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ORIGINAL ARTICLE

Who is more likely to adopt and comply with the electronic patient-reported outcome measure (ePROM) mobile application? A real-world study with cancer patients undergoing active treatment

Mangyeong Lee[1,2] · Danbee Kang[2,3] · Sooyeon Kim[2,3] · Jihyun Lim[2] · Junghee Yoon[1,3,4] · Youngha Kim[2] · Sungkeun Shim[1,2] · Eunji Kang[2,5] · Jin Seok Ahn[6] · Juhee Cho[1,2,3,7,8] · Soo-Yong Shin[1,9] · Dongryul Oh[10]

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Abstract

Purpose This study aims to identify factors associated with the adoption and compliance of electronic patient-reported outcome measure (ePROM) use among cancer patients in a real-world setting.

Methods This prospective cohort study was conducted at the Samsung Medical Center in Seoul, Korea, from September 2018 to January 2019. Cancer patients aged 18 years or older who owned smartphones and who were receiving chemotherapy or radiation therapy were eligible for this study. Patients were asked to use the app to report their symptoms every 7 days for a total of 21 days (3 weeks). Logistic regression was performed to identify the factors associated with the adoption and compliance.

Results Among 580 patients, 417 (71.9%) adopted the ePROM app and 159 (27.4%) out of 417 had good compliance. Patients who had greater expectations regarding the ease of use (adjusted odds ratio [aOR] 2.67, 95% CI: 1.28–5.57) and usefulness (aOR 1.69, 95% CI: 1.05–2.72) of the ePROM app were more likely to adopt the app than those who did not. Patients who had greater satisfaction with usefulness (aOR 1.89, 95% CI 1.10–3.25) were more likely to comply with using the app, but satisfaction with ease of use was not related to the compliance.

Conclusion While expectation regarding the ease of use and usefulness of the ePROM app was associated with the adoption of the app, satisfaction with ease of use was not related to compliance with the ePROM app. Satisfaction with usefulness was associated with the compliance of ePROM app use.

Keywords Patient-reported outcomes · Mobile application · Adoption · Compliance · Symptom monitoring · Real-world data

Introduction

Over 90% of cancer patients experience one or more symptoms directly caused by cancer and/or its treatment [1, 2]. These symptoms have a negative impact on the completion of planned treatment, as well as the patients' quality of life (QoL). This often results in serious complications and life-threatening outcomes [3]. Therefore, healthcare professionals have historically tried to assess and report the symptoms of cancer patients during cancer treatment [4]. However, it is often difficult to monitor and manage symptoms in a timely manner via traditional methods, such as staff-administrated or paper-based surveys [4].

Recently, there has been a growing use of electronic patient-reported outcome measure (ePROM) with personal computers or smartphones, which captures symptoms more efficiently [5–11]. Both clinical trials and a large real-world population-based study have demonstrated that using the ePROM in oncology settings has clinical benefits in reducing unexpected clinical visits and improving overall health status [11–14]. Current clinical trials have reported that cancer patients who received chemotherapy in addition to active

Mangyeong Lee and Danbee Kang contributed equally as co-first authors.

✉ Soo-Yong Shin
sy.shin@skku.edu

✉ Dongryul Oh
dongryul.oh@samsung.com

Extended author information available on the last page of the article

symptom management were more likely to live longer than those who received the usual care [11].

Despite the demonstrated clinical utility and efficacy of using ePROM in clinical trials, ePROM adoption and compliance can be challenging in the real-world setting. A study evaluating willingness to use ePROM among 202 breast cancer patients found that 96 patients had never used ePROM and the nonexposed group had lower willingness to use it than the exposed group (56% in the nonexposed group vs. 92% in the exposed group) [15]. Another study which evaluated the feasibility of PRO monitoring at home found that 40% of cancer patients preferred an automated telephone interface (ATI) compared to a web-based interface (WBI) [16]. In this study, patients who were older, who were living in rural areas, or who were less educated preferred ATI over WBI [16]. To enhance adoption and reduce the attrition rate in clinical trials or practices, it is recommended to ensure the usability and accessibility of ePROM [17, 18]. Several studies have reported that perceived ease of use and usefulness for mobile health applications (mHealth apps) were associated with the adoption and sustained use of mHealth apps [19–24]. However, little is known about how these factors may be associated with the adoption of the ePROM app and compliance from the patient's perspective. Thus, we have conducted a study to identify factors associated with the adoption and compliance of ePROM use among cancer patients during treatment in a real-world setting.

Methods

Participants

This prospective cohort study was conducted at the Samsung Medical Center in Seoul, Korea, from September 2018 to January 2019. Cancer patients aged 18 years or older who owned smartphones and who were receiving chemotherapy or radiation therapy were eligible for this study. Because the application was available only for Android devices, iPhone users (iOS devices) were excluded from the study. We also excluded patients who were expected to end cancer treatment within 3 weeks as we aimed to observe the adoption and compliance of the ePROM app use for 3 weeks (21 days). Trained researchers explained the purpose and procedures of the study at outpatient clinics and ambulatory units. Written informed consent was obtained from all participants. The study was approved by the Institutional Review Board of the Samsung Medical Center (SMC 2017–06-033).

ePROM mobile application

We developed an ePROM app in which patients could report symptoms during cancer treatment (Fig. 1). First, 20 cancer patients and 10 healthcare professionals were interviewed to discover and define unmet needs related to symptom monitoring and management. Next, 200 cancer patients were surveyed to determine which user interface design they preferred the most. Then, the research team invited technical developers to implement a prototype of the ePROM app. Finally, a pilot study of 30 cancer patients was conducted to refine its usability problems. Based on findings during the development process, we defined three main functions of the ePROM app: (1) Symptom Assessment, (2) Summary Report, and (3) Information for Self-management. Symptom Assessment is the main function of the app, allowing patients to report pre-specified symptoms depending on the type of cancer and treatment. The symptom assessment screen of the ePROM application was designed to show one question (item) per page. For the symptom assessment, the Korean translation of the Patient-Reported Outcomes version of the Common Terminology Criteria for Adverse Events (PRO-CTCAE-K) was used [25]. The PRO-CTCAE-K

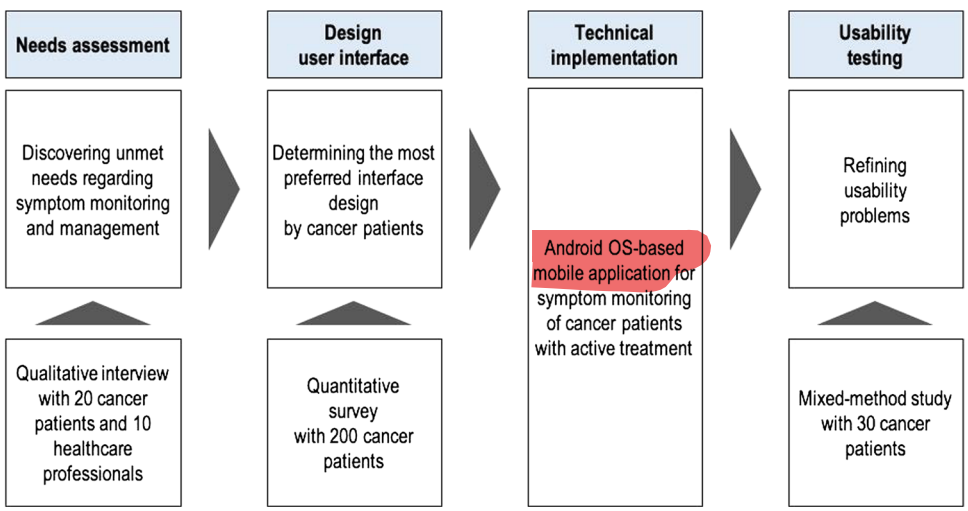

Fig. 1 Development process of ePROM mobile application

Item Library includes 124 items representing 78 symptomatic toxicities drawn from the CTCAE. Patients were asked to report the frequency, severity, and interference of symptomatic toxicities such as pain, fatigue, nausea, and hand-foot syndrome. For this study, we selected items for anticipated adverse events based on previous preclinical data and regimen-specific information for each cancer. We built seven customized sets: breast, lung, gastric, colorectal, lymphoma, head, and neck, as well as other cancers, and each set included 54 to 89 items representing 28 to 54 symptoms. The customized sets were determined according to a publication by the U.S. National Cancer Institute [26] and opinion of experts in anti-cancer treatment.

The Summary Report function was created to allow patients to observe changes in symptoms over time. The app provided two ways of summarizing the data reported by patients: the most recent report sorted by symptom severity and a weekly graph of symptom change. Lastly, the Information for Self-management function allowed patients to obtain health information that could help them cope with each symptom (S1 Figure in the Supplementary information section).

After obtaining written informed consent, the researchers installed the app on the patients' smartphones. Patients were informed about the features of the app and how to use it. Trained researchers provided education and user manuals to patients prior to the intervention; then, patients were asked to complete an initial entry. Researchers provided additional education if patients had problems to use the ePROM. Once they completed the initial entry, patients were asked to report their symptoms every 7 days for a total of 21 days (3 weeks). However, the researcher did not provide any alarms or reminders for patients to encourage them to report their symptoms.

Measurement

In the context of mHealth, adoption is the choice of acquiring and using a new product [27], and compliance is the degree to which patients conform to recommended instructions [28]. In this study, we considered that a patient adopted the ePROM app if the patient used the app voluntarily again after installation at a scheduled period (7 days after the initial report). We considered a patient as having "good compliance" if the patient who adopted the app continued to use the app following the instructions (reporting symptoms regularly and keeping a 7-day interval (±2 days) for 21 days).

According to previous studies, younger people, people with higher education, and people who were more knowledgeable about mHealth were more likely to use the app. People who felt ease of use or usefulness were also more likely to adopt mHealth apps [19, 20, 24]. Similarly, therapeutic compliance or continuous use is associated with satisfactory experience [21, 23]. In this study, we evaluated the expectation and satisfaction of ePROM app use in terms of ease of use and usefulness by asking patients at the initial and final surveys (after 21 days). Seven questions were asked for ease of use ($n = 3$) and usefulness ($n = 4$). Questionnaires were developed by the study team based on the Technology Acceptance Model and Expectation Confirmation Model [29, 30]. Specific questions were included in the S1 File. All questions were asked using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), except for one question inquiring if it was "easy to use the app (yes and no)."

In addition, we asked about experience in Internet usage, self-confidence in using smartphones, and knowledge regarding mobile apps. Five questions were asked regarding the participants' knowledge of mobile app use, and asked patients whether they correctly knew the icons and the corresponding functions for time, battery, WiFi, GPS, and Bluetooth (S1 File). We also asked about sociodemographic factors including age, sex, educational level, and family income. Clinical information such as type of cancer; Surveillance, Epidemiology, and End Results (SEER) stage; type of current treatment; and comorbidities was obtained through electronic health records.

Qualitative interview

Considering the possibility of missing important factors associated with the adoption and compliance of ePROM app use, the study team decided to conduct additional qualitative interviews. We tried to recruit patients with different adoption and compliance behaviors: (1) no adoption, (2) adoption with poor compliance, and (3) adoption with good compliance. Taking saturation into consideration, we planned to recruit 10 patients per group [31]. Study participants were asked to participate in the qualitative interviews following the final survey. Individual, semi-structured, and face-to-face interviews were conducted by trained researchers in a quiet place in the hospital, such as in an education room. Patients were asked about their experience of using the ePROM app, the specific reason why they did or did not use the app, and what made them continue to keep using the app following the instructions (compliance). We also asked about unmet needs regarding the major functions of the app and any suggestions for future applications for symptom monitoring. A total of 27 participants participated in the qualitative interviews (no adoption group (5), poor compliance group (9), and good compliance group (13)). The interviews lasted an average of 25 min. (15–45 min), and all interviews were audio-recorded and transcribed. We conducted a thematic analysis based on Braun and Clarke's method [32].

Statistical analyses

Descriptive analyses were performed to compare differences in the responses between the groups depending on the adoption and compliance of the ePROM app use. To identify factors associated with the adoption and compliance of the ePROM app use, we performed two multivariable logistic regressions. For the analyses, we re-categorized the 5-point Likert scale responses regarding ease of use and usefulness into dichotomous items (strongly agree vs. others). We adjusted for sex (male vs. female), age, and education (≤ high school vs. ≥ college), which are well-known factors associated with mobile app use [33, 34]. We excluded self-confidence in using smartphones from the analyses because this factor can be explained by ease of use [35]. All statistical analyses were performed using STATA 15.0 (Stata Corp LP, College Station, TX, USA) and R 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was defined using a 95% confidence interval (CI), and a $p < 0.05$.

Results

Participants' characteristics

Of the 1012 patients contacted, 610 (60.3%) agreed to participate in the study. After excluding participants whose surveys were incomplete ($n = 30$), 580 participants were included in this study. Of these, 163 (28.1%) no longer used the ePROM app after installation (no adoption group), 159 (27.4%) adopted the app with good compliance, and 258 (44.5%) adopted the app with poor compliance (Fig. 2).

The mean age of the study participants was 54.5 (SD = 10.3), and 45.5% of the participants were female (Table 1). Compared with the no adoption group, participants in the adoption group were more likely to be younger (53.9 years vs. 56.2 years, $p = 0.01$) and were less likely to have lower educational attainment (51.6% vs. 60.9%, $p = 0.04$). They also had a lower possibility of receiving chemotherapy (67.6% vs. 79.1%, $p = 0.02$). Further, the adoption group was more likely to use internet services via computers (66.5% vs. 55.6%, $p = 0.02$) and smartphones (89.6% vs. 82.5%, $p = 0.02$) and have higher confidence in smartphone use (63.0% vs. 53.5%, $p = 0.04$), and had higher knowledge scores than the no adoption group, respectively. Among the adoption group, participants with good compliance were likely to have higher education than those with poor compliance (S1 Table in the Supplementary information section).

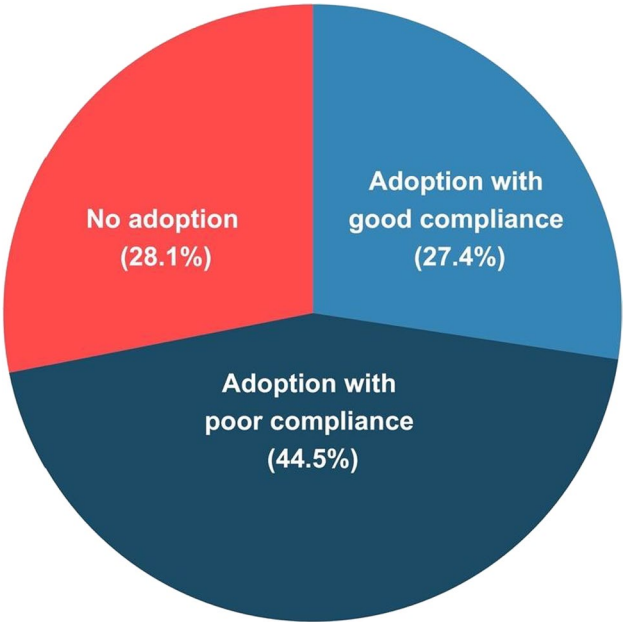

Fig. 2 Adoption and compliance of using the electronic patient-reported outcome measure mobile application (ePROM app) in the study participants ($n = 580$). "No adoption" was determined if those who stopped used the app again within 7 days after the initial entry. Among the adoption group, their compliance level was determined as "Good" or "Poor" depending on whether they completed reporting symptoms regularly, keeping a 7-day interval (±2 days) for 21 days

Difference in expectation of using the ePROM app between the adoption and no adoption group and the factors associated with adoption

In terms of expectation of using the ePROM app, the adoption group was more likely to report ease of use (96.3% vs. 89.2%, $p < 0.01$) and ease of symptom input (21.1% vs. 10.0%, $p < 0.01$) compared to the no adoption group (Table 2). The adoption group was also more likely to report that the app was useful for understanding their health (22.6% vs. 13.2%, $p = 0.01$), obtain information to manage symptoms (11.4% vs. 20.8%, $p < 0.01$), manage symptoms during treatment (22.6% vs. 13.2%, $p = 0.01$), and easily notify their clinician about their symptoms (25.9% vs. 17.0%, $p = 0.03$) compared with the no adoption group. In a multivariable analysis, easy to use the app (adjusted odds ratio [aOR] 2.67, 95% CI: 1.28–5.57), easy to input symptoms (aOR 2.33, 95% CI: 1.31–4.15), helpful to recognize my health (aOR 1.88, 95% CI: 1.12–3.17), helpful to obtain information to manage symptoms (aOR 2.05, 95% CI: 1.18–3.56), helpful to manage symptoms during treatment (aOR 1.91, 95% CI: 1.14–3.22), and useful to notify clinician of symptoms (aOR 1.69, 95% CI: 1.05–2.72) were significantly associated with the adoption of the app (Table 2).

Table 1 Participant characteristics ($n=580$)

	Overall ($n=580$)	Adoption ($n=417$)	No adoption ($n=163$)	*P* value
	n (%)	*n* (%)	*n* (%)	
Age, mean (SD), years	54.5 (10.3)	53.9 (10.6)	56.2 (9.4)	**0.01**
Gender, male	316 (54.5)	217 (52.0)	99 (60.7)	0.06
Final education, less than high school	312 (54.2)	214 (51.6)	98 (60.9)	**0.04**
Family income, monthly				0.23
< USD 200	128 (22.1)	87 (20.9)	41 (25.2)	
≥ USD 200	439 (75.7)	322 (77.2)	117 (71.8)	
Type of cancer				**0.04**
Breast	117 (20.2)	90 (21.6)	27 (16.6)	
Lung	107 (18.5)	67 (16.1)	40 (24.5)	
Colorectal	91 (15.7)	62 (14.9)	29 (17.8)	
Head and neck	65 (11.2)	53 (12.7)	12 (7.4)	
Hematology	43 (7.4)	29 (7.0)	14 (8.6)	
Stomach	28 (4.8)	17 (4.1)	11 (6.8)	
Others	129 (22.2)	99 (23.7)	30 (18.4)	
SEER stage				0.36
In situ and localized	108 (18.6)	80 (19.2)	28 (17.2)	
Regional	279 (48.1)	207 (49.6)	72 (44.2)	
Distant	178 (30.7)	119 (28.5)	59 (36.2)	
Unknown	15 (2.6)	11 (2.6)	4 (2.5)	
Current treatment				**0.02**
Chemotherapy	410 (70.8)	281 (67.6)	129 (79.1)	
Radiation therapy	79 (13.6)	65 (15.6)	14 (8.6)	
Both	90 (15.5)	70 (16.8)	20 (12.3)	
Comorbidity, yes	240 (41.4)	165 (39.6)	75 (46.0)	0.16
Internet usage via				
Desktop computer	357 (63.4)	268 (66.5)	89 (55.6)	**0.02**
Smartphone	206 (87.6)	362 (89.6)	132 (82.5)	**0.02**
Self-confidence in using a smartphone				**0.04**
Confident	339 (60.3)	254 (63.0)	85 (53.5)	
Not confident	223 (39.7)	149 (37.0)	74 (46.5)	
Knowledge of using a smartphone[a]	188 (32.4)	149 (35.7)	39 (23.9)	**< 0.01**

Values in bold indicate statistically significant results

Abbreviation: *SEER*, Surveillance, Epidemiology, and End Results

[a]It was assessed utilizing a 5-item questionnaire which asked whether participants knew exactly each basic functionality of a smartphone; the values indicate the number of those who got full marks

Difference in satisfaction of using the ePROM app between the good compliance and poor compliance group and the factors associated with compliance of using ePROM app

There were no factors which were strongly positively correlated with expectation and satisfaction (S2 Table). Among the adoption group, the good compliance group was more likely to show greater satisfaction in terms of helpfulness to recognize my health (22.41% vs. 13.2%, $p=0.02$) and manage symptoms during treatment (18.3% vs. 11.2%, $p=0.05$) compared with the poor compliance group (Table 3). In a multivariable analysis, helpful to recognize my health (aOR 1.89, 95% CI 1.10–3.25) and manage symptoms during treatment (aOR 1.79, 95% CI 1.00–3.21) were significantly associated with good compliance with the app.

Qualitative findings about perceived benefits and unmet needs to using the ePROM app among no adoption, adoption with poor compliance, and adoption with good compliance

The no adoption group had a low awareness of the ePROM app and felt more comfortable communicating in person instead of using digital or mobile devices (S3 Table in the Supplementary information section). Among the adoption group, both the

Table 2 Expectation of ease of use and usefulness of using electronic patient-reported outcome measure mobile application (ePROM app) by adoption ($n=580$)

	Adoption ($n=417$) *n* (%)	No adoption ($n=163$) *n* (%)	*p* value	Adjusted OR[c] (95% CI)
Expectation of ease of use[a]				
Easy to use the app	389 (96.3)	141 (89.2)	**< 0.01**	**2.67 (1.28, 5.57)**
Easy to understand symptom information	85 (20.8)	27 (17.0)	0.30	1.20 (0.74, 1.95)
Easy to input symptoms	85 (21.1)	16 (10.1)	**< 0.01**	**2.33 (1.31, 4.15)**
Expectation of usefulness[b]				
Helpful to recognize my health	91 (22.6)	21 (13.2)	**0.01**	**1.88 (1.12, 3.17)**
Helpful to obtain information to manage symptoms	84 (20.8)	18 (11.4)	**< 0.01**	**2.05 (1.18, 3.56)**
Helpful to manage symptoms during treatment	91 (22.6)	21 (13.2)	**0.01**	**1.91 (1.14, 3.22)**
Useful to notify clinician of symptoms	104 (25.9)	27 (17.0)	**0.03**	**1.69 (1.05, 2.72)**

Values in bold indicate statistically significant results

Abbreviations: *OR*, odds ratio; *CI*, confidence interval

[a,b]We dichotomized the responses based on "yes" ("easy to use the app" item only) or "strongly agree" to each question

[c]No adoption vs. adoption; Adjusted for age, sex, and education

Table 3 Satisfaction with ease of use and usefulness of using ePROM app by compliance ($n=417$)

	Good compliance ($n=159$) *n* (%)	Poor compliance ($n=258$) *n* (%)	*p* value	Adjusted OR[c] (95% CI)
Satisfaction with ease of use[a]				
Easy to use the app	151 (99.3)	232 (96.3)	0.06	5.36 (0.67, 43.11)
Easy to understand symptom information	34 (22.4)	60 (24.9)	0.57	0.83 (0.51, 1.36)
Easy to input symptoms	35 (22.9)	47 (19.4)	0.41	1.18 (0.71, 1.95)
Satisfaction with usefulness[b]				
Helpful to recognize my health	34 (22.4)	32 (13.2)	**0.02**	**1.89 (1.10, 3.25)**
Helpful to obtain information to manage symptoms	27 (17.7)	31 (12.8)	0.19	1.39 (0.79, 2.46)
Helpful to manage symptoms during treatment	28 (18.3)	27 (11.2)	**0.05**	**1.79 (1.00, 3.21)**
Useful to notify clinician of symptoms	33 (21.7)	42 (17.4)	0.29	1.30 (0.77, 2.18)

Values in bold indicate statistically significant results

Abbreviations: *OR*, odds ratio; *CI*, confidence interval

[a,b]We dichotomized the responses based on "yes" ("easy to use the app" item only) or "strongly agree" to each question

poor and good compliance groups agreed that the ePROM app helped them understand the changes in their symptoms, whereas the poor compliance group reported that the ePROM app had limited reflection of their health status and the inclusion of too many items made them feel fatigued. All of the participants also responded that feedback from their physician based on their symptom reports would reinforce their compliance.

Discussion

In our study, approximately 70% of our study participants adopted the ePROM app after initial use. Patients who had greater expectations regarding the ease of use and usefulness of the ePROM app were more likely to adopt the app than those who did not. Patients who had greater satisfaction with usefulness were more likely to comply with using the app, but satisfaction with ease of use was not related to compliance with the ePROM app. Patients who were satisfied with using the ePROM app found it to be helpful in recognizing and managing symptoms and were more likely to comply with the ePROM app use.

About 72% of our study participants adopted the ePROM app after initial use. Patients who had greater expectations of ease of use for the ePROM app were about three times more likely to adopt the app than patients who had lower expectations of ease of use. Similarly, patients who had greater expectations of the usefulness of the ePROM app were two times as likely to adopt the app. In addition, those who adopted the app were

likely to be younger, be highly educated, be more knowledgeable about smartphones, and have higher confidence in using a smartphone. This might be because the expectation of ease of use and usefulness at the initial use of the app is affected by their ability to use digital technologies. In previous studies, old age, lower education, and lack of knowledge about digital devices were associated with an individual's ability to utilize digital technology [36, 37]. A participant's limited ability to use digital technology may affect them by making them feel that the app is difficult and not useful, resulting in low willingness to adopt the app [38, 39]. In the qualitative interviews, some patients in the study claimed that they did not use the ePROM app because they were not familiar with smartphones. Another patient did not use the app because they were afraid to make a mistake while using the ePROM app. In addition, in two intervention studies conducted in the USA, patients who received prior technology training were more likely to be engaged with Internet-based health services than those who did not receive the training [40, 41]. Therefore, before starting to use ePROM, it is important to provide patients with sufficient technology training that considers individual psychological barriers toward using the app or the actual ability to use it.

In our study, only one-third of our study population was in the good compliance group. This is lower than the results of previous ePROM studies [42–44] in which compliance rates varied from 75 to 90%. This might be due to the difference between a clinical research setting and a real-world setting. In most previous studies, the compliance of the app was evaluated in a clinical trial that supported and encouraged study participants to keep using the app [42–45]. For example, patients received regular reminders through the ePROM system, or the central data manager or nurse provided backup calls or hospital-owned tablet PCs in the clinical waiting room if the patients missed reporting symptoms [42–44]. However, in our study, we did not provide any support or feedback regarding app use and emphasized individual autonomy in using the app. We believe that this is a more realistic value which we would expect regarding compliance with app use. Nevertheless, researchers and healthcare professionals should recognize this relatively lower compliance of ePROM use in a real-world setting. It is recommended to consider proper timing of alarms or reminders encouraging individual participation. However, since implementing proper alarms is another research topic, this study will be one of our future research.

In terms of compliance, patients who strongly agreed that using ePROM was helpful in recognizing and managing symptoms better were about two times more likely to comply with the ePROM app use. However, satisfaction with ease of use with the ePROM app was not associated with compliance. This might be because we evaluated compliance among patients who had already adopted the app. Patients who did not have technical barriers (who were able to adopt the app) to use the ePROM app would give more value to the clinical benefits of using the app when they continue to use rather than the ease of use. This is possible. In a longitudinal qualitative study with 17 adults, both voluntary and self-motivated attitudes toward their own health goals were associated with the continued use of mHealth apps when users' assessment of the app and its capabilities were positive [46]. Another longitudinal study with 711 people also reported that the perceived effect on changing health behaviors was a relatively stronger predictor for continued use of physical activity trackers than perceived ease of use [47]. In addition, being informed about individual patients' health status by self-monitoring might contribute to good compliance and improve motivation toward reporting symptoms [48, 49]. In other words, it is important to determine how much the participants experience the substantial benefits of the app. In our qualitative findings, patients with good compliance said that the use of ePROM helped them not only to recognize symptoms but also to prepare and manage the symptoms. In contrast, the poor compliance group tended to think that the questions in the ePROM app were less reflective of their health status at that time, and regular reporting of symptoms was tiring. The benefits of using ePROM systems in oncology care are the early identification of symptoms that can be easily unaddressed or overlooked by healthcare professionals [2, 50, 51]. However, given that it focuses on individual active participation, one needs to address how to justify their role in ePROM-based care and motivate them continuously. The patients in our study told that physicians' feedback to their reports would be a compelling justification for the need to self-report symptoms. Therefore, it would be important to provide physician's feedback to patients who use the app. Patients would be more likely to use the app if physicians provide feedback on symptoms which patients reported using the app. In addition, researchers and physicians need to find ways to deliver the feedback on the app use at current clinical setting.

In addition to the physician's efforts, it needs to address various approaches to optimize the ePROM-based clinical practice. Firstly, it is recommended to avoid elements that can reduce user engagement or motivation while they are interacting with ePROM [52]. For instance, poor compliance group in our study mentioned that the feeling of having too many questions or repeating the same questions over and over caused fatigue. Although we explained about the ePROM and provided a user manual, it might not be enough for patients to understand and comply the whole process. Visualizing the progress of symptom assessment (e.g., progress bar chart on the bottom of the screen) might be helpful for patients to check the progress of survey and use it more actively.

The ePROM is a complex intervention involving a range of clinician-driven care based on symptom assessments and as well as patient self-management [53]. In fact, the activation of self-management, onboarding patients to participate in symptom assessment and management is much

more complex than just giving them a program and leave to them to use it or not [53]. In this study, we provided a face-to-face education as well as a user manual prior to the intervention. However, it might not be enough to empower patients to use the ePROM freely. Considering that self-management requires understanding individual roles, knowledge,and skills, and facilitating environment, more intensive training or education might be necessary for patients to use the ePROM [53, 54].

Our study contains several limitations. While we evaluated the repeated behaviors to evaluate compliance with the ePROM app, the follow-up period was insufficient to determine compliance level. However, a real-world study regarding mHealth app usage reported that more than 80% of mHealth app users stopped using the app between days 1 and 10 [55]. Thus, it might be possible to determine their behavior change for 3 weeks, which can be considered as the typical duration of treatment with chemotherapy or radiotherapy. Second, we did not include all psychosocial or behavioral factors that might be associated with the adoption and compliance with ePROM use. However, little is known about the factors associated with the adoption and compliance of ePROM. Thus, we conducted a qualitative study to identify possible psychosocial and behavioral factors, and the results of the qualitative interviews confirmed our quantitative results. Lastly, because we conducted this study at a single tertiary hospital in Seoul, Korea, the results of this study might not be generalizable to populations in other settings.

Conclusion

The low compliance with ePROM app use is an issue that needs to be addressed in real-world settings. Before starting the ePROM app implementation in a clinical setting, it is recommended to provide an educational program that reduces psychological barriers or resistance to app use and raises the awareness of PRO. It is also recommended to consider any kind of support that motivates patients to comply with the app use, justifying the value of collecting their symptoms using the app.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00520-021-06473-6.

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Author contribution Conceptualization: M Lee, D Kang, S Kim, J Lim, J Yoon, Y Kim, S Shim, E Kang, JS Ahn, J Cho, SY Shin, D Oh.
Methodology: M Lee, D Kang, S Kim, J Lim, J Yoon, Y Kim, S Shim, E Kang, JS Ahn, J Cho, SY Shin, D Oh.
Investigation: M Lee, J Yoon, Y Kim, S Shim.
Data curation: M Lee, D Kang, J Lim.
Formal analysis: M Lee, D Kang, J Lim.
Visualization: M Lee, D Kang, J Lim.
Writing—original draft preparation: M Lee, D Kang, S Kim, J Lim.
Writing—review and editing: M Lee, D Kang, S Kim, J Lim, J Yoon, Y Kim, S Shim, E Kang, JS Ahn, J Cho, SY Shin, D Oh.
Supervision: J Cho, SY Shin, D Oh.
Resource: JS Ahn, D Oh.
Funding Acquisition: J Cho, D Oh.
M Lee, Mangyeong Lee; D Kang, Danbee Kang; S Kim, Sooyeon Kim; J Lim, Jihyun Lim; J Yoon, Junghee Yoon; Y Kim, Youngha Kim; S Shim, Sungkeun Shim; E Kang, Eunji Kang; JS Ahn, Jin Seok Ahn; J Cho, Juhee Cho; SY Shin, Soo-Yong Shin; D Oh, Dongryul Oh

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Data availability Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

Code availability The primary author has full control of all codes and agrees to allow the journal to review the codes if requested.

Declarations

Ethics approval The study was approved by the Institutional Review Board of the Samsung Medical Center (SMC 2017–06-033).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

References

1. Shi Q, Smith TG, Michonski JD et al (2011) Symptom burden in cancer survivors 1 year after diagnosis: a report from the American Cancer Society's Studies of Cancer Survivors. Cancer 117:2779–2790. https://doi.org/10.1002/cncr.26146
2. Deshields TL, Potter P, Olsen S et al (2014) The persistence of symptom burden: symptom experience and quality of life of cancer patients across one year. Support Care Cancer 22:1089–1096. https://doi.org/10.1007/s00520-013-2049-3
3. National Chemotherapy Advisory Group (2009) Chemotherapy services in England: ensuring quality and safety. NHS National Cancer Action Team. https://webarchive.nationalarchives.gov.uk/20130104173757/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/DH_104500. Accessed 15 Feb 2020
4. Trotti A, Colevas AD, Setser A et al (2007) Patient-reported outcomes and the evolution of adverse event reporting in oncology. J Clin Oncol 25:5121–5127. https://doi.org/10.1200/jco.2007.12.4784
5. Schick-Makaroff K, Molzahn A (2015) Strategies to use tablet computers for collection of electronic patient-reported

outcomes. Health Qual Life Outcomes 13:2. https://doi.org/10.1186/s12955-014-0205-1
6. Benze G, Nauck F, Alt-Epping B, et al. (2017) PROutine a feasibility study assessing surveillance of electronic patient reported outcomes and adherence via smartphone app in advanced cancer. Ann Palliat Med 6: 705–705. https://doi.org/10.21037/apm.2017.07.05
7. Christie A, Dagfinrud H, Dale Ø et al (2014) Collection of patient-reported outcomes;-text messages on mobile phones provide valid scores and high response rates. BMC Med Res Methodol 14:52. https://doi.org/10.1186/1471-2288-14-52
8. Jensen RE, Snyder CF, Abernethy AP et al (2014) Review of electronic patient-reported outcomes systems used in cancer clinical care. J Oncol Pract 10:e215–e222. https://doi.org/10.1200/JOP.2013.001067
9. Boumans R, Van Meulen F, Hindriks K et al (2018) Proof of concept of a social robot for patient reported outcome measurements in elderly persons. Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction: 73–74. https://doi.org/10.1145/3173386.3177013
10. Boumans R, van Meulen F, Hindriks K et al (2019) A feasibility study of a social robot collecting patient reported outcome measurements from older adults. Int J Soc Robot 1–8. https://doi.org/10.1007/s12369-019-00561-8
11. Basch E, Deal AM, Dueck AC et al (2017) Overall survival results of a trial assessing patient-reported outcomes for symptom monitoring during routine cancer treatment. JAMA 318:197–198
12. Kotronoulas G, Kearney N, Maguire R et al (2014) What is the value of the routine use of patient-reported outcome measures toward improvement of patient outcomes, processes of care, and health service outcomes in cancer care? A systematic review of controlled trials. J Clin Oncol 32:1480–1510. https://doi.org/10.1200/JCO.2013.53.5948
13. Basch E, Deal AM, Kris MG et al (2016) Symptom monitoring with patient-reported outcomes during routine cancer treatment: a randomized controlled trial. J Clin Oncol 34:557. https://doi.org/10.1200/JCO.2015.63.0830
14. Denis F, Basch E, Septans A-L et al (2019) Two-year survival comparing web-based symptom monitoring vs routine surveillance following treatment for lung cancer. JAMA 321:306–307. https://doi.org/10.1001/jama.2018.18085
15. Hartkopf AD, Graf J, Simoes E et al (2017) Electronic-based patient-reported outcomes: willingness, needs, and barriers in adjuvant and metastatic breast cancer patients. JMIR Cancer 3:e6996. https://doi.org/10.2196/cancer.6996
16. Stover A, Henson S, Jansen J et al (2019) Demographic and symptom differences in PRO-TECT trial (AFT-39) cancer patients electing to complete weekly home patient-reported outcome measures (PROMs) via an automated phone call vs. email: implications for implementing PROs into routine care. 26th Annual Conference of the International Society for Quality of Life Research 28: S1-S2. https://doi.org/10.1007/s11136-019-02257-y
17. Schoen MW, Basch E, Hudson LL et al (2018) Software for administering the National Cancer Institute's Patient-Reported Outcomes Version of the Common Terminology Criteria for Adverse Events: usability study. JMIR Hum Factors 5:e10070. https://doi.org/10.2196/10070
18. Aiyegbusi OL (2020) Key methodological considerations for usability testing of electronic patient-reported outcome (ePRO) systems. Qual Life Res 29:325–333. https://doi.org/10.1007/s11136-019-02329-z
19. Deng Z, Hong Z, Ren C et al (2018) What predicts patients' adoption intention toward mHealth services in China: empirical study. JMIR Mhealth Uhealth 6:e172. https://doi.org/10.2196/mhealth.9316
20. Dou K, Yu P, Deng N et al (2017) Patients' acceptance of smartphone health technology for chronic disease management: a theoretical model and empirical test. JMIR Mhealth Uhealth 5:e177. https://doi.org/10.2196/mhealth.7886
21. Cho J (2016) The impact of post-adoption beliefs on the continued use of health apps. Int J Med Inform 87:75–83. https://doi.org/10.1016/j.ijmedinf.2015.12.016
22. Lee M, Kang D, Yoon J et al (2020) The difference in knowledge and attitudes of using mobile health applications between actual user and non-user among adults aged 50 and older. PLoS ONE 15:e0241350. https://doi.org/10.1371/journal.pone.0241350
23. Chiu W, Cho H, Chi CG (2020) Consumers' continuance intention to use fitness and health apps: an integration of the expectation–confirmation model and investment model. Inf Technol People. https://doi.org/10.1108/ITP-09-2019-0463
24. Koh U, Horsham C, Soyer HP et al (2019) Consumer acceptance and expectations of a mobile health application to photograph skin lesions for early detection of melanoma. Dermatology 235:4–10. https://doi.org/10.1159/000493728
25. Cho J, Yoon J, Kim Y et al (2019) Linguistic validation of the US National Cancer Institute's Patient-Reported Outcomes Version of the Common Terminology Criteria for Adverse Events in Korean. J Glob Oncol 5:1–10. https://doi.org/10.1200/JGO.18.00193
26. Dueck AC, Mendoza TR, Mitchell SA et al (2015) Validity and reliability of the US National Cancer Institute's Patient-Reported Outcomes Version of the Common Terminology Criteria for Adverse Events (PRO-CTCAE). JAMA Oncol 1:1051–1059. https://doi.org/10.1001/jamaoncol.2015.2639
27. Gao S, Krogstie J (2016) Understanding users' intention to use mobile services from the perspective of lifestyle. Encyclopedia of E-Commerce Development, Implementation, and Management\\: 10. https://doi.org/10.4018/978-1-4666-9787-4.ch106
28. Jin J, Sklar GE, Oh VMS et al (2008) Factors affecting therapeutic compliance: a review from the patient's perspective. Ther Clin Risk Manag 4:269. https://doi.org/10.2147/tcrm.s1458
29. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 319–340. https://doi.org/10.2307/249008
30. Bhattacherjee A (2001) Understanding information systems continuance: an expectation-confirmation model. MIS Q 351–370. https://doi.org/10.2307/3250921
31. Guest G, Namey E, Chen M (2020) A simple method to assess and report thematic saturation in qualitative research. PLoS ONE 15:e0232076. https://doi.org/10.1371/journal.pone.0232076
32. Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3:77–101. https://doi.org/10.1191/1478088706qp063oa
33. Jiang Y, West BT, Barton DL et al (2017) Acceptance and use of eHealth/mHealth applications for self-management among cancer survivors. Stud Health Technol Inform 245:131
34. Zhang X, Guo X, Lai K-h et al (2014) Understanding gender differences in m-health adoption: a modified theory of reasoned action model. Telemedicine and e-Health 20:39–46. https://doi.org/10.1089/tmj.2013.0092
35. Venkatesh V, Davis FD (1996) A model of the antecedents of perceived ease of use: development and test. Decis Sci 27:451–481. https://doi.org/10.1111/j.1540-5915.1996.tb00860.x
36. Eshet Y (2004) Digital literacy: a conceptual framework for survival skills in the digital era. J Educ Multimed Hypermed 13:93–106
37. Lankshear C, Knobel M (2008) Origins and concepts of digital literacy. Peter Lang
38. Tennant B, Stellefson M, Dodd V et al (2015) eHealth literacy and Web 2.0 health information seeking behaviors among baby boomers and older adults. J Med Internet Res 17:e70. https://doi.org/10.2196/jmir.3992
39. Mackert M, Mabry-Flynn A, Champlin S et al (2016) Health literacy and health information technology adoption: the potential

for a new digital divide. J Med Internet Res 18:e264. https://doi.org/10.2196/jmir.6349
40. Stein JN, Klein JW, Payne TH et al (2018) Communicating with vulnerable patient populations: a randomized intervention to teach inpatients to use the electronic patient portal. Appl Clin Inform 9:875. https://doi.org/10.1055/s-0038-1676333
41. McInnes DK, Solomon JL, Shimada SL et al (2013) Development and evaluation of an internet and personal health record training program for low-income patients with HIV or hepatitis C. Med Care S62-S66. https://doi.org/10.1097/MLR.0b013e31827808bf
42. Bae WK, Kwon J, Lee HW et al (2018) Feasibility and accessibility of electronic patient-reported outcome measures using a smartphone during routine chemotherapy: a pilot study. Support Care Cancer 26:3721–3728. https://doi.org/10.1007/s00520-018-4232-z
43. Basch E, Dueck AC, Rogak LJ et al (2018) Feasibility of implementing the patient-reported outcomes version of the common terminology criteria for adverse events in a multicenter trial: NCCTG N1048. J Clin Oncol 36:3120. https://doi.org/10.1200/JCO.2018.78.8620
44. Basch E, Pugh SL, Dueck AC et al (2017) Feasibility of patient reporting of symptomatic adverse events via the patient-reported outcomes version of the common terminology criteria for adverse events (PRO-CTCAE) in a chemoradiotherapy cooperative group multicenter clinical trial. Int J Radiat Oncol Biol Phys 98:409–418. https://doi.org/10.1016/j.ijrobp.2017.02.002
45. Basch E, Iasonos A, Barz A et al (2007) Long-term toxicity monitoring via electronic patient-reported outcomes in patients receiving chemotherapy. J Clin Oncol 25:5374–5380. https://doi.org/10.1200/JCO.2007.11.2243
46. Vaghefi I, Tulu B (2019) The continued use of mobile health apps: insights from a longitudinal study. JMIR Mhealth Uhealth 7:e12983. https://doi.org/10.2196/12983
47. Hermsen S, Moons J, Kerkhof P et al (2017) Determinants for sustained use of an activity tracker: observational study. JMIR Mhealth Uhealth 5:e164. https://doi.org/10.2196/mhealth.7311
48. Lee K, Kwon H, Lee B et al (2018) Effect of self-monitoring on long-term patient engagement with mobile health applications. PLoS ONE 13:e0201166. https://doi.org/10.1371/journal.pone.0201166
49. Bidargaddi N, Pituch T, Maaieh H et al (2018) Predicting which type of push notification content motivates users to engage in a self-monitoring app. Prev Med Rep 11:267–273. https://doi.org/10.1016/j.pmedr.2018.07.004
50. Snyder CF, Blackford AL, Wolff AC et al (2013) Feasibility and value of PatientViewpoint: a web system for patient-reported outcomes assessment in clinical practice. Psychooncology 22:895–901. https://doi.org/10.1002/pon.3087
51. Basch E, Iasonos A, McDonough T et al (2006) Patient versus clinician symptom reporting using the National Cancer Institute Common Terminology Criteria for Adverse Events: results of a questionnaire-based study. Lancet Oncol 7:903–909. https://doi.org/10.1016/S1470-2045(06)70910-X
52. Cechetti NP, Bellei EA, Biduski D et al (2019) Developing and implementing a gamification method to improve user engagement: a case study with an m-Health application for hypertension monitoring. Telematics Inform 41:126–138. https://doi.org/10.1016/j.tele.2019.04.007
53. Chan RJ, Howell D, Lustberg MB et al (2020) Advances and future directions in the use of mobile health in supportive cancer care: proceedings of the 2019 MASCC Annual Meeting symposium. Support Care Cancer 28:4059–4067. https://doi.org/10.1007/s00520-020-05513-x
54. World Health Organization (2009) WHO guidelines on hand hygiene in health care: first global patient safety challenge clean care is safer care. World Health Organization, Geneva. https://www.ncbi.nlm.nih.gov/books/NBK144022. Accessed 10 July 2021
55. Baumel A, Muench F, Edan S et al (2019) Objective user engagement with mental health apps: systematic search and panel-based usage analysis. J Med Internet Res 21:e14567. https://doi.org/10.2196/14567

Authors and Affiliations

Mangyeong Lee[1,2] · Danbee Kang[2,3] · Sooyeon Kim[2,3] · Jihyun Lim[2] · Junghee Yoon[1,3,4] · Youngha Kim[2] · Sungkeun Shim[1,2] · Eunji Kang[2,5] · Jin Seok Ahn[6] · Juhee Cho[1,2,3,7,8] · Soo-Yong Shin[1,9] · Dongryul Oh[10]

1 Department of Digital Health, SAIHST, Sungkyunkwan University, Seoul, South Korea

2 Center for Clinical Epidemiology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

3 Department of Clinical Research Design and Evaluation, SAIHST, Sungkyunkwan University, Seoul, South Korea

4 Patient-Centered Outcomes Research Institute, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

5 Department of Medical Device Management and Research, SAIHST, Sungkyunkwan University, Seoul, South Korea

6 Division of Hematology-Oncology, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

7 Cancer Education Center, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

8 Department of Health, Behavior and Society and Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

9 Center for Research Resource Standardization, Samsung Medical Center, Seoul, South Korea

10 Department of Radiation Oncology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea