7):1885-91. PMCID: PMC5999556.
56. Cella D, Choi SW, Condon DM, Schalet B, Hays RD, Rothrock NE, Yount S, Cook KF, Gershon RC, Amtmann D, DeWalt DA, Pilkonis PA, Stone AA, Weinfurt K, Reeve BB. PROMIS® Adult Health Profiles: Efficient Short-Form Measures of Seven Health Domains. Value Health. 2019 May;22(5):537-544. doi: 10.1016/j.jval.2019.02.004. PMID: 31104731; PMCID: PMC7201383.
57. Stanford/Garfield Kaiser Chronic Disease Dissemination Study. Psychometrics reported in: Lorig KR, Sobel DS, Ritter PL, Laurent D, Hobbs M. Effect of a self-management program for patients with chronic disease. Effective Clinical Practice. 2001:4, 256-262.
58. Cyranowski JM, Zill N, Bode R, Butt Z, Kelly MA, Pilkonis PA, & Cella D. Assessing social support, companionship, and distress: National Institute of Health (NIH) Toolbox Adult Social Relationship Scales. Health Psychology. 2013:32(3), 293.
59. Allgaier AK, Kramer D,Saravo B, Mergi R, Fejtkova S, & Hegerl U. Beside the Geriatric Depression Scale: the WHO-Five Well-being Index as a valid screening tool for depression in nursing homes. International Journal of Geriatric Psychiatry. 2013:28(11), 1197-1204.
60. Jeong HS, Park S, Lim SM, Ma J, Kang I, Kim J, Kim EJ, Choi YJ, Lim JH, Chung YA, Lyoo IK, Yoon S, Kim JE. Psychometric Properties of the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C) in Public First Responders. Subst Use Misuse. 2017 Jul 3;52(8):1069-1075. doi: 10.1080/10826084.2016.1271986. Epub 2017 Mar 21. PMID: 28323556.
61. Bayliss EA, Edwards AE, Steiner JF, Main DS. Processes of care desired by elderly patients with multimorbidities. Family Practice. 2008;25(4):287-93. PMCID: PMC2504745.
62. Shapira N, Barak A, Gal I. Promoting older adults' well-being through Internet training and use. Aging & Mental Health. 2007;11(5):477-84.
63. Swanholm E, McDonald W, Makris U, Noe C, Gatchel R. Estimates of Minimally Important Differences (MIDs) for two Patient-Reported Outcomes Measurement Information System (PROMIS) computer-adaptive tests in chronic pain patients. Journal of Applied Biobehavioral Research. 2014;19(4):217-32.
64. SAS Institute Inc. Analytics Software & Solutions. Cary, NC: SAS; 2020. Available from: https://www.sas.com/en_us/home.html. [Accessed July 15, 2020]