Examining usage behavior of a goal-supporting mHealth app in primary care among patients with multiple chronic conditions

Examining usage behavior of a goal-supporting mHealth app in primary care among patients with multiple chronic conditions: A qualitative study

Farah Tahsin[1], Tujuanna Austin[1], Brian McKinstry [2], Stewart W Mercer [3], Mayura Loganathan[4], Kednapa Thavorn[5,6,7], Ross Upshur[1,8], Carolyn Steele Gray[1,8]

[1] Institute of Health Policy Management, and evaluation, University of Toronto;

[2] Centre for Medical Informatics, Usher Institute University of Edinburgh; Scotland

[3] Centre for Populations Health Sciences, Usher Institute, University of Edinburgh, Scotland

[4] Mount Sinai Academic Family Health Team; Toronto, Canada

[5] Ottawa Hospital Research Institute, Ottawa, ON, Canada

[6] School of Epidemiology and Public Health, Ottawa, ON, Canada

[7] Faculty of Pharmacy, Chiang Mai University, Chiang Mai, Thailand

[8] Bridgepoint Collaboratory for Research and Innovation, Lunenfeld-Tanenbaum Research Institute, Sinai Health System

Corresponding Author: Farah Tahsin (farah.tahsin@mail.utoronto.ca)

Word count: 5811

Number of tables: 3

Abstract: (Word count: @326)

Background: Although mobile health (mHealth) applications are increasingly being used to support patients with multiple chronic conditions (multimorbidity), the majority of mHealth apps experience low interaction and eventual abandonment. To tackle this engagement issue, it is important to understand social-behavioral factors that impact patients' usage behavior when developing a mHealth program.

Objective: The aim of this study is to explore the social and behavioral factors contributing to the patients' usage behavior of a mHealth app called the electronic Patient Reported Outcome (ePRO). The ePRO app supports goal-oriented care delivery in interdisciplinary primary care models.

Methods: A descriptive qualitative study was used to analyze interview data collected for a larger mixed-method pragmatic trial. The original 15-month trial was conducted in six primary care teams across Ontario between 2018 and 2019. The eligibility criteria for patients were: 60 years or over with 10 or more visits within the previous 12 months of study enrollment. For this analysis, patients were classified as long-term or short-term users based on their length of usage of the ePRO app during the trial. Bandura's Social Cognitive Theory (SCT) was used to categorize social-behavioral factors that contributed to patients' decisions to continue/discontinue the app.

Results: The patient-provider relationship emerged as a key factor that shaped patients' experiences with the app and subsequent decisions to continue using the app. Other factors that contributed to the patients' decisions to continue using the app were: personal and social

circumstances, perceived usefulness, patients' prior experience in goal-related behaviors, and confidence in one's capability. There was an overlap of experience between long-term and short-term app users but in general, long-term users perceived the app to be more useful and their goals to be more meaningful than short-term app users. This observation was complicated by the fact that patient health-related goals are dynamic and changed over time.

Conclusion: Complex patients' usage behavior of a goal-supporting mHealth is shaped by an array of socio-behavioral factors that can evolve. To tackle this dynamism, there should be an emphasis on creating adaptable health technologies that are easily customizable by patients and able to respond to their changing contexts and needs.

Trial Registration: ClinicalTrials.gov NCT02917954;
https://clinicaltrials.gov/ct2/show/NCT02917954

Background:

Mobile health (mHealth) applications are being increasingly used to deliver care and support patients with chronic conditions. [1–3] Managing chronic conditions effectively is an ongoing task that often requires sustained support from an interdisciplinary team of health providers. Continued involvement of multiple health providers in supporting chronic disease management can be costly to the health system [4] and demands time and resources of providers as well as their patients. [5] This management may be particularly challenging for patients with complex needs. Individuals with complex care needs are those who live with multiple chronic conditions (multimorbidity) [6] and experience additional health and biopsychosocial-related challenges due to increased treatment requirements, reduced functional ability, and socioeconomic challenges. [7] To improve patient experience and tackle this issue of high health care burden and costs mHealth

64 is considered to be an effective and efficient solution. [8] mHealth offers an array of
65 functionalities, which can include: remote monitoring of patients' vital signs and symptoms,
66 ongoing and timely communication with multiple providers, information sharing such as
67 scheduled appointments, drug prescriptions, and renewals. [9]

68 The positive benefit of using apps/web-based platforms to support complex patients is
69 documented in the current literature. [10,11] For example, when patients with chronic illness use
70 mHealth apps they are more likely to be engaged with health-promoting behavior such as fruit
71 consumption and physical activity. [12] However, the benefits are more likely to be realized if
72 technologies are used as intended. Instead, most mHealth apps experience high attrition [13,14],
73 defined as when an individual disengages from a technology-based intervention after initially
74 committing to using the technology. [15]

75 Attrition has been considered a major challenge in mHealth-based interventions. [15–17] Previous
76 research has identified that only a small number of participants use mHealth apps in the long
77 term and the majority of the patients abandon the app after a short period. [16,18] The reason
78 behind high attrition varies. Critical factors that drive attrition can include having available social
79 support and capital, trust in technology, intention, and ability to use the app. [19–21] A meta-
80 analysis evaluating the rates of attrition in mHealth interventions shows that many attrition-
81 focused studies had relatively short intervention (less than 2 months) or follow-up periods. [15]
82 This synthesis work suggests a need to advance knowledge on attrition by exploring socio-
83 cognitive factors that contribute to patients' app usage in the long-term and real-world settings. [15]
84 To address this gap in the literature, this paper explores community-dwelling patients' perception
85 of the long-term use of a mHealth app by applying Bandura's Social Cognitive Theory to unpack
86 socio-cognitive factors that play a role. The research question informing this study is: *What are*

the social and behavioral factors that contribute to continued or discontinued usage of a goal-management app tailored for patients with complex chronic conditions?

Method:

Description of electronic Patient Reported Outcomes (ePRO) Intervention:

The ePRO tool is both a mHealth app and a portal that enables goal-oriented care delivery through facilitating goal creation and monitoring by complex chronic patients working in collaboration with an interdisciplinary primary care team. [9,22,23] User-centered co-design methods were used to develop the app through multiple iterations. [24] The co-design method was operationalized by using inputs from patients with complex care needs, caregivers, and the primary care team. [24,25] The usability and feasibility of the app were assessed during usability testing [24] and exploratory trial [25] of the ePRO. The findings from the exploratory trial informed the modification of the ePRO app to meet patients' needs.

In a usability study of the ePRO trial, it was found that the app experienced gradual attrition of participants despite the tool scoring moderate usability. [26] The qualitative analysis presented in this paper was conducted to deeply explore social-behavioral factors that may be influencing patients' low engagement with the ePRO app found in the usability study. Of note, ePRO is not an open-source app and was only available for study participants for the duration of the trial. The screenshot of the app interface can be found in previous publication. [27]

Description of the Study Design:

We conducted a descriptive qualitative sub-study, drawing on patients' interview data collected as part of a larger 15-month multi-site pragmatic stepped-wedge trial of the electronic Patient Reported Outcomes (ePRO) tool.[22,23] Following stepped wedge trial design, 6 sites were

randomized into two intervention clusters and, two different clusters received the ePRO intervention at two different time points. As a result, the first group used the ePRO app for 12 months after a 3-month control period, and the second group used the app for 9 months after a 6-month control period. [22] The qualitative descriptive approach seeks to present data as close to how the participant would understand the phenomenon as possible; referred to as "staying close to the data". [28] This approach allowed us to present patient's direct description their experience of ePRO intervention and the factors they perceive as contributing to their discontinuation/continuation of use, without too many interpretive interferences from researchers. [27] Therefore, the findings of this study closely represent patient's experience with the intervention.

A 2-stage sampling strategy was used to recruit participants for the study. First, we recruited Family Health Teams (FHTs) and then we recruited patients within each FHTs. FHTs are designed to provide integrated, multidisciplinary primary care and are typically led by physicians or nurse practitioners. [29] A purposeful sampling strategy [30] was used to recruit six FHTs across geographically diverse areas (urban, rural, suburban) of Ontario, Canada from 2018-2019; this FHT recruitment process is described in detail in another publication. [27,31] The categorization of sites in rural, urban and suburban settings was consistent with Statistics Canada's definition of rurality. [32] The geographic location of FHT was important to capture the variation of the study participants. The eligibility criteria for FHTs were an Ontario-based FHT and willingness to participate in the ePRO study. Ontario is the largest province in Canada, with the highest population density, and the majority of services provided by the primary care teams are funded by the Ministry of Health.

Quantitative data (surveys, chart audits) were collected from all six sites, whereas qualitative data were collected from three case sites. [22,23] At first, four out of six sites agreed to participate as case sites. But one site dropped out due to low patient recruitment. [22,23] The patient interviews, demographic surveys, and research memos collected in these three case sites were used to answer the research question of this paper.

Participants and Interviews:

Eligibility criteria for the recruited patients within FHTs were: 60 years or over with 10 or more visits to the FHT within the previous 12 months. 10 or more visits [33] and age 60 years and over [25] were chosen because both factors are considered as an indicator complexity of this study population and used as a recruitment strategy for the exploratory trial. [25]

Using FHT EMRs, eligible patients were identified. Then, the list of eligible patients was given to FHT providers to assess whether the patients met the following additional criteria: 1) perceived willingness to engage in goals of care conversation; 2) ability to use a smartphone or tablet in English or have a caregiver who could do this on their behalf; 3) capable of providing consent to participate; 4) willing to complete surveys every 3 months thereafter until the trial concluded. [51] Eligible patients were approached by their FHT staff (i.e. care coordinators, administrators) and asked if they would be willing to speak to a research team member about the project. Recruitment occurred during a scheduled office visit or by phone. A detailed description of the recruitment procedure has been described elsewhere. [44,51]

Patient's demographic information was collected through a demographic survey at the beginning of the study. The first set of interviews was conducted at the midpoint of the trial, 4-6 months after patients started using the app (the timing of the interviews depended on if they were in the

12 or 9-month use group). The second round of interviews was conducted at the end of the study trial. The purpose of the two sets of semi-structured interviews was to explore patients' overall experience with ePRO intervention and how that experience changes over time. The semi-structured interview guide addressed the following topics: 1) perception and experience of using the ePRO app; 2) patients' relationship with their care team; 3) perception and experience of setting goals through ePRO; 4) impact of ePRO on patients' daily lives. Following the first set of interviews, the semi-structured interview guide for the study was modified for the second set of interviews. Findings from the first set of interviews guided the iteration process for the semi-structured interview guide and were decided by the research team members (FT: Research Coordinator, TA: Graduate Research Assistant, JS: Research Coordinator, and CSG: Research Scientist/Principal investigator with extensive qualitative research experience).

Interviews were 25-40 minutes long and were conducted by one of four research team members (FT, TA, JS, and CSG). Each interview was audiotaped and transcribed using a commercial transcription service. Transcripts were checked for accuracy against recordings by a member of the research team.

Ethics approval was received from the University of Toronto Health Sciences Research Ethics Board and the Research Ethics Boards of three participating primary care practices. All patient participants provided informed verbal and written consent before initiation of study activities.

The theoretical framework for data analysis:

Multiple theories and frameworks have been used to explore the relationship between patients' social-behavioral factors and mHealth/eHealth usage. [13,34] One such theory is Bandura's Social Cognitive Theory (SCT) [35] which explains human behaviors through a model of interactions

among behavioral, environmental, and social factors. This model has been used extensively to uncover which social and behavioral constructs may influence patients' usage behavior of a mHealth app. [36–38] **Table 1** shows the five key domains of SCT theory. SCT is particularly well-suited to examine the patients' usage behavior of a mHealth app like ePRO because this app enables users to evaluate and monitor their goals over time and modify/change their behavior. [27] SCT also allowed us to understand the social-cognitive related factors that contribute to the process by which patients decide to continue or discontinue app usage. For example, one of the SCT domains reciprocal determinism is helpful to identify how personal, environmental and behavioral factors can influence one's decision to continue/discontinue app use. Similarly, behavior capability and goal efficacy domains were helpful to identify how one's skills and confidence can influence their decision on app usage.

This theory was used to guide data analysis to explore how complex patients' personal beliefs and attitudes and physical and social environmental factors impacted their engagement pattern (long-term and short-term app use) with ePRO. While SCT can be used as an explanatory framework, it was applied to this study to help categorize factors influencing use and relate those to engagement patterns. During the interview debrief sessions, memoing activities and initial reading of the transcripts, the authors (TA, FT, CSG) agreed that SCT demonstrated a fit with the interview data. Since we chose SCT as the right analytical tool based on emerging interview data, we did not encounter the challenge of forcing data into categories.

Table 1: Domains of Social Cognitive Theory[35]

Domain	Overview

Reciprocal Determinism	The dynamic and reciprocal interaction of person (individual with a set of learned experiences), environment (external social context, technology, aids), and behavior (responses to stimuli to achieve goals). In SCT, these components behavior, environment, and individual are seen as acting bidirectionally.
Behavior Capability	A person's actual ability to perform a behavior through essential knowledge and skills.
Goal Efficacy	The level of a person's confidence in his or her ability to successfully perform a behavior.
Usage Reinforcement	The internal and external responses to a person's behavior affect the likelihood of continuing or discontinuing the behavior.
Outcome Expectancies	The anticipated consequences of a person's behavior. Outcome expectations can be health-related or not health-related.

A combination of two techniques was applied to analyze the study data. In stage 1, the transcripts were inductively coded by two analysts (FT and TA). During the analysis, the research team met to discuss the identified codes and resolve any coding discrepancies. After coding four transcripts, the team decided that the coding scheme was appropriate. We reached the data saturation after coding 12 transcripts. The saturation of data was decided when no new codes emerged from the transcripts. [39] After coding all 22 transcripts, the codes were mapped onto the SCT categories meaning inductively identified codes were plotted within the categories of SCT to form themes. [40]

The first stage allowed us to see the social and behavioral factors related to usage. However, in order to see how these factors related to each other and changed over time, we engaged in the second analysis stage of restorying.

Re-storying is defined as the method of rewriting participants' oral data temporally to draw a link between prior experience with subsequent experiences. [41] Restorying revealed how themes related to each other and changed over time. It also allowed us to more clearly see pattern differences across different user groups (short vs. long-term users) which allowed us to more directly address our question regarding social and behavioural factors that were related to continued or discontinued usage. Restorying allowed us to generate exemplary narratives of long-term and short-term app users as a means to illustrate these patterns. The definitions of long term and short app users are described below.

To re-story patient data, two analysts (FT and TA) constructed a matrix of themes distinguished between long-term and short-term app users (**Appendix 1, Table 1**). After examining both columns of long-term and short-term app users, two research team members created one storyline for each group that captured the experience of the overall group. The re-storying allowed for seeing the connections between constructs of SCT within the context of patient use of ePRO and how those connections influenced usage progression over 15 months.[42] While, one of the major criticisms of SCT is that it does not recognize the wider social structure that influences an individual's usage behavior; [43] the analytic method of re-storying addresses this challenge by highlighting the social contexts influencing usage behavior over time. A detailed description of the two-stage method can be found in **Appendix 1**.

To enhance the rigor of this study, the researchers undertook several strategies to increase the credibility and trustworthiness of the findings.[44] The research team members met regularly to

discuss codes and findings. Additionally, throughout the re-storying process, both researchers discussed the accuracy of the storyline. Member checking[39] was conducted with study participants to examine the accuracy of the two storylines and overall interpretation of the study findings. Furthermore, having two data analysts helped ensure the dependability of the findings.[43] Both analysts (FT and TA) had graduate-level training in qualitative data analysis. Additionally, one team member (CSG : scientist/principal investigator with extensive qualitative research experience) provided supervisory support during the analysis.

Categorizing patients into long-term and short-term app users:

Based on patients' app-automated usage logs, patients were categorized into two categories: long-term users and short-term users. Of the 22 interviewed individuals, 9 were short-term users and 13 were long-term users. Participants who did not use the ePRO app after initial onboarding or used it for less than 3 months were categorized into the "short-term user" group. In contrast, the participants who used the ePRO app for more than 3 months were categorized into the "long-term user" group. The 3-month cut-off period was determined because the app experienced a sharp decline in usage at 3 months. [26] This 3-month cut-off period is also consistent with the previous literature. [45]

Results:

There were 44 study participants in the larger pragmatic trial, with 37 participants from the three case sites. Of the 37 patients who were invited to participate in the interview, in total, 22 patients were interviewed. Among 22 interviewed patients, 17 patients participated in both interviews, 3 patients participated in only mid-point interviews and 2 patients participated in the last interview only. Fifteen participants did not participate in the interviews because of scheduling issues,

illness, being out of the country when the interview was being scheduled, or not responding to interview requests. Among 22 interviewed patients, 17 patients participated in both interviews, 3 patients participated in only mid-point interviews and 2 patients participated in the last interview only.

Demographic description of the participants:

The demographic information of the study participants can be found in **Table 2**. The mean age of the 22 interviewed participants was 75.1 (SD 5.67) and 45.45% of participants self-identified as female. We also reported the demography of participants (N=15) who did not participate in the interview to show any demographic differences between the interviewed versus non-interviewed groups. It is worth noting that there were more non-interviewed participants in the lowest income quintile. However, we did not identify any statistically significant demographic differences between the interviewed and non-interviewed participants. We conducted descriptive statistical analysis (students' t-test for continuous variables and Mann-Whitney U test for categorical variables) to explore the differences between groups (interviewed/non-interviewed, short term/long term).

Table 2: Demographic Table

Variable	**Total – Interviewed Participants (N=22)**	**Total- Non-interviewed Participants (N=15)**
Age (mean/SD)	75.1 (5.6)	71.14 (6.5)
Sex n (%)		
Female	10 (45.4)	5 (33.3)

Smartphone comfort level (means, SD*)[a]	2.17(1.4)	3.64 (1.4)
# of Chronic Condition (means, SD*)	4.88(2.1)	3.07(1.8)
Family income, n(%)		
$0-29K	1 (4.5)	4 (26.6)
$30-$59K	7 (31.8)	4 (26.6)
$60-$89K	3 (13.6)	3 (20.0)
>$90K	4 (18.1)	3 (20.0)
Education, n(%)		
Less than high-school	2 (9)	2 (13.3)
High-school	2 (9)	4 (26.6)
Some college/university	4 (18.1)	3 (20.0)
University (Undergraduate, Graduate)	4 (18.1)	5 (33.3)

*SD= Standard deviation

[a] The range of the smartphone comfort level score is 1–5. A higher score indicates a higher comfort level with the smartphone

Summary description of the themes:

The patient interviews revealed insights about the factors that influenced patients' decision to continue/discontinue app usage. When discussing their usage of the ePRO app, patients identified what encouraged them to use the app including factors relating to their social and clinical relationships, capability to use the app and perform goal-related activities, and their expected outcomes from the ePRO app. **Table 3** summarises these factors in relation to SCT domains. Additionally, to provide a contextual understanding of these factors long-term user and short-term narratives generated by re-storying the data are first presented **(Box 1)**, followed by a more in-depth exploration of each factor as they emerged in the full data set.

One major decision that was made during the analysis is to collapse three domains of SCT goal efficacy, behavior capability, and outcome expectancies into one because it was identified that patients' confidence in their goal and technological skills were linked with the anticipated outcome of the ePRO app. Previous studies on goal-setting behavior have also identified that in a real-world setting, individuals' confidence in health-related goals is confounded by their outcome expectancies, their capability and skill level for performing various goals and activities, and their technological and health literacy. [43,46] Applications of SCT in the literature have found that the relationship between multiple domains of SCT is multi-directional rather than unidirectional as suggested by the original SCT. Meaning SCT domains can be both antecedents and consequences of each other. [43] For example, individuals who receive no feedback on their performance, may lose motivation to continue engaging with a task and anticipate negative outcomes from their performance. Hence, in this analysis, we grouped these three domains together to retain the interrelationship as factors that contributed to patients' usage behavior: confidence and skills in goals, confidence, and skills in technology, and outcome expectancies.

Table 3: Description of the themes:

Categories	Exemplary quotes	
	Long term user	**Short term user**
Reciprocal Determinism: This domain refers to the dynamic relationship between individual, context, and behavior.	"They [care team] always know what to do with me, so there was no problem setting goals because they know that I am trying to be active and healthy. and I kept using it (ePRO app) daily because I know they (care team) are watching my data" [Female, patient # 18]	"I just did not know if anyone is looking at my data, there was no communication from you guys [research team] or my nurse or doctor here. There was no feedback for me about my data, so I felt like I am talking to the void when I was putting my information in. I would like to know if I was doing well or not. It would be helpful to talk to others (peers) about our goals, to see who else is doing the same thing as me and how they are feeling." [Female, patient #16]
Goal efficacy, behavior capability, and outcome expectancies: This domain refers to individuals' confidence and skills in achieving their goals in the ePRO and the perceived		

usefulness of the app. **Sub-theme 2a: Confidence and skills in goals**	"*When my dietician first asked what goal I wanted to set, I knew it would be tracking my everyday walk, I knew it would be easy to keep up at because I have been doing this for long time. But ePRO made me more accountable, I wanted that accountability. I liked how the device asked me if I have achieved my goal for that day. Clicking yes to that felt good and I kept doing that*" [Male, patient #7]	"*Setting any goal was hard for me because my conditions flare up here and there and throws me off my routine. So I wasn't sure how well I can keep up with the goals…I sprained my ankle in last winter so then I was off my walking for 5 weeks. Considering all these troubles, I didn't work on my goals, and the app became redundant because what would I track*. When the app asked Did I achieve my goal for the day, I did not want to keep saying no" [Male, Patient # 2]
Sub-theme 2b: Confidence and skills in technologies	*"I expected the app to have some direction for me about how I was doing on my goals, it was nice to see what I was accomplishing weekly basis. No complaints about the app, very easy to use…nothing complicated that anyone will have difficulty with…But I have used*	*"The small fonts or buttons in this phone [*ePRO*] was trouble…but I thought I will get used to it (the phone) but did not at the end. I was sometimes working on my goals but could not record it on the phone, so I lost interest in the phone…then I forgot about my goals too because I was not tracking it or doing anything about it"* [Male, Patient #21]

	computer all my life for work so using this phone or any other phone is not a problem" [Female, Patient #3]	
Sub-theme 2c: Outcome expectancies	*"The main reason I enrolled-I wanted to stay on track of my goals and feel healthier over time-I thought the app was helpful to keep me on track.* [Male, patient #1]	*"When my doctor suggested this app, I did not know what to expect because there is nothing important, I need to work on, in my opinion anyway. My doctor suggested some goals but nothing very important… I could not make a purpose of it (ePRO)"* [Male, Patient #11]
Domain 3: Usage Reinforcement This domain refers to the internal or external responses that encourage or discourage behavior change	*" I was bedridden so [*provider's name*] she was 'gung-ho' that I join her walking group for my recovery. And she said, "why don't you try this new thing we are doing, this will be good for you?". And She was right, it was nice to have the app because I know every Monday, I will have to say how many times I walked last week, so I tried to go out over weekends…She was there for me throughout, walking alongside me in*	*" My doctor did not think ePRO was helping me that much, because both of us thought I am doing fine without it, everything [*diabetic symptoms*] was on track, so we decided maybe I do not need it."* [Male, patient #17]

	every walking group" [Female, patient #6]	

Description of the themes:

In the section below, we elaborate on themes identified in the data according to the SCT domains. Some domains had richer information compared to others. For example, the themes related to reciprocal determinism, goal efficacy, and outcome expectancies had more nuanced data compared to the other two themes, which are: behavior capability and usage encouragement.

Theme 1: Reciprocal determinism

Reciprocal determinism focuses on the dynamic interaction among person-context-behavior and the influence of this dynamic interaction on individuals' behavior. As demonstrated in the long-term and short-term user narratives, as well as in **Table 3**, social and clinical relationships are key factors for the continued use of the ePRO app.

Six (46%) long-term users described their longstanding relationship with their primary care providers as being beneficial to set meaningful goals.

"*I got lucked out with my providers, they will always know exactly how to deal with me and keep me out of the hospital, which is my main goal. My doctor knows that my nurse, and dietitian here (primary care team) know that, so it was easy to set those goals to keep my blood sugar low."* [Long-term user, male, Patient #7]

Short-term users also described a good relationship with their providers. However, four (44%) short-term users described their providers did not discuss the ePRO app during their clinic visits.

Participants listed the following reasons for not discussing ePRO app with their providers: clinicians' heavy workload, not having enough time during the visit, feeling unnatural to discuss the app during a regular clinic visit, and feeling their goals are personal work and did not fall under providers' responsibility. One person described that,

*"Dr. [*physician's name*] is great, but he is really busy, so I did not want to waste his time talking about my walking schedule. He needs to check my blood pressure level; I would not bring up how many times I walked last month. Feels irrelevant for him to know that."* [Short-term user, male, patient #2]

Another way the patient-provider relationship influenced app usage was when patients faced any sorts of technical errors to use the app or had to modify their goals after the initial goal-setting process. Specifically, long-term users were more likely to reach out for support and tended to report more instances of connection with their providers around the ePRO app. Some of the common technical challenges were: 1) being logged out of the app due to prolonged inactivity, 2) forgetting passwords, and 3) inability to modify/change goals based on patients' needs. In terms of modifying goals, ePRO did not allow patients to modify their own goals so primary care providers had to modify the goals for them. Therefore, when patients needed to modify their goals, they were uncertain about how to do that.

"After they (government) changed the number of blood glucose tests I can do per week, my goal had to be changed because I wanted to test my glucose level daily but after they changed it, now I only test twice a week, but I still it report it on the phone just not daily. And my nurse over here changed it (frequency of reporting) for me" [Long-term user, male, patient #12]

When faced with these technical difficulties or needed modifications patients either abandoned the ePRO app or reached out to their health providers/ research team to solve the issue. The majority of long-term users (56%) chose the latter option.

"I was locked out of the app when I was on vacation…after I got back, I contacted the dietician over here (care team) and she connected me to you guys. Everything got resolved within 2 days, I kept using it" [Long-term user, male, patient #1]

Short-term users, on the other hand, decided to abandon the app and did not reach out for support when they faced similar technical difficulties.

"It would be good if I could change my goals in the app because walking 5 km is what I set out to do at the beginning. It was too ambitious of a goal in this bad winter. I never reached 5 km, so I never had anything to report on the app…I did not reach out to my nurse practitioner, I guess I forgot about it (ePRO) for a while, and then I asked you (research team) to take it away" [Short-term user, female, patient #22]

Both long-term and short-term users also reflected relationships with peers and their communities could influence their app usage behavior. For example, one patient discussed that being able to communicate with their peers would be useful to understand others' experiences with the ePRO app.

"Sometimes I felt that the app does not give me enough feedback. There could be more photos, a thumbs up if I did well. I'm a unique person so when I found I felt that way I thought, well I wonder if anyone else is feeling that way. So, communicating with other people that are using it without divulging your specific things would be nice." [Long-term user, female, patient #19]

Importantly, unexpected changes in these relational contexts also influenced patients' usage behavior. For example, a sudden transition to a caregiving role, a move away from social ties, or a divorce.

"After my marriage fell apart, I moved to this area with my partner and I have to keep going back to the city to meet my friends, which makes it harder for me to meet people here. I am currently in an anxiety support group here, but I went off track with my other goals. I check the app (ePRO) sometimes but not regularly because I have nothing to report on" [Long-term user, Female, patient #14]

Theme 2: Goal efficacy, behavior capability, and outcome expectancies:

Patients' confidence, skills, and anticipated outcome from the app influenced their usage behavior. While presented as distinct domains in SCT, data from this study suggests that the domains of goal-efficacy, behavior capability, and outcomes expectancies are linked.

The re-storying work reveals these connections, which are best represented in the long and short-term user narratives below. However, some participants' account also shows that individuals' confidence in themselves to achieve goals (perceived goal efficacy), skills necessary to use the app (behavior capability), and their commitment to engage with the app to achieve set goals (outcome expectancies) are intertwined and influence each other. These outcome expectancies were also related to app functionality. This collapsed theme consisted of sub-themes: (1) patients' confidence and skills with goals and its impact on ePRO use (sub-theme 2a: Confidence and skills with goals), (2) patients' confidence and skills in using technologies and its impacts on ePRO use (sub-theme 2b: confidence and skills in technologies); and (3) patients' expected

outcome from the ePRO app and its impact on their usage behavior (sub-theme 2c: outcome expectancies).

Sub-theme 2a: Confidence and skills with goals

This subtheme demonstrates patients' description of how their confidence in their goals and their skills to perform the goals have influenced their ePRO usage behavior. Prior goal-setting experience and familiarity with goal-related tasks influenced patients' confidence in achieving goals set in the ePRO app. Patients who had been working on a goal for a long time were more confident in their skills to perform a goal. Five (38%) long-term users had already been working on a number of health-related goals prior to enrolling in the study and had been tracking their progress using electronic or paper-based tools like calendars, wearable technologies, and hand-written notes. For these participants, the ePRO app was viewed as an additional electronic way to track their goals. These participants demonstrated confidence that they had the necessary skills to set appropriate goals and perform those with the use of ePRO and because of having the confidence and skills they also had better outcome expectancy from the ePRO app.

"I did pretty well in terms of crushing all my goals…because I already had the same goals, I was already continuing with the exercise program. So, it (ePRO goals) was just a continuation. I just kept up with the same tasks, swimming, walking that I was doing before joining your study." [Long-term user, female, Patient #3]

In contrast, patients who did not have any prior goal-setting experience reflected that setting a meaningful goal was difficult for them. Consequently, their providers had to suggest some goals for them, but some patients found those goals were not personally meaningful. In these cases, not

having prior goal-setting experience negatively impacted patients' ability to create meaningful goals, which, in turn, impacted their usage behavior.

"I've never had health goals before, so could not come up with one when they (health provider) asked me what I want to put in here (ePRO app). I got some kidney conditions, so my doctor suggested I set daily goals of drinking eight glasses of water and tracking them. I did not think I need to track it; I remember it anyway. I don't need a phone to tell me I need to hydrate. I did not think the goal was anything important for me to track on a phone" [Short-term user, male, Patient #11]

In terms of individuals' confidence in achieving their goals, some long-term users indicated their traits such as "will-power", "self-discipline", and "motivation" boosted their confidence that they will be able to reach their goals.

*"It [*Achieving health goals*] has nothing to do with the phone [*ePRO app*]. It has everything to do with the person. You have to be determined that you are going to walk. And you're going to set your goal -- you're going to walk a block and you're going to walk back. You have to have determination. You have to have the willpower to say, I'm going to do it and that's it. ePRO is not going to do it for you, but it was good to have to see my progress. I thought it (ePRO) was a neat way to see how I am doing"* [Long-term user, female, patient #6]

Additionally, patients reflected that their confidence and skills to perform a goal changes over time depending on their health. When patients felt that they were not able to perform their goals because of health and life circumstances and they did not have "enough" to report on the app, they discontinued using the app.

*"Initially, I set up my goal to go 3 miles walking every day. But after my surgeries and my accident, there was no way I could do it. I was barely getting out to walk my dogs. I was falling short every day and it made no sense for me to use the app, I just felt sad that it [*ePRO*)] kept showing me I was not the go-getter anymore. I did not know how to pause it [*ePRO*]"*
[Short-term user, female, Patient # 15]

Sub-theme 2b: Confidence and skills with technologies

Not surprisingly, patients who did not think they had the necessary technological skills to use the ePRO app had discontinued their usage.

A number of patients (67%) the patients discussed that they were tech-savvy enough to be able to use the app. *" I found the app to be user-friendly, very clean, nothing too difficult, but I am good with computers and all that stuff, a tech-junkie. I use computers, phones, iPad all the time"*
[Long-term user, female, Patient #19]

Some participants stated that they needed help using the ePRO app because often fonts were too small.

" *I never had to use the computer for my work so never learned it. Now I got muscular dystrophy, so the fonts were way too small for me, so I did not use the app at all. I used the app [*ePRO*] on my computer, but I am not very good at it. My wife must help me a lot. I cannot even send an email; she will just do it for me. I ended up not using it [*ePRO on the computer*] at all*.
[Short-term user, male, Patient # 17]

Sub-theme 2c: Outcome expectancies

Patients described their anticipated outcomes from the ePRO app. Typically for long-term users, ePRO seemed like a beneficial addition to their health. One long-term user described that while enrolling in the study, they anticipated ePRO would make them more accountable towards their goals.

" I wanted to get off my oxygen tank, I do not want to lug this machine everywhere. So I need to drop some pounds…by walking, exercising…I thought this phone would show me how I am doing, am I doing it too much, am I getting any good." [Long-term user, female, Patient # 20]

On the other hand, three (33%) patients who were short-term users described that they discontinued using the app because they did not think the app was "well-developed" to be implemented in the real world. Therefore, they did not think the app would be a beneficial addition to their life. One short-term user described their dissatisfaction with the functionality of the app,

*"I think that's all [*research on people taking control over their health*] a great idea I just feel that the actual implementation isn't as far advanced as it needs to be for it to work effectively, at least for me. I use my fitbit anyways to count my steps which is far better because that watch automatically counts my steps. I could not see any use for it [*ePRO app*] to work on my goals. I did not see any benefit for my health from it."* [Short-term user, male, Patient#10]

Theme 3: Usage reinforcement

The usage reinforcement domain of SCT suggests that internal and external factors such as internal satisfaction or external rewards can encourage/discourage individuals' behavior change. Five long-term users reported that they felt a sense of accomplishment (i.e., internal reward) when they were able to "check off" their goals in the ePRO app. The app had a question "did you

achieve your goal yesterday?" and patients had the option of reporting yes or no option. Some patients found that exercise rewarding.

*"Well, to be honest, the only thing it did was – I do it [*check off the list*], used to do it every Monday morning, and it focused me on not smoking. That was the motivation every Monday morning, you know"* [Long-term user, female, patient #20]

Some short-term users identified that they already used many other legacy devices such as calendars, notebooks, cell phones, glucose monitoring devices, etc. These participants found reporting the same measures in two different tools to be redundant and they did not think of the ePRO app as an important addition to their health-related goals.

"*I am an old school paper-pencil, calendar on refrigerator person, so that helps me to visualize my progress every day. I see them every day before breakfast, so I know what I had to do that day. The phone [*ePRO*] just stayed on my night table."* [Short-term user, female, patient # 22]

One unexpected external influence can be discouragement from providers. Two (22%) participants reported receiving advice from their providers to discontinue the use of ePRO. The factors that contributed to providers' discouragement were patients' frail health, patients' anxiety with the app that they were not being able to reach their goals, and changed health-related priorities.

"*My breathing issue has gotten worse in winter so I was not working on my goals anymore…When I told her [*health provider*] that I am worried about not reaching my goal, I feel anxious that I am not reaching my goal, she said "just forget about it [*ePRO*] for now, let's get back you to feeling good first", so I thought okay one thing off my list. I felt better."* [Short-term user, female, patient #13]

481 **Long-term and short-term user stories:**

482 The two narratives presented in **Box 1** offer a composite understanding of long-term and short-
483 term users of the ePRO app, linking elements of the stories shared by different participants to
484 SCT domains.

485 **Box 1: Long-term and short-term user stories**

Elaine: A long-term user

Elaine considers herself to be a healthy individual whose diabetic symptoms are well-managed through diet and exercise. She thinks herself "lucky" to have great health providers who have helped her to manage her symptoms for the past two and a half years. She has multiple other chronic conditions such as chronic pain and hypertension, but controlling diabetic symptoms is her foremost priority as she heard it can affect her other conditions. At first, she joined the ePRO study because her dietician at the Family Health Team encouraged her to do so (*SCT domain: Reciprocal determinism (social support)*). After talking to her dietician and talking to the ePRO study recruiter, Elaine agrees ePRO would be a good addition to be more accountable towards her health-related goals (*SCT domain: outcome expectancies*). With her dietician, she decides on three goals that she always thought would be important to live a healthy lifestyle. Elaine's goals are: 1) lowering daily sugar intake; 2) joining walking programs with her peers facilitated by her dietitian; and, 3) swimming every weekend in the local community center. She feels confident that she will be successful in achieving these goals as she has always been self-disciplined ("No TV from 9 am to 6 PM") and has always kept a personal calendar to track her physical activity level. Also, she considers herself not in frail health, so she does not think working towards those exercise-related goals will be hard for

her (*SCT domain: Goal Efficacy and outcome expectancies*). Also, she has been working on those goals before ePRO intervention, so she is confident she has the necessary skills to work towards her goal (*SCT domain: Behavior capability*) and so she thinks ePRO will be beneficial for her to track those goals (*SCT domain: Outcome expectancies*).

Elaine considers herself tech-savvy. However, she experiences a few technological challenges while using ePRO. The most challenging one has been being logged out of ePRO after taking a break from the tool during Christmas time when she visited her family in Scotland for 15 days. After not using ePRO while she was away, Elaine got locked out of the app. After returning from her holidays, she contacted her dietician to resolve the issue (*SCT domain: reciprocal determinism*). Her dietician asked her to contact the research team as she could not fix the technical issue for Elaine. Elaine's technical issue was resolved in two days, and she continues to use the app until the end of the study. In the final reflection, Elaine believes the app is good for her to be accountable towards her goal and she derives satisfaction from that accountability. At the end of the study, Elaine plans to continue to track her goals through her calendar, which was how she tracked her goals before using the ePRO app. She thinks ePRO would benefit from having a communication feature. That way, she could communicate with her peers who are also using ePRO and working towards similar goals.

Josh: A short-term user story

Josh is a 76-year-old man with several concurrent chronic conditions including diabetes, hypertension, and arthritis. Josh considers himself to have a fair understanding of his ailments and considers his conditions are fairly well-managed. Josh is the primary caregiver to his wife who is ill. As a result of this caregiving role, Josh finds he does not often have time to participate in social groups, such as walking groups offered through his local community

center (*SCT domain: Reciprocal determinism: social support*). Josh is a patient at a Family Health Team where he has access to both primary care and allied health services. At the suggestion of his family physician, Josh agrees to participate in the ePRO study (*SCT domain: Reciprocal determinism*). However, he does not expect the app to be useful because considered himself to be "tech illiterate" so he does not think he will be able to use the app without his wife's help, and he does not think he has any important goals to work toward because he already has a healthy lifestyle (*SCT domain: behavior capability and outcome expectancies*).

Additionally, Josh is hesitant to set a goal because he never had a health-related goal before and is uncertain if he has the necessary skills or discipline to keep up with a specific goal (*SCT: behavior capability*) so he is not sure if ePRO would add value to his life (*SCT: Outcome expectancies*). However, with assistance from the ePRO study team and his family doctor, Josh creates the following SMART goals: 1) Eat at least one fruit every day and 2) walk for at least 10 minutes every day.

At the beginning of the study, Josh completes his check-in questions regularly. Over time, Josh begins checking in on the app less and less, eventually not using the technology at all. When the ePRO study team reaches out to Josh, he states that he forgot his password and was unable to log in to the ePRO platform, so he does not use it. While Josh describes himself as "computer illiterate" he finds the ePRO app and web platform easy to use. Josh also finds that whenever he meets with this healthcare provider, they do not discuss his goals, but rather speak about his medications and management of his conditions resulting in goal setting becoming less of a priority (*SCT domain: Behavior Enforcement*). Josh finds ePRO to be good

for self-monitoring, but he does not find the technology useful for communicating with his healthcare team.

Discussion:

This study used descriptive qualitative methods and restorying analytic techniques to explore the social and behavioral factors contributing to the patients' usage behavior of the ePRO tool. Study findings show that patient-provider relationships, patients' social relationships, and patient personal circumstances play a central role in their decision to continue or discontinue the use of the ePRO app.

Leveraging the SCT as an analytical tool for data analysis, we were able to identify social-behavioral factors that contribute to patient's decision to continue/discontinue app usage such as their social and environmental factors and relationships (domain 1), their confidence and skills in using technology, confidence and skills in setting/performing goals, expected outcomes from intervention (domain 2) and encouraging factors (domain 3). Study data reveals that the SCT constructs of goal efficacy and behavior capability are also importantly related, as capability and skill influence perceived confidence in completing a task. This interrelationship makes sense theoretically. SCT suggests that performing a behavior successfully increases individuals' confidence in their ability to accomplish goals because they believe they have the skills to achieve goals through behavior change. [35] Additionally, performing a behavior successfully also impacts one's outcome expectancies because one believes they have the skills and confidence to receive benefit from an action. [35,47]

505 The stories show the themes of the interactions and links between concepts that the descriptive
506 analysis could not. For example, one important interpretive theme that emerges from Josh and
507 Elaine's stories is that patients' confidence and prior experience in goal setting influenced their
508 capability, and expectations from this goal-oriented intervention. Josh and Elaine had
509 approached their goals with varying degrees of experience, confidence, and attachment to the
510 goal. For example, Elaine's prior experience with goal setting helped her feel more competent
511 and skilled to achieve future goals, which subsequently, increased her intention to track goals
512 through ePRO. Whereas Josh's lack of experience with goal setting made it challenging for him
513 to make meaning of his goal which translated into his reduced interest in tracking goals through
514 ePRO.

515 Furthermore, the stories also show an important divergence in how long-term and short-term
516 users react to technical errors, in an interpretive manner. App-related technical error is
517 ubiquitous and many app-based interventions experience significantly high attrition after users
518 experience an error. [48] As such, it is important to explore patients' strategies to mitigate the risk
519 and what factors contribute to their motivation to resolve such technical errors. [24,42,49] The
520 patient-provider relationship emerged as an important mitigating factor when resolving technical
521 errors. In Elaine's story, her strong relationship with her providers, the meaningfulness of her
522 goals, and the satisfaction received from achieving goals influenced her motivation to
523 proactively troubleshoot the problem and get back to the app. This was a common occurrence
524 among many long-term users who would more readily troubleshoot technical errors with their
525 primary care providers. While this study provides an initial indication of the influence of the
526 patient-provider relationship on technology usage behavior, future studies should be used to
527 determine the strength of this influence. [50] On the other hand, for Josh, the combination of

technical error and lack of meaning in his goals contributed to discontinuing the app usage. This finding shows that participants' goal-setting success was related to user experience with the app. If participants face difficulties to use the app interface, they may abandon the goal-tracking exercise altogether, as demonstrated in Josh's story. In sum, the factors such as the patient-provider relationship, and app user experience can play an important role in a patient's decision to continue/discontinue a goal-oriented app.

Another important study finding that emerged from the interview data is the importance of meaningful goal-setting for an effective behavior change intervention. Hence, when setting patients' goals, a strong focus on patient's perception of the meaningfulness or fit of the goal in their daily lives should be accounted for. Because this meaningfulness of the goal can not only influence behavior change as well as it can influence patients' adherence to a newly adopted technology. [51,52] This goal-oriented conversation between patient-provider should also include an exploration of goal setting and monitoring tools the patient may already be using such as calendars, health monitoring devices, or personal phones. Because the study data suggests that often patients prefer devices/tools that they are familiar with rather than adopting a new tool. [53]

Comparison of themes with previous research:

Customizable technologies:

The findings of this article support previous study findings that health technologies are often discontinued and abandoned because a technology lack features of meaningful customization which is not part of users' already existing devices such as personal phones. [53] Additionally, the study findings suggest that health-related goals change over time for patients with multiple chronic conditions, and so designing apps that offer patient-driven customization and

modification techniques will be helpful to repurpose the same technology at multiple time points of the lifecycle. For example, one patient (Patient #15) shared that their ability to achieve their goals has changed over time because of emerging health issues but they were unsure how to modify the goals in the ePRO app. This design feature in the ePRO was intentional based on a previous exploratory trial of the app (which was under 4 months). [25] In the exploratory trial of ePRO, it was found that the patients preferred provider consultations while changing their goals, hence, the app required the providers to change or modify goals on behalf of patients. However, in this longer pragmatic trial of ePRO, where patients used ePRO for 9-12 months, patients preferred to change or modify their goals on their own, as demonstrated in the current study finding. This contradiction may be due to the prolonged use of ePRO; for example, with prolonged use patients' confidence in using the app changed which in turn helped them feel like they could take charge of their goals. This finding demonstrates the importance of longitudinal evaluation of mHealth apps compared to shorter follow-up time because patients' confidence, skills, and health needs from the app change over time which may not be captured in a shorter trial. [15]

For example, previous studies with shorter follow-up periods have identified factors such as health literacy, motivation, capabilities, and social/environmental structures, social support has an impact on mHealth engagement; [54,55] however, this study shows that patients' motivation, capability, and social/environmental factors change over time. A systematic review on mHealth intervention for patients with depression supports this finding that patients' engagement with intervention changes over time, [56] perhaps because their treatment needs and goals change over time. This changing needs of patients from their mHealth app intervention and its impact on their usage behavior is further supported by another study conducted among patients with chronic

illness. [18] Thus, we need to consider how our technologies can adapt to how users evolve over time.

Importance of chronic care paradigm shift from self-management to co-management of chronic conditions:

In the current chronic care paradigm, the task of goal management is often left to patients. [3,57] Our study findings highlight those discussions around goal-oriented care are a one-time occurrence for study participants which was facilitated by introducing the ePRO app. After setting goals with patients, providers often leave it up to patients to be responsible for their own goals. On the other hand, patients do not bring up the topic of goals in their discussion as they perceive that their providers "are too busy" to attend to patients' goals, and providers' time could be better spent on other condition-related concerns. The study finding reflects that there is a need for an ongoing conversation between patient-provider about patient-centered goals to ensure the goals and associated devices/tools are appropriate for the patient's needs and serve the purpose that the goal/device set out to do. Similarly, the interview data suggests that patients considered their providers' enthusiasm for the ePRO intervention important and influenced patients' interest in two ways, which are: (a) monitoring of patient data by providers was considered important and (b) providers' encouragement to keep using the ePRO app. [58] This finding highlights the need for further education and training tools for health care providers on how to effectively have a goal-oriented conversation with patients and within interprofessional teams. [10,59]

Strengths:

The descriptive qualitative approach of this research allowed us to identify multiple social-behavioral factors that influenced patients' enrollment in the study and subsequent

discontinuation/continuation with the study. Additionally, by using a re-storying method, the findings were in an interpretive manner, allowing for the identification of nuanced patterns and interrelationships between identified themes. Furthermore, the longitudinal timeline of the study (15 months) allowed us to explore the factors that contribute to patients' usage behavior long term, which is underexplored in the current literature. [15] Lastly, since Bandura's SCT has been widely used to explore an individual's behavior and action toward health-enhancing behavior, we were able to compare the findings of the current study with previous literature. [35,36,47,60] For example, previous studies have identified that patients' self-efficacy, motivation, capacity, social and environmental influences, and perceived consequences are impacts patients' usage behavior of the mHealth app.

Limitations:

Due to scheduling conflict or loss-to follow-up of participants, we were not able to interview all participants at both different time points. *As a result, a potential limitation of the study is that those who participated in the interviews may be unique as compared to those who chose not to. However, the sample size was too low to assess whether the difference between the two groups was significant.* However, the interviews that were conducted were in-depth and had rich information. Furthermore, the patient population represented in this study was recruited from only three of the six FHTs involved in this study. It is possible some additional findings may have been generated by looking across all six sites. However, the sample in this study represents 91% of the total participants in the study. As is the case with case study research it is also possible findings may not be transferable to other models of primary care such as community health centers or solo practice environments. Furthermore, the participant demography suggests that the study patient population were less complex and well-resourced meaning on average

patients had a low number of chronic conditions, had high income and educational attainment level, which might not be representative of general complex patients. Therefore, the finding of the study may not be transferable for patients living in resource-poor communities or who have lower income or education levels. Additionally, the underrepresentation of low-income individuals is a common occurrence across multiple research studies and requires attention in study design to facilitate this population's participation. [61]

Conclusion:

In many cases, mHealth or any health innovations will have expected impacts if people use the innovations as intended. To better predict, explain, and increase the actual usage of innovations, we need to understand why different target user groups continue or discontinue to use an innovation. The current study identifies that multi-level factors contribute to complex patients' decision to continue/discontinue a goal-oriented app. Additionally, our findings show that there is a need for ongoing, productive patient-provider interaction to create, modify and change patients' goals according to their changing health and social needs. Future research should consider patients' social and behavioral contexts while implementing mHealth apps and similar technological interventions for complex patients.

Abbreviations:

ePRO: electronic Patient Reported Outcome

SCT: Social Cognitive Theory

FHT: Family Health Teams

Funding Statement: The study was funded by Canadian Institute for Health Research (CIHR) eHealth Innovation Partnerships Program (eHIPP) program (CIHR–143559). The funders did not have any involvement in the study's design, execution, analyses, interpretation of the data, review, or approval of the manuscript for publication.

Authors' Contribution:

FT: data collection, writing-first draft, reviewing and editing; **TA:** data collection and analysis; writing-first draft, reviewing and editing; **BM**: writing-critical review and editing; **JN:** writing-critical review and editing; **ML:** writing-critical review and editing; **JS:** data collection; **SM:** writing-critical review and editing; **RU**: writing-critical review and editing; **CSG:** conceived and designed the study, data collection, writing-initial draft, reviewing and editing, supervision.

Bibliography:

1. Lewis J, Ray P, Liaw ST. Recent Worldwide Developments in eHealth and mHealth to more Effectively Manage Cancer and other Chronic Diseases - A Systematic Review. *Yearbook of medical informatics*. 2016;(1):93-108. doi:10.15265/iy-2016-020

2. Putranto D, Kep S, Ns E, et al. Mobile applications for managing symptoms of patients with cancer at home: A scoping review. Published online 2020. doi:10.1111/ijn.12842

3. Morton K, Dennison L, May C, et al. Using digital interventions for self-management of chronic physical health conditions: A meta-ethnography review of published studies Europe PMC Funders Group. *Patient Educ Couns*. 2017;100(4):616-635. doi:10.1016/j.pec.2016.10.019

4. Rosella LC, Fitzpatrick T, Wodchis WP, Calzavara A, Manson H, Goel V. *High-Cost Health Care Users in Ontario, Canada: Demographic, Socio-Economic, and Health Status Characteristics*. Vol 14. BioMed Central Ltd.; 2014:532. doi:10.1186/s12913-014-0532-2

5. Hajat C, Stein E. The global burden of multiple chronic conditions: A narrative revie[1] C. Hajat and E. Stein, "The global burden of multiple chronic conditions: A narrative review," Preventive Medicine Reports, vol. 12. Elsevier Inc., pp. 284–293, 01-Dec-2018.w. *Preventive Medicine Reports*. 2018;12:284-293. doi:10.1016/j.pmedr.2018.10.008

6. Schaink AK, Kuluski K, Lyons RF, et al. A Scoping Review and Thematic Classification of Patient Complexity: Offering a Unifying Framework. *Journal of Comorbidity*. 2012;2(1):1-9. doi:10.15256/joc.2012.2.15

7. Bodenheimer T, Lorig K, Holman H, Grumbach K. Patient self-management of chronic disease in primary care. *Journal of the American Medical Association*. 2002;288(19):2469-2475. doi:10.1001/jama.288.19.2469

8. Gee PM, Greenwood DA, Paterniti DA, Ward D, Miller LMS. The eHealth Enhanced Chronic Care Model: A Theory Derivation Approach. *J Med Internet Res 2015;17(4):e86 https://www.jmir.org/2015/4/e86*. 2015;17(4):e4067. doi:10.2196/JMIR.4067

9. Steele Gray C, Barnsley J, Gagnon D, et al. Using information communication technology in models of integrated community-based primary health care: Learning from the iCOACH case studies. *Implementation Science*. 2018;13(1):1-14. doi:10.1186/s13012-018-0780-3

10. Gordon K, Steele Gray C, Dainty KN, DeLacy J, Ware P, Seto E. Exploring an Innovative Care Model and Telemonitoring for the Management of Patients With Complex Chronic Needs: Qualitative Description Study. *JMIR Nursing*. 2020;3(1):e15691. doi:10.2196/15691

11. Mahmood A, Kedia S, Wyant DK, Ahn SN, Bhuyan SS. Use of mobile health applications for health-promoting behavior among individuals with chronic medical conditions. *Digital Health*. 2019;5. doi:10.1177/2055207619882181

12. Greenhalgh T, Procter R, Wherton J, Sugarhood P, Hinder S, Rouncefield M. What is quality in assisted living technology? The ARCHIE framework for effective telehealth and telecare services. *BMC Medicine*. 2015;13(1):1-15. doi:10.1186/s12916-015-0279-6

13. Gammon D, Johannessen LK, Sørensen T, Wynn R, Whitten P. An Overview and Analysis of Theories Employed in Telemedicine Studies A Field in Search of an Identity. *Methods Inf Med*. 2008;47. doi:10.3414/ME0484

14. Eysenbach G. The Law of Attrition. *Journal of Medical Internet Research*. 2005;7(1):e11. doi:10.2196/jmir.7.1.e11

15. Meyerowitz-Katz G, Ravi S, Arnolda L, Feng X, Maberly G, Astell-Burt T. Rates of Attrition and Dropout in App-Based Interventions for Chronic Disease: Systematic Review and Meta-Analysis. *J Med Internet Res 2020;22(9):e20283 https://www.jmir.org/2020/9/e20283*. 2020;22(9):e20283. doi:10.2196/20283

16. Murray E, White IR, Varagunam M, Godfrey C, Khadjesari Z, McCambridge J. Attrition revisited: Adherence and retention in a web-based alcohol trial. *Journal of Medical Internet Research*. 2013;15(8):e162. doi:10.2196/jmir.2336

17. Fleming T, Bavin L, Lucassen M, Stasiak K, Hopkins S, Merry S. Beyond the Trial: Systematic Review of Real-World Uptake and Engagement With Digital Self-Help Interventions for Depression, Low Mood, or Anxiety. *J Med Internet Res 2018;20(6):e199 https://www.jmir.org/2018/6/e199*. 2018;20(6):e9275. doi:10.2196/JMIR.9275

18. Yin K, Jung J, Coiera E, et al. Patient work and their contexts: Scoping review. *Journal of Medical Internet Research*. 2020;22(6):e16656. doi:10.2196/16656

19. Tsai CH. Integrating social capital theory, social cognitive theory, and the technology acceptance model to explore a behavioral model of telehealth systems. *International Journal of Environmental Research and Public Health*. 2014;11(5):4905-4925. doi:10.3390/ijerph110504905

20. Wang Y, Xue H, Huang Y, Huang L, Zhang D. A Systematic Review of Application and Effectiveness of mHealth Interventions for Obesity and Diabetes Treatment and Self-Management. *Advances in Nutrition (Bethesda, Md)*. 2017;8(3):449-462. doi:10.3945/AN.116.014100

21. Anna, Schache K, Kieser A, et al. No Title. 2019;7(8):e15021. doi:10.2196/15021

22. Steele Gray C, Chau P, Tahsin F, et al. *Supporting Goal-Oriented Primary Health Care for Seniors' with Multimorbidity and Complex Care Needs Using Mobile Technology: Mixed-Methods, Stepped-Wedge Cluster Randomized Trial of the EPRO Tool. (Preprint)*.; 2021. doi:10.2196/preprints.29071

23. Steele Gray C, Khan AI, Kuluski K, et al. Improving Patient Experience and Primary Care Quality for Patients With Complex Chronic Disease Using the Electronic Patient-Reported Outcomes Tool: Adopting Qualitative Methods Into a User-Centered Design Approach. *JMIR Research Protocols*. 2016;5(1):e28. doi:10.2196/resprot.5204

24. Steele Gray C, Gill A, Khan AI, Hans PK, Kuluski K, Cott C. The Electronic Patient Reported Outcome Tool: Testing Usability and Feasibility of a Mobile App and Portal to Support Care for Patients With Complex Chronic Disease and Disability in Primary Care Settings. *JMIR mHealth and uHealth*. 2016;4(2):e58. doi:10.2196/mhealth.5331

25. Gray CS, Gravesande J, Hans PK, et al. Using exploratory trials to identify relevant contexts and mechanisms in complex electronic health interventions: Evaluating the electronic patient-reported outcome tool. *Journal of Medical Internet Research*. 2019;21(2). doi:10.2196/11950

26. Tahsin F, Tracy S, Chau E, et al. Exploring the relationship between the usability of a goal-oriented mobile health application and non-usage attrition in patients with multimorbidity: A blended data analysis approach. *Digital Health*. 2021;7:205520762110455. doi:10.1177/20552076211045579

27. Steele Gray C, Chau E, Tahsin F, et al. Assessing the implementation and effectiveness of the Electronic Patient Reported Outcome Tool for Seniors with Complex Care Needs: Mixed Methods Study (Preprint). *Journal of Medical Internet Research*. 2021;23. doi:10.2196/29071

28. Sandelowski M. Focus on research methods: Whatever happened to qualitative description? *Research in Nursing and Health*. 2000;23(4):334-340. doi:10.1002/1098-240x(200008)23:4<334::aid-nur9>3.0.co;2-g

29. Glazier RH, Redelmeier DA. Building the patient-centered medical home in Ontario. *JAMA*. 2010;303(21):2186-2187. doi:10.1001/jama.2010.753

30. Patton MQ. *Qualitative Evaluation and Research Methods, 2nd Ed*. Sage Publications, Inc; 1990.

31. Singh H, Tahsin F, Nie JX, et al. Exploring the perspectives of primary care providers on use of the electronic Patient Reported Outcomes tool to support goal-oriented care: a qualitative study. *BMC medical informatics and decision making*. 2021;21(1):366. doi:10.1186/s12911-021-01734-0

32. Statistics Canada. *Focus on Geography Series, 2016 Census.* Statistics Canada; 2017. Accessed June 14, 2022. https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Index-eng.cfm

33. Upshur R. The complexity score: towards a clinically relevant, clinician-friendly measure of patient multi-morbidity. *International Journal of Patient Centred Medicine*. 2012;2(4).

34. Middelweerd A, Te Velde SJ, Mollee JS, Klein MCA, Brug J. App-Based Intervention Combining Evidence-Based Behavior Change Techniques With a Model-Based Reasoning System to Promote Physical Activity Among Young Adults (Active2Gether): Descriptive Study of the Development and Content. *JMIR Res Protoc 2018;7(12):e185 https://www.researchprotocols.org/2018/12/e185*. 2018;7(12):e7169. doi:10.2196/RESPROT.7169

35. Bandura A. Social cognitive theory: An agentic perspective. *Annual Review of Psychology*. Published online 2001. doi:10.1146/annurev.psych.52.1.1

36. Kim E, Han S. Determinants of Continuance Intention to Use Health Apps among Users over 60: A Test of Social Cognitive Model. *International Journal of Environmental Research and Public Health*. 2021;18(19):10367. doi:10.3390/IJERPH181910367

37. Grace-Farfaglia P. Social Cognitive Theories and Electronic Health Design: Scoping Review. *JMIR Human Factors*. 2019;6(3). doi:10.2196/11544

38. Sniehotta FF, Scholz U, Schwarzer R. Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *https://doi.org/101080/08870440512331317670*. 2007;20(2):143-160. doi:10.1080/08870440512331317670

39. Creswell JW, Miller DL. Determining Validity in Qualitative Inquiry. *Theory Into Practice*. 2000;39(3):124-130. doi:10.1207/s15430421tip3903_2

40. Creswell JW. *Qualitative Inquiry & Research Design*.; 2007. doi:10.1111/1467-9299.00177

41. Ollerenshaw jo A, Creswell JW. Narrative research: A comparison of two restorying data analysis approaches. *Qualitative Inquiry*. 2002;8(3):329-347. doi:10.1177/10778004008003008

42. Gucciardi E, DeMelo M, Offenheim A, Stewart DE. Factors contributing to attrition behavior in diabetes self-management programs: A mixed method approach. *BMC Health Services Research*. 2008;8. doi:10.1186/1472-6963-8-33

43. Beauchamp MR, Crawford KL, Jackson B. Social cognitive theory and physical activity: Mechanisms of behavior change, critique, and legacy. *Psychology of sport and exercise*. 2019;42:110-117. doi:10.1016/j.psychsport.2018.11.009

44. Lincoln YS, Guba EG. Establishing Trustworthiness. Naturalistic inquiry. In: *Naturalistic Inquiry*. ; 1985.

45. Bradway M, Pfuhl G, Joakimsen R, Ribu L, Grøttland A, Årsand E. Analysing mHealth usage logs in RCTs: Explaining participants' interactions with type 2 diabetes self-management tools. *PLoS ONE*. 2018;13(8). doi:10.1371/journal.pone.0203202

46. Vancouver JB, Thompson CM, Williams AA. The changing signs in the relationships among self-efficacy, personal goals, and performance. *J Appl Psychol*. 2001;86(4):605-620. doi:10.1037/0021-9010.86.4.605

47. Brown LA, Wiley JF, Wolitzky-Taylor K, et al. Changes in self-efficacy and outcome-expectancy as predictors of anxiety outcomes from the CALM study. *Depression and anxiety*. 2014;31(8):678. doi:10.1002/DA.22256

48. Stangeland S, Karlsen B, Oord ER, Graue M, Oftedal B. Dropout From an eHealth Intervention for Adults With Type 2 Diabetes: A Qualitative Study. *J Med Internet Res 2017;19(5):e187 https://www.jmir.org/2017/5/e187*. 2017;19(5):e7479. doi:10.2196/JMIR.7479

49. Inal Y, Wake JD, Guribye F, Nordgreen T. Usability evaluations of mobile mental health technologies: Systematic review. *Journal of Medical Internet Research*. 2020;22(1). doi:10.2196/15337

50. Dou K, Yu P, Deng N, et al. Patients' Acceptance of Smartphone Health Technology for Chronic Disease Management: A Theoretical Model and Empirical Test. *JMIR Mhealth Uhealth 2017;5(12):e177 https://mhealth.jmir.org/2017/12/e177*. 2017;5(12):e7886. doi:10.2196/MHEALTH.7886

51. Mohr DC, Cuijpers P, Lehman K. Supportive accountability: A model for providing human support to enhance adherence to eHealth interventions. *Journal of Medical Internet Research*. 2011;13(1):e30. doi:10.2196/jmir.1602

52. Deci EL, Ryan RM. Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology*. 2008;49(3):182-185. doi:10.1037/A0012801

53. Greenhalgh T, Wherton J, Sugarhood P, Hinder S, Procter R, Stones R. What matters to older people with assisted living needs? A phenomenological analysis of the use and non-use of telehealth and telecare. *Social Science and Medicine*. 2013;93:86-94. doi:10.1016/j.socscimed.2013.05.036

54. Szinay D, Perski O, Jones A, Chadborn T, Brown J, Naughton F. Perceptions of Factors Influencing Engagement With Health and Well-being Apps in the United Kingdom: Qualitative Interview Study. *JMIR mHealth and uHealth*. 2021;9(12):e29098. doi:10.2196/29098

55. Choudhury A, Asan O, Choudhury MM. Mobile health technology to improve maternal health awareness in tribal populations: mobile for mothers. *Journal of the American Medical Informatics Association*. 2021;28(11):2467-2474. doi:10.1093/jamia/ocab172

56. Molloy A, Anderson PL. Engagement with mobile health interventions for depression: A systematic review. *Internet Interventions*. 2021;26:100454. doi:10.1016/j.invent.2021.100454

57. May C. The Burden of Treatment and the Burden of Symptoms : the problem of workload and institutional boundaries in chronic disease. Published online 2014:1-6.

58. Hanley J, Fairbrother P, McCloughan L, et al. Qualitative study of telemonitoring of blood glucose and blood pressure in type 2 diabetes. *BMJ Open*. 2015;5(12):1-9. doi:10.1136/bmjopen-2015-008896

811 59. Gray CS, Grudniewicz A, Armas A, Mold J, Im J, Boeckxstaens P. Goal-Oriented Care: A Catalyst for
812 Person-Centred System Integration. *International Journal of Integrated Care*. 2020;20(4):1-10.
813 doi:10.5334/IJIC.5520

814 60. Williams KE, Bond MJ. The roles of self-efficacy, outcome expectancies and social support in the
815 self-care behaviours of diabetics. *http://dx.doi.org/101080/13548500120116076*. 2010;7(2):127-
816 141. doi:10.1080/13548500120116076

817 61. Joseph G, Kaplan CP, Pasick RJ. Recruiting Low-Income Healthy Women to Research: An Exploratory
818 Study. *Ethnicity & Health*. 2007;12(5):497-519. doi:10.1080/13557850701616961

819

820