Experiences and Perceptions of Distinct Telehealth Delivery Models for Remote Patient Monitoring among Older Adults in the Community

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Abstract

Three major telehealth delivery models—home-based, community-based, and telephone-based—have been adopted to enable remote patient monitoring of older adults to improve patient experience and reduce healthcare costs. Even though prior work has evaluated each of these delivery models, we know less about the perceptions and user experiences across these telehealth delivery models for older adults. In the present work, we addressed this research gap by interviewing 16 older adults who had experience using all these telehealth delivery models. We found that the community-based telehealth model with in-person interactions was perceived as the most preferred and useful program, followed by home-based and telephone-based models. Persistent needs reported by participants included ease of access to their historical physiological data, useful educational information for health self-management, and additional health status tracking. Our findings will inform the design and deployment of telehealth technology for vulnerable aging populations.

Introduction

Older adults are vulnerable to chronic diseases and other age-related health issues. According to the Centers for Disease Control and Prevention, approximately 85% of older adults in the United States have at least one chronic health condition, and over 60% of older adults are affected by multiple chronic conditions or live with two or more chronic diseases.[1] With the rising aging population, it is urgent to ensure that they have equal and effective access to high-quality care. Among many care delivery models and methods, telehealth is considered to be a promising approach for providing remote patient monitoring (RPM) of aging populations to ensure timely and high-quality care, decreased healthcare costs, and improved quality of life.[2]

There are different types of telehealth delivery models designed to provide RPM to older adults. A well-known model is the home-based remote intervention which has the advantage of providing flexibility of location and time for RPM. This model allows older adults, especially those who experience mobility and transportation barriers, to use technologies to measure physiological parameters at home and to communicate with healthcare providers remotely.[3] There has been an increasing amount of work that investigates the usefulness and effectiveness of home-based telehealth delivery.[4-6] Prior work has shown that home-based telehealth can enhance older adults' self-management of chronic conditions, and ultimately, improve clinical outcomes.[5,7,8] In addition, research also highlighted both clinical and non-clinical factors that play an important role in older adults' acceptance of home-based telehealth interventions, such as perceived usefulness,[4] usability,[6] social and financial considerations,[9] technology proficiency,[9,10] and providers' opinions.[11,12] However, the usability of home-based telehealth systems for the aging population has been found to be problematic, as many older adults may not be able to use and navigate the system by themselves at home.[6] Those factors and potential barriers could impact the adoption and uptake of home-based telehealth services by older adults.

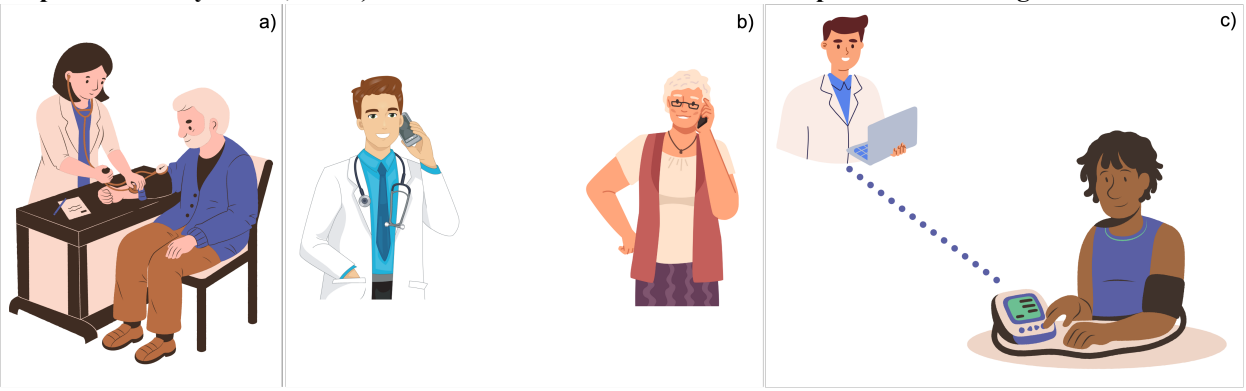
In parallel, community-based telehealth wellness programs are increasingly being deployed as part of efforts to reduce the burden for older adults, especially those with lower socioeconomic status and other barriers. Furthermore, these programs allow older adults to get additional technical support often needed to benefit from RPM. This telehealth delivery model allows community-dwelling older adults to use telehealth for RPM in community settings (such as in congregate housing or community centers) at a lower cost and with support. For example, older adults can use a multi-user telehealth wellness kiosk in an independent retirement community to assess their physiological parameters and view educational videos.[13] Such systems are perceived to be beneficial, and privacy concerns are limited; however, usability issues persist with the use of the telehealth kiosk (e.g., system navigation).[13] To alleviate the challenges faced by older adults in using telehealth technologies, an alternative approach for providing community-based telehealth services is to send support staff or technicians to the site to assist older adults with the operation of telehealth devices.[14]

The strongest evidence found that regardless of the operational setup, community-based telehealth programs were found to reduce emergency visits and hospital readmissions.[15,16]

A common, and widely used alternative delivery model, is to rely on telephone to enable patient-provider direct verbal communication for regular wellness checkups.[17] An advantage of this model is the low cost of operation which requires less investment in information technologies (compared to the cost of developing, deploying, and maintaining telehealth kiosks or devices at home or in community settings). Prior work has adopted this model to provide telemedicine and health education to help patients better manage various chronic conditions and physical disabilities, such as osteoarthritis and spinal pain,[18] diabetes,[19] obesity,[20] among others. Specifically, telephone-based telehealth interventions were primarily utilized to provide health and social services to vulnerable and minority older adults during the COVID-19 pandemic due to the practice of social distancing and quarantine.[21] For example, a study highlighted the benefits of providing telephone-based health and social support to community-dwelling older adults with mild cognitive impairment or mild dementia during the height of the COVID-19 confinement.[22]

Despite the existing body of literature focused on each telehealth delivery model, there is limited research investigating and comparing the perceptions and user experiences of older adults across these telehealth models. Questions such as which telehealth service model is preferred by older adults, reasons why, and what aspects need improvement remain unanswered. One possible reason for this research gap is that it is challenging to find older adults who have experience with using all major telehealth models. In this work, we had a unique opportunity to investigate these research questions by interviewing older adults who had been exposed to different telehealth service models before and during the pandemic. Our contributions are twofold: 1) an empirical, in-depth understanding of older adults' preferences and opinions about different telehealth delivery models; and 2) best practices to inform the design of healthcare services and telehealth interventions tailored to the needs and preferences of older adults.

Figure 1: Illustration of Comparative Telehealth Delivery Models from the *Telehealth Intervention Programs for Seniors (TIPS) Program*: a) *TIPS-in-Person* – a supervised telehealth delivery model; b) *TIPS-in-Touch* – a telephone delivery model; and c) *TIPS-at-Home* – a home-based remote patient monitoring model.



Background

We conducted our study in the context of a telehealth service program, called the Telehealth Intervention Programs for Seniors (TIPS). TIPS was first launched in 2014 in the tri-state area of the United States (New York, New Jersey, and Connecticut) providing health and wellness checkups to community-dwelling aging populations. Since its inception, this program has recruited more than 2,000 elderly participants who are over 55 years old and registered as Medicare or Medicaid beneficiaries. These participants can use the service for free. Many of them have multiple chronic conditions and low socioeconomic status. To alleviate the challenges faced by older adults in using telehealth technologies and to provide intergenerational social support, TIPS provides trained technicians (e.g., college students recruited from local colleges) on-site to assist older adults to collect health data. TIPS participants can access this program by visiting their local community center, or their long-term care facility that is staffed twice weekly by trained technicians. To increase participation and engagement, the service is offered in conjunction with other activities and events that take place in the facility such as educational events and exercises. During each visit, the technicians operate the telehealth devices (blood pressure cuffs, pulse oximeters, and tablet computers for data entry) to collect objective health biomarkers (blood pressure, weight, pulse oximetry, etc.) and ask a series of questions to record participants' recent medical history (hospitalization, medication taken, and overall feeling) (Figure 1a). If necessary, they can also provide or refer participants to appropriate wrap-around social services. The collected data are transferred to a secure,

HIPAA-compliant data server, which can be accessed remotely by a team of registered nurses. After reviewing the alerted physiological data for a particular participant (for example, an alert can be automatically triggered by the system if a patient's SpO2 is less than 90%), a nurse would contact him/her to discuss and assess their health status and determine next steps (e.g., whether it is necessary to contact their primary care physician). This model combines a community-based telehealth model with in-person interactions and intergenerational social support. In the remaining of the paper, we refer to this model as "*TIPS-in-Person*".

In 2020, the program rapidly pivoted its operations after the COVID-19 outbreak and a federal stay-at-home order. Due to restrictions on in-person interactions, TIPS launched a weekly check-in model, "*TIPS-in-Touch*", that facilitated contact with participants via phone calls (Figure 1b). Technicians called TIPS participants weekly to assess their health status, concerns, and needs, according to a protocol developed by the team. For example, they would ask the participants how they were feeling, whether they had hospitalized, whether they have fallen, and what they needed. The technicians would also provide information and instructions about COVID-19. If deemed necessary, participants could receive follow up calls from the program telehealth nurses and get connected to other services and support. This model provided unexpected benefits including a safe space for seniors to share concerns and to socialize.

In early 2021, TIPS launched a "*TIPS-at-Home*" program to a subset of TIPS participants to deliver in-home vital signs monitoring with the most critical health needs. They received equipment (e.g., blood pressure cuff, pulse oximetry, etc.) to use at home to capture their blood pressure, pulse, oxygen level and weight along with a pre-programmed, user-friendly tablet for remote vital signs monitoring, recording, reporting, and follow-up (Figure 1c). Special training for TIPS-at-Home users was provided after the equipment was set up at each participant's living place. At the time of this study, more than 100 participants had enrolled in the TIPS-at-Home program. Like other models, there was no cost associated with this model.

Table 1. Participant Characteristics for the Interview Study.

ID	Gender	Age	Language Spoken	Self-Reported Technology Proficiency*	Self-Reported Multiple Chronic Conditions^	Self-Rated Health Status§	TIPS Site Location
P1	Female	64	English	2	Yes (n = 2)	Fair	Congregated Housing
P2	Male	75	English	Not reported	Not reported	Not reported	Congregated Housing
P3	Female	76	Spanish	2	Yes (n = 2)	Good	Congregated Housing
P4	Male	55	Spanish	Not reported	Not reported	Not reported	Congregated Housing
P5	Male	65	English	5	Yes (n = 1)	Poor	Congregated Housing
P6	Male	61	English	Not reported	Not reported	Not reported	Congregated Housing
P7	Female	67	English	4	Yes (n = 3)	Fair	Congregated Housing
P8	Female	67	English	4	Yes (n = 4)	Good	Congregated Housing
P9	Female	65	English	Not reported	Yes (n = 3)	Not reported	Congregated Housing
P10	Female	68	English	2	Yes (n = 4)	Fair	Congregated Housing
P11	Female	61	English	Not reported	Yes (n = 5)	Not reported	Congregated Housing
P12	Female	68	English	3	Yes (n = 4)	Good	Community Center
P13	Female	81	English	3	Yes (n = 1)	Fair	Community Center
P14	Female	70	English	Not reported	Yes (n = 3)	Not reported	Community Center
P15	Female	81	English	Not reported	Not reported	Not reported	Community Center
P16	Female	78	English	Not reported	Yes (n = 3)	Fair	Community Center

Note: During the intake of the program, each participant was asked to complete an intake form to report their demographics, including age, gender, language spoken, ethnicity, technology proficiency, multiple chronic conditions, health status, and so on.

*Self-Reported Technology Proficiency: each participant self-rated their proficiency and familiarity with technology on a scale of 1 to 5, with 1 representing "not proficient at all" and 5 representing "very proficient".

^Self-Reported Multiple Chronic Conditions: each participant self-reported whether they had multiple chronic conditions. If their answer was "Yes", they were asked to indicate their chronic conditions based on a pre-defined list, including diabetes, hypertension, chronic obstructive pulmonary disease, stroke, obesity, liver disease, respiratory issues, and a few others. N represents the number of chronic conditions they selected from the list.

§Self-Rated Health Status: each participant was asked to self-rate their health status based on four scales: excellent, good, fair, and poor.

Methods

We conducted semi-structured interviews with 16 TIPS participants from December 2021 to January 2022. The eligibility of the participants included: 1) self-reported cognitive ability to consent to participate in the study and English speaking; 2) having participated in all three models of TIPS telehealth delivery. The TIPS program manager and site coordinator facilitated participant recruitment by reaching out to the group of participants who had used all three models. If a candidate participant expressed interest in talking to the researchers, the program manager and site coordinator set up the phone interview. For example, to reduce the participants' concern about getting spam calls, the manager and coordinator would tell the study participants the time of the phone interview and the phone number the researchers will be calling from. We reached data saturation and subsequently concluded the study after conducting interviews with 16 TIPS participants. Table 1 summarizes participant characteristics for the interview study. The study was approved by the Institutional Review Board at Pace University. Participants received a $25 gift card as compensation for their time.

The interview focused on the perceived benefits, effectiveness, and barriers of each TIPS model, unmet user needs, and aspects that need to be improved. Participants were also asked to rate their satisfaction with each TIPS model on a scale of 1 to 5 (1 represents "not satisfied at all" while 5 represents "very satisfied"). Finally, participants were asked to choose their preferred TIPS model and to explain the rationale. The interview questions were developed based on our prior work[14] and tested and refined iteratively by the researchers. The interview guide was cognitively tested with similar older adult participants and TIPS site managers and coordinators (n=5) to ensure the validity, clarity, appropriateness, and relevance of the questions. The interviews were conducted via phone by two trained qualitative researchers and were audio-recorded. Consent was obtained from each participant before the interview.

All recordings were transcribed verbatim for data analysis. Two researchers first used an open coding technique [23] to code the transcripts. More than fifty codes were generated through this open coding process. All the codes were discussed among researchers to determine which codes to keep, merge, or discard. Following a thematic analysis approach,[24] the researchers then grouped the generated codes into high-level categories, which represent major themes of the study findings. The themes are related to TIPS participants' perceptions of the program overall, perceived benefits and barriers of using each TIPS model, and aspects that indicate that the program can be enhanced.

Results

Overall Perceptions of TIPS

Regardless of the delivery model, participants overall perceived TIPS as a beneficial program that enabled them to monitor their well-being closely and to detect health deterioration in a timely manner: "*TIPS is very good for people like me that [sic] my weight and my blood pressure go up and down. It [TIPS] is very good because it keeps me in control of my health. I can see where I stand every week.*" [P#14] Participants rated all TIPS models as a 5 on a 5-point Likert scale, which might indicate that they were all satisfied with the TIPS service in general, regardless of different models.

Most of our participants had received follow-up calls from the program nurses regarding their out-of-range measurements, one participant shared: "*They [nurse] said my blood pressure was very high, like very high. And I indeed had some pain in my heart. So, they asked me if I am dizzy or something like that and told me to call my doctor right away.*" [P#4] Such follow-up calls were perceived as useful ("*It was very helpful, especially when I wasn't getting appointments at my doctor's office. They [nurses] called and checked on me often*." [P#6]), informative ("*They spoke clearly and intelligent [sic], and the conversation consisted of whether I was doing my vitals, if I had any problem doing it, and if I had any new medication*." [P#14]), caring and timely ("*I could tell that they are concerned, if something doesn't seem to be right, they will call you right away to see how you are feeling. So, I'm proud about that*." [P#11]).

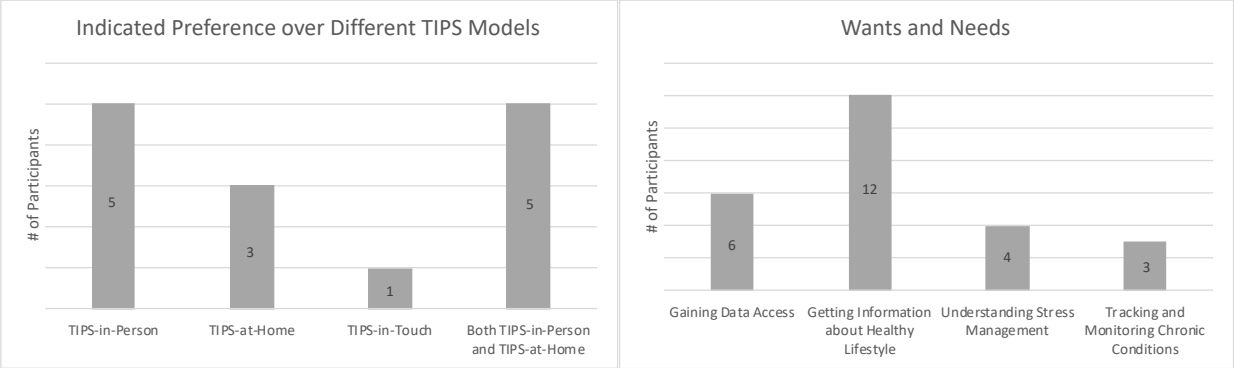
Given the perceived benefits of TIPS, all participants mentioned that they would like to continue using and participating in the TIPS program: "*Definitely. I think it's a beautiful program and I'll stay in it because I'm keeping an eye on everything, my oxygen, my blood pressure*." [P#13]

Comparative TIPS Telehealth Delivery Models

Out of 16 participants, 14 explicitly stated their preferred TIPS model and 2 stated that they had no preference (Figure 2, Left). Five of them (5/14, 35.7%) equally rated *TIPS-at-Home* and *TIPS-in-Person* models as their most preferred telehealth model and expressed an interest in using both models if possible: "*To be honest, I like both because*

sometimes I can't make it downstairs [for TIPS-in-Person], but I can do it upstairs. Like if I'm sick and I can't be around people or anything like that, I'd rather stay up in my apartment and take it myself. So, it would be great if I can do both." [P#11] Three participants (3/14, 21.4%) preferred *TIPS-at-Home* and another five (5/14, 35.8%) chose *TIPS-in-Person* as their preferred model, while only one participant (1/14, 7.1%) favored *TIPS-in-Touch*. The perceived benefits and challenges of each model are elaborated below and summarized in Table 2.

Figure 2: Left: Participants' Indicated Preference across TIPS Models. Right: Participants' Expressed Wants and Needs for better Remote Patient Monitoring Service.



<u>*Perceptions of TIPS-in-Person*</u>: Two primary reasons were observed for the preference for the *TIPS-in-Person* model during analysis of participant discussions. The first reason was that participating in TIPS could promote their socialization. For example, this model provided more opportunities for participants to interact with their peers (e.g., other senior residents in the community): "*I pretty much enjoy going downstairs, having a seat, and talking with people [...] I live in a large senior building, and I don't know a lot of the tenants personally. But since the program, I got to meet people that I probably see often but never really had a conversation with them.*" [P#6]. More importantly, participants mentioned that having the opportunity to interact with the technicians of the program was a critical reason for their participation and engagement in the program. This intergenerational social service could help the participants socialize with young generations and gain emotional support: "*Before all this [TIPS], I went into a depression. So it [TIPS] helped me because that person [technician] spent time talking with me and offering me other services. […] And it was very nice that the program takes their time for seniors. I can feel that their heart is in it. And I'm going to cry because I'm very sentimental, but it is just nice to know somebody cares and looks out for us*." [P#12]

The second major reason for preferring an in-person telehealth delivery model over others is that some study subjects did not feel confident using the technology equipment by themselves. Even though they had also enrolled in the home-based program, sometimes they needed to ask their caregivers to operate the devices. Therefore, they would prefer the technician to operate the telehealth equipment to take measurements: "*Because they're more familiar with it than I am*."

No other participants mentioned any major concerns about the *TIPS-in-Person* model. Issues noted was forgetting to attend check-ins or transportation barriers to participate in TIPS. As such, some participants mentioned that they had missed some TIPS sessions: "*I might go there every two weeks because I sometimes just simply forget to go*." [P#15]

<u>*Perceptions of TIPS-at-Home*</u>: The participants who perceived the *TIPS-at-Home* model as very beneficial indicated the benefit of being able to monitor their health status at home: "*Since I do have a problem with my blood pressure, TIPS-at-Home has given me the opportunity to monitor it on a regular basis other than going every other month or every three months to my doctor. And the TIPS-at-Home program is just absolutely the best thing. I mean, during the whole pandemic, you were able to keep an eye on your blood pressure and things like that because we weren't going to the community center [where TIPS-in-Person service was offered before the pandemic]. Having that opportunity to do it at home was the best*." [P#16] In addition, analysis of participant responses revealed a preference for measuring physiological parameters at home due to convenience and the ability to measure more frequently compared to going to a community setting for the in-person service: "*I like the equipment model because number one it's convenient for me because I'm not home on those days that they are in the office [TIPS-in-Person site], and number two I think it's just easier for me to do it at home. Let's say if I'm not able to do it at my normal time, I can always do it later on, which makes it even more convenient*". [P#9]

Despite the positive experience observed with the *TIPS-at-Home* model, participants mentioned several issues with using the telehealth devices by themselves at home. For example, they initially didn't know how to use the system due to a lack of in-depth training. Also, they reported occasional system malfunction ("*One time it wasn't doing anything. It wasn't taking my weight and the pressure cuff was not working*" [P#11]). In one case, an error message was difficult for users to understand ("*Sometimes it'll say that an error occurred, but I don't really understand why that is. I just turn it off, give it a minute and then turn it back on*." [P#15]). Lastly, participants mentioned the infrequent use of *TIPS-at-Home* devices because they did not remember to take the readings ("*I'd say not a lot [taking readings]. In the past month, maybe about two times? Three times? I couldn't remember to do this*." [P#12]) or had limited motivation to measure their physiological parameters given their good health condition ("*Because I feel really good. I don't feel like I need it [taking readings] really*." [P#1]).

Perceptions of *TIPS-in-Touch*: As the phone-based, *TIPS-in-Touch* model didn't involve any collection and measuring of physiological parameters, the discussion between TIPS participants and technicians was limited. This model was determined to be the least preferred and useful model, as explained by one participant: "*Well, usually it was only a couple of minutes. I mean, if you don't have any concerns, their main concern is to see if you are having any problems*." [P#16] Even so, our participants expressed their appreciation that the program attempted to reach out to them with social support during the pandemic: "*They did call every two weeks. They call and the person would then ask us questions, how are we doing, any change in our medicine, have I fallen lately? Just to spend time with us when the pandemic started.*" [P#12]

Table 2. Perceived Benefits and Challenges of Different TIPS Models.

TIPS Model	Perceived Benefits	Perceived Challenges
TIPS-in-Person (Figure 1a)	• Allow participants to interact with their peers and TIPS technicians face-to-face. • No need to operate the devices alone or at home.	• May forget or experience transportation barriers to visit a TIPS site to use the service.
TIPS-in-Touch (Figure 1b)	• Stay in touch with the program and reduce feelings of isolations during the pandemic.	• Limited usefulness as this model does not involve physical biometrics monitoring.
TIPS-at-Home (Figure 1c)	• Flexibility for self-monitoring of participant health status. • Participants can collect vital parameters at any time and at home, which is perceived as more convenient compared to the TIPS-in-Person model.	• Lack of in-depth training leads to insufficient knowledge of knowing how to operate the devices. • System malfunctioning and error messages that are difficult to interpret. • Forget to take readings due to lack of reminders.

Wants and Unmet Needs

Even though all participants reported that they are very satisfied with the current services offered by TIPS, some stated that the program can be improved by offering additional features (Figure 2, Right). For example, a few participants (n = 6, 37.5%) expressed an interest in gaining access to their aggregated data (e.g., physiological parameters) so they could be aware of their health status over time and share the data with their primary care physicians: "*A lot of times I forget what the readings are and when my doctor asks me, he likes to know, 'What's been your reading for the last week?'*" [P#2]. However, the current practice does not allow TIPS participants to easily access their data. In the *TIPS-in-Person* model, participants receive a paper record of their readings on that day. However, they are not able to put everything together to see any trends over time of their readings. Similarly, for the tablet-based application they are using in the *TIPS-at-Home* model, they can view the readings right after measuring their biometrics; however, participants reporting struggling with finding the historical data within the application: "*See, this is where I'm having trouble with now. I can't go into the computer and look at what happened the last week or the last month. Because it used to show me. I could come and peek into the computer, and I could see what happened to me. The difference between Monday. The difference between Tuesday and Saturday. Now I can't find it. I don't know what to look through now. I'd like to go and see what happened last month compared to this month*." [P#13] To keep track of their readings, participants mentioned that they would write down the numbers for easy access and sharing with others: "*And I write my numbers down, the dates, the pressure, and the oxygen level. I write it down on the book*." [P#9]

Participants also brought up other desired services. For example, a majority of participants (n=12, 75%) expressed an interest in getting more information and knowledge about healthy lifestyles, such as sleep habits, weight control, and diet:

"*Something about diet. I'm very picky about what I eat, and unfortunately, being Spanish, I love fried food. So when TIPS comes once a week, I would like to have somebody there with a knowledge of diets and nutrition to tell us what to do*." [P#14]

"*Yeah, because I haven't been sleeping well. I can go to sleep at, I'll say at, all right, five o'clock. I wake up about 10 o'clock, 10 or something to 11. I look at the time a lot. But after that, like this morning, I haven't been back to sleep since about 12 last night. And I need to go to sleep. […] And I do different things to make me go to sleep, but that's not working too much*." [P#1]

Participants (n=4, 25%) also mentioned the need to know how to better manage their stress level ("*How about the stress level? My anger gets out of control at times*." [P#8]) or mood ("*Your moods. Ways to pick yourself up. Because when you're by yourself, sometimes you slip into depression. Especially since you have nobody to talk to. So, if they add some information like that and you know, things like what to look out for when you're by yourself and stuff like that. I mean, it is very helpful*." [P#12]).

Lastly, because TIPS participants have multiple chronic conditions such as diabetes, they mentioned the usefulness of tracking and monitoring diabetic information (n=3, 25%): "*I was going to say, and I brought this up when they gave us the machine. It would be fantastic if they would be able to program these machines to include blood sugar levels. I say a lot of people are diabetic, so why not also monitor the diabetic numbers? Because some people take numbers from diabetes, two times a day, one time a day, but it would be great if it would also track your diabetes numbers*." [P#9]

Discussions

Our study revealed that the *TIPS-in-Person* supervised telehealth delivery model was favored the most by the participants. A primary reason cited by the participants is that this model provided them with an opportunity to not only socialize with their peers but also to connect with the technicians (e.g., college students recruited from medical schools) for intergenerational social support. This finding aligns with previous studies showing that older adults have the desire to socialize with their peers and in particular, with younger generations.[25,26] More importantly, older adults could benefit drastically from social activities and interactions; for example, research has shown that there is an association between social relationships and cognitive functioning of older adults.[27] Therefore, it is evident that telehealth services for older adults should address the multiple dimensions of wellness, including physical, social, spiritual, and mental well-being.[28] Future implementations of telehealth RPM for older populations should incorporate components that meet the social needs of older adults.

Conversely, we observed the telephone-based model (TIPS-in-Touch) was considered the least useful mainly because this model didn't allow them to keep track of their health status. However, most participants expressed their appreciation for this service as it provided social support and COVID-19-related information to them, making them feel less isolated and helping them to stay informed during the pandemic.

Finally, the home-based model (TIPS-at-Home) was the second most preferred model, though a few participants evaluated this model as equally useful as the TIPS-in-Person model. This model allowed the use of the service more frequently and flexibly without the need to physically visit a TIPS site. In particular, this model could benefit older adults who are homebound or who have difficulty leaving home without help.[29] However, similar to prior work,[6,9,10] our participants pointed out the technical barriers in using the home-based technology, due in part to their low self-efficacy or lack of knowledge and skills about the use of computing devices.[30,31] These problems might be overcome by providing comprehensive onboarding and regular refresher training, as well as on-call technical support. Another problem mentioned by a few participants is that they often forgot to use the device for measurement, leading to infrequent or even discontinued use of the service. This is not an uncommon issue for the use of health information technologies (e.g., a mobile health application for self-monitoring). That is, healthcare consumers often utilize such technologies and services most frequently at the time of the adoption and gradually reduce their usage over time.[32,33] The technology adoption literature suggested that long-term engagement is primarily driven by the extent of benefits offered by technology (relative advantage) and whether the users can recognize these benefits (result demonstrability).[34] From this perspective, it might be helpful to better inform telehealth users about the benefits of maintaining a high level of service usage. Another way to increase patient engagement is to monitor the usage of

telehealth services and to then have technicians or supporting staff call those participants once they have stopped tracking their physiological data on a regular basis.

Our interviews also revealed several unmet user needs. For example, older participants would like to access their personal data to better utilize them. In the current practice, users receive a copy of their physiological measurements in paper forms, but they could not make use of these data. We believe it would be useful to provide older adults with access to their aggregated data and appropriate visualizations of these data. By doing so, patients can view their health status trends and share the data with other people (e.g., primary care physicians, caregivers, etc.). The design of such data management tools, however, needs thorough and careful consideration. Most data management tools for healthcare consumers are implemented as mobile or web applications. Given the digital divide faced by aging populations,[35] merely providing a mobile or web application may yield limited benefits or even cause more issues. Therefore, future research needs to investigate how to enable secure access to patient-generated data while accounting for the unique needs of older adult users. For example, a viable solution might be to provide additional data access to the caregivers of older adults who might have greater technology proficiency. Another important consideration for designing such data access and management tools is to ensure the intuitiveness and easy-to-grasp nature of data visualization so that users can make sense of their health status with a limited cognitive workload.[36] Prior work has proposed a set of "best practices" for designing such visualization tools, such as presenting both macro-level (the overall pattern) and micro-level (individual parameters) trends over time, and simplifying the interface with larger fonts, greater spacing, and better visual contrasts.[14,35,37,38]

In addition to gaining access to their data, participants also expressed an interest in, and need for, additional health tracking and educational services from TIPS, such as how to live a healthy lifestyle related to sleeping and diet, and how to better manage stress. Providing such tailored health information to older populations could not only promote health behavior change but could also augment the telehealth program to make it be perceived as more beneficial for better patient engagement. Future work can investigate what and how educational information can be offered to community-dwelling older adults.

Several study limitations should be noted. First, we did not evaluate the actual usage data of different models. Such analyses may provide additional insights into user preferences and engagement. Our future work will analyze how often the same group of participants used each model, how many participants discontinued the use of telehealth, and when. Second, this program has unique characteristics that may not apply to other telehealth programs for older adults. For example, this program offers all the services, including the on-site help of technicians and home-based technologies, for free to its participants. As prior work pointed out, the cost of telehealth devices and services could become a significant barrier for many older adults with low socioeconomic status due to the financial burden.[39] However, with the increasing coverage of telehealth services by the Centers of Medicare and Medicaid,[40] the financial burden of using telehealth could be alleviated for older adults. Third, we used convenient sampling to recruit our study participants, which may lead to selection bias. For example, we might be oversampled on “higher-risk” patients, who were given priority to enroll in the TIPS-at-Home program given the limited budget. Therefore, this participant selection bias might have skewed the results as they were all satisfied with the TIPS program and found the program useful. Lastly, most of the study participants were female due to a high ratio of female to male community residents. Also, their primary language is English. As prior work found that less English proficient older adults may have more barriers in accessing to high-quality healthcare service,[41] more research should focus on this population. In our future work, we will balance the group of participants by sex, age, race, language, and other factors that may affect older adults’ perceptions and attitudes.

Conclusion

In this work, we report findings from a qualitative study on older adults’ preferences and perceptions of different telehealth delivery models: home-based, telephone-based, and community-based interventions. Our findings reveal that the supervised community-based approach with in-person interaction was perceived as the most preferred model, followed by home-based and telephone-based models. Whether a model provides social support (e.g., peer-to-peer and intergenerational interaction) and how easy the device is to operate, were critical considerations for evaluating the usefulness and user experience of telehealth care models. Aspects that can be improved to better meet the users’ needs include providing data management and visualization tools, additional health tracking services, and tailored educational information. We conclude this paper by discussing the implications of our results regarding what factors need to be considered when designing such telehealth services for older adults, and how to provide more tailored support to better engage the aging population in self-management and tracking of health status.

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