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ORIGINAL RESEARCH

Technology for Behavioral Change in Rural Older Adults with Obesity

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ABSTRACT

Background: Mobile health (mHealth) technologies comprise a multidisciplinary treatment strategy providing potential solutions for overcoming challenges of successfully delivering health promotion interventions in rural areas. We evaluated the potential of using technology in a high-risk population.

Methods: We conducted a convergent, parallel mixed-methods study using semi-structured interviews, focus groups, and self-reported questionnaires, using purposive sampling of 29 older adults, 4 community leaders and 7 clinicians in a rural setting. We developed codes informed by thematic analysis and assessed the quantitative data using descriptive statistics.

Results: All groups expressed that mHealth could improve health behaviors. Older adults were optimistic that mHealth could track health. Participants believed they could improve patient insight into health, motivating change and assuring accountability. Barriers to using technology were described, including infrastructure.

Conclusions: Older rural adults with obesity expressed excitement about the use of mHealth technologies to improve their health, yet barriers to implementation exist.

KEYWORDS
Aging; mixed-methods; qualitative; technology

Introduction

The epidemic of obesity affects everyone, even older adults aged ≥65 years[1] and is associated with considerable disability[2] and morbidity.[3] Effective weight-management interventions require frequent interactions for encouraging behavioral change in this population.[4,5] Although intentional weight loss in older adults is safe and effective,[6] its delivery in usual care settings

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is difficult due to time-management challenges for clinical providers.[7] The difficulties are exacerbated in rural areas where individuals with obesity face minimal access to specialized health promotion programs and trained professionals.[8] This rapidly growing older adult population in rural areas must therefore travel or adopt different modalities to obtain quality care and treatment to prevent marginalization and risk progressively higher medical comorbidity.

Mobile health (mHealth) technologies may provide a potential solution for delivering health-promotion interventions to older adults by overcoming these barriers to providing care. Real-time, motivating, patient-oriented feedback with messaging based on adaptable sensor technologies are promising for eliciting behavioral change and could improve physical function in this population. Older adults are the fastest growing demographic using technology,[9] and rural areas are obtaining increasing access to broadband and cellular service (http://www.broadband.gov/rural_areas.html) making the implementation of mHealth interventions possible, even in this population. Devices, applications and platforms that can provide automated health behavior change can improve adherence,[10–19] potentially overcoming the limits of interventions relying heavily on self-motivation,[20] and interactions with busy clinicians who often focus on health issues other than obesity.[21]

There is limited understanding of how best to leverage the promise of technology to deliver effective, practical, and lasting behavioral change interventions that target the vulnerable and difficult-to-reach population of rural older adults with obesity.[22,23] Our primary aim explored the perceptions of how technology could potentially improve one's health in rural older adults with obesity. The findings from this study will provide insight into effective approaches for supporting health behavior change in this population. We anticipate these results will allow us to tailor a multicomponent obesity intervention that improves physical function and weight loss in older adults with obesity using mHealth devices as tools for behavioral change.

Methods

Study design

We undertook a convergent parallel mixed-methods study, involving collection of both qualitative and quantitative data, using semi-structured interviews, focus groups, and a self-reported questionnaire between October 2016 and April 2017. We chose a qualitative approach to permit exploration of the use of technology in older adults, a subgroup where literature is limited on this topic. We also sought to gain insight about three different stakeholder groups (patients, clinicians, and community leaders) related to

behavioral change and technology use. The protocol was reviewed by the Institutional Review Board that has oversight over the hospital and university setting.

Sampling strategy

We conducted purposive and snowball sampling of the three groups to identify potentially eligible participants.[24–27] We anticipated that each group would provide different viewpoints and unique insights. Our rationale was that information from these distinct groups would enhance triangulation, a method reflective of the Triangulation Design Model for primary care studies put forth by Creswell et al which requires the integration of convergent quantitiative and qualitative data.[28] These methods coupled with our inductive approach can contribute to our understanding of how technology could support health behavior change and improve health among older adults with obesity. In our study design, we aimed to conduct 4 focus groups (6–8 participants each), 4 community leader semi-structured interviews, 6 clinician interviews, and 8 patient participant semi-structured interviews. Interviewers reviewed and reflected on their field notes where similar themes and consistent information led to theoretical saturation for older adult participants.[29,30]

Study site and recruitment

All patient participants were selected from a rural, primary care academic practice in the Section of General Internal Medicine at Dartmouth-Hitchcock. Dartmouth is located in Lebanon, NH, on the New Hampshire/Vermont border, and is the state's only academic medical center. The primary care clinic serves about 4,000 older adults over age 65, and subjects were accessible through the primary author's (JAB) involvement as a member of an interdisciplinary geriatric team. Dartmouth's catchment area ranges of all Northern New England with patients traveling up to 2–3 hours to receive care. This rural area has geographic and weather related challenges, particularly in the winter.

Patient recruitment posters were placed in visible common areas of the clinic, the adjoining 396-bed hospital, and the Center for Health & Aging. This interdisciplinary center integrates geriatric education, research, and community educational resources, and is located one mile from the medical center. We also recruited through local listservs and through our Centers' research and clinical networks across Northern New England. All interested participants were then subject to pre-assessment eligibility through a medical record review by a HIPAA waiver before acquiring full informed

consent for the requisite aim. Participants needed to be English-speaking, have a body mass index $\geq$30 kg/m^2 or a waist circumference $\geq$88 cm in females or $\geq$102 cm in males. A signed informed consent using a standard script was conducted. All those that were approached for screening procedures participated. Six community leaders were approached, two who felt that they could not meaningfully contribute to this study. All approached clinicians agreed to participate. No data from health records, other than self-report data (see below), were abstracted for clinicians or community leaders. Patient participants were compensated with fresh fruit and vegetable snacks and a $25 gas card.

Community leaders of aging services organization were chosen from the immediate area (Lebanon, Thetford, Lyme, White River Junction) using local geriatric networking and email lists acquired through our aging center's extensive aging services network. All interviewed community leaders led aging initiatives within their respective communities (e.g., directing town senior centers). Two areas (Lyme, Thetford) are considerably more populated and 'less rural' than others (Lebanon, White River Junction). Clinicians were all primary-care internal-medicine physicians, three of whom had additional training in geriatric medicine. Clinician participants were recruited following presentation of the research study at a faculty clinician meeting held at Dartmouth. All study-related activities, including informed consent, were conducted at the Center for Health and Aging.

Interviews & focus groups

A total of 19 open-ended 1:1 semi-structured interviews were conducted, each lasting 45–60 min (8 patients, 7 clinicians, 4 community leaders). We exceeded our target for clinicians by one additional interview due to their willingness to participate. We conducted 5 patient focus groups in lieu of 4 due to weather-related issues. A total of 21 participants were interviewed as part of the focus groups, each lasting 90–120 min. No repeat interviews were conducted. Two investigators (JAB, ABZ) were present at all the focus groups. JAB is a male staff geriatrician with formal qualitative training and ABZ is a female Project Coordinator with quality improvement training, ensuring diverse backgrounds in the interviewing process. JAB conducted all clinician and community leader interviews and both JAB and ABZ conducted all participant interviews and focus groups in equal proportions. Patient participants who had a relationship with JAB were interviewed by ABZ to reduce and minimize the risk of bias. Both investigators had formal training in interviewing, self-reflection and focus group training. We elected to stop conducting additional interviews following our 21st focus

group and 8th individual interview participant as no additional information was obtained.

Semi-structured interview guides with clarifying probes were used for all interactions (Appendix 1). The goal of the questionnaire was to hear the patient's perspective about challenges to weight loss and wellness in overweight adults living in rural areas, and how technology could improve their health. Therefore, questions focused on how participants felt that technology (specifically, wearable activity tracking devices or smartphones) could be helpful in improving their health and how using technology could be useful for tracking/monitoring health. Semi-structured guides were iteratively developed by the transdisciplinary research team that allowed questions and viewpoints from the different stakeholder groups. Participants of the three groups were encouraged to elaborate their responses to provide additional details regarding their perspectives and experiences. Initial audio recordings were reviewed by another investigator (ECS) to provide feedback to improve quality of interview technique and ensure consistency of approach.

Data analysis

Each interview or focus group session was digitally recorded at the study site and transcribed by medical students or by an independent commercial transcription service, all of which were reviewed by the lead author. No other individuals were present other than the interviewer(s) and study participants. To protect the security of patient information, all data were de-identified prior to analysis and stored on password-protected computers in accordance with institutional privacy requirements, along with all questionnaires or other study-related documents. Each transcript was reviewed by JAB, and imported into *Dedoose* (www.dedoose.com), a software application that facilitates coding and analysis of qualitative data, allowing integration with other quantitative characteristics. All identifying information was eliminated on upload. We developed a codebook using a combination of *a priori* researcher-driven codes derived from interview and focus group guides and codes generated through inductive review of transcripts. The codebook consisted of 30 codes organized within 7 domains; these categories served as the foundation for the analysis. All qualitative data were managed and coded using *Dedoose*. Coding was completed in stages throughout the study and involved multiple researchers to enhance the 'trustworthiness' of our findings.[31] The lead author reviewed the data and coded segments of text corresponding to the categories in the codebook. A second researcher, JAN, subsequently reviewed all coded excerpts and identified all discrepancies. In conjunction with a third researcher (ECS),

the coded data were reviewed to resolve disagreements and reach consensus. Following coding, excerpts were reviewed and discussed to identify relationships and construct the main themes reported in this paper. Transcripts were not returned to participants for correction.

Quantitative data

At the conclusion of the interview or focus groups, all participants were provided with a survey asking for self-reported basic demographic and weight information, in addition to specific questions related to technology use (Table 1). Survey data was collected using RedCAP (http://www.project-redcap.org/), a secure, web-based application platform designed to support data capture for research studies. Descriptive statistics were applied to data.

Results

Participant demographics

There were 7 primary care clinicians (including 3 geriatricians), 4 community leaders and 29 patient participants. The clinicians had a mean age of 46.7 years (71.4% female) and been in practice for 14 ± 9.5 years (median 15 years), while community leaders had a mean age of 64.3 years (50% female) and had been in their positions for 13.5 ± 5.5 years (median 13 years). Of patient participants ($N = 29$), 16 (55%) were female, their mean age was 72.9 years (SD = 4.6), their mean BMI was 32.9 kg/m^2

Table 1. Baseline characteristics of study participants.

Characteristic	Patients $N = 29$	Clinicians $N = 7$	Community Leaders $N = 4$
Demographic Information			
Age, years ± s.d.	72.9 ± 4.6	46.7 ± 12.1	64.3 ± 8.73
Female sex (%)	16 (55.2)	5 (71.4)	2 (50.0)
Weight, lbs	205.8 ± 26.4	150 ± 33.7	172.5 ± 40.3
Body Mass Index, kg/m^2	32.9 ± 2.5	23.76 ± 2.08	26.4 ± 4.57
Medicare Insurance	27 (96.4)	–	–
Race			
White	29 (100.0)	**	4 (100.0)
Asian	–	**	–
Years in Role	–	14 ± 9.47	13.5 ± 5.51
Quantitative Survey			
Do you use email (% yes)	28 (96.6)	–	–
Do you like using technology?* (% yes)	19 (65.5)	4 (57.1)	3 (75.0)
How comfortable are you with using technology or electronics?# (% very comfortable)	12 (41.4)	3 (42.9)	2 (50.0)
Have you ever used a fitness device/tracker (e.g. a Fitbit, Jawbone, etc.)? (% yes)	11 (37.9)	4 (57.1)	1 (25.0)

Values represented are mean ± standard deviation, or count (%).
*Rated at yes/somewhat/no.
#Rated at 'not at all comfortable, somewhat comfortable, pretty comfortable, very comfortable.
**Not shown to protect identity.

(SD = 2.5), and 22 (76%) had a college education, while only 6 (21%) had a mean household income of >$100,000. Other baseline characteristics are represented in Table 1.

The potential of technology to improve the health of older adults with obesity

Figure 1 presents a model summarizing the results of the transcripts as to how technology could improve the health of older adults with obesity based on our qualitative analyses. Overall, older adults were open to the use of technology and felt that it has the potential to aid in their wellness. For instance, older adults were aware of the existence of various fitness devices (e.g., Fitbit) and home-based sensors that could prompt individuals to track their health (e.g., steps, nutrition). They also acknowledged that they could increase their knowledge through other means (i.e., Internet/web searches). All participants expressed that technology-based modalities could potentially increase patients' insight into health problems, increase motivation to change health behaviors, and provide a sense of accountability to themselves and to their healthcare provider. Many of the interviewed participants agreed that these three major perceptions were viewed as important factors for prompting behavioral change (e.g., healthier eating, physical activity), and that in this way, technology could ultimately lead to improved health. All three groups also identified barriers to the use of technology among older adults in rural communities, including a lack of accessibility and the complexity of technology; privacy was not brought up as a significant concern in the patient population. Below, we elaborate on these

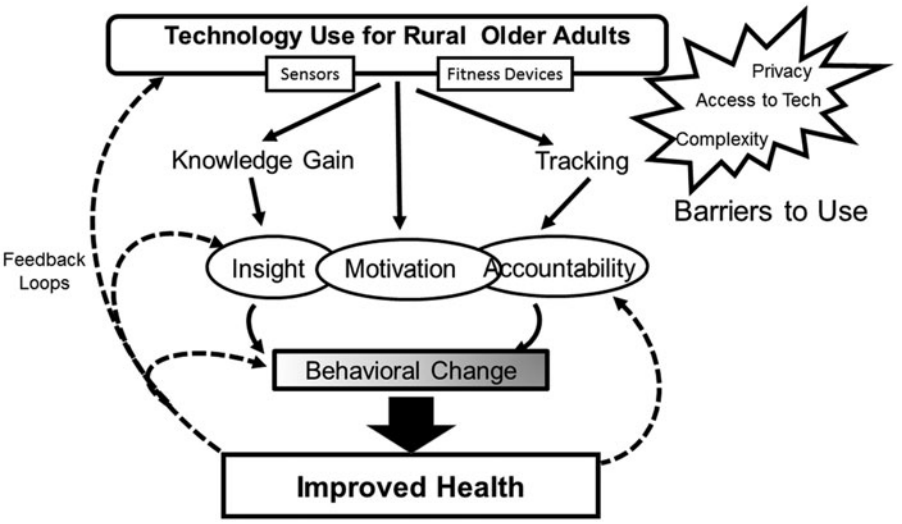

Figure 1. Using Technology to improve the health of older adults with obesity.

Table 2. Technology benefits, barriers and potential for behavioral change.

Domain	Code	Illustrative quote
Behavioral factors	Insight	I think it takes something overwhelming and nebulous as weight loss and puts it into baby steps so I feel like that's how it can be used and people to communicate quickly
	Motivation	I think by kind of using all the tools it's motivating and inspiring when you see that you've had a day where you really ate healthy.
	Accountability	I think it's just one of those things where just steady, little nudges might help keep people on track and then the accountability issue, I mean, I think that's probably what helps most with like Weight Watchers is just knowing somebody's checking in and (chuckles) and there's some tracking that.
Benefits of using technology	Gain of Knowledge	One thing I do want to get that you have is that Fitbit thing just to keep an eye on things, make sure I'm doing something
	Tracking	I think for seniors in a rural area to get computers and that type of thing available and get people to be able to use them so that they can get at the information and track what they're doing, it's a, it's a big thing
Barriers to technology adoption	Access to Tech	The other barrier is Internet connection. Be it cost or the availability of the Internet connection in that area.
	Complexity	But if it, again, we have to balance what is important and not because if it's going to be too technical, it's not heavy so I don't think that will be an issue. If it's too technical though if it will be costly for them to do this out of a trial period
	Privacy	I guess the first thing is how intrusive would I feel it to be

findings (Table 2) and provide illustrative examples excerpted from interviews and focus groups with patients, clinicians, and community leaders.

Promoting positive behavioral changes through technology

The three groups described the behavioral aspects of introducing technology within a clinical realm to improve older patients' health. Each group felt that this provided insight, motivation and accountability. Generally, clinicians expressed that the accountability and motivation was important for their patients which was corroborated by patients and community leaders. In their view, technology could help to establish healthy habits and positive behaviors; these behavioral changes could lead to health changes. Goal setting was pervasive throughout all the interviews and focus groups.

> *Focus Group #2 Participant*: *I think, uh, by kind of using all the tools it's motivating and inspiring when you see that you've had a day where you really ate healthy.*

Clinician #6: *. a daily message about healthful living or maybe prompts you to get your steps in and the feedback device of a pedometer, 10,000 steps or something, I mean that seems effective for a lot of people to have a concrete goal to nudge them to, to keep doing stuff when they might want to take a day off.*

Community Leader #4: *But I think if it comes on a devices that becomes broader than "this is the thing that is making me lose weight" it's better.*

Furthermore, all groups felt that technology would lead to a gain of knowledge; however, the groups also felt that any mHealth device and its functions would require individual personalization as each individual responds to different messages and modalities. Such an approach would have the greatest potential to motivate behavioral change.

Community Leader #4: *So I think there's a place for the Fitbit, which is just actually measuring how you're moving, I think there's absolutely a place for recording what you're doing and doing that in an electronic way that let's you kind of look back and again, for me that's a really helpful thing, but I think broadly I hear that people writing things down that is helpful to them. So having a way to do that.*

Patient Participant #7: *If—if I wear it and I'm conscious of it, I'm going to set some goals and I'm going to—I'm going to walk 2,000 steps a day or 4,000 steps or I can check and see how far I've done today, and if I've only walked a few hundred, then maybe I'm sitting around too much today and things like that. So, I think that's very beneficial.*

Patient Participant #4: *It gave me information that I found interesting and told me I wasn't as slothful as maybe I would've thought, but I didn't see how I could improve it any, at the time, whatever that time was.*

Barriers to using technology

The evidence was clear that rural areas face lack of access to adequate telecommunication systems but there was little information provided in terms of the reasons for such.

Clinician #2: *… the other barrier is Internet connection. Be it cost or the availability of the Internet connection in that area.*

Focus Group #5 Participant: *… there are people who don't have computers out there and can't access this stuff, ….*

Focus Group #1 Participant: *I think for seniors in a rural area to get computers and that type of thing available and get people to be able to use them so that they can get at the information and track what they're doing, it's a big thing to learn.*

Community Leader #1: *A lot of folks don't have cellphones, don't have tablets, and don't know how to turn on a computer, so it'd be really challenging.*

Community Leader #2: *Okay, so you need some rudimentary, uh, computer skills in understanding.*

Many participants, particularly clinicians, did not feel that technology was the complete solution, but perhaps an adjunct to existing tools/therapies in obesity management. They expressed concerns that the success of technology based programs is dependent on individual motivations and also challenged by the complexity of the technology and restricted access to the resources and knowledge necessary to implement the technology.

Clinician #4: *For the patient who's not convinced that this is the right thing, I'm not sure that's going to be as useful, because they're just going to take it off and put it on the counter and not listen to the messages. But for somebody who's already invested in it…*

Focus Group #2 Participant: *I think that one of the problems with technology is, I find it's easy enough to use a cell phone, so when I can get online somewhere, that's fine, but, I think, um, most big institutions and so forth don't realize how few people actually have, uh, computers and internet in their homes, and stuff like that, and have to go to the library to do everything. So I, I'm of a mind still, certainly you want to step forward in this, but on the other hand if you really want to reach a lot of people you gotta find a way to do it that isn't just a, just with technology.*

On the other hand, community leaders were less skeptical about the use of technology, and patients were most optimistic of overcoming these barriers. One strategy mentioned was to engage local community settings and to leverage social connections for improving one's health. It was suggested that barriers to motivation could be overcome if technology was used in a social context.

Community Leader #4: *I think anything you can do from a technological perspective … to keep it as community-ey as possible. Like if you're playing, you know, Words With Friends on the computer it feels different than if you're just playing it by yourself. And I think to the extent you can do it seeing each other, connecting with each other, um, you know taking pictures of yourself (laughing). …*

Surveys & apprehensive comments related to the use of technology

At the conclusion of each focus group and interview, a number of quantitative questions were asked of all participants. These results suggested that clinicians were least likely to enjoy using technology but were equally comfortable in using technology as the patient group. While all clinicians used technology on a daily basis, we observed that they used a fitness tracking device most often, and also noted that their patients needed to be ready to use fitness devices. Below are some representative quotations from the open-ended questioning.

Clinician #4: I think first, the patient has to be open to using it.

Clinician #3: … clearly what we know about behavior modification is that we need relatively quick interval check in and positive feedback and so the ability to send in a weight and check-in in smaller intervals through technology is something that has got some potential.

Clinicians also were not as optimistic about the outcomes received from such devices, stating the limited data available, the technological savviness of the population, the potential barriers of usability (ie: visual or dexterity challenges) in this population.

Clinician #6: I think it, I think it has potential, um, I would hope. I mean I think, you know, there is that recent study that showed that it didn't seem to help. (chuckles) But I think there is some other studies with text messages and other stuff.

Clinician #5: But anyway, I think that there is some good evidence that says that these fitness things don't really help you to lose any weight. I've had encouraged people to use the app, My Fitness Pal…

Clinician #3: I think it would be hard for them to read. And I wonder if they have the physical dexterity to manipulate this slide thing

Clinician #2: …some of my patients have like you know some visual impairments. Having messages might be difficult for them to you know to accommodate to.

Conversely, many patient experiences differed from those of clinicians. For example, there were individuals with existing devices that were very satisfied with their devices, knowledge/skills gained, and their motivations to use their device for health improvement.

Focus Group #1 Participant: But it did give me self-satisfaction to get the achievement I walked further than the London subway system.

Patient Participant #1: And I think it's an incredibly powerful tool, but you have to wanna use it.

Discussion

This exploratory study highlights the barriers and facilitators in using technology in an older adult population with obesity, specifically in a rural area. All stakeholder groups, including clinicians, patients and community leaders felt that technology was promising in health promotion by providing insight, motivation and accountability that could lead to limited feedback loops driving behavioral change. However, key barriers were identified including access to technology, privacy concerns for clinicians, and the potential complexity in using such devices. If not effectively addressed,

these barriers may limit the potential of technology to improve health among older adults, particularly in rural settings.

Figure 1 presents a model of how technology could improve the health of older adults with obesity based on our qualitative analyses. Considerable bias and stigma are often faced by older adults particularly with novel and emerging technologies and this was in part reflected by the attitudes of the clinicians. Epidemiologic studies have demonstrated favorable attitudes towards Internet technologies.[32] Other qualitative researchers have provided detailed depictions of older adults' attitudes about technology in general suggesting that the stereotype of older adults being afraid and unwilling to use technology is simply not true.[33] Mitzner[34] conducted focus groups in 113 adults aged 68–85 years and demonstrated that technology was acceptable because it supported activities, was convenient, and had interesting features. Our patient cohort had predominantly positive attitudes of using technology, suggesting that training and education of this age spectrum may be important in early stages of intervention development to ensure adherence and acceptance. These endeavors could inform intervention developers of the potential outcome benefits. Usability is a key issue in this population.[35] Similar to our own results, older adults desire human contact[35] when interacting with specific interfaces and react negatively if human contact is omitted. Older adults are the fastest growing demographic of technology users[9] and our results suggest that this population should not be excluded from using devices in routine and usual care settings, and specifically in research settings. Specific sensory barriers, including vision and dexterity impairments, should be accounted for in the usability and design of any technology products and in their deployment. Technology can assist in developing a community among patients, and our study demonstrated these points clearly.

The potential for using mHealth in behavioral change should not be understated. Our exploratory results suggest that mHealth can impact patient, provider and community engagement with the potential for two-way feedback. All groups acknowledged the importance of providing motivation and accountability. However, clinicians were less optimistic about its effectiveness. Technology often encompasses multiple spheres, including remote monitoring, telemedicine, and electronic health records. EHRs are known to be a primary cause of physician burnout,[36] while other reasons for potential apprehensiveness include the quantity of data,[37] or patient motivation to use such equipment.[38] While these specific issues were not explored in these studies, we speculate that these issues could be the reason for the results observed. Telemedicine appears to have a significant importance to clinicians compared to other forms[39] of mHealth devices. Our qualitative results are in line with a large healthcare survey that consumers

were more likely to prefer newer technologies than providers.[33] Importantly, all participants viewed technology as a tool, not as a substitute to medical care. This finding is consistent with other studies suggesting the importance of human interaction.[40] For example, Currie et al.[41] evaluated pain in older adults; in their descriptive work, participants sought eHealth interventions alongside in-person interventions.

Social support is a component of successful aging, that is, aging while maintaining quality of life,[42] as is engagement in social activities.[43,44] The use of technology is associated with improved self-rated health and subjective well-being, in part mediated by reduced loneliness.[45] The PRISM trial used Internet access coupled with a resource guide, calendar, photo feature, email and games, to evaluate 300 older adults at risk for social isolation that lived independently in the community. These authors discovered improved perceived social support and well-being at six months and exemplifies that technology can take on a social function.[46] Another study demonstrated the importance of including all family members in the implementation of technology[47] as older adults easily adopt the enthusiasm of younger generations. Although by not including caregivers in our study we limit the conclusions we can draw from the mHealth technology's improvement of health through social support, it has been previously demonstrated that this can be accomplished through emerging technologies.[46] We can conclude that the mHealth technology would be able to take on this function as well.

The main thematic barriers were complexity and access to technology, and these correspond to those evaluated by others.[34,48] These barriers could potentially be overcome with the use of various strategies. For instance, usability testing on the target population can tailor an application and device to a specific population. Direct contact with computers (e.g., a 20-hour computer course) can improve attitudes, behaviors, and training self-confidence.[40] The rural nature of this study is also important. All participants recognized limited access to broadband in rural areas. While access has increased considerably, it still lags behind its urban counterparts with lower bandwidth and less reliable connectivity. We anticipate that Internet availability will increase in the coming years. While our findings highlighted some of these factors, all groups were concerned about privacy of such technologies but to lesser degrees. This factor is consistent with other studies that have reported that maintaining independence supercedes such concerns and that other forms of technology,[49,50] such as sensors or contactless monitoring would be important later in life, particularly when health declines.[51]

The mixed-methods process (involving the collection of both qualitative and quantitative data) enhances the rigor of our design, allowing

for an in-depth view of a topic that has not been fully addressed. We used a semi-structured guide, process, and validated coding and analytical techniques. An important strength is our use of three participant groups – patients, community-leaders and clinicians. Each of these groups view management of obesity and treatment differently, hence allows the provision of distinct views related to this analysis.

Our analysis has several important limitations. First, only a small group of individuals were chosen in each group in a convenience manner. Much of the data is self-reported and the group of physicians was limited to primary care internal medicine physicians at an academic medical center. Private practitioners, family practitioners, and subspecialists may have different attitudes and responses in relation to this population. Similar generalizability concerns exist with the community leaders, all of whom have a favorable relationship with Dartmouth. The views exhibited may also differ in other regions. Sampling was not random and is non-representative. The lack of racial or ethnic diversity and the high level of education of our sample of older participants limit generalizability. Nearly all of the older patient participants (97%) in this study were Internet users, compared to national estimates showing that about two thirds (67%) of seniors over age 65 use the internet.[9] Therefore, the participants in this study had prior exposure to technology and may have viewed the use of technology for health behavior change more favorably. Finally, our patient participants had unique access to a rural-based academic medical center, which may not be fully representative of rural populations. It is critical for future studies to explore the potential for using technology for health promotion among older adults from low-income groups, underrepresented minorities, and among those with no prior exposure to online or other digital technologies.

Our findings yield insights necessary to inform future studies aimed at leveraging the use of digital technology for health behavior change among rural older adults with obesity. It may be especially important to expand on our preliminary findings reported here to explore the potential for using technology to support obesity management and health promotion among older adults from lower income groups, underrepresented minorities, and with no prior experience using technology. Obesity in older adults is a serious public-health concern across the country, and technology could afford new opportunities to expand the reach, impact, and scalability of treatment efforts.

The findings of this study provide a rationale to evaluate different mHealth technologies to elicit behavioral change in rural older adults with obesity. In our population, we demonstrated that technology could afford new opportunities to help in improving one's health and that stereotypical

barriers that older adults cannot use (or are not receptive to using) technology is ill-founded. The results lay the foundation for implementing a rural mHealth obesity study and that there is interest in our community to do so, both from patients, community leaders, and clinicians alike. This study provides mHealth development teams insight into potential design issues that should be considered prior to full implementation.

Take away points

- Mobile health and technology are viable options to improve health in older adults with obesity
- A number of barriers exist that could impede dissemination, particularly in rural areas
- Technology can be helpful in improving health yet need to be targeted to older adults to enhance dissemination

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APPENDIX 1: Interview questions

RURAL barriers to health (<10 minutes)

1. In the area in which you live, what types of "wellness activities" are available? By "wellness activities", we mean any opportunities for improving your health—either nutrition or physical activity-related.
2. Are there any activities that are missing in your area that you might enjoy participating in?
3. Are there any specific barriers that older adults who live in rural areas have to deal with that adults who live in less rural areas do not?
   Probes: Lack of resources or programs, distance or weather, hard to start a new routine, health problems

mHEALTH TECHNOLOGY (15 min): Ways to improve technology delivery for behavioral change

Technology and health

1. How do you think technology (i.e. fitness devices, smartphones, or computers) can be helpful or used for improving the health of older adults?
   Probe: Tracking and monitoring health
2. What experience do you have in using technology to track and monitor your health?
   Probe: What has worked? What hasn't worked?
3. For those who have *not* used an mHealth device to track or monitor your health, please share why not.