



Older Adults' Engagement in Technology-Mediated Self-Monitoring of Diet: A Mixed-Method Study

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Abstract

Purpose: This feasibility study explored older adults' use of a nutrition app called *Appetitus* (<https://apps.apple.com/us/app/appetitt/id1001936854?ign-mpt=uo%3D2>; <https://play.google.com/store/apps/details?id=no.nr.appetitt&hl=e>) and addressed their engagement in technology-mediated self-monitoring of diet. Undernutrition is a significant challenge among older adults and is associated with poorer health experiences. Digital health for self-monitoring of diet has the potential to increase awareness of personal nutrition, and the scarcity of research reporting older adults' ability and willingness to engage in technology-mediated dietary self-monitoring warranted this study.

Design and Methods: An explorative mixed-methods design combining descriptive analysis of log data with qualitative analysis of interviews with *Appetitus* users was implemented.

Findings: Twenty-five older adults self-monitored their diet using *Appetitus* over an 8-week trial period. Eighty percent of the participants used the app regularly in the trial period. The most engaged users recorded their food consumption daily for 8 weeks. Personal interest in nutrition and commitment to the project facilitated regular use of *Appetitus*. Poor health and the perception that using a nutrition app lacked personal relevance contributed to irregular self-monitoring. For inexperienced technology users, participation in this project became a springboard to using tablet technology and the Internet beyond the *Appetitus* app.

Conclusions: The majority of the participants regularly used *Appetitus* for self-monitoring of diet; they found the tablet technology and *Appetitus* app easy to use.

Clinical Relevance: Older adults are able and willing to use self-monitoring tools. Nutrition apps can empower older adults to make better informed decisions about their diet. Patients' self-monitoring can provide valuable and detailed health-related information to healthcare professionals and mediate patient-centered care practices.

The increasing deployment of digital health is a central part of the solution to the challenges of rising demands on healthcare systems as greater numbers of older adults live with chronic conditions (Storeng, Vinjerui, Sund, & Krokstad, 2020). Technology can alleviate some of the pressure on healthcare systems by providing flexible solutions in patients' homes that support patients' self-care abilities (Kruse et al., 2020).

Malnutrition, particularly protein-energy undernutrition, is prevalent among older adults, dramatically

increasing their need for advanced services. Older adults who receive home care services are at a high risk for developing undernutrition (Cereda et al., 2016). It is therefore relevant to explore opportunities in preventative strategies and early interventions in the area of undernutrition in the home care setting. Good nutrition can be ensured through a varied diet, with energy levels adapted to body weight and activity levels (Findalen et al., 2012). Increasing older adults' awareness of undernutrition and offering support for a varied

diet with meals spread throughout the day can be initial steps to stimulate appetite and prevent undernutrition (Findalen et al., 2012).

Technology holds great potential when it comes to increasing people's awareness of health-related behaviors because it can offer immediate personalized feedback on an individual's behavior (Chen, Gemming, Hanning, & Allman-Farinelli, 2018). There are numerous commercial apps for self-assessment of diet; however, these apps are less appropriate for targeting undernutrition among older adults because they thematically focus on weight loss, require detailed food and beverage recording, and tend to have complex user interfaces (Hingle & Patrick, 2016). Poor usability experiences are a major barrier for technology adoption among older adults (Takemoto et al., 2018; Wildenbos, Peute, & Jaspers, 2018). Through a literature search, we identified four studies that developed and tested technological self-assessment solutions, such as apps, to target the explicit challenge of undernutrition among home-dwelling older adults (Astell et al., 2014; Kraft et al., 2012; Lindhardt & Nielsen, 2017; van Doorn-van Atten, Haveman-Nies, Heery, de Vries, & de Groot, 2018). Only Astell et al. (2014) included a comprehensive self-assessment of diet. In the other studies, the users recorded their weight, appetite, or selected items in their diet as part of a nutrition intervention. None of the interventions focused explicitly on stimulating appetite, varying diet, or providing information about enriching meals and beverages with protein and energy.

We developed a tablet computer application about nutrition called *Appetitus* with older, inexperienced technology users in mind. In this article, we explore older participants' use of *Appetitus* and discuss factors that affect their engagement in technology-mediated self-monitoring of diet.

Methods

Study Design and Sampling

Our feasibility study used a mixed-methods approach with 25 older adults 68–95 years of age from four municipalities in Norway. We provided them with a 3G-connected iPad with *Appetitus* installed; we encouraged them to use *Appetitus* regularly for 8 weeks.

We collaborated with local healthcare professionals in three home care organizations and one senior center in Norway to recruit participants. We asked the professionals to approach older adults whom they anticipated would benefit from participating in a nutrition intervention and would manage to use *Appetitus* independently. We recruited 39 participants in October

and November of 2016, 14 of whom withdrew. Nine withdrew their consent prior to the start of the trial, and one died. Four participants withdrew shortly after the trial started. Two explained that their withdrawal was due to illness burden, and one found the reporting of food and beverage consumption too tiring after the initial introduction. One did not want to explain.

In the home care setting, the healthcare professionals gave the participants introductions to and follow-up support for the *Appetitus* app and iPad (Farsjø, Kluge, & Moen, 2019). We asked the professionals to meet with the participants three times to support their use of the app and the iPad. The participants began using *Appetitus* after their first meeting with the healthcare professionals. We expected the professionals to introduce *Appetitus* to the older adults shortly after we initially met with them; however, we cannot guarantee that all of the participants recruited from home care services had access to *Appetitus* for 8 weeks. At the senior center, we organized introductions, and follow-ups were organized as an 8-week course with five group meetings. Senior volunteers gave technical support related to the iPad and *Appetitus* app. A nurse with special nutritional expertise offered nutrition care follow-up in two of the group meetings. See Table 1 for information about participants.

The Nutrition App: *Appetitus*

Thematically, *Appetitus* focuses on supporting weight gain or weight maintenance. The Norwegian guidelines on preventing and treating undernutrition guided the structuring of advice embedded in the app (Guttormsen et al., 2009). The app's main screen presents a meal plan with four main meals and two snack meals (Figure 1, left). Users can browse through 147 meal suggestions and log their food and beverage consumption. The users receive personalized feedback in the form of a gradually filling figure that visualizes energy and fluid in daily consumption. The feedback is individualized to reflect users' needs based on the common recommendation of 30 kilocalories energy, 1.2 g protein, and 30 mL fluid per kilogram of body weight (Findalen et al., 2012) (Figure 1, right). Meal serving size can be adjusted in the app, but the content of the meal as presented in the pictures is not adjustable.

We applied user-centered design, prototype testing with older adults, and empirical evaluation to develop *Appetitus*. The user interface aligned with recommendations for app development for older adults: a stable user interface, no menu function, large touch fields,

Table 1. Information About Participating Older Adults

Gender	n (%)
Female	18 (72)
Male	7 (28)
Age, years	
Mean (range)	79.48 (68–95)
Nutritional status according to mini nutritional assessment–short form, n (%)	
Malnutrition	4 (16)
Risk for malnutrition	13 (52)
Normal nutrition status	8 (32)
Grocery shopping, n (%)	
Independent	13 (52)
Receiving help from family or healthcare services	12 (48)
Dependence in food preparation, n (%)	
Independent: make dinner regularly	13 (52)
Partly independent: heat precooked dinner or eat dinner at senior center	8 (32)
Dependent: need all meals prepared and served	4 (16)
Experience with touch technology, n (%)	
No prior experience	15 (60)
Prior experience (tablet or smartphone)	10 (40)
Internet user pattern, n (%)	
Daily	12 (48)
Weekly	4 (16)
Never	9 (36)

Note. N = 25.

good contrast, and large text size (Fuglerud, Leister, Bai, Farsjø, & Moen, 2018).

Data Collection

When the participants used Appetitus to record food or beverage consumption, log data were automatically transferred to the University of Oslo's IT platform

(Service for Sensitive Data), developed for research purposes in compliance with Norwegian privacy regulations. The log data from Appetitus included an automatically generated user ID, time stamp, which item the user recorded as consumed, and action (specified as “add” or “undo”). The user ID could not be linked to an individual participant due to privacy concerns.

We collected demographics in structured interviews with participants prior to the test period. We interviewed all of the participants a second time in their homes on average 8 weeks and 5 days after the first interview. In this semistructured interview, we obtained their general experience of study participation, duration of the testing period, and use pattern of the app and iPad. We recorded and transcribed the interviews.

Ethical Considerations

Older adults received oral and written information about the study before providing their written consent. The Norwegian Centre for Research Data approved the study (project number 44004) according to the pre-General Data Protection Regulation (GDPR) rules.

Analysis

We used SPSS version 26 (IBM Corp., Armonk, NY, USA) and Excel 2016 (Microsoft Corp., Redmond, WA, USA) to process and analyze the log data. We used descriptive statistics to summarize the participants' demographics and to describe usage patterns in the log data. We summarized the log data at the individual level and created the variables “number of recording periods per day,” “number of total use days,” and

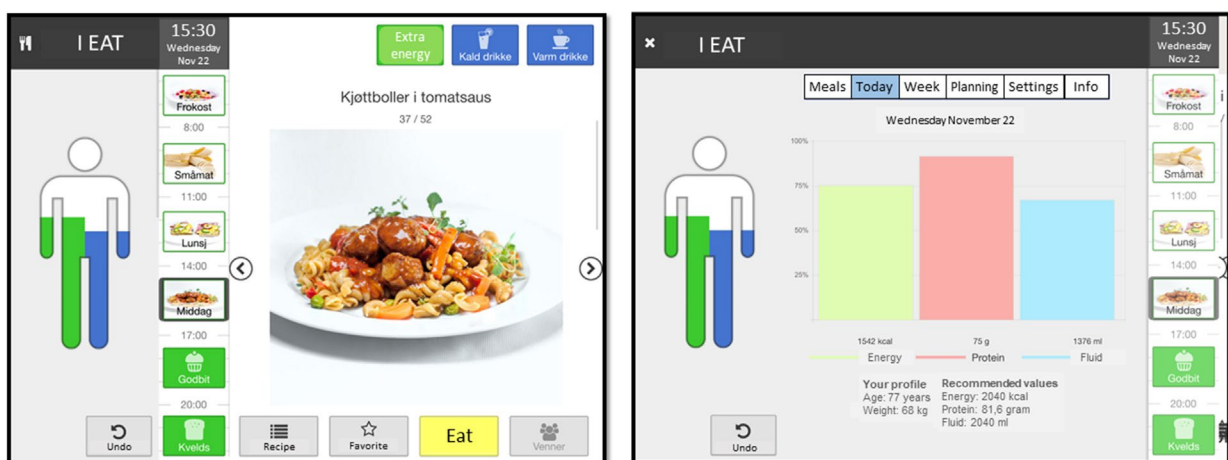


Figure 1. Screenshot from Appetitus. [Colour figure can be viewed at wileyonlinelibrary.com]

“use days per week.” Based on the variable “use days per week,” we created the variable “user pattern,” which contained three user pattern categories: daily use, weekly use, and occasional use. Figure 2 is a flowchart that describes the cut points we set for the three categories. We encouraged the healthcare professionals to introduce the users to Appetitus shortly after we met them the first time; however, we cannot guarantee that all of the participants had access to Appetitus for 8 weeks. Thus, we considered weekly recording in Appetitus for 6 weeks or more as regular use. Based on findings regarding use pattern in digital tools, we differentiated between daily and weekly use (Slettemeås, Mainsah, & Berg, 2018).

We inductively analyzed the interview data based on the procedure Graneheim and Lundman (2004) described. We extracted meaning units (sentences and paragraphs) from interview transcripts that were relevant to our research questions and sorted the coded and condensed text into categories. For privacy, we could not code log data with demographic variables and interview data; however, our qualitative interviews included descriptions of user patterns. Fourteen of the informants described daily Appetitus use, whereas the others described their use as less regular, consistent with weekly or occasional use patterns. In the final stage of the analysis, we examined specific characteristics in the interview data and demographics from the perspective of the three use patterns: daily use, weekly use, and occasional use. We present the results in three themes: (a) user patterns, (b) engagement in self-monitoring, and (c) increasing confidence with digital technology.

Results

User Patterns

The majority of the participants used the Appetitus app over an 8-week period (Figure 3); however, there

was a decline in the number of participants who used the app in the last weeks of the trial. This is probably related to a combination of decline in use at the end of the trial and the possibility that professionals delayed in introducing participants to the app. Figure 4 visualizes the three different user patterns in a scatterplot with regression and trend lines (Loess line). Fourteen participants met the criteria of daily users, using Appetitus 7 days per week for the majority of the weeks in the trial period. The trend line (see Figure 4) visualizes the daily users’ consistent high use of Appetitus over time. The negative regression line is affected by those participants’ whose trial periods were less than 8 weeks. Six participants were weekly users; they also recorded their consumption in the app regularly in the trial period, but they had fewer days of use per week (Table 2). Five participants occasionally recorded consumption in the app; their use was characterized by 1 or 2 user days 1 week, followed by a week or 2 where they did not use the Appetitus app.

The number of times per day that participants used the app to record their consumption varied from one to nine. The daily users employed the app to record their consumption more regularly throughout the day compared to the weekly and occasional users (Figure 5). This indicates that those using Appetitus daily had consistent use of the app over time.

Engagement in Self-Monitoring

The interviews illuminated the participants’ reflections on what contributed to or hindered their regular use of Appetitus over time. Those who stated that they used Appetitus daily took it very seriously, with several describing how they strived to record throughout the day to ensure they remembered to record everything they consumed. Most daily users found

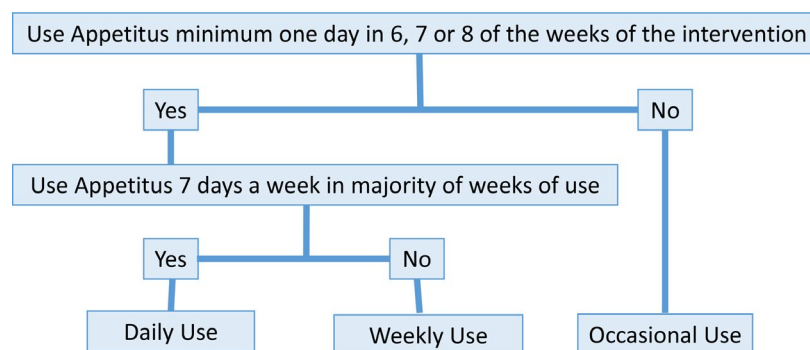


Figure 2. Flowchart of cut points for user pattern categories. [Colour figure can be viewed at wileyonlinelibrary.com]

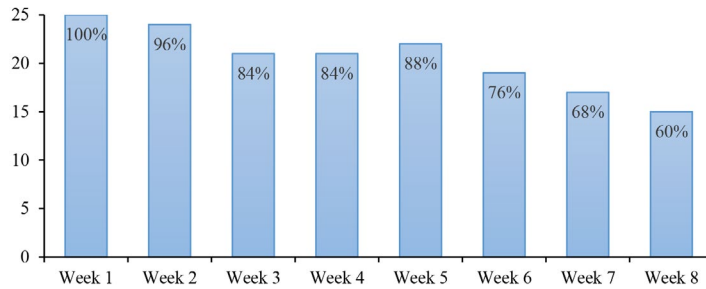


Figure 3. Percentage of participants who used the app each intervention week (N = 25). [Colour figure can be viewed at wileyonlinelibrary.com]

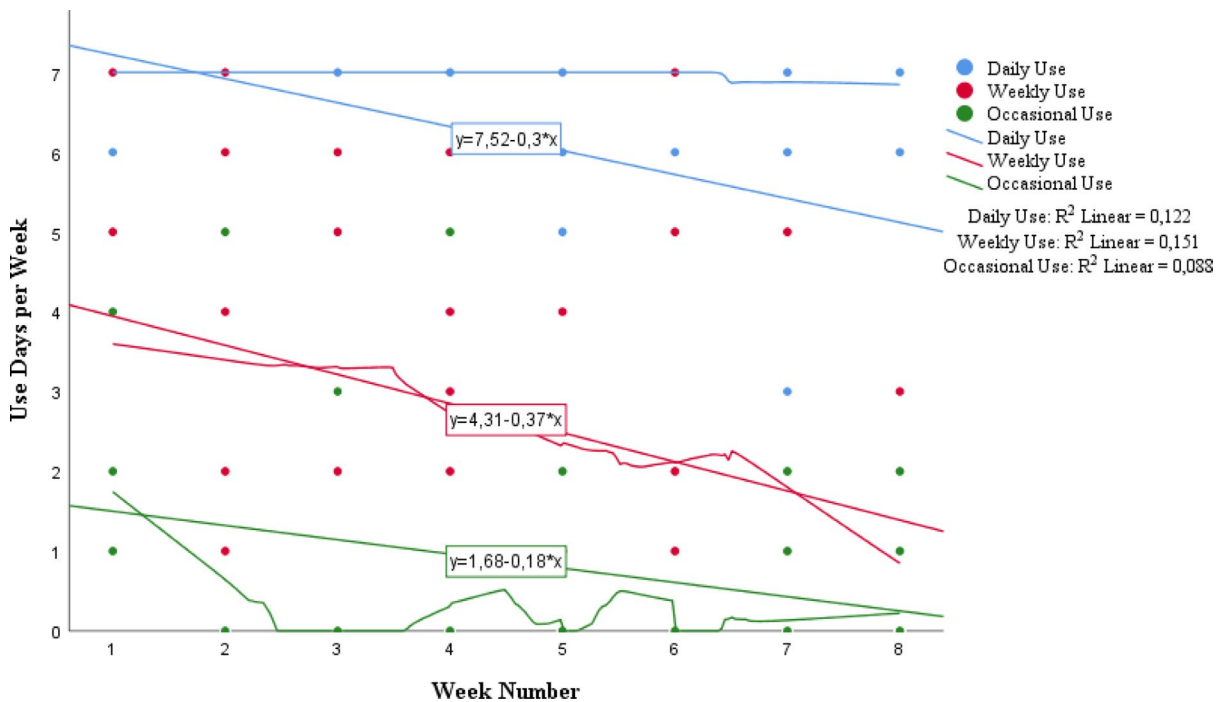


Figure 4. Grouped scatter plot of “use days per week” by week number. [Colour figure can be viewed at wileyonlinelibrary.com]

Table 2. Mean Weekly User Days During the Trial Period

	Daily use (n = 14)	Weekly use (n = 6)	Occasional use (n = 5)
Weekly user days mean (range)	6.5 (5.2–7.0)	3.0 (1.4–4.8)	1.1 (0.5–2.0)

self-assessment of diet to be an interesting activity, stating that daily recording of food and beverage consumption led to increased awareness of their food intake: “I think this has been very interesting. I have to pay attention [to my diet] every day. I cannot record everything in the evening, because then I would forget. I record after each meal. I think that’s fine” (Male, 84 years).

Those who described their recording pattern in Appetitus as less regular appreciated that recording their food and beverage consumption in Appetitus had given them an overview of their diet. One participant explained that he intentionally used the app to record his consumption on select days: “I have not done it consistently, but I have done it in periods... . I don’t have to do it every day for a long time—my eating habits are still displayed [in Appetitus]” (Male, 69 years).

Many participants explained that desire to contribute to research was a strong reason to participate in the project and use the app for the whole trial period. They believed that nutrition for older adults was an important topic to study and well worth their time and dedication.

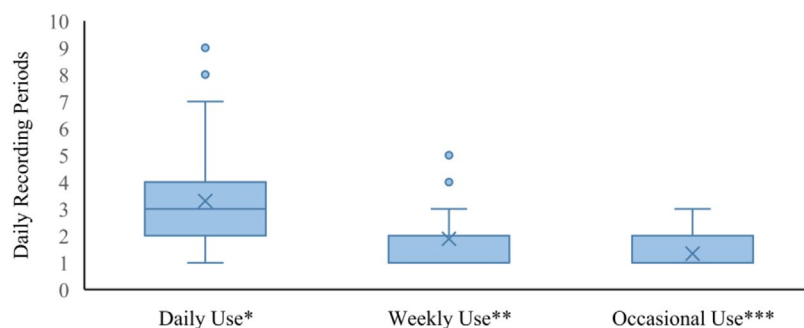


Figure 5. Boxplot of daily recording periods. * Number of recording days for this group = 712. ** Number of recording days for this group = 133. *** Number of recording days for this group = 39. [Colour figure can be viewed at wileyonlinelibrary.com]

Most of the participants described it as quick and easy to record their daily consumption in Appetitus; however, some participants expressed relief that the project period was over so that they could stop recording. One participant who used the app daily described how it restricted her: “I think in a way I felt a little bit tied up. If I was going out one afternoon, I had to bring this [iPad] with me” (Female, 95 years).

Several of the participants who described their user pattern as less regular shared the feeling that recording was a burden, which might explain their irregular recording patterns. Several also described their health as fragile, explaining that low energy levels had negatively affected their use of the app. They could not always record as planned simply because they forgot about it or did not have the energy to do it.

Among the older adults who described their use pattern as occasional, several said that they only used the app for recording purposes when they were with healthcare professionals. One participant explained that he struggled to understand the purpose of using the Appetitus app independently:

I have not really understood my role in this project. What was I supposed to do? Look at the content [pictures and suggestions for enriching food and beverages] in Appetitus? I entered and checked [my consumption], and we [the participant and the nurse] concluded that I didn't consume enough. (Male, 78 years)

Two participants who only used Appetitus with healthcare professionals received help regularly from home care personnel or family members to prepare most of their meals. They were therefore not self-reliant in planning and preparing meals. This may build upon the experiences of little personal relevance

of using this app as expressed in the quote above and influence use pattern.

Increasing Confidence With Digital Technology

The participants described learning to use the Appetitus app and iPad as easy; this was a shared experience between the experienced and inexperienced technology users. Experience with touch technology did not seem to influence whether the participant used Appetitus on a regular basis. Among those who described using the app daily, only half had prior experience with touch technology. One participant described her previous reservations toward using technologies, such as tablets, and how the project changed her attitude:

But I discovered that it was not that difficult after all. I've thought I've been too old. It hasn't been necessary, that's been my reasoning. But that was stupid, I could have started long ago! But now I make the effort to learn to use it. (Female, 89 years)

As this quote points out, many of the participants experienced increased confidence in using technology, and the project became a springboard to further technology use. One participant who got access to the Internet for the first time expressed her enthusiasm: “It is life before and after the tablet!” (Female, 71 years).

Learning to access information on the Internet and use social platforms to connect with family were appreciated additional activities on the iPad. Some participants downloaded games such as chess or solitaire and used the iPad as a source of entertainment. Several of the participants pointed out that their relatives were engaged in their use of the iPad, and this generated additional support when they learned to use the iPad beyond using Appetitus.

Discussion

The majority of the older adults who participated in this study regularly used the *Appetitus* app during the trial period. Older adults' adoption of technology is dependent upon both individual and social factors as well as the qualities of the technology and delivery modality (Kruse et al., 2020). Experiencing *Appetitus* as easy to use, finding its use personally relevant, and being committed to supporting research all facilitated the use of *Appetitus* over time. Coley et al. (2019) found altruistic reasons were a strong motivator for older adults' participation in an eHealth study with a preventative focus. Similar to our study, participation was tightly connected to experiencing the study topic as relevant to themselves personally or to their age group (Coley et al., 2019). Research suggests that older adults show interest in measures that can help improve diet and lifestyle, maintain an active lifestyle, and stay independent (Bloom et al., 2017; Coley et al., 2019).

Perception of usefulness is a key factor in older adults' adoption of technology (Wildenbos et al., 2018). Interest in nutrition and the recognition of a personal nutritional challenge might have motivated the older adults in this study to regularly self-monitor their diet in *Appetitus*. Further, using self-monitoring technology also has the potential to make people aware of health challenges and support people to make better informed decisions and adopt health-promoting behavior. Studies indicate that regular self-monitoring of diet can have a positive impact on food choices and contribute to dietary change (El Khoury et al., 2019). For example, studies have demonstrated that recording fruit and vegetable consumption in an app can be a powerful tool to increase awareness of low consumption levels, leading to increased consumption (Mummah et al., 2017; Steinert, Haesner, Tetley, & Steinhagen-Thiessen, 2016). This article as well as our previous work suggests that interest in and awareness of an age-friendly diet increased among older adults as they used *Appetitus* to self-monitor their diets—many implemented dietary changes (Aure, Kluge, & Moen, 2020). It is still unclear how long and how often it is necessary to engage in dietary self-monitoring to foster long-standing eating habits that are beneficial for health (Michie, Yardley, West, Patrick, & Greaves, 2017).

Having knowledge and skills in using tablet technology was not crucial to the older adults' ability to use *Appetitus* or whether they used it regularly. This indicates that the app was user friendly and that the participants received sufficient training and support from the healthcare professionals during the trial (Aure

et al., 2020; Wildenbos et al., 2018). The app's interface is the outcome of an extensive co-design process accompanied by iterative evaluations and a pilot study with potential users, ensuring that the final version of the interface was suitable for older adults, including those without prior technology use (Fuglerud et al., 2018). Getting access to the tablet technology might have motivated participation in the project, as tablets are costly (Kruse et al., 2020). However, some of the older adults agreed to participate despite having little interest and low confidence in their ability to master the tablet technology. Our results illustrated that many of those without technology experience increased their confidence in their own abilities to use modern technologies when introduced to the iPad and *Appetitus* app through this project. Other studies in which older adults are given access to tablet technologies through research projects report similar findings (Østensen, Gjevjon, Øderud, & Moen, 2017; Vaportzis, Gow, & Giatsi Clausen, 2018).

In the same vein, we found that the older adults appreciated opportunities to access information on the Internet and to keep in touch with family. Although use of digital technology and the Internet has increased sharply among older adults in Norway, where 65% of older adults 71 to 80 years of age used the Internet daily in 2018, their adoption of health-related technologies may still depend on their perceptions of the technology as relevant and useful (Sletteameås et al., 2018; Takemoto et al., 2018). Poor usability experiences (e.g., where entering data is considered to be cumbersome) can negatively influence the sustained use of digital health technology (Wildenbos et al., 2018). Older adults can therefore benefit from technology developed especially for their needs regarding both user interface and content (Takemoto et al., 2018). In this way, digital health can be a gateway to technology use for inexperienced users.

Our results indicate that older adults who depend on help for food preparation might experience using *Appetitus* to self-monitor and evaluate their diet as less personally relevant, affecting their adherence to using the app. In addition, poor health with reduced energy levels hindered daily use of *Appetitus*. Narrowing the self-monitoring of diet to specific meals (e.g., dinner) or using more limited time periods could help those who struggle to use the app regularly (Chen et al., 2018). Steinert et al.'s (2016) study on using an app to record health-promoting activities, such as eating fish twice per week, suggests that limited and personally adapted goal-setting of dietary behavior can lead to behavioral change.

There are emerging technical advances in more automatic methods to assess diet using image analysis and wearable sensors (Hassannejad et al., 2017). This creates opportunities for user adoption, including among those who are not benefitting from self-assessment technologies, such as older adults with declining health. Adopting such technologies in real-life settings is not uncomplicated regarding feasibility, and also ethical and privacy concerns will constrain the uptake of such innovations.

Strengths and Limitations

The results of this feasibility study must be interpreted with some caution. Our sample is small, the participants were a group of older adults with good cognitive functioning, and they do not represent the full spectrum of patients receiving home care in Norway (Helvik et al., 2015). Cognitive health can therefore be considered as a factor that influences the uptake of Appetitus. Declining cognitive health negatively influences the ability of older adults to use digital health applications (Wildenbos et al., 2018). A strength of the study was the stability of the Appetitus app during the test period, which contributed to focused data collection over the entire test period.

Implications for Research

Further studies need to evaluate the effect of using digital health tools and technology-mediated self-monitoring to prevent and treat undernutrition among older adults. Recruiting eligible participants in this cohort is challenging (Lindhardt & Nielsen, 2017; Locher et al., 2013). By integrating findings from quantitative and qualitative analysis, we can draw inferences on how factors such as personal interest, health experiences, and care dependency affect older adults' engagement in self-monitoring their diet.

Clinical Implications

Our results suggest that the structure of the research project, with regular follow-up from healthcare professionals, positively influenced participants' motivation to continue self-monitoring over time. Our study indicates that defined periods of use and structured follow-up can be a strategy to gain acceptance of use among patients in other real-life settings. Self-reporting of eating can be visualized to increase both patients' and healthcare professionals' awareness of dietary challenges. Digital health self-monitoring tools

can thus be a mediator for focused health dialogs that promote patient-centered practice (Chen et al., 2018).

Conclusions

Older adults with good cognitive health are able and willing to record their diet for several weeks. When the digital health technology is considered easy to use, previous technological experience is not crucial to their ability to use self-monitoring technology. When properly introduced, digital health technology can be an enabler for aging in place, empowering older adults to be active participants in ongoing health discussions, and facilitating health-promoting activities, such as maintaining a healthy diet.

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Clinical Resource

- Geriatric nutrition: Nutritional issues in older adults. <https://www.uptodate.com/contents/geriatric-nutrition-nutritional-issues-in-older-adults>

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